“If you know your enemies and know yourself, you will not be imperiled in a hundred battles... if you do not know your enemies nor yourself, you will be imperiled in every single battle.”

Sun Tzu
Acknowledgements

• Dr. Ryan Thum, GVSU, Annis Water Resources Institute
• Liz LaRue, Matthew Zuellig
• Dustin Wcisel
• Paul Hausler, Mark Heilman, Ann Hruska, Lisa Huberty, Mike Netherland, Pam Tyning
Hybrid watermilfoils

- Eurasian watermilfoil hybridizes with native northern watermilfoil
  - Concern that hybrids are more aggressive
  - Harder to kill?

Hybridization as a stimulus for the evolution of invasiveness in plants?

Norman C. Ellstrand* and Kristina A. Schierenbeck*

*Department of Botany and Plant Sciences, University of California, Berkeley, CA 94720

Evidence of hybridity in invasive watermilfoil (Myriophyllum) populations

Michael L. Moody* and Donald H. Les

Department of Ecology and Evolutionary Biology, University of Connecticut, Storrs, CT 06269-3043

Communicated by David L. Dilkher, University of Florida, Gainesville, FL, July 2, 2002 (received for review March 10, 2002)
Hybridization more recent in U.P.

Menominee River Watershed (younger invasion)  Lower Peninsula (older invasion)
Lower peninsula populations

- Hybrid Lake
- EWM Lake
Menominee watershed populations

Studied: Relationship between treatment history and incidence of hybrids.

Results

- Hybrids ~8X more likely to exist in treated lakes than untreated (P=0.04)
- Multiple distinct hybrid clones
  - One hybrid clone shared among five lakes (4 treated, 1 untreated)
Menominee populations

Length gained (cm)

Hybrid

EWM

78% more
Lower peninsula populations

Length gained (cm)

- Hybrid: More than 60 cm
- EWM: 34 cm

46% more
Growth rates

• Hybrids have faster growth rates \textit{on average}.

  – But, not \textit{all} hybrids necessarily grow faster than \textit{all} EWM.
Hybrid diversity

- There is not one monolithic hybrid lineage with a fixed set of characteristics necessarily.

- Hybrids have originated from different parental EWM and NWM on many occasions.

- Dr. Thum assumes hybridization is ongoing—i.e., each year we have new hybrids that have never existed before.
Genetic diversity in EWM

- Menominee
- LP MI

51 genotypes
Why is hybrid diversity important?

- Each lake with NWM invaded by EWM has potential to form a new hybrid

- Any general traits that arise repeatedly through hybridization can happen instantaneously

- New hybrid lineages may have new traits
General versus unique traits

• General traits – common in different hybrid lineages
  – Faster growth
  – Reduced sensitivity to low-dose 2,4-D

• Unique traits – sporadic in different hybrid lineages
  – Reduced fluridone sensitivity
Thoughts after the Menominee River Watershed (MEF) study:

- Multiple hybrid clones exist in MEF watershed
- Likely that management is impacting these species and promoting hybridization or just allowing hybrid seed to emerge from seed bank
- Management may also open up or create new niches
- If hybrids more resistant/tolerant to herbicides, then managers may induce evolution in the milfoils they are trying to control
2,4-D Sensitivity Assays

- Exposed meristems (12 cm) for 2 days to:
  - Menominee River watershed
    - 0, 100, 150, 200, 500 µg/L (ppb)
    - N = 244
  - Lower Peninsula MI
    - 0, 200, 500 µg/L (ppb)
    - N = 176
2,4-D Sensitivity Assays

- Individually planted
- Grown out for 3 weeks
- Temperatures –similar to field applications
- Measured the extent of reduced 2,4-D sensitivity
  - $\frac{\text{Length}_{\text{treated}}}{\text{length}_{\text{control}}}$
Menominee R. Watershed

![Graph showing the effect of 2,4-D treatment on plant length in different hybrids and EWMs. The x-axis represents 2,4-D Treatment (µg/L ae), ranging from 0 to 500. The y-axis represents Length treated/Length control, ranging from 0 to 1.2. Different lines represent different hybrids and EWMs, with specific colors and markers for each. The graph shows a decrease in length treated as the 2,4-D treatment increases.](image)
Lower peninsula

[Graph showing the relationship between 2,4-D treatment (µg/L ae) and length treated/length control for different genotypes.]

- Hybrid 1
- Hybrid 2
- Hybrid 3
- Hybrid 4
- Hybrid 5
- Hybrid 6
- EWM 1
- EWM 2
- EWM 3
- EWM 4
- EWM 5
- EWM 6
- EWM 7
- EWM 8
- EWM 9
Hybrid watermilfoils

- Faster growth on average
  - Increased risk of rapid takeover, spread, and recolonization of treated areas

- Reduced sensitivity to low-dose 2,4-D
  - Increased risk of low efficacy in 2,4-D treatments that fail to reach target exposures

- Increased risk of low efficacy/failure at target 2,4-D?
  - More research needed

- Increased risk of fluridone failure
  - More research needed
Where are we at?

• Collecting genetic data, laboratory herbicide screens, and confirming resistance/susceptibility in the field
• Trying to establish whether there are any ‘broad’ correlations between major “genetic groups” and qualitative herbicide response

Where are we going?

• Uncovering the genetic mechanism(s) for susceptibility/resistance so that genetic tests that assay the precise gene(s) involved in response can be developed
• Much longer term study (5-10 years on the low-end/optimistic estimate)
Bottom line... know your enemy...and yourself:

• Monitor aquatic vegetation pre and post treatment
• Have a management plan
• Understand the financial risks of treatment
• Identify your lake’s priority “environmental services”
• Do genetic testing to know what you’re fighting
• Stay tuned for *upcoming* herbicide/genotype testing capabilities...
Mechanical harvesting

Suction method

Herbicide

Considering the options

Hand pulling

Suction method
Acknowledgements

- Dr. Ryan Thum, GVSU, Annis Water Resources Institute
- Liz LaRue, Matthew Zuellig
- Dustin Wcisel
- Paul Hausler, Mark Heilman, Ann Hruska, Lisa Huberty, Mike Netherland, Pam Tyning
For more information about milfoil genetic testing, contact:

Dr. Ryan Thum  
Grand Valley State University  
Annis Water Resources Institute  
740 W. Shoreline Dr.  
Muskegon, MI  49441  
(616) 331-3989

Available now from AWRI: Genetic sampling costs: $30-40 per sample depending on how many samples.

Stay tuned... the ability to sample milfoil for genetics and then bioassay for herbicide resistance will be available commercially in the next year or so.