Habitats Invaded by European Frogbit (*Hydrocharis morsus-ranae*) in Lake Ontario Coastal Wetlands

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What Is *Hydrocharis morsus-ranae*?

- Member of Hydrocharitaceae
- Similar to and confused with American frogbit (*Limnobium spongia*)
  - Native to SE United States
- Range
  - Native to most of Europe and northern Asia
  - Introduced and invasive in United States and Canada
- Non-rooted, floating aquatic plant
- Shallow water, little to no wave energy
Introduction and Dispersal

• 1932- Central Experiment Farm arboretum in Ottawa, Ontario
  – From trench, to Dows Lake, to Rideau Canal and onward (Minshall 1940)
• Common in St. Lawrence River, Lake Ontario, Lake Champlain, and inland
• Less common in Lake Erie
• Map from Catling and Porebski 1995
Reproduction

• Turions (asexual winter buds) form on stolons
  – Abscess in fall
  – Float to surface in spring
• Up to 10 ramets grow from each new turion
  – Each ramet can produce 10 new turions
• Turions viable for 16-24 months (Burnham 1998)
• Sexual reproduction is possible
  – Much less prevalent (Burnham 1988)
Impacts

• Rapid population growth rate creates dense mats
• Tough yet flexible stolons interlock
  – Creates thick, floating mats
• 95% decline in native submersed vegetation species (Catling et al. 1988)
• Fewer snails, crustacea, and insect larve under mats (Catling et al. 1988)
• Inhibits recreational boating activity
Goals

• Quantify invasion characteristics
  – Spatially within wetlands
  – Among hydrogeomorphic classes
  – Correlations with hydrologic, chemical, and physical data

• Data from Great Lakes Indicators Consortium: Implementing Great Lakes Coastal Wetland Monitoring Project
  – EPA-GLRI 2010
  – Only using Lake Ontario Data
Data Collection

• 45 vegetation quads per wetland
  – Three vegetation zones (not always)
    • SAV, emergent, meadow marsh
  – Three transects per wetland, perpendicular to elevation gradient
  – Five quads per transect in each zone
• 15 quads per transect
• 3 transects
Plant Quad Data Used

• Species cover and occurrence
  – Frogbit

• Habitat data
  – Water depth
  – Organic depth
  – Detritus cover
  – Invasive cattail (Typha angustifolia, Typha X glauca)
    • Dominant emergent species
Water Quality Data Used

• Site level data
  – Mostly collected in SAV

• Parameters
  – TN, NO\textsubscript{2}/NO\textsubscript{3}-N, TP, OP, alkalinity, specific conductance, chloride, and color
Statistical Analyses

• Kruskal-Wallace for cover and occurrence
  – HGM
  – Zone

• Principal Components Analysis
  – Chemistry and physical habitat characteristics
    • Transformed for normality and standardized (z-score)

• Non-parametric correlations
  – Principal components vs frogbit cover and occurrence
Results: Average Cover

• Present in 29 of 34 sites (85%)
• All zones: 7.54%
  – Range: 0.0-35.4%
• Emergent zone: 16.0%
  – Range: 0.0-39.7%
• Greatest cover in emergent zone
  – $\chi^2 = 36.196$, df = 2, p=0.000
  – SAV $\approx$ Meadow Marsh
Results: Quad Occurrence

- All zones: 29.8%
  - Range: 0.0-100%
- Emergent zone: 51.5%
  - Range: 0.0-100%
- Most prevalent in emergent zone
  - $\chi^2 = 30.099$, df = 2, p=0.000
  - SAV ≈ Meadow Marsh
Frogbit Cover and Occurrence Along Vegetation Transect

Percent Cover or Occurrence in Quads

Quad Location On Transect

SAV
Emergent
Meadow Marsh

Occurrence
Coverage

Quad 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Results: Cover and Occurrence by HGM

- No significant differences among HGM
  - Cover
    - All zones: $H(2) = 0.132, P = 0.936$
    - Emergent zone only: $H(2) = 0.609, P = 0.738$
  - Occurrence
    - All zones: $H(2) = 0.025, P = 0.988$
    - Emergent zone only: $H(2) = 0.609, P = 0.738$
Frogbit Cover by HGM and Zone

Average Frogbit Cover

- **Barrier Beach**: All zones vs. Emergent
  - Coverage in all zones
  - Coverage in emergent areas

- **Lacustrine**: All zones vs. Emergent
  - Coverage in all zones
  - Coverage in emergent areas

- **Riverine**: All zones vs. Emergent
  - Coverage in all zones
  - Coverage in emergent areas
Frogbit Occurrence by Zone and HGM

- Barrier Protected
- Lacustrine
- Riverine

Percent of quads with Frogbit present

- All zones
- Emergent
Results: PCA

- Three PCs retained 68.8% of variance

<table>
<thead>
<tr>
<th>PC1</th>
<th>PC2</th>
<th>PC3</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Runoff&quot;</td>
<td>&quot;Growth Inhibitors&quot;</td>
<td>“Water and Phosphorus&quot;</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Specific Conductance (+)</th>
<th>Detritus Cover (+)</th>
<th>Water Depth (+)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chloride Ion (+)</td>
<td>Organic Depth (+)</td>
<td>Total P (+)</td>
</tr>
<tr>
<td>Alkalinity (+)</td>
<td>Color (+)</td>
<td>Ortho P (+)</td>
</tr>
<tr>
<td>Total N (+)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NO₂/NO₃-N (+)</td>
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Results: Correlations

<table>
<thead>
<tr>
<th>PC</th>
<th>Emergent Cover</th>
<th>Emergent Occurrence</th>
<th>All Zones Cover</th>
<th>All Zones Occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Runoff</td>
<td>r = -0.346, p = 0.048</td>
<td>r = -0.370, p = 0.034</td>
<td>r = -0.286, p = 0.107</td>
<td>r = -0.264, p = 0.137</td>
</tr>
<tr>
<td>Growth Inhibitors</td>
<td>r = -0.054, p = 0.766</td>
<td>r = -0.062, p = 0.732</td>
<td>r = 0.001, p = 0.997</td>
<td>r = 0.115, p = 0.525</td>
</tr>
<tr>
<td>Growth Enhancers</td>
<td>r = 0.111, p = 0.537</td>
<td>r = 0.101, p = 0.577</td>
<td>r = 0.162, p = 0.369</td>
<td>r = 0.108, p = 0.548</td>
</tr>
</tbody>
</table>

• “Runoff” was the only correlated PC
  • Emergent
    • Cover and Occurrence significant
  • All Zones
    • Not significant
  • All negative correlations
Discussion

• European frogbit prevalent throughout Lake Ontario

• Frogbit can achieve high densities
  – Site level maximum: 35.4%
  – Emergent zone maximum: 39.7%
  – Individual quads: 100%

• Ecosystem effects
What was most invaded?

- No differences among HGM
- Drastic differences among vegetation zones
  - Mostly in emergent
    - Protection from waves
    - Deep enough water
  - Meadow marsh
    - Only if sufficient standing water
  - SAV
    - Only if protected
Discussion: Runoff

• Frogbit decreased with increasing “runoff”
  – Europe: mesotrophic and low salt waters
  – What if we clean up the lakes?

• Mechanism still unknown
  – Direct chemical inhibition?
  – Indirect effects?
  – Need controlled experiments
The Other Great Lakes and Beyond

• Extrapolating results may be tricky
  - Lake Ontario is unique
  - Hydroperiod, nutrient combinations, species assemblage, etc.

• Most vulnerable areas:
  - Any HGM
  - Emergent zones
  - Low runoff
Literature Cited


