Current state of knowledge regarding cattail (*Typha* spp.) genetics and hybridization

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Wetlands
Wetlands are threatened by invasive plant species

- Aggressive growth results in monocultures that are hard to eradicate
- Decrease native plant biodiversity
- Effects reverberate through the food web
- Effects on ecosystem properties?
Cattails
(Typha spp.)
North American *Typha* spp.

- *Typha latifolia* (L)
- *Typha angustifolia* (A)
- *Typha x glauca* (A x L)
- *Typha domingensis* (D)
  - A x D
  - D x L

Midwest
"*T. angustifolia* is probably native to Eurasia but is now established throughout much of the US. It is abundant in the Midwest, where it hybridizes with common cattail to produce the mostly sterile "hybrid cattail" (*Typha x glauca")."
There are 3 problems with important consequences

1) Are *Typha* spp. native or invasive?
2) How do we identify *Typha* spp.?
3) Given that *Typha* spp. hybridize, are the hybrids sterile?

- Concept of species gets blurred…
- Consequences for restoration
PROBLEM 1: Are *Typha* spp. native or invasive?

- *Typha latifolia* = native
- *Typha angustifolia* = believed to be invasive from Eurasia... debatable
- *Typha x glauca* = native or invasive?
Typha latifolia

Typha angustifolia

In County map
- Green: Present in state/Native
- Green: Present in county/Native
- Blue: Present in state/Exotic
- Blue: Present in county/Exotic
Pollen records in Piermont Marsh, NY

European Settlement
~ 1650

Pederson et al. 2005
Pollen from *Typha latifolia* and *Typha angustifolia* has been present since the Holocene (~12,000 years before present)
T. angustifolia and T. latifolia pollen

Monads

Tetrads

Typha x glauca = dyads / tetrads / triads
Identification based on pollen (Finkelstein 2003)

- *Typha angustifolia* = monads (22.7 +/- 2.6 μ m), more angular
- *Sparganium* = monads (25.3 +/- 2.7 μ m), more rounded
Separating *T. angustifolia* and *T. x glauca*

<table>
<thead>
<tr>
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<th>% abundance (mean)</th>
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<tbody>
<tr>
<td></td>
<td><em>T. angustifolia</em></td>
</tr>
<tr>
<td>Monads</td>
<td>96.5–100 (99)</td>
</tr>
<tr>
<td>Dyads</td>
<td>0–3 (1)</td>
</tr>
<tr>
<td>Triads</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Tetrads</td>
<td>0–0.1 (0.01)</td>
</tr>
</tbody>
</table>

*Table 4.* Percent abundance of monads, dyads, triads, and tetrads on eight reference slides each of *Typha angustifolia* and *Typha x glauca* (*n* = 8).
How are invasive species defined?

- Non-indigenous species or strains that replace native vegetation, causing economic, environmental, and human health harm

A neutral terminology to define ‘invasive’ species

Robert I. Colautti* and Hugh J. MacIsaac

ABSTRACT

The use of simple terms to articulate ecological concepts can confuse ideological debates and undermine management efforts. This problem is particularly acute in studies of nonindigenous species, which alternatively have been called ‘exotic’, ‘introduced’, ‘invasive’ and ‘naturalised’, among others. Attempts to redefine com-

Broader definition: includes non-native AND native species that heavily colonize an area
PROBLEM 2: How do we identify *Typha* spp.?

- Morphological traits overlap between parental species and hybrids
- High variability within a species
PROBLEM 3: Are hybrids sterile?

• It depends on the hybrid…

• First-generation (F1) hybrids thought to be sterile

• Introgression may be widespread
  – Back-crosses to either parent are more common than previously thought, at least for *Typha x glauca*
  – Advanced generation hybrids
  – Hybrid swarm
Problem 2 + Problem 3 = *Typha* spp. are a genetic headache

- Use of molecular markers (different mutation rates)
  - Isozymes / VNTR / AFLP / RAPD / Microsatellites / DNA Sequencing

Cattail sleuths use forensic science to better understand spread of an invasive species

*By Joy Marburger, Steve Travis, and Steve Windels*

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**ALL CATTAILS ARE NOT CREATED EQUAL.** Mounting evidence suggests that a European invader is hybridizing with native cattails in three national parks in the Great Lakes region. This is posing a threat to native biodiversity and causing a “hybrid swarm” into areas where cattails (*Typha* spp.) have never been seen. The invasive narrowleaf cattail (*T. angustifolia*), which has been spreading inland from the eastern seaboard since the early 1800s, has the ability to hybridize with the native broadleaf cattail (*T. latifolia*). In doing so, it has given rise to a new species of cattail (*T. x glauca*), first described in the 1960s. This hybrid has the ability to disrupt many ecosystem services traditionally associated with freshwater wetlands. This may be related to its ability to tolerate both of the habitats occupied by its parents (and then some).

All of this comes as no surprise to many taxonomists who have recognized the difficulty in identifying these hybrid cattails.
Who’s working with molecular tools?

• Isozymes
  – McNaughton 1965 (Stanford University)
  – Lee & Fairbrothers 1969, 1973; Lee 1975 (Rutgers University)
  – Mashburn et al. 1978
  – Sharitz et al. 1980 (University of Georgia-SREL)

• VNTR
  – Keane et al. 1999 (University of Cincinnati, OH)

• AFLP
  – Lamote et al. 2005 (Belgium)

• RAPD
  – Marcinko-Kuehn et al. 1999 (McMaster University, Ontario, Canada)
  – Snow, Selbo, Goldberg, and Wildova (Ohio State University / U. of Michigan)
  – Travis, Windels, and Marburger (University of New England / INDU)
  – Geddes and collaborators (NEIU)

• Microsatellites
  – Tsyusko-Omeltchenko et al. 2003; Tsyusko et al. 2005 (Ukraine / U of GA-SREL)

• DNA sequences
  – Zhang et al. 2008 (Florida Atlantic University; *Typha domingensis* and *Typha latifolia*)
Band     latifolia   angustifolia

1.0 kb       +                –
1.8 kb       –                +
2.0 kb         –                +

Diagnostic band scores from Marcinko Kuehn et al. 1999
Back-crosses are common

<table>
<thead>
<tr>
<th></th>
<th>SM</th>
<th>L</th>
<th>A</th>
<th>L</th>
<th>A</th>
<th>G</th>
<th>B</th>
<th>B</th>
<th>SM</th>
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From Wildova and Snow (unpublished)

From Travis et al. (unpublished)

http://mipn.org/Final%20YIR%202005%20Cattail%20Sleuths%202011-26-05.doc
My research

• Is there a difference in how different *Typha* species affect ecosystem properties?
  – Plant species richness
  – Nutrient pools (C, N, and P)
  – Nitrogen transformation (denitrification, nitrogen fixation)

• *Typha* species identified using a complementary approach:
  – Morphological traits
  – “Ecological information”
  – Molecular tools
Field Site: Cowles Bog Wetland Complex
Morphological traits

glaucan →
angustifolia
“Ecological information”

**Graph 1:**
- **Y-Axis:** Typha density (stems/m²)
- **X-Axis:** Site/species
- **Data Points:**
  - Native
  - Restored (glaucum)
  - Glaucum
  - Latifolia
  - Angustifolia

**Graph 2:**
- **Y-Axis:** Species richness (# of species)
- **X-Axis:** Typha density (stems/m²)
- **Data Points:**
  - N
  - R
  - L2
  - L1
  - G2
  - G3
  - G1
  - A
- **Equation:** $R^2 = 0.8953$
### Molecular tools: RAPDs

Diagnostic band scores from Marcinko Kuehn et al. 1999

<table>
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<tr>
<th>Band</th>
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<th>angustifolia</th>
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<tbody>
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<td>1.0 kb</td>
<td>+</td>
<td>−</td>
</tr>
<tr>
<td>1.8 kb</td>
<td>−</td>
<td>+</td>
</tr>
<tr>
<td>2.0 kb</td>
<td>−</td>
<td>+</td>
</tr>
</tbody>
</table>

Series/ morphology

Species

![Image of RAPD primer A8](image-url)
Experiment to characterize species

• Genetic analyses (RAPDs) and ecological information to identify species

• 3 different species were transplanted as rhizomes:
  – *Typha latifolia* (parental species)
  – *Typha angustifolia* (parental species)
  – *Typha x glauca* (hybrid)

• Currently analyzing 100 specimens per species using molecular tools
Mean leaf length (cm) vs. SPECIES:

- argustifolia
- glauca
- latifolia

Number of new sprouts vs. SPECIES:

- argustifolia
- glauca
- latifolia

18 days

Growth pattern supports genetic identification

P < 0.001
Nutrient pools: Carbon (SOM)

Mean SOM (%)

Site (by geographic location)

Invasion history (older to younger)

P < 0.001
R² = 0.812
Nutrient pools: NO$_3$ and NH$_4$

![Graph showing mean NO$_3$ and NH$_4$ concentrations across different sites with P < 0.001 and R$^2$ values of 0.782 and 0.962 respectively.](image)

Invasion history (older to younger)
Denitrification and N fixation

**Mean denitrification (nmol/g/d)**

- $P = 0.002$
- $R^2 = 0.718$

**Nitrogen fixation (nmol/g/d)**

- $P = 0.001$
- $R^2 = 0.741$

Invasion history (older to younger)
Implications for restoration practices

• Not all *Typha* are equal
  – Underscores the need for proper identification using a complementary approach

• *Typha* species differentially affect ecosystem properties

• Soil “legacy” from invasive species may have implications for restoration
  – History of invasion may be critical in determining these legacies
  – Restoration may not be effective if soil legacies are not addressed
Thanks

- NSF (DBI 0610405 to PG)
- IL-IN SeaGrant (NOAA) (co-PIs Larkin (CBG) and Tuchman (LUC))
- Carbon Scholarship (LUC) to T. Grancharova

- J. Kelly and T. Grancharova
- Bryan and Paula Pickett
- Bobbi Lammers-Campbell
- Joy Marburger (NPS), Dan Mason (NPS), Sean Burns (GLERC intern)
- Blake Anderson, Eric Appelbaum, Priscilla Andrade, Chris Calderaro, Monika Freyman, Amy Galanter, Kathi Jo Jankowski-Giefer, Jeff Kampman, Dan Larkin, Gina Lettiere, Shane Lishawa, Owen McKenna, Mark Mitchell, Michal Olszewski, Raphael Porto, Joe Schluep, Anna Sjodin, Cindy Stowell, Lane Vail, Alison Varty