Foot of Storm King Mountain
Thomas Pope, 1880s
New York State Museum
What are Intertidal Plants?
Estuary Arrowhead
*Sagittaria subulata*
(Alismataceae)
Hudson River Estuary

- Battery Park (Manhattan) north to Federal Dam at Troy (just north of Albany)

- 153 miles long (by comparison, the Delaware Estuary is 130 mi, Potomac is 110 mi, and Connecticut is 60 mi)

- Tidal amplitude usually 3--4 feet

- Tributaries tidal for only a short distance, if at all
Why Study Intertidal Plants?

- Intertidal plants are poorly known, even among botanists.
Intertidal plants are poorly known, even among botanists.

Informal survey of professional botanists who spend a substantial amount of time in the field in the Mid-Atlantic

“Have you ever seen *Lilaeopsis chinensis* in the field?”

n = 31

Only 32% responded with “Yes.”

Most had never heard of the species.

**Eastern Grasswort**

(*Lilaeopsis chinensis*, Apiaceae)
Why Study Intertidal Plants?

• Intertidal plants are poorly known, even among botanists.

• What we do know reveals at least several species are restricted to the intertidal habitat.
Estuary Bidens

(*Bidens bidentoides*, Asteraceae)
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(Bidens bidentoides, Asteraceae)
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• The intertidal habitat is quite rare.
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- The intertidal habitat is quite rare.

- The intertidal habitat is extreme.
Intertidal Plants Inhabit Extreme Environments

• high tides inundate plants and low tides expose plants, twice each day

• salinity often fluctuates widely

• turbidity fluctuates widely

• sediment accumulates rapidly

• waves often are strong

• substrate is dynamic
Extreme Environments often Select for Extreme Adaptations

Estuary Arrowhead
(Sagittaria subulata, Alismataceae)
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- The intertidal habitat is quite rare.
- The intertidal habitat is extreme.
- Intertidal habitats face multiple threats.
Salinity Matters!

*Bolboschoenus robustus*

*Bolboschoenus novae-angliae*

*Bolboschoenus fluviatilis*
Problems detected in 8 species of Hudson River intertidal plants.

<table>
<thead>
<tr>
<th>Species</th>
<th>Problem</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. <em>Bidens eatonii</em> (Asteraceae)</td>
<td>misidentifications</td>
</tr>
<tr>
<td>2. <em>Bidens hyperborea</em> (Asteraceae)</td>
<td>misidentifications</td>
</tr>
<tr>
<td>3. <em>Cardamine longii</em> (Brassicaceae)</td>
<td>misidentifications</td>
</tr>
<tr>
<td>4. <em>Crassula aquatica</em> (Crassulaceae)</td>
<td>taxonomic complexity</td>
</tr>
<tr>
<td>5. <em>Eleocharis olivacea</em> (Cyperaceae)</td>
<td>misidentifications, taxonomic complexity</td>
</tr>
<tr>
<td>6. <em>Isoetes riparia</em> (Isoetaceae)</td>
<td>taxonomic complexity</td>
</tr>
<tr>
<td>7. <em>Najas muenscheri</em> (Hydrocharitaceae)</td>
<td>taxonomic complexity</td>
</tr>
</tbody>
</table>
In Preparation: A New Identification Manual for the Northeast

Extensive Geographic Coverage

(860,500 mi², 22 states, 5 provinces)
One example of taxonomic complexity in intertidal plants: *Najas muenscheri* (Hydrocharitaceae)

1. **NAJAS L.** Water-nymph. Characters of the family; vegetatively plastochronia of the mop. Counts of lf-teeth in the descriptions do not include those of the sheath.

1 Dioecious; lower side of the midvein of the lvs (and often also the internodes) prickly ......................... 1
2 Monoecious; lf-surface and internodes smooth.
   2 Lf-teeth multicellular, evident at 10×, 7–15 per side; lvs becoming recurved in late season; seedcoat pitted, the areolae in ca 12–18 ladder-like rows, distinctly wider than long .................................
   2 Lf-teeth unicellular, minute, 20 or more per side (except in no. 5); lvs spreading or ascending; seedcoat smooth or pitted with areolae in ca 20 or more rows, the areolae about as long as or longer than wide.
3 Seeds pitted, dull, fusiform or nearly cylindric; anthers 1- or 4-locular.
4 Style apical.
   5 Anthers 4-locular; seeds mostly 1.2–2.5 mm, with areolae in 20–45 rows; widespread ... 3. *N. guadelupensis* var. *m.*
   5 Anthers unilocular; seeds mostly 3.3–3.8 mm, with areolae in 50–60 rows; Hudson R. ... 4. *N. marina* L. Alkaline w.-n. Dioecious; stems 0.5–4.5 dm, 0.5–4 mm thick, often prickly.
4 Style offset from the apex of the fr and seed; anthers unilocular ................................. 5.
3 Seeds smooth, glossy, broadest above the middle; anthers unilocular .................................

4. **Najas muenscheri** R. T. Clausen. Hudson R. w.-n. Monoecious; stems 3–9 dm, ca 1 mm thick; lvs 1–1.5 mm, spreading, minutely serrulate with 50–100 unicellular teeth per side; anthers monotheocal and with a single microsporangium; seeds 3.3–3.8 mm, slender, fusiform-cylindric, with 50–60 rows of minute, rectangular areolae. Abundant on tidal mudflats along the Hudson R. (*N. guadelupensis* var. *m.*)

(Gleason & Cronquist 1991: 646)
Why Study Intertidal Plants?

Given their restrictiveness and the numerous environmental threats they face, intertidal plants are sensitive indicators of environmental health.
Why Study Intertidal Plants?

Given their restrictiveness and the numerous environmental threats they face, intertidal plants are sensitive indicators of environmental health.

Intertidal plants should be conservation priorities.
Objective

Conduct conservation assessments of vascular plant species restricted or nearly restricted to intertidal habitats.

Spongy Arrowhead
(*Sagittaria montevidensis* ssp. *spongiosa*, Alismataceae)

Smith’s Bulrush
(*Schoenoplectiella smithii*, Cyperaceae)
Methods

1. Documented the diversity of intertidal plants.
Cardinalflower (Lobelia cardinalis) Campanulaceae

Pickerelweed (Pontederia cordata) Pontederiaceae
Methods

1. Documented the diversity of intertidal plants.
   • previous field experiences on other tidal rivers of the Mid-Atlantic (Bohemia, Delaware, Manokin, Manumuskin, Mullica, Nanticoke, Northeast, Sassafras, Susquehanna)
   • literature review
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*Discovered 32 species are restricted or nearly restricted to intertidal zones in the Hudson Estuary.*
Methods

2. Reviewed herbarium specimens to assemble baseline on historic occurrences.

8 herbaria house collections of Hudson intertidal specimens.

850 intertidal specimens located, identified, and georeferenced.
Isoetes riparia, Englm.

High water line.

Mouth of creek, just above Peekskill.

Aug. 1869.

W.H. Leggott legis.
Methods, cont.

3. Conducted field work.
   • explored historic sites as well as many previously unexplored sites
   • worked during daily narrow window of opportunity
Hudson River Field Participants

Suneeti Jog, The Nature Conservancy
Jenna Dorey, NYBG
Erik Kiviat, Hudsonia
Nava Tabak, Scenic Hudson
Sarah Walker, NYBG
David Werier, N.Y. Flora Assocn.
Charlie Zimmerman, NYBG
Hudson River Estuary Study Sites

Historic (1825-2003) 92 sites

Current (2011-2014) 118 sites
What is it like to look for an intertidal plant?
4. Analyzing data.

• comparing historic to current occurrences

• investigating patterns of occurrence with GIS (geographic information systems)

• determining conservation status of each species
Methods, cont.

Conservation Status Categories

Secure (future is bright): >15 sites; >10,000 plants

Imperiled (future in question)
   a. moderately: 5–15 sites and/or 1000–10,000 plants
   b. critically: <5 sites; <1000 plants

Extirpated (already gone): historic only
Results: Secure Species

Water Hemp
(Amaranthus cannabinus, Amaranthaceae)

34 populations known
Imperiled Species

River Quillwort
(*Isoetes riparia*, Isoetaceae)

3 populations known
(129 plants total)
Imperiled Species
River Quillwort
(*Isoetes riparia*, Isoetaceae)
3 populations known
(129 plants total)
First sighting on Hudson since 1941

historic  current
Extirpated Species

Parker’s Pipewort
(Eriocaulon parkeri, Eriocaulaceae)

last collection from Hudson River: 1944
Summary of Conservation Status for Intertidal Species
(n = 32)

- Secure: 21 (65%)
- Imperiled: 6 (19%)
- Extirpated: 5 (16%)
Examples of Declines in Intertidal Plants

River Quillwort (Isoetes riparia)
15H, 3C, -80% change; 129 plants currently known

American Waterwort (Elatine americana)
11H, 3C, -73% change; 46 plants currently known

Smith’s Bulrush (Schoenoplectiella smithii)
11H, 5C, -55% change; 38 plants currently known

Pygmy Riverweed (Crassula aquatica)
5H, 2C, -60% change; 580 plants currently known
Likely causes of declines

1. Pollution, especially from excess nutrients
2. Competition from invasive species
3. Habitat destruction, esp. from development
4. Erosion, esp. from ship-induced wave action
5. Sedimentation
6. Dredging
Ample Evidence of Eutrophication
A Few of the Invasive Plant Species of Hudson River Intertidal Zones

**Phragmites australis** (Poaceae) present for decades, continues to invade, many poplns known

**Kyllinga gracillima** (Cyperaceae) new to Hudson, 2 poplns known

**Cyperus fuscus** (Cyperaceae) new to New York, 3 poplns known

**Cyperus diformis** (Cyperaceae) new to Hudson, 2 poplns known
Reasons for Hope

The Hudson River Estuary Habitat Restoration Plan

Hudson River Estuary Program
New York State Department of Environmental Conservation
Andrew M. Cuomo, Governor
Joe Martens, Commissioner
Application of Conservation Science:
Identification of Critical Areas

<table>
<thead>
<tr>
<th>Site</th>
<th># intertidal spp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>HISTORIC SITES</td>
<td></td>
</tr>
<tr>
<td>Rogers Island (Columbia Co.)</td>
<td>13</td>
</tr>
<tr>
<td>Saugerties (Orange Co.)</td>
<td>12</td>
</tr>
<tr>
<td>Stony Creek (Dutchess Co.)</td>
<td>11</td>
</tr>
<tr>
<td>Iona Island (Rockland Co.)</td>
<td>10</td>
</tr>
<tr>
<td>CURRENT SITES</td>
<td></td>
</tr>
<tr>
<td>Stockport Creek mouth (Columbia Co.)</td>
<td>10</td>
</tr>
<tr>
<td>Croton River (Westchester Co.)</td>
<td>9</td>
</tr>
<tr>
<td>Saugerties (Ulster Co.)</td>
<td>8</td>
</tr>
<tr>
<td>Hannacrois Creek mouth (Albany Co.)</td>
<td>7</td>
</tr>
</tbody>
</table>
### Application of Conservation Science: Revision of NYNHP Ranks

<table>
<thead>
<tr>
<th>Species</th>
<th>NYNHP Listing</th>
<th>Current # Sites</th>
<th>Change Necessary</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Bidens hyperborea</em></td>
<td>S1</td>
<td>NA</td>
<td>remove from list (specimens misidentified)</td>
</tr>
<tr>
<td><em>Cardamine longii</em></td>
<td>S2</td>
<td>NA</td>
<td>remove from list (specimens misidentified)</td>
</tr>
<tr>
<td><em>Limosella australis</em></td>
<td>S3</td>
<td>8</td>
<td>upgrade to S2</td>
</tr>
<tr>
<td><em>Najas muenscheri</em></td>
<td>S1</td>
<td>23</td>
<td>downgrade to S3</td>
</tr>
<tr>
<td><em>Plantago cordata</em></td>
<td>S3</td>
<td>17</td>
<td>upgrade to S2</td>
</tr>
<tr>
<td><em>Sagittaria montevidensis</em></td>
<td>S2</td>
<td>28</td>
<td>downgrade to S3</td>
</tr>
<tr>
<td><em>Sagittaria subulata</em></td>
<td>S3</td>
<td>51</td>
<td>remove from list (too many poplns.)</td>
</tr>
<tr>
<td><em>Schoenoplectiella smithii</em></td>
<td>not listed</td>
<td>5</td>
<td>add to list as S1</td>
</tr>
</tbody>
</table>

**S1 = 1--5 sites**

**S2 = 6--20 sites**

**S3 = 21--35 sites**
1. This is the first comprehensive study of the Hudson’s intertidal plants.

2. Intertidal plants are worth conserving.
   • unique elements of our shared natural heritage
   • inhabit very few places

3. Intertidal plants provide essential ecosystem services.
   • stabilize shorelines
   • buffer effects of storms
   • provide food and shelter for animals

4. Intertidal plants are indicators of environmental health.

5. Results of this project will inform future restoration projects.
Acknowledgments

Funding: Hudson River Foundation, Anonymous Private Trust, Linde Ostro, Stephan Chenault

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Assistance with microscopy: Charles Zimmerman

Assistance with maps: Becky Hrdy, Michelle Naczi