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

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Hydrilla: Why Should We Care?

- Hydrilla
  - Introduced in Florida in 1950’s
  - In 1995 $14.5M in management costs in FL
  - Great Lakes Basin at risk
Hydrilla: Why Should We Care?

- Hydrilla
  - Introduced in Florida in 1950’s
  - In 1995 $14.5M in management costs in FL
  - Great Lakes Basin at risk

- Risk assessment
  - Direct early monitoring efforts
## Hydrilla Risk Assessment Collaborative

<table>
<thead>
<tr>
<th>Team Member</th>
<th>Project Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>USACE, Buffalo District</td>
<td>Project Management and Technical Oversight</td>
</tr>
<tr>
<td>USACE, Engineer Research Development Center</td>
<td>Technical Guidance and Oversight</td>
</tr>
<tr>
<td>Ecology and Environment, Inc. (E&amp;E Inc.)</td>
<td>Project Management, Risk Assessment Lead</td>
</tr>
<tr>
<td>Texas Tech University</td>
<td>Distributional Modeling</td>
</tr>
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<td><strong>University of Toledo</strong></td>
<td><strong>Dispersal Modeling</strong></td>
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<tr>
<td>North Carolina State University</td>
<td>Hydrilla Growth Studies</td>
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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?
Downstream Flow

Natural Dispersal Analysis

• Choose infested and connected lakes
Natural Dispersal Analysis

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

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- 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

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

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<th>T-Test Results</th>
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- In areas surrounding the Great Lakes, lakes often highly connected
  - Michigan
  - Wisconsin
  - Minnesota
Natural Dispersal Analysis Results

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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 and B have same attraction (area), so based off distance more likely to travel to Lake A.
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
\[ T_{ij} = A_i O_i W_j c_{ij}^{-\alpha} \]

\[ A_i = \frac{1}{\sum_{j=1}^{N} W_j c_{ij}^{-\alpha}} \]

<table>
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<tr>
<th>Parameter</th>
<th>Description</th>
<th>How value determined</th>
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<tr>
<td>( T_{ij} )</td>
<td># of boaters travel from watershed i to watershed j</td>
<td>Calculate</td>
</tr>
<tr>
<td>( A_i )</td>
<td>Balancing factor, ensure all boats leaving i reach j</td>
<td>Calculate</td>
</tr>
<tr>
<td>( O_i )</td>
<td># of boats traveling from watershed i</td>
<td>Estimate</td>
</tr>
<tr>
<td>( W_j )</td>
<td>Attractiveness of watershed j (Waterbody Surface Area)</td>
<td>Estimate</td>
</tr>
<tr>
<td>( c_{ij} )</td>
<td>Distance from watershed i to watershed j (Centroid of watershed based on waterbody surface area)</td>
<td>Estimate</td>
</tr>
<tr>
<td>( \alpha )</td>
<td>Distance coefficient</td>
<td>Calculate</td>
</tr>
<tr>
<td>( N )</td>
<td>Total number of waterbodies</td>
<td>Calculate</td>
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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 (C_{ij}) traveled within watershed **scalar**, for when \( i = j \).
2. \( W_j \) (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: $\sum (\text{Actual Area} - \text{Predicted Area})^2$
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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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)

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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Comparison of Current and 10 year Predicted Proportions
Watersheds surrounding GLB expected to have largest proportion next 10yrs:

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<tr>
<th>Watershed Name</th>
<th>Current Proportion</th>
<th>2025 Proportion</th>
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<tbody>
<tr>
<td>1 Upper Ohio</td>
<td>0.515</td>
<td>1</td>
</tr>
<tr>
<td>2 Scioto</td>
<td>0.370</td>
<td>1</td>
</tr>
<tr>
<td>3 Muskingum</td>
<td>0.17</td>
<td>0.99</td>
</tr>
<tr>
<td>4 Great Miami</td>
<td>0.0</td>
<td>0.79</td>
</tr>
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<td>5 Susquehanna</td>
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<td>2  St. Clair-Detroit</td>
</tr>
<tr>
<td>3  Western Lake Erie</td>
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<td>0.0514</td>
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<td>0</td>
<td>0.0392</td>
</tr>
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<td>3 Western Lake Erie</td>
<td>0</td>
<td>0.0365</td>
</tr>
<tr>
<td>4 Southern Lake Erie</td>
<td>0</td>
<td>0.0338</td>
</tr>
<tr>
<td>5 Southwestern Lake Ontario</td>
<td>0</td>
<td>0.0134</td>
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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?
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?