Potential Spread of Hydrilla (*Hydrilla verticillata*) in the Great Lakes Basin

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Hydrilla: Why Should We Care?

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  - In 1995 $14.5M in management costs in FL
  - Great Lakes Basin at risk

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- Risk assessment
  - Direct early monitoring efforts

Hydrilla Risk Assessment Collaborative

Team Member	**Project Role**
USACE, Buffalo District	Project Management and Technical Oversight
USACE, Engineer Research Development Center	Technical Guidance and Oversight
Ecology and Environment, Inc. (E&E Inc.)	Project Management, Risk Assessment Lead
Texas Tech University	Distributional Modeling
University of Toledo	**Dispersal Modeling**
North Carolina State University	Hydrilla Growth Studies

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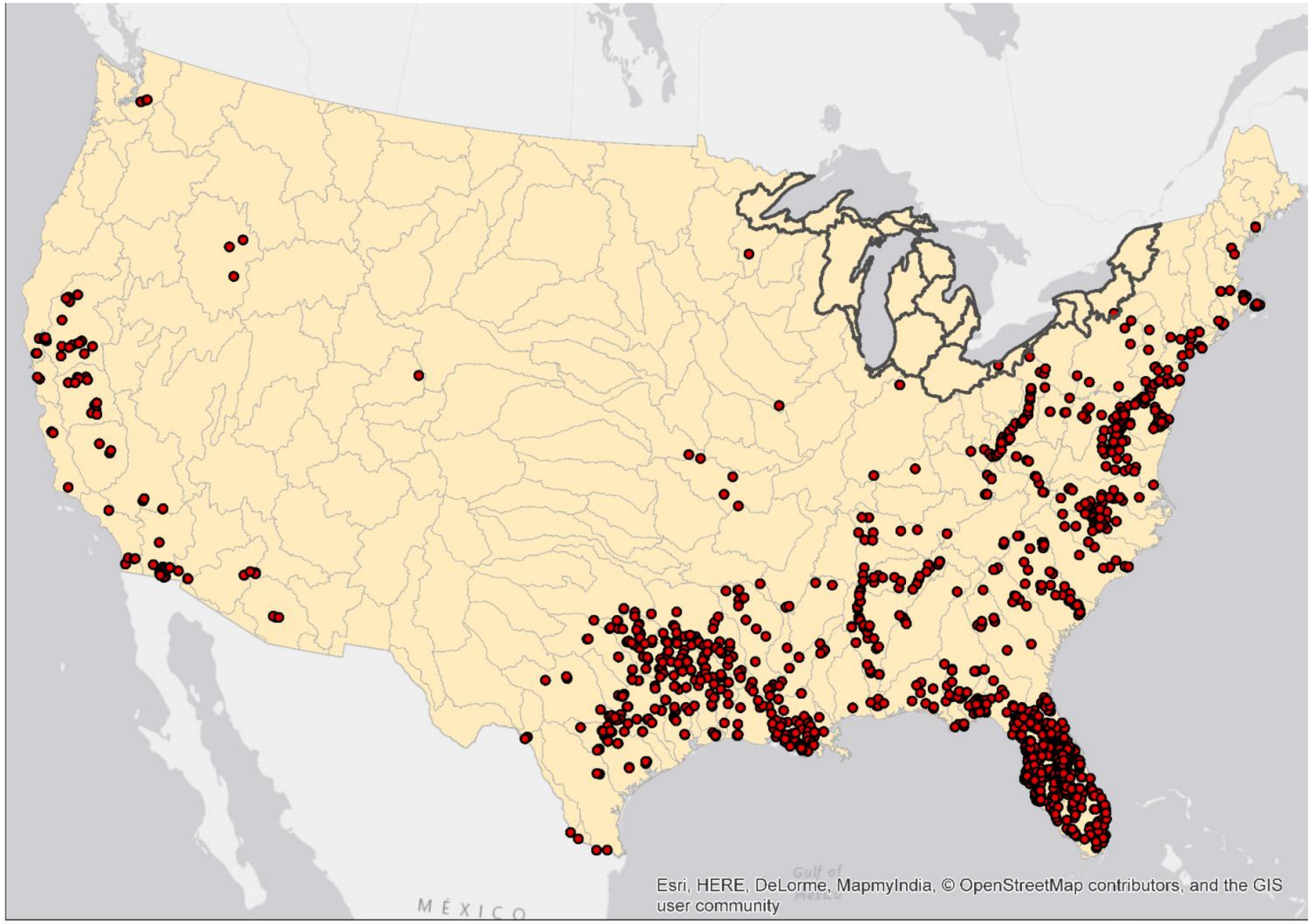
Assess the current distribution of hydrilla

- Data
  - Hydrilla occurrence data (compiled by E&E Inc. from Early Detection Distribution Mapping System and Global Biodiversity Information Facility)
  - Location and size of lakes and rivers -National Hydrologic Database



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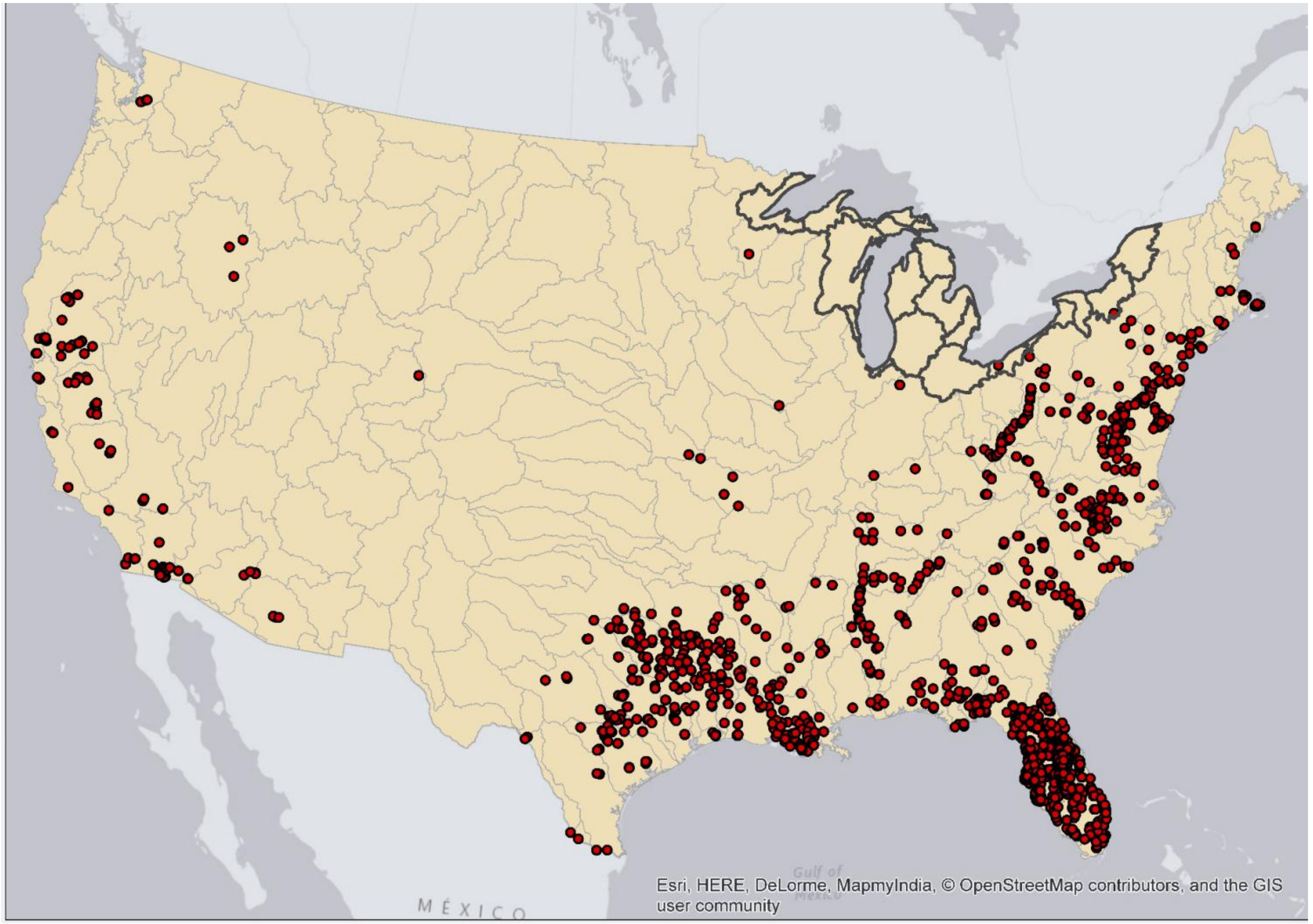
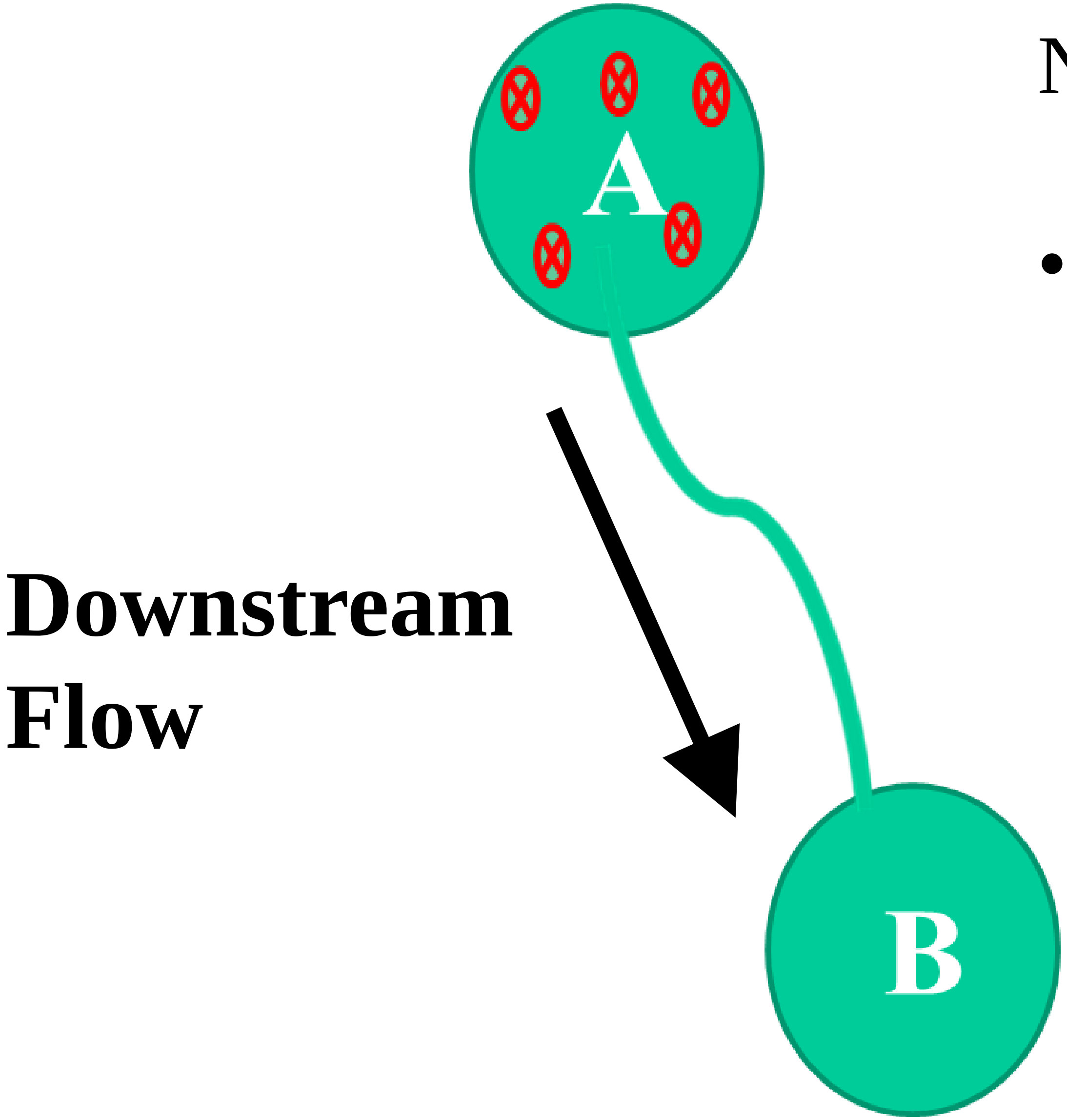


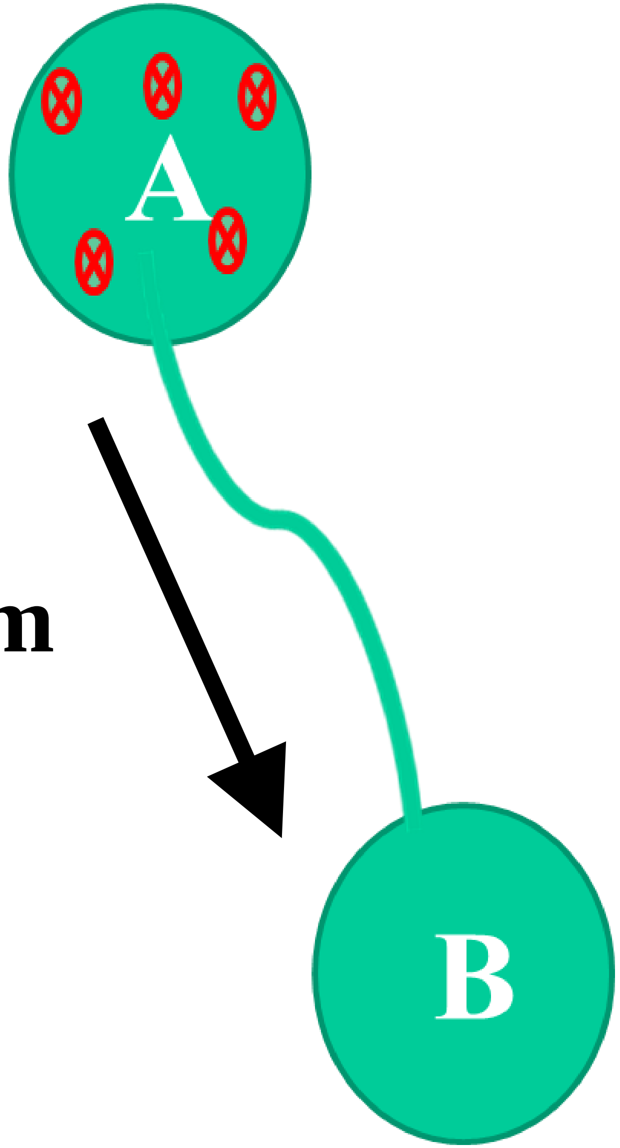
Does proximity play a role in natural dispersal?



Natural Dispersal Analysis

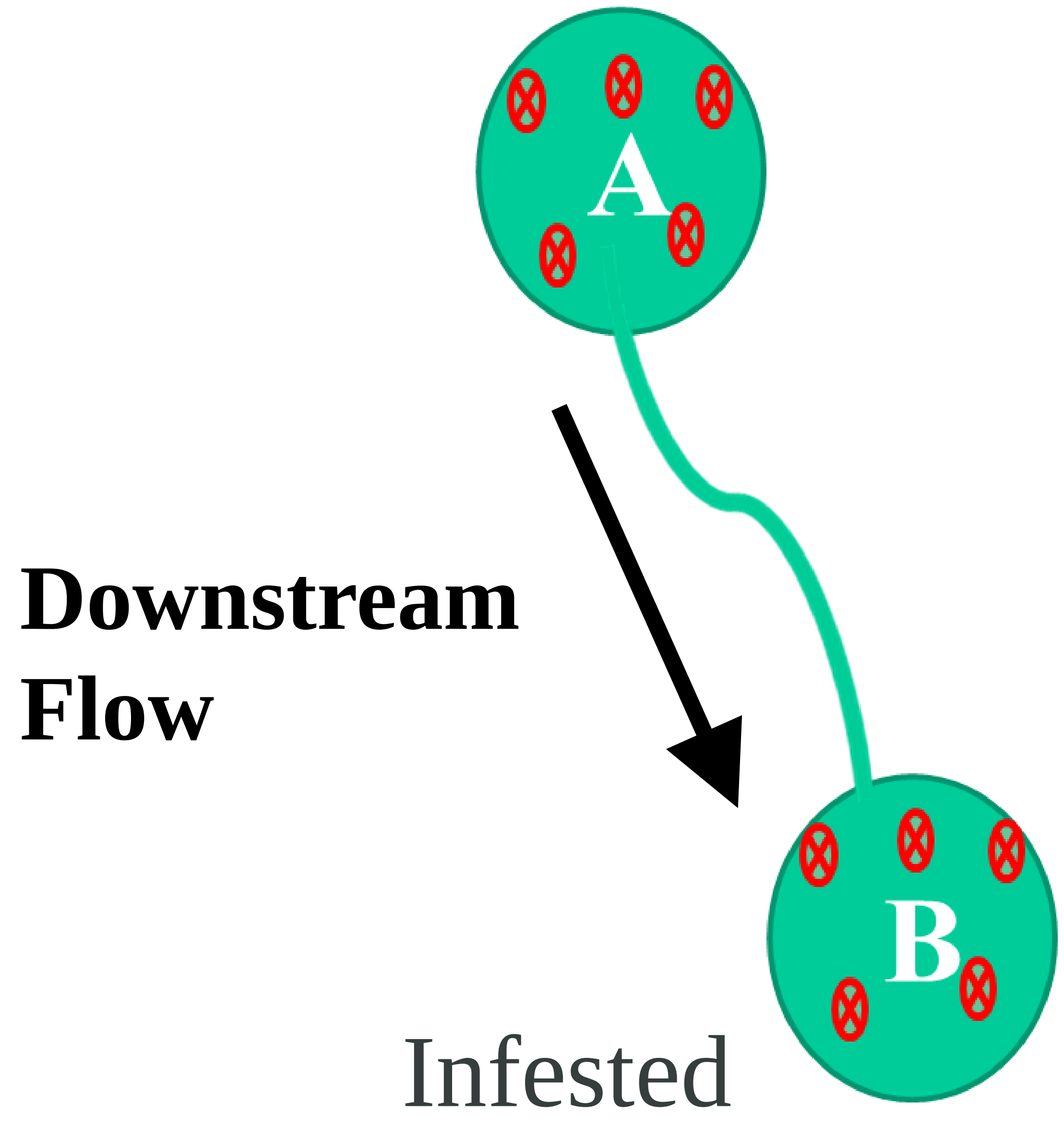
- Choose infested and connected lakes

Downstream Flow



Natural Dispersal Analysis

- Choose infested and connected lakes
- Follow the downstream flow categorize downstream lake/ reservoir at infested or not infested/not detected



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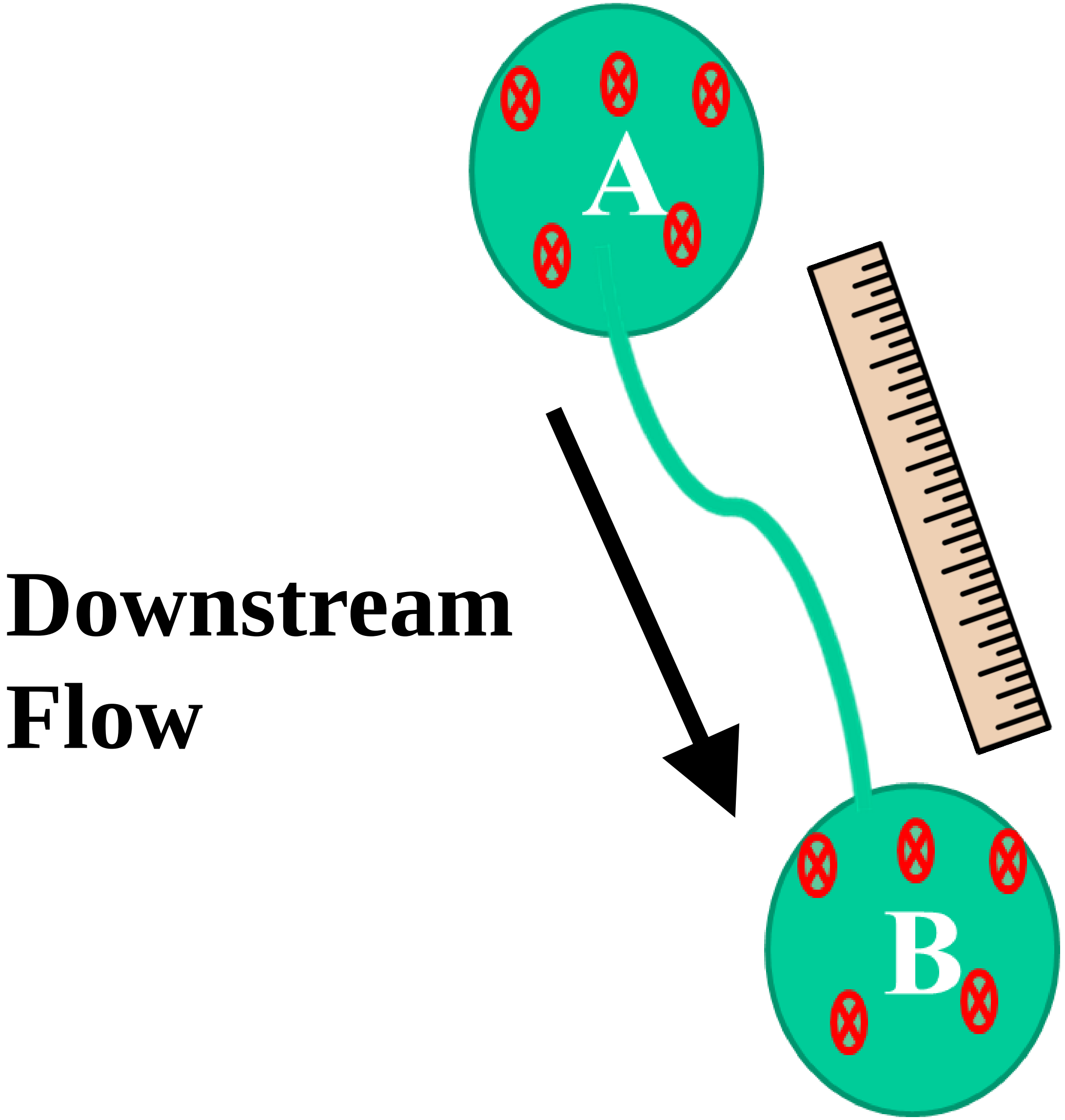

Natural Dispersal Analysis

- Choose infested and connected lakes
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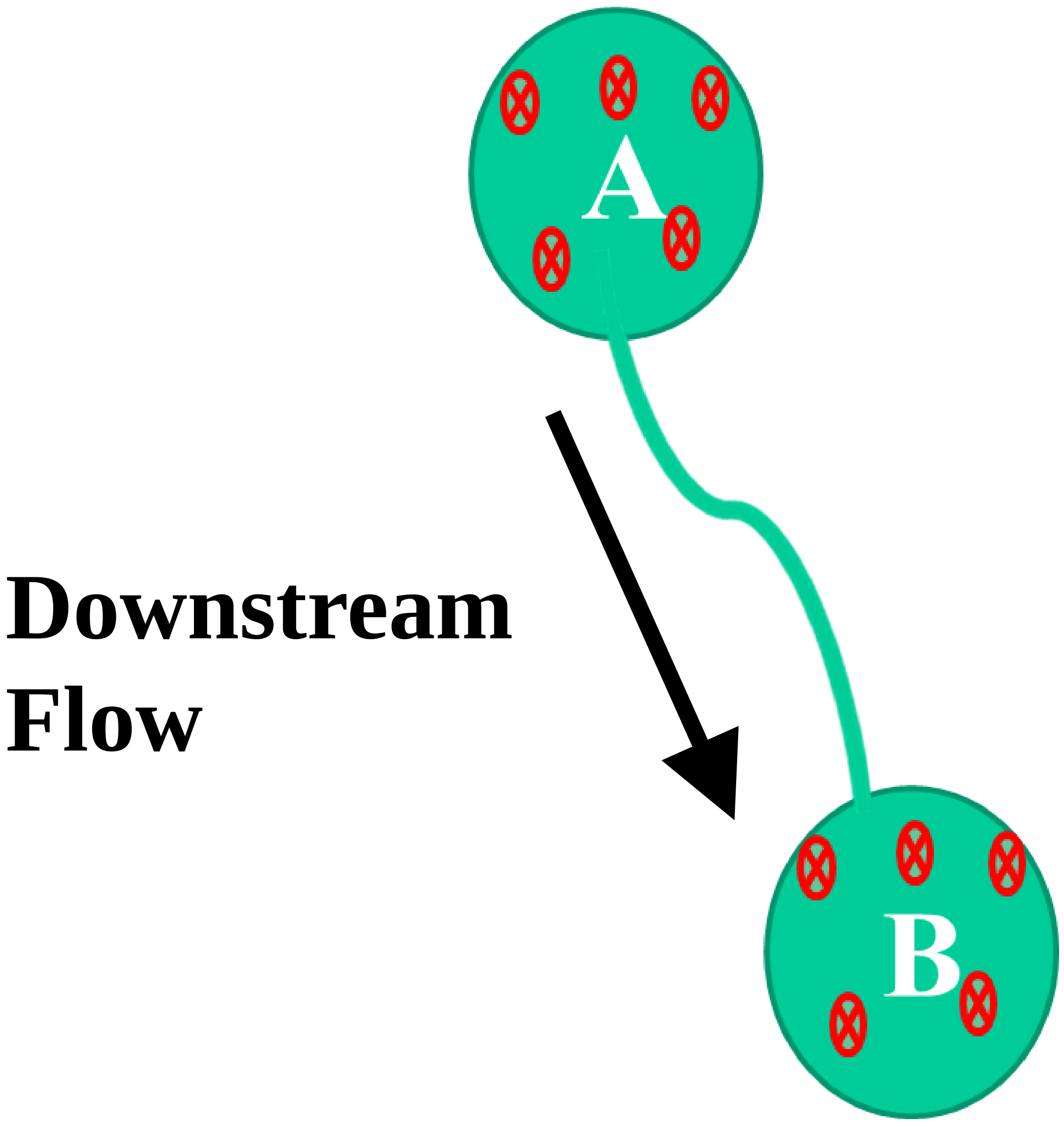
- Measure distance between



Natural Dispersal Analysis

- Choose infested and connected lakes
- Follow the downstream flow categorize downstream lake/ reservoir at infested or not infested/not detected
- Measure distance between
- Identify any patterns

Natural Dispersal Analysis Results

T-Test Results	
P Value	0.5
Mean Distance to Infested	23.66km
Mean Distance to Not Infested	13.52km
Sample Size	22

- Results do not give us confidence to make a conclusion about the relationship of proximity and infestation

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- In areas surrounding the Great Lakes, lakes often highly connected
  - Michigan
  - Wisconsin
  - Minnesota
- In these areas we expect to see lakes in closer proximity to infested lakes to have a higher probability of becoming infested due to downstream connections
- Such as other invasive species
  - Zebra mussels (Bobeldyk, 2005)

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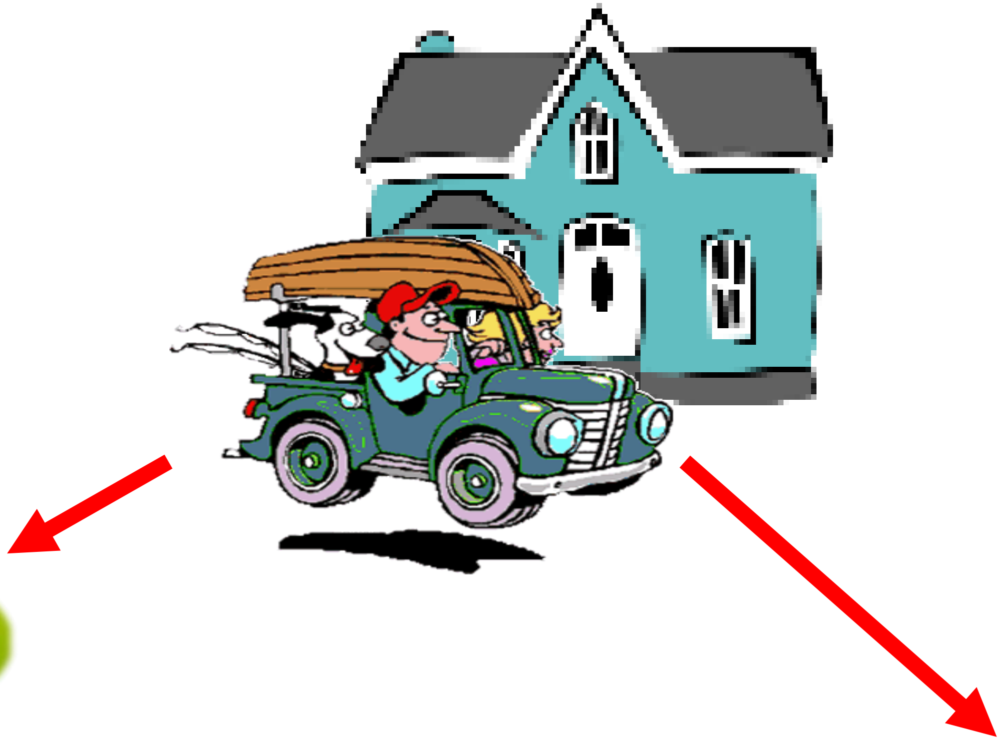
    - **Do this by constructing a gravity model.**

Lake A

Lake B

Lake A and B have same attraction (area), so based off distance more likely to travel to Lake A.

Lake A



Lake B

Lake B although a further distance, has a larger attraction (area). More likely to travel to Lake B.

Potential spread of hydrilla in the Great Lakes Basin (GLB) via recreational boats between watersheds

$$T_{ij} = A_i O_i W_j c_{ij}^{-\propto} \qquad A_i = \frac{1}{\sum_{j=1}^{N} W_j c_{ij}^{-\propto}}$$

Parameter	Description	How value determined
T_{ij}	# of boaters travel from watershed i to watershed j	Calculate
A_i	Balancing factor, ensure all boats leaving i reach j	Calculate
O_i	# of boats traveling from watershed i	Estimate
W_j	Attractiveness of watershed j (Waterbody Surface Area)	Estimate
c_{ij}	Distance from watershed i to watershed j (Centroid of watershed based on waterbody surface area)	Estimate
$\propto$	Distance coefficient	Calculate
N	Total number of waterbodies	Calculate

Methods – Data Collection

- Hydrilla occurrence data (compiled by E&E Inc. Early Detection from Distribution Mapping System and Global Biodiversity Information Facility)
- Boater registrations
- Location and size of lakes and rivers -National Hydrologic Database
- Length of Great Lakes and ocean shorelines - National Hydrologic Database
- Hydrological Unit Code (HUC) data broken into watersheds generated by the US Geological

Can we model current distribution?

- Modeled with yearly intervals to determine:
  - Watershed infestation
  - Number of boats leaving infested watershed
  - Extent of infestation (area)

- Need to parameterize…

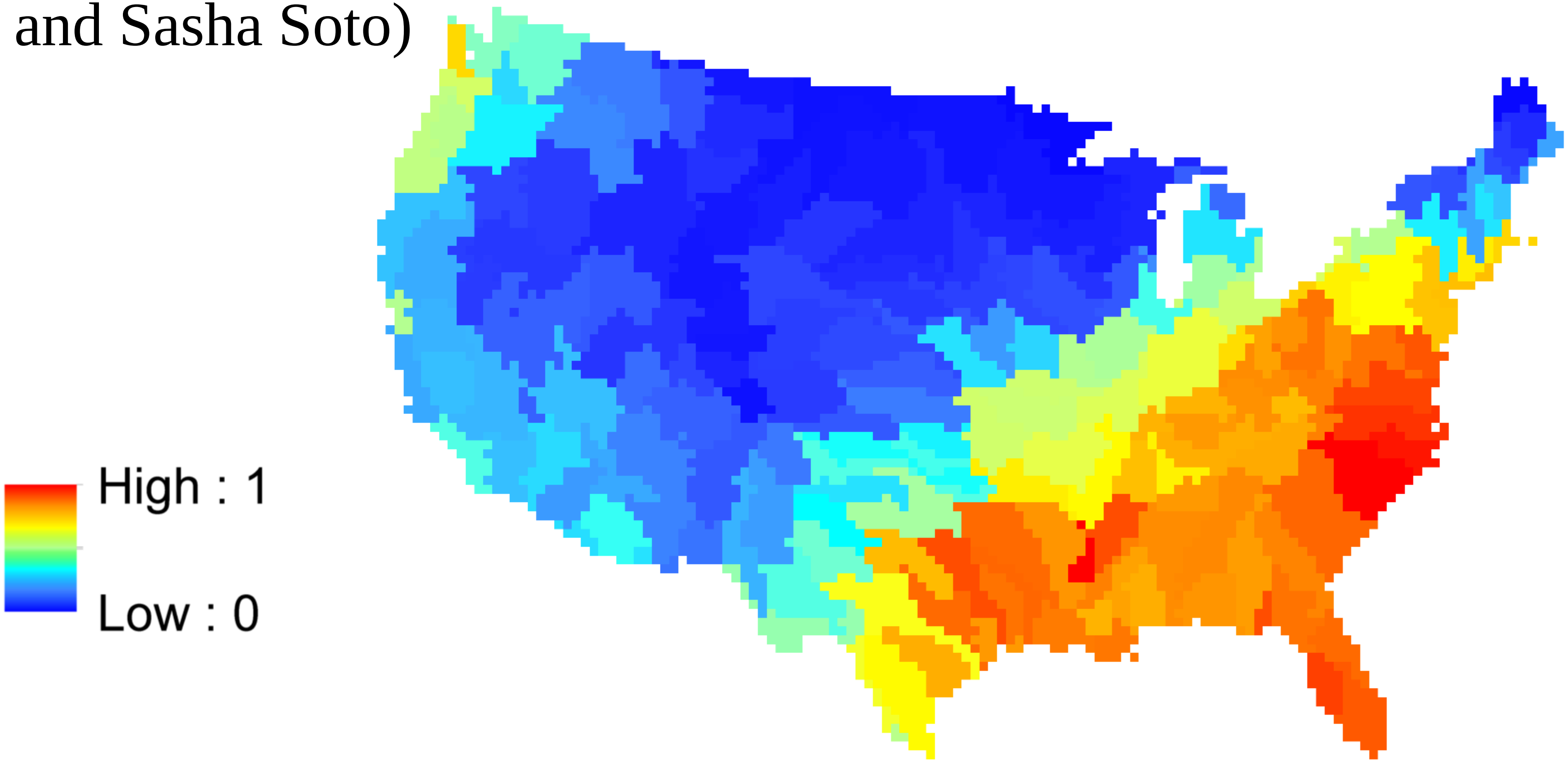
Parameters

1. Distance (Cij) traveled within watershed **scalar**, for when i = j.
2. Wj (Attraction) - lake/river surface area + **scalar** *shoreline length
   - Scalar converts shoreline to equivalent amount of surface area
3. Infestation probability - probability of each boat leaving an infested watershed infests a different watershed
4. Area infested - mean surface area infested in a watershed
5. Alpha - distance coefficient
6. Habitat Suitability- Habitat suitability probability (MaxEnt) * **scalar** (*y*)
   - Adjust weight of MaxEnt

Parameterization Routine

- Varied the parameters by +/- 2 orders of magnitude
- Initiated model with the first known infestation in Florida
- Ran model for 62 years (1953 – 2015), each step = 1 year
- Calculated which model fit best with present day occurrence, use to predict into the future
  - Goal is to minimize: $\Sigma(\text{Actual Area} - \text{Predicted Area})^2$

MaxEnt results: Niche model gives us probability of habitat suitability (Unpublished data from Texas Tech University, Dr. Matthew Barnes and Sasha Soto)



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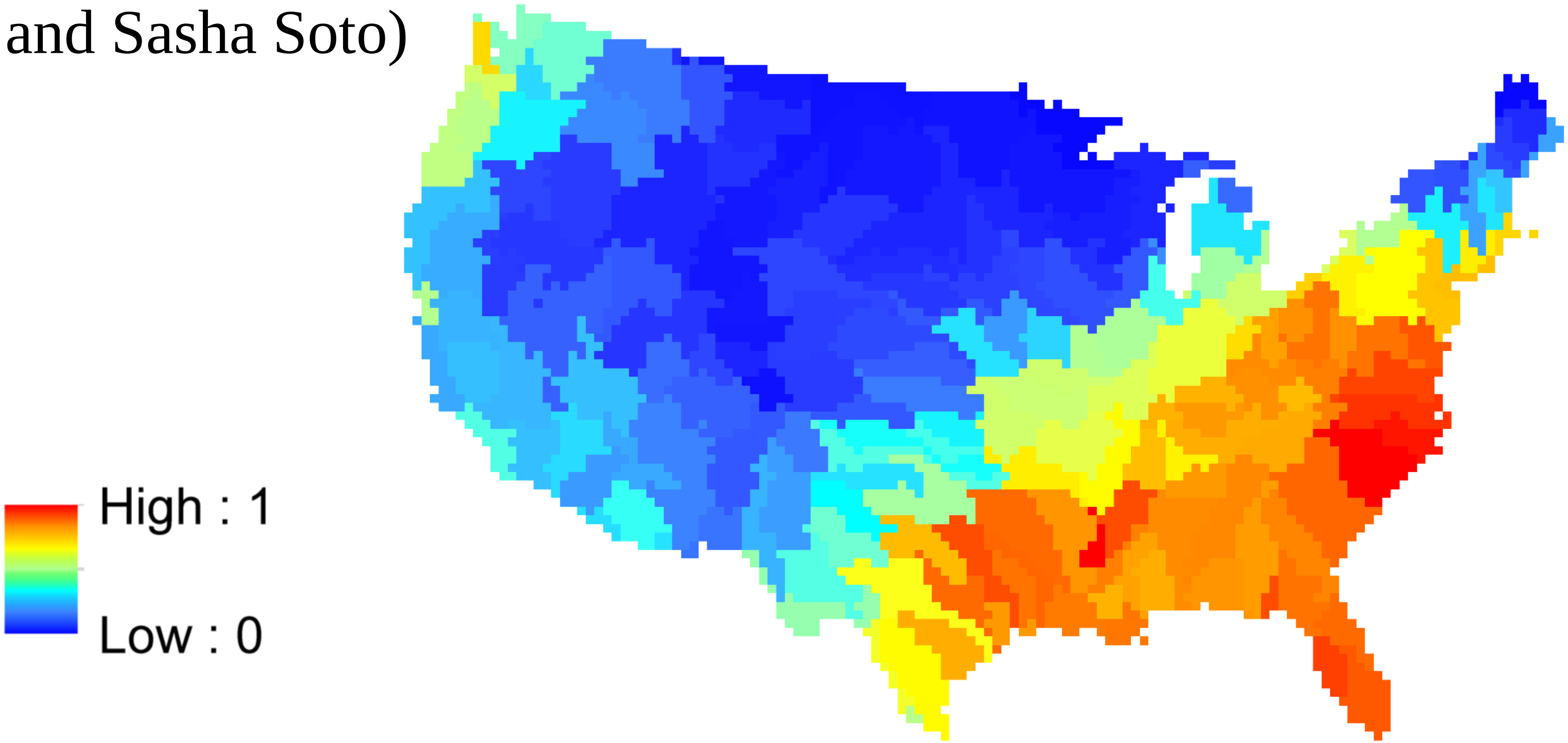
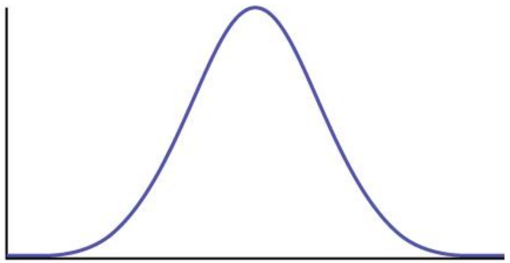


Habitat Suitability Probability ✖ Original Infestation Probability = New Infestation Probability

Model Stochasticity

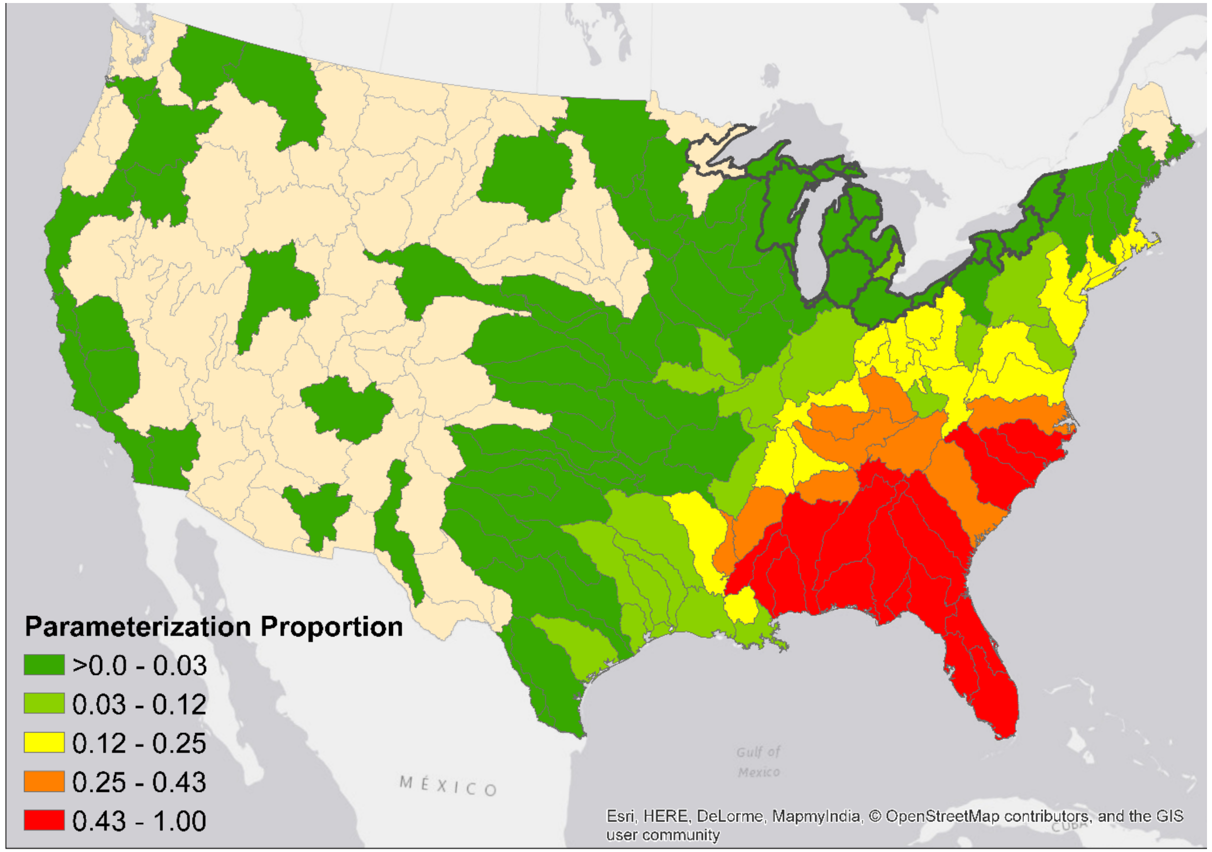
- Estimate potential distribution outcomes by allowing random variation in inputs
  - Area infested per year in each watershed

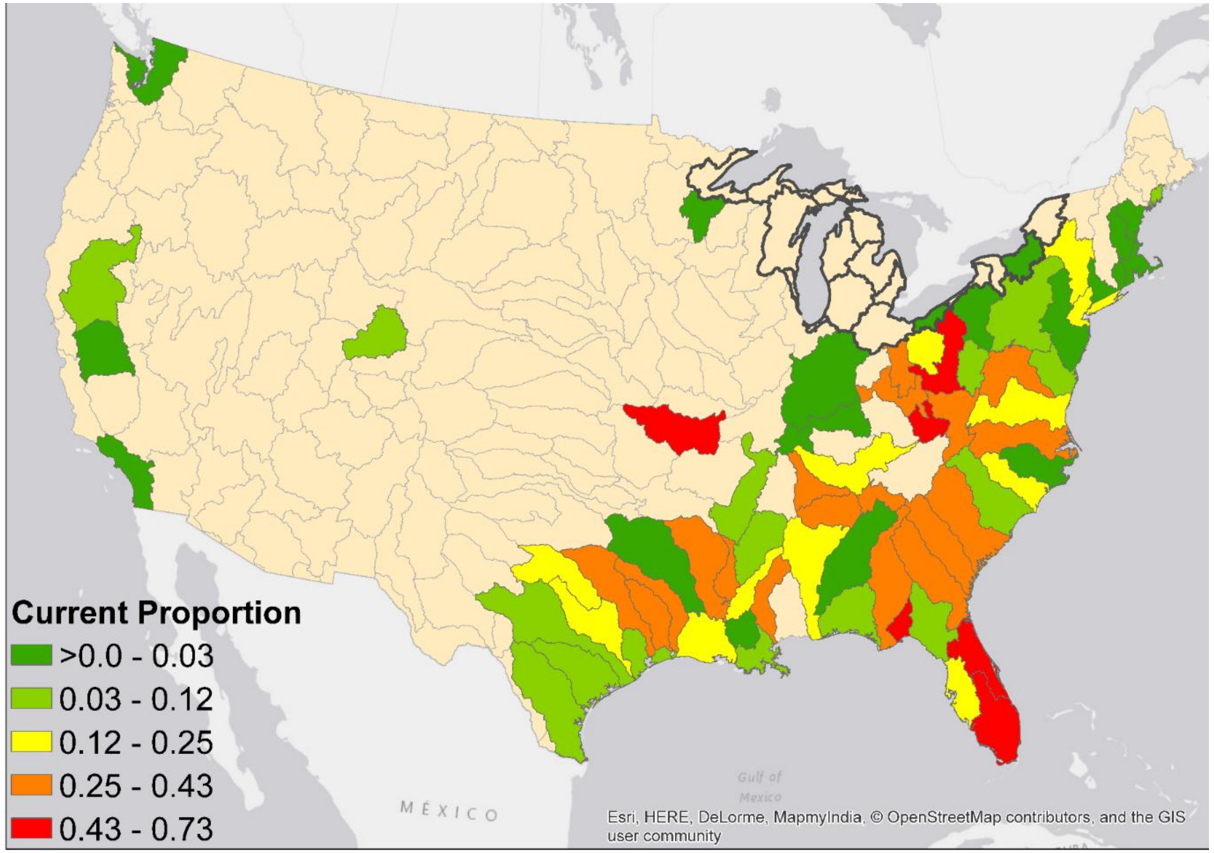


  - Probability that boats leaving a watershed will infest the watershed it travels to
    - For each boat leaving an infested watershed - bin(infestation probability)

Parameterization (Avg. of 1000 Trials for 62 years 1953-2015)

Actual Current Proportion Distribution (2015)

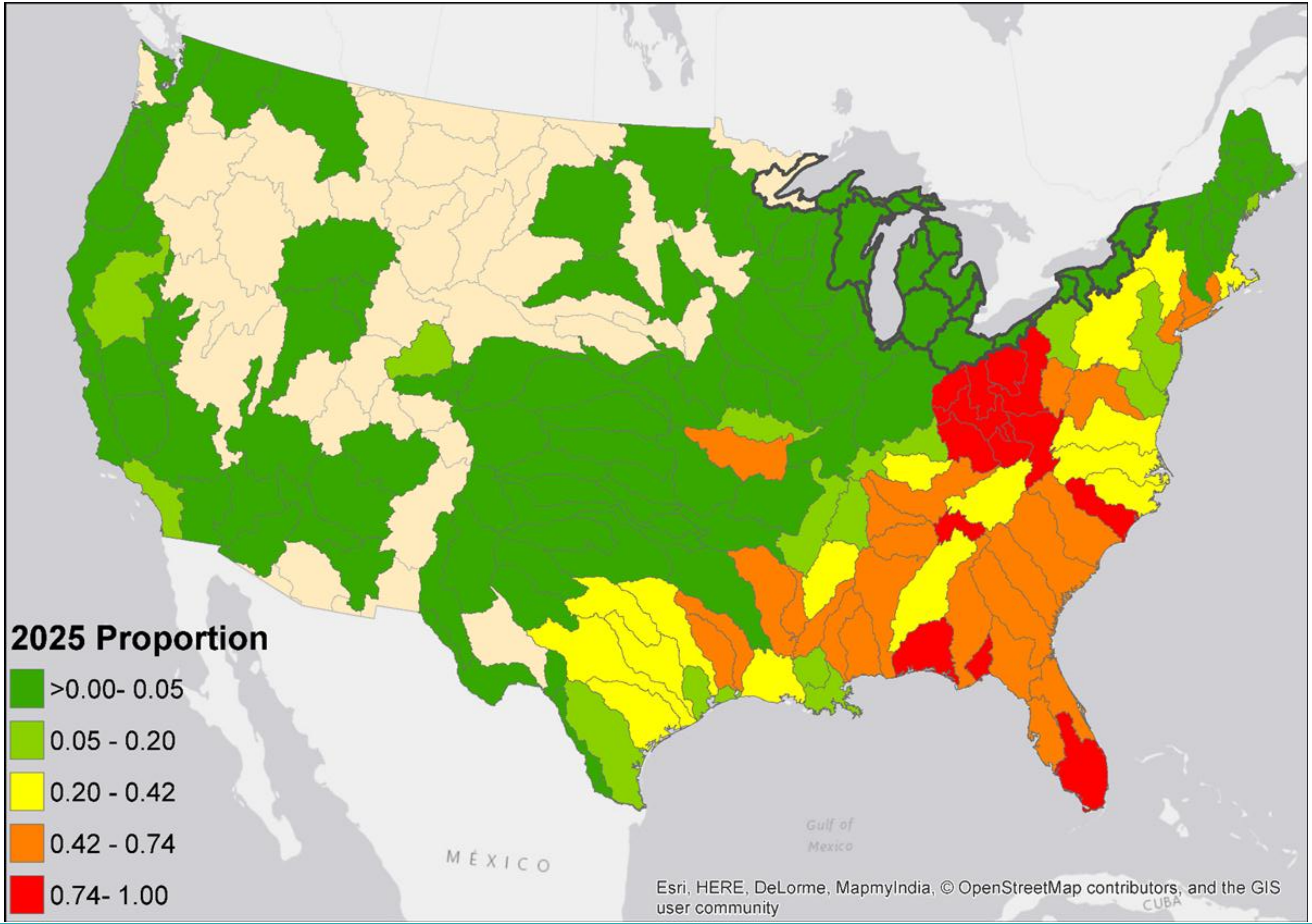




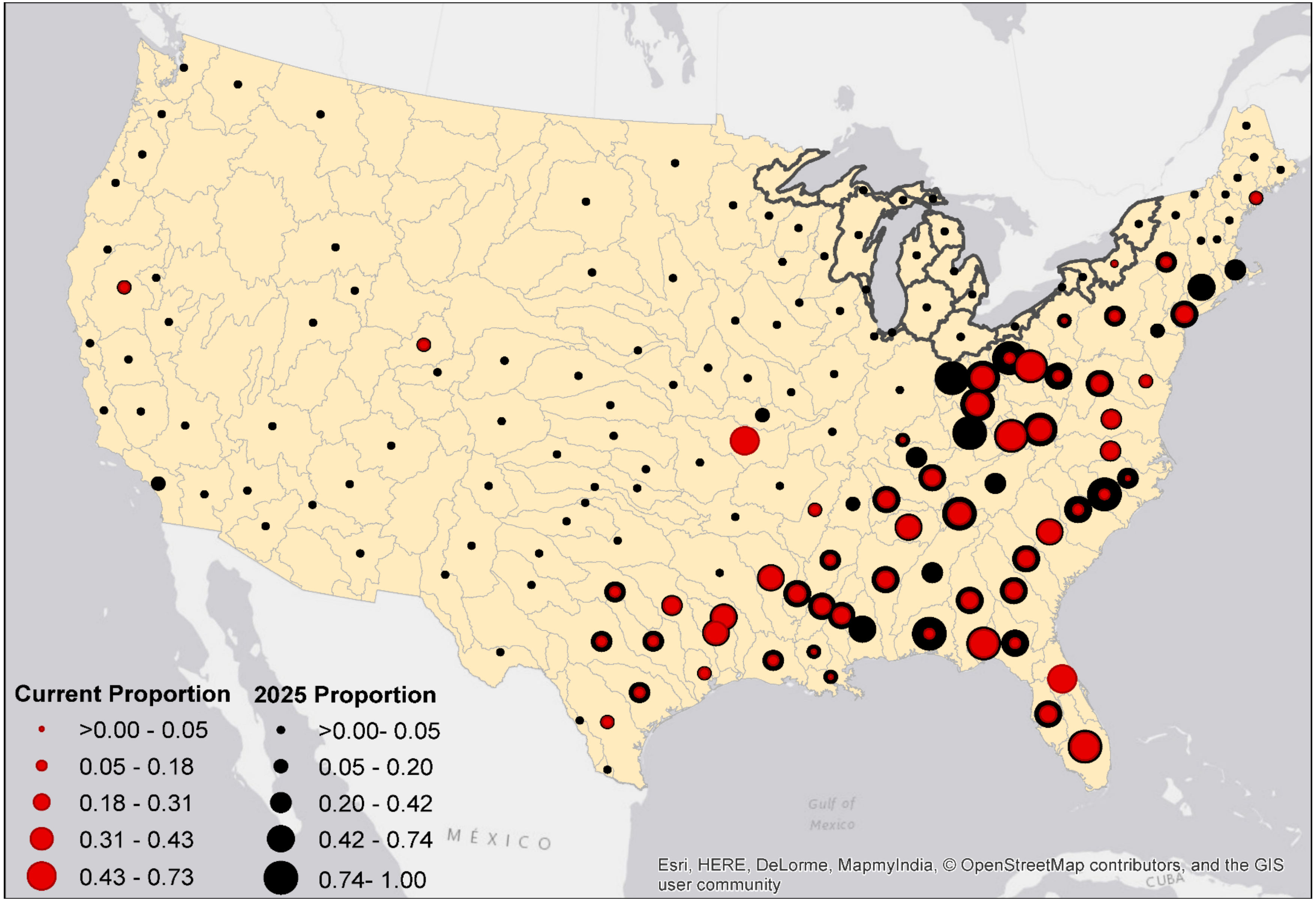
Future…

- Started with current distribution
- Used best fit parameterizations
- Ran 1000 trials for 10 years and took the average

10 Year Prediction (Average of 1000 trials)



Comparison of Current and 10 year Predicted Proportions



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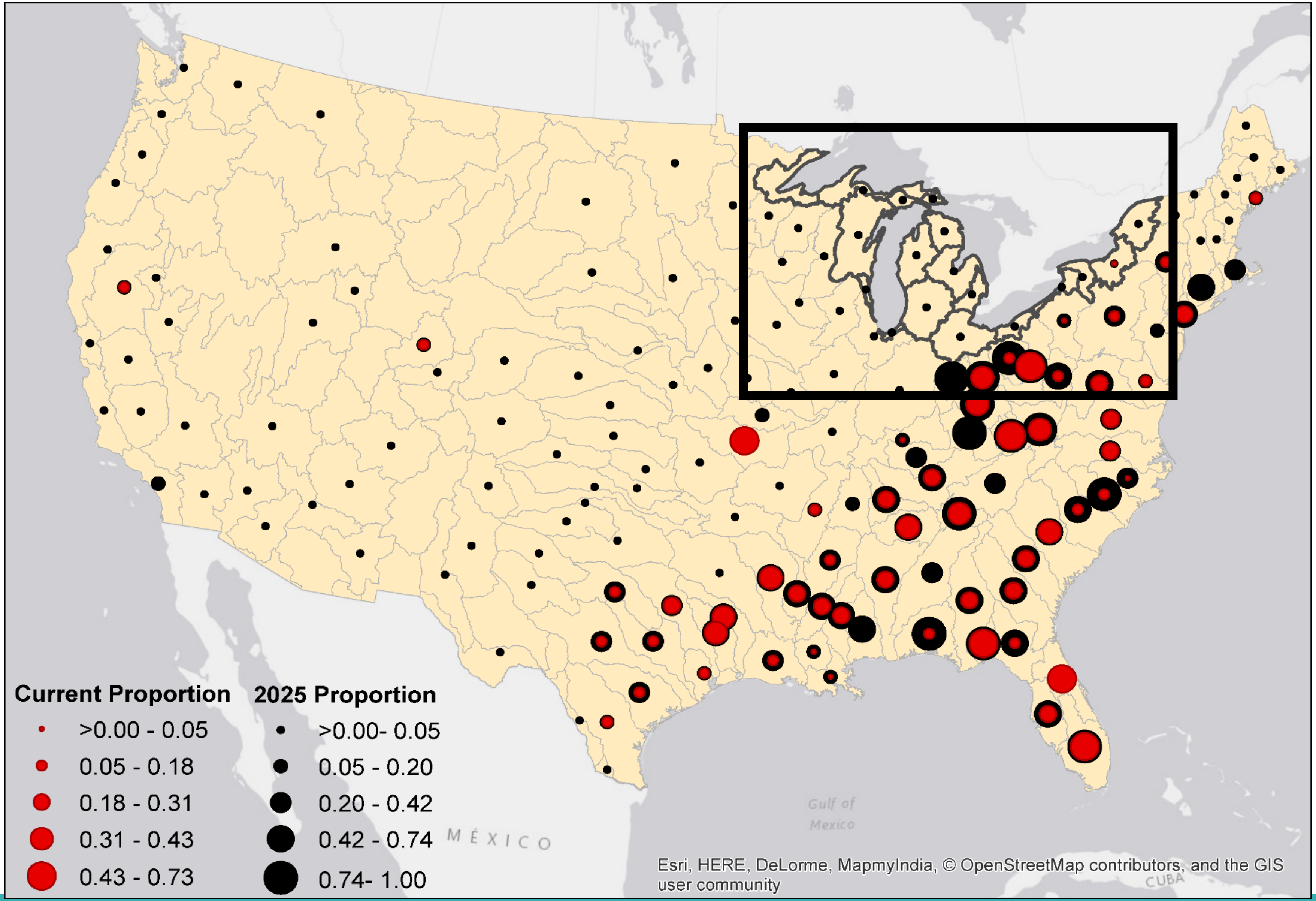

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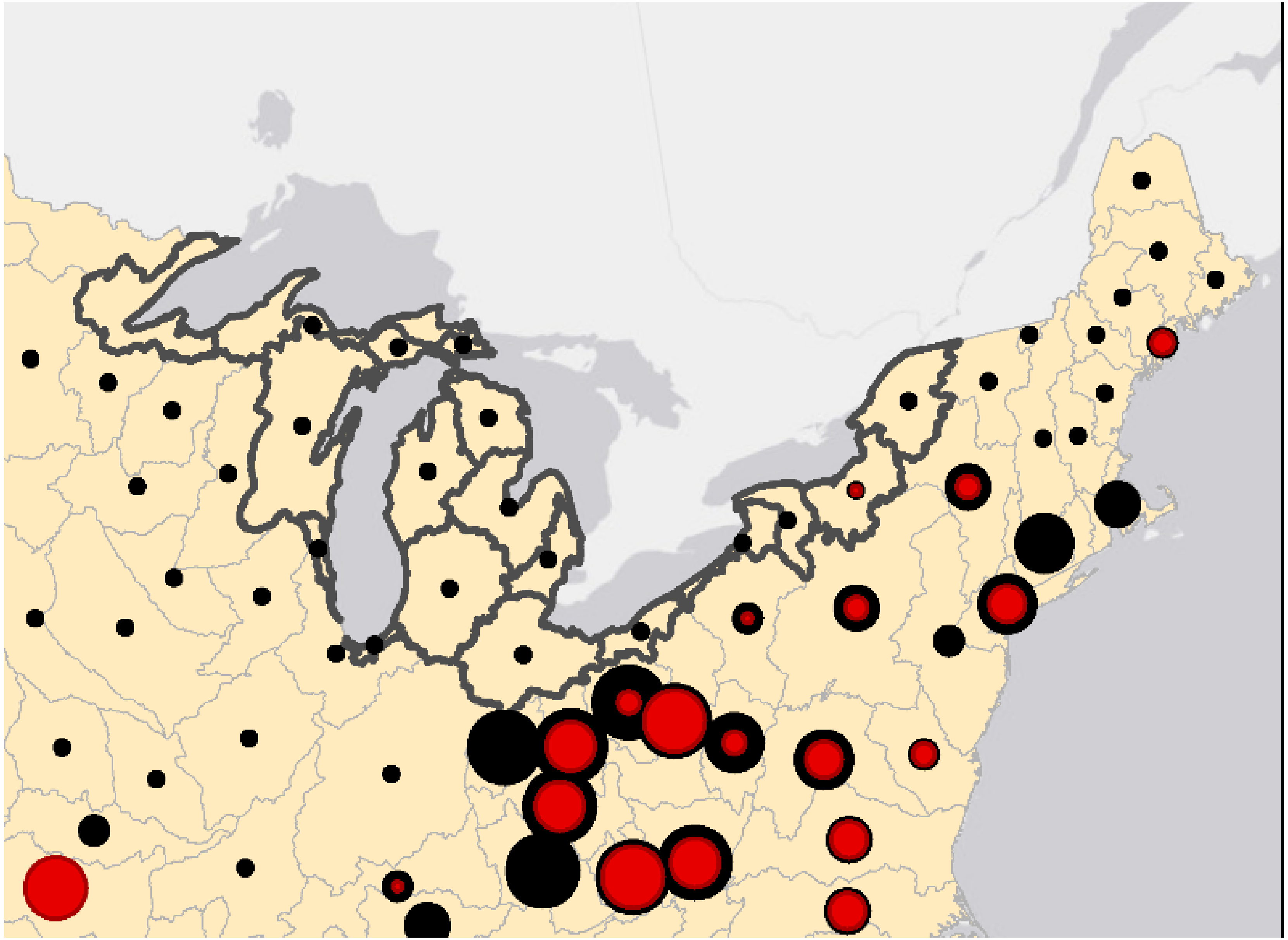
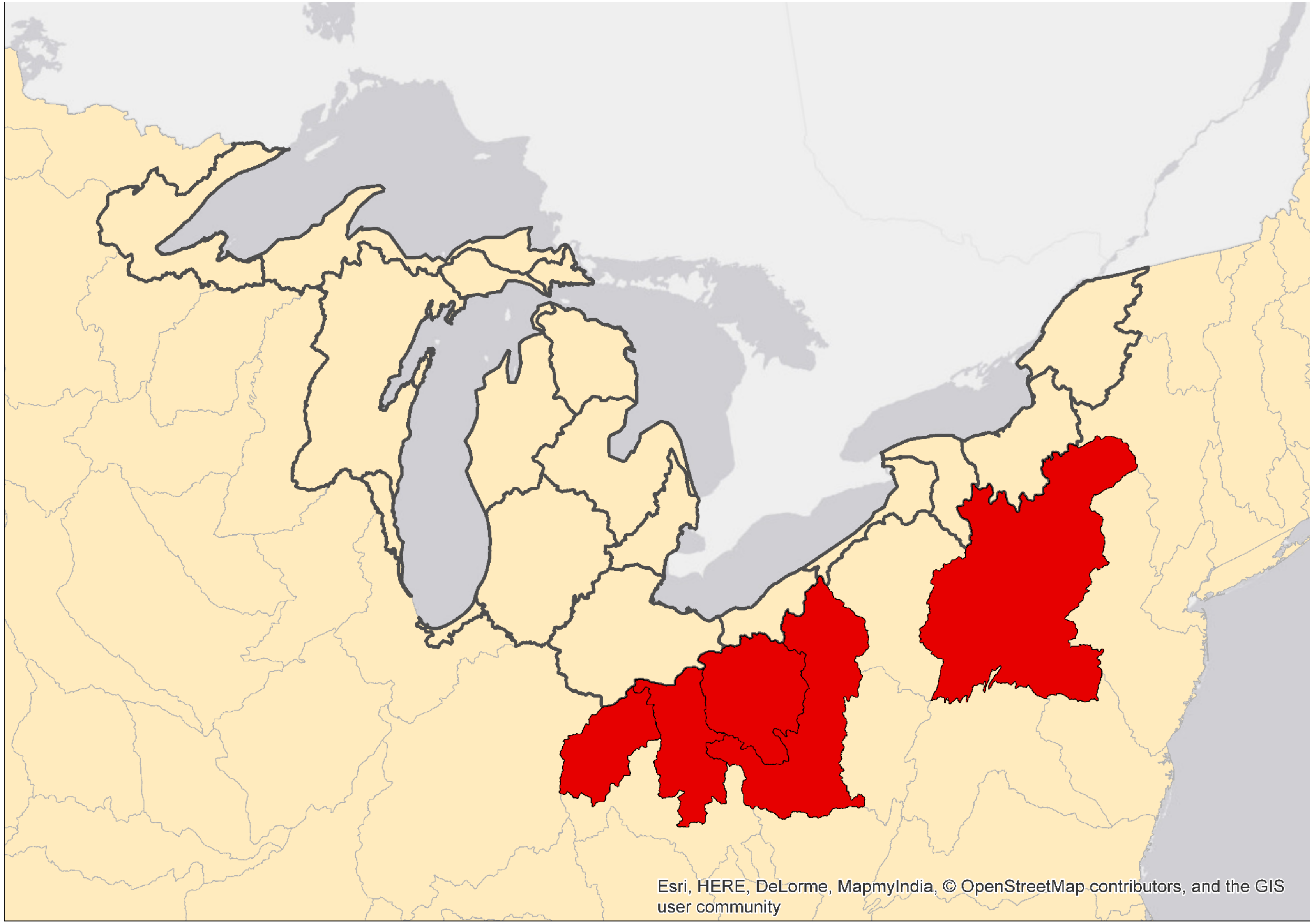


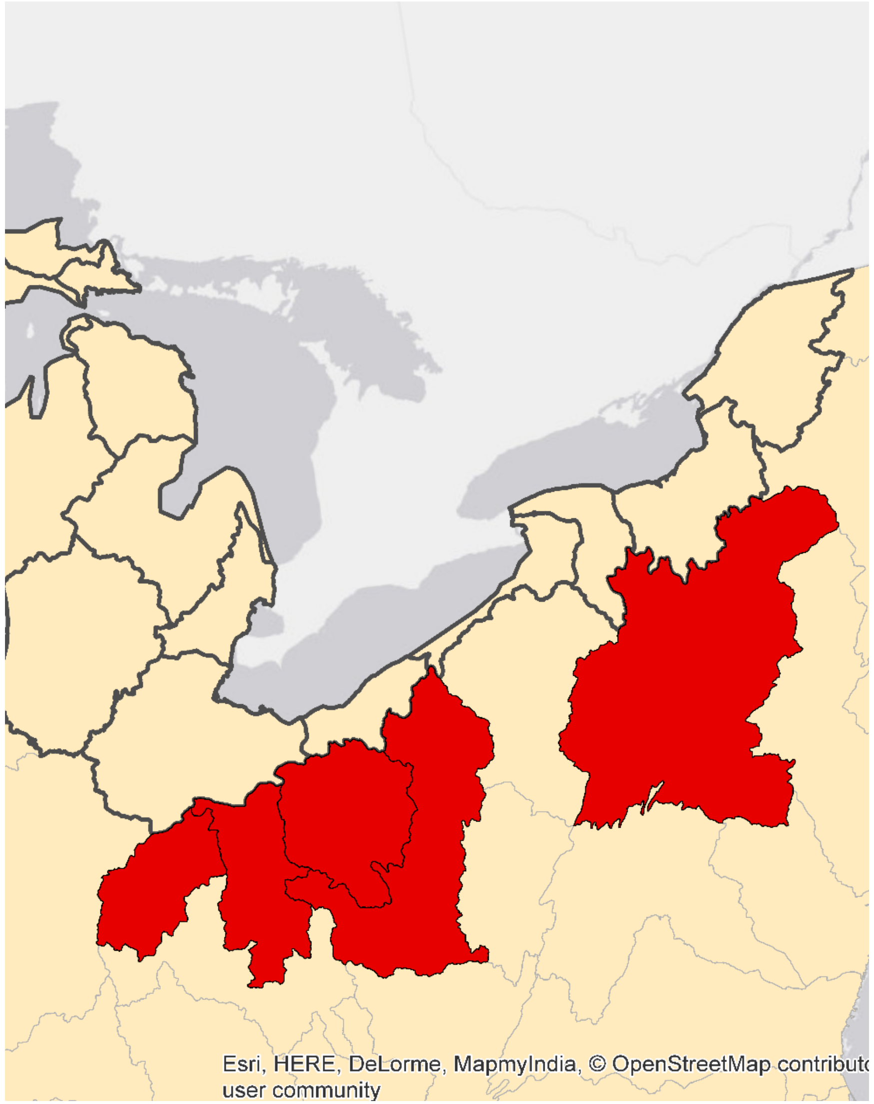
Watersheds surrounding GLB expected to have largest proportion next 10yrs:

	Watershed Name
1	Upper Ohio
2	Scioto
3	Muskingum
4	Great Miami
5	Susquehanna



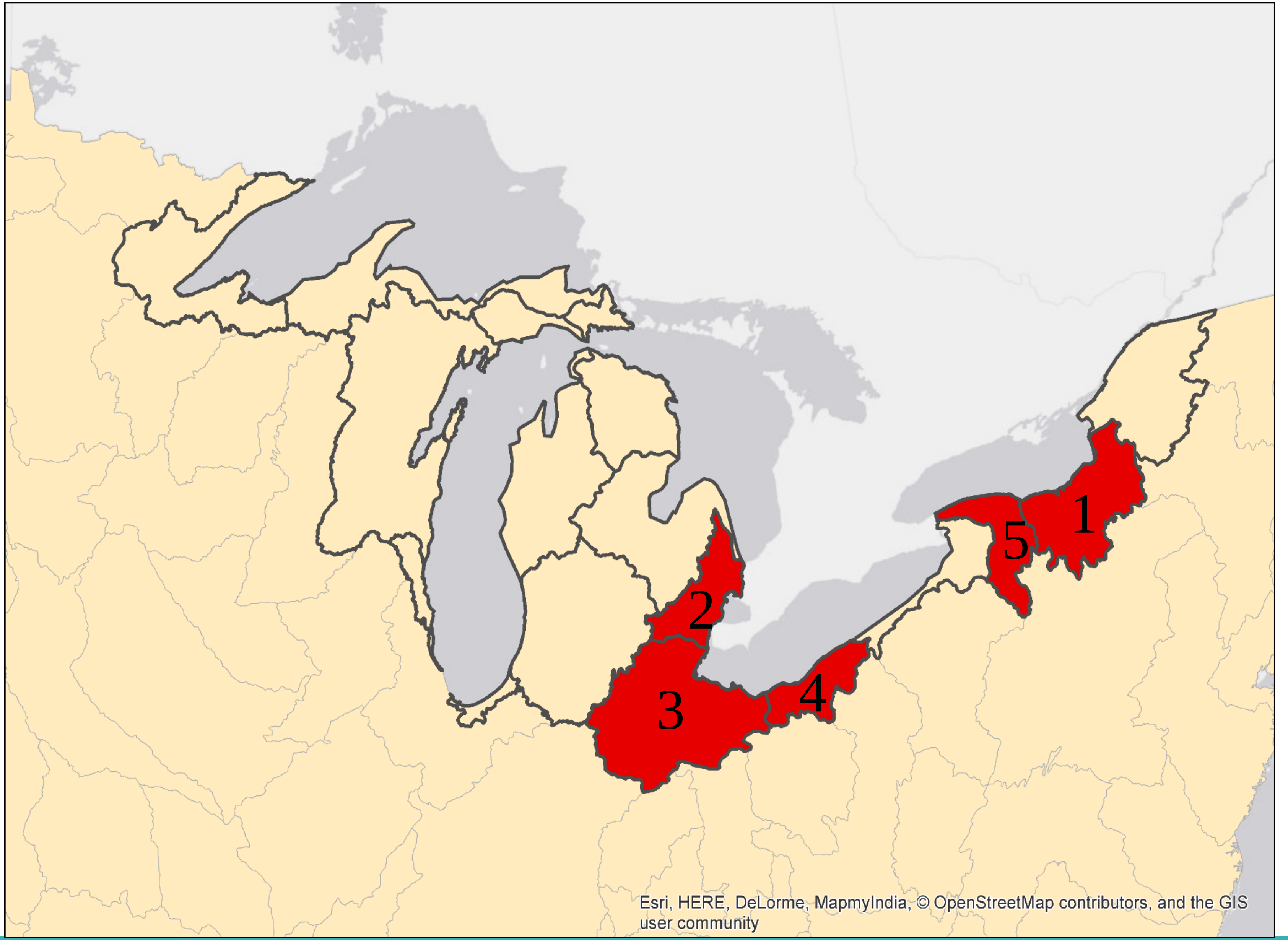
Watersheds surrounding GLB expected to have largest proportion next 10yrs:

	Watershed Name	Current proportion	2025 Proportion
1	Upper Ohio	0.515	1
2	Scioto	0.3700	1
3	Muskingum	0.17	0.99
4	Great Miami	0	0.79
5	Susquehanna	0.07	0.27



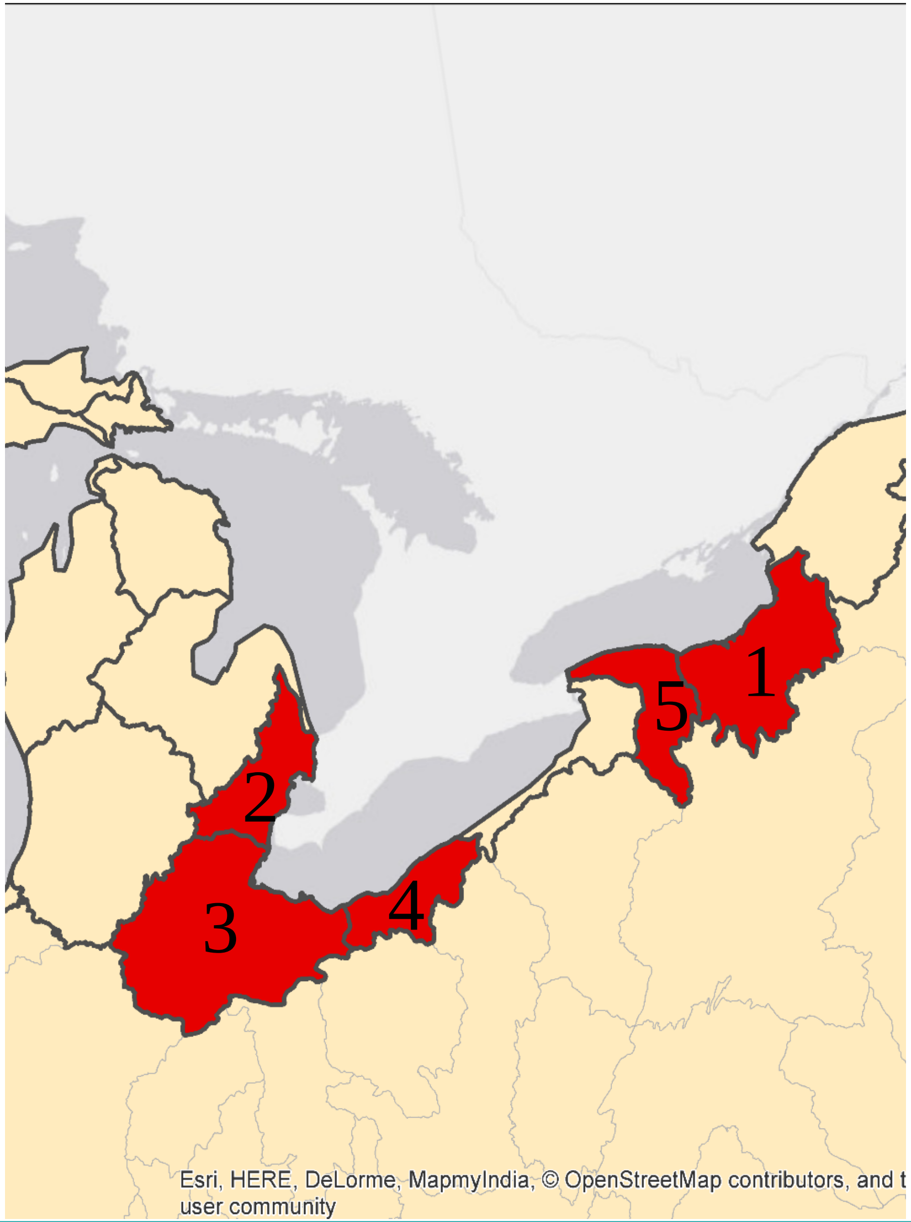
GLB Watersheds expected to have largest proportion in next 10yrs:

	Watershed Name
1	Southeastern Lake Ontario
2	St. Clair-Detroit
3	Western Lake Erie
4	Southern Lake Erie
5	Southwestern Lake Ontario



GLB Watersheds expected to have largest proportion in next 10yrs:

	Watershed Name	Current proportion	2025 Proportion
1	Southeastern Lake Ontario	0.03	0.0514
2	St. Clair-Detroit	0	0.0392
3	Western Lake Erie	0	0.0365
4	Southern Lake Erie	0	0.0338
5	Southwestern Lake Ontario	0	0.0134



Summary

- Can not make a conclusion about the relationship of proximity and infestation
  - Expect it will play a role in GLB
- Have model that replicates current conditions, giving confidence that model predicts where hydrilla will show up next
- Areas already with hydrilla are expected have an increase in infestations
- Great Lakes watersheds are at risk for future introductions of hydrilla

What’s Next?

- Where do we direct monitoring efforts for Great Lakes Basin?

investigativepost.org

google.com

Thank you

USACE, Buffalo District

USACE, Engineer Research Development Center

Ecology and Environment, Inc.

Texas Tech University

North Carolina State University

Sara Guiher, Kailey Doherty, Jessica Sherman, Stephanie Numner, Jake Kvistad, Wendy Stevens, and Casey Yanos


Questions?