DEPARTMENT OF ECOLOGY
State of Washington

Response to the discovery of variable-leaf and western watermilfoil hybrids in Washington

Wesley Glisson

Outline

1. Introduction to watermilfoils
2. Watermilfoil hybridization
3. Discovery of new hybrid watermilfoil in WA
4. Response: Management + surveys
5. Response: Genetic research

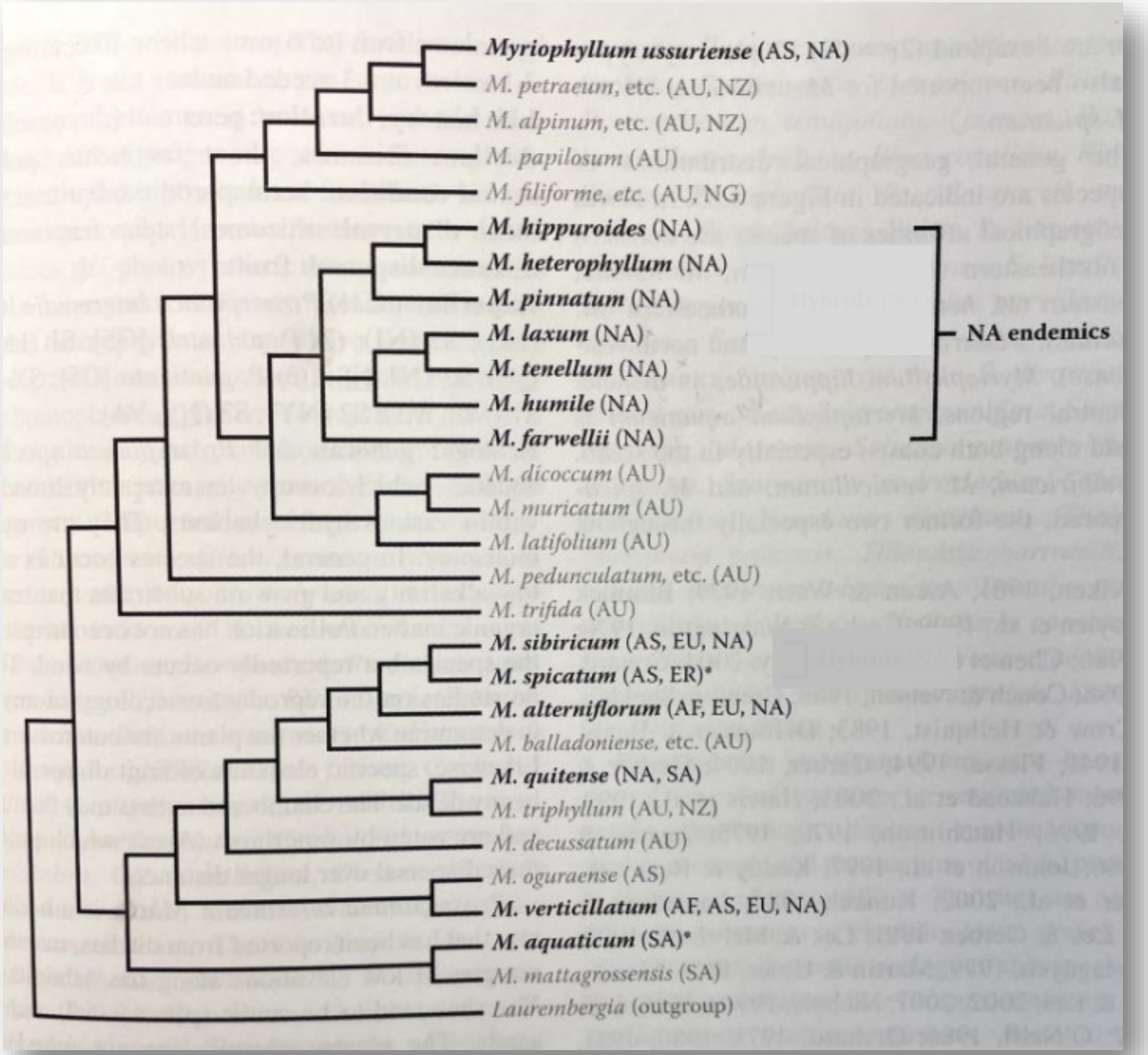
Watermilfoil (*Myriophyllum*)

- 68 species worldwide
- Characteristics (in NA)
  - Aquatics (OBL)
  - Column-like shape
  - Pinnately-compound leaves
    - Whorls of 3–6
  - Flowers on emergent spikes

Watermilfoils in North America

14 total species

12 native (7 endemics)

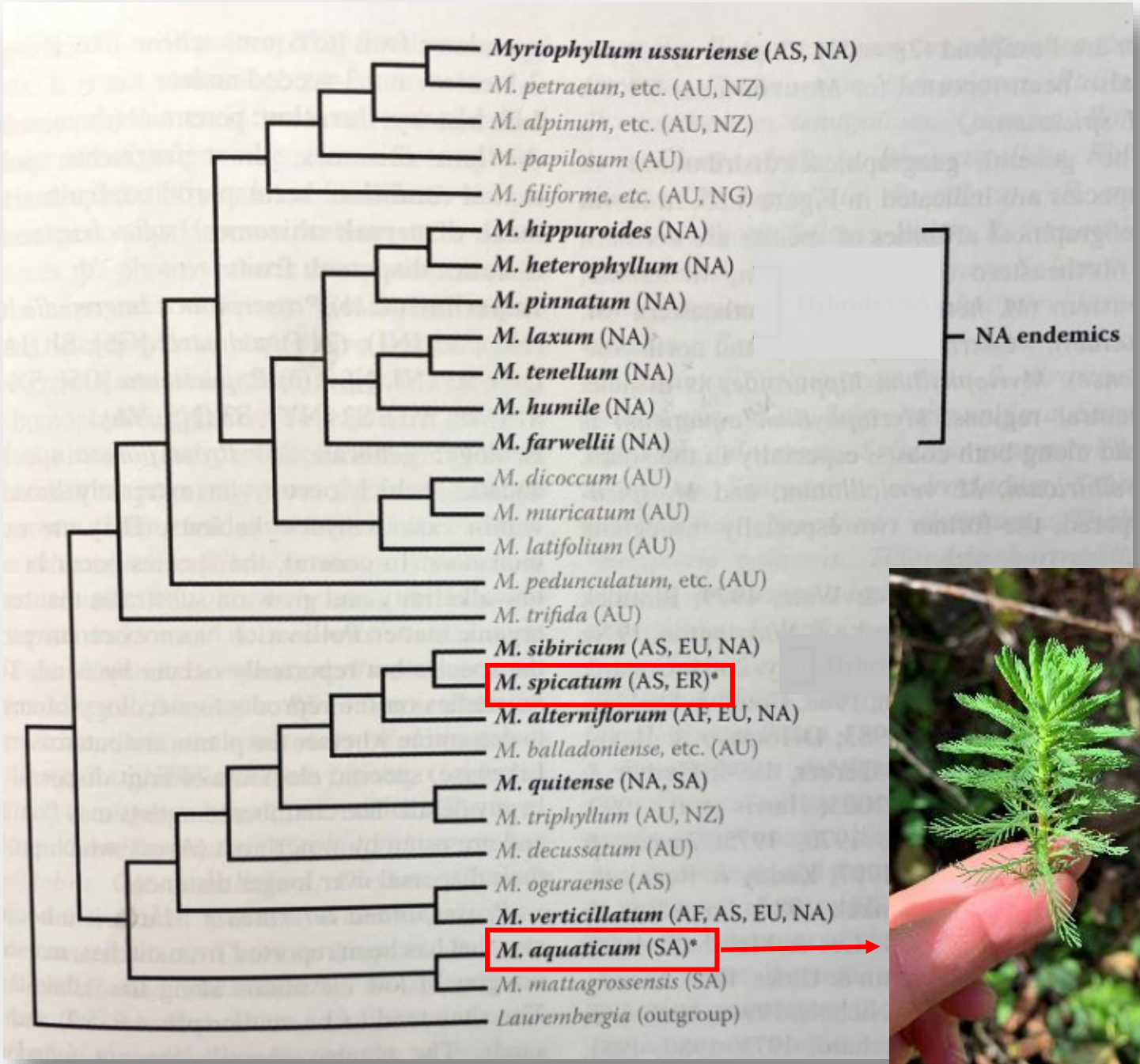


Watermilfoils in North America

14 total species

12 native (7 endemics)

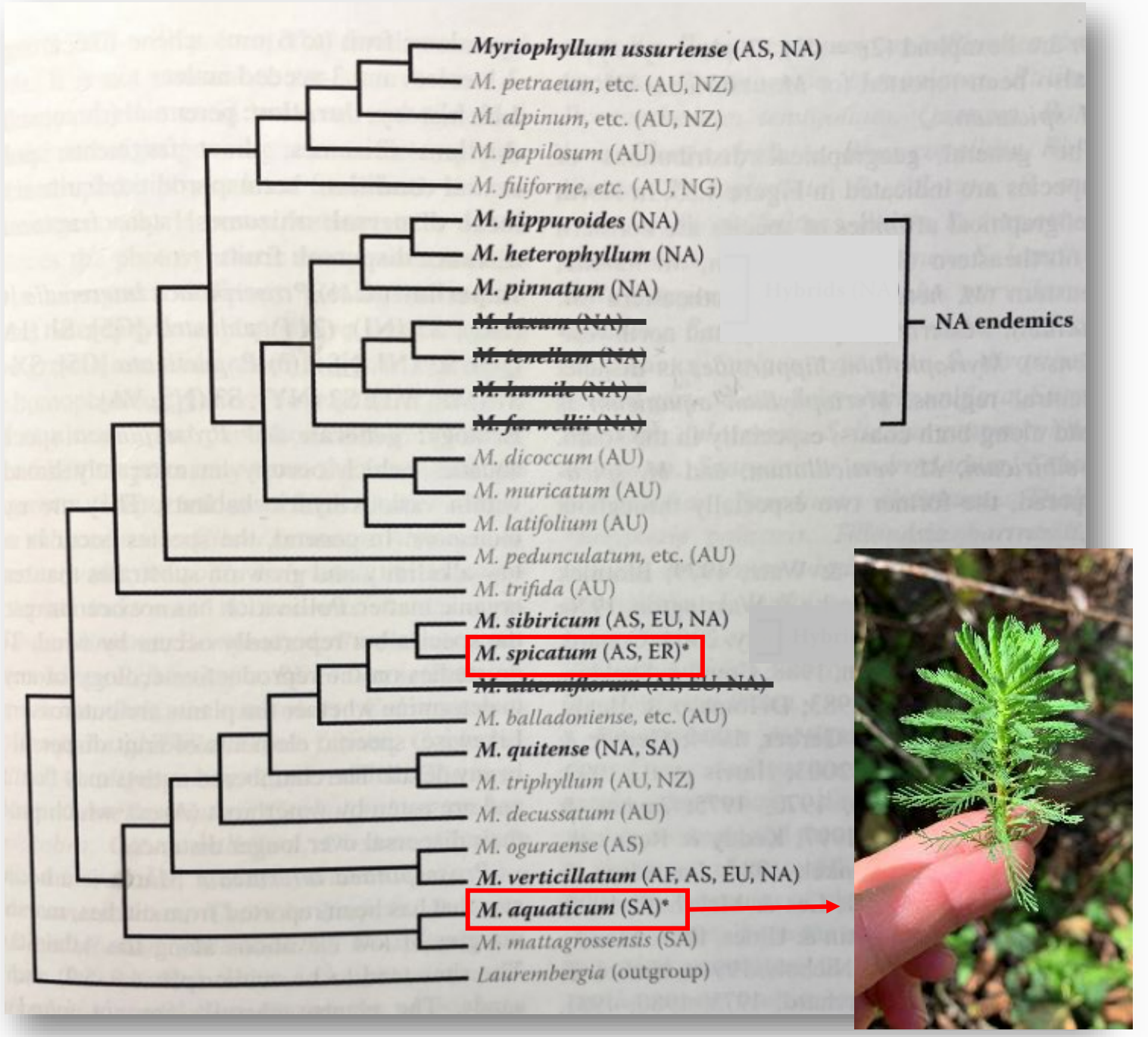
2 introduced



Watermilfoils in Washington

9 total species

6 native



Watermilfoils in Washington

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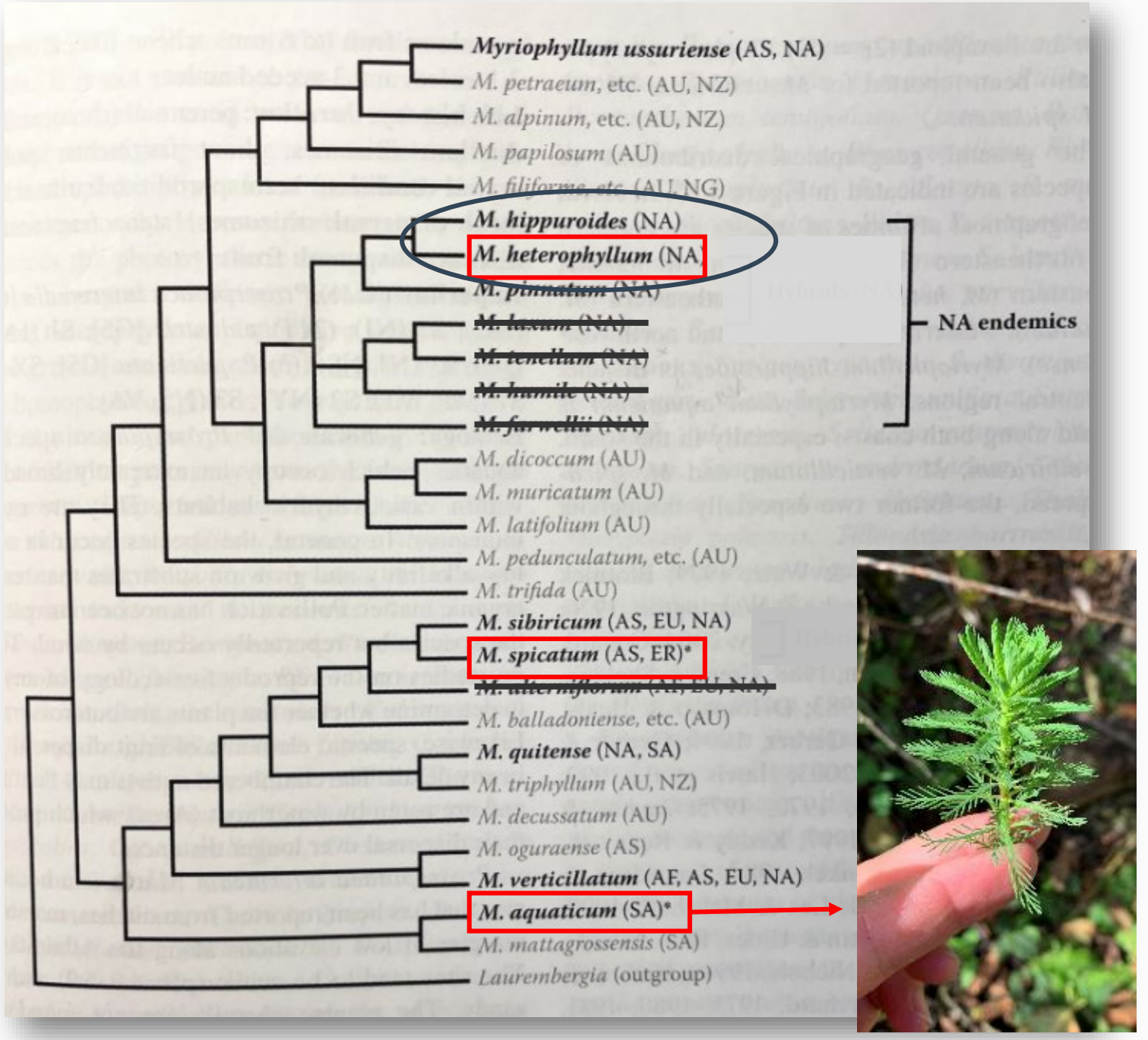
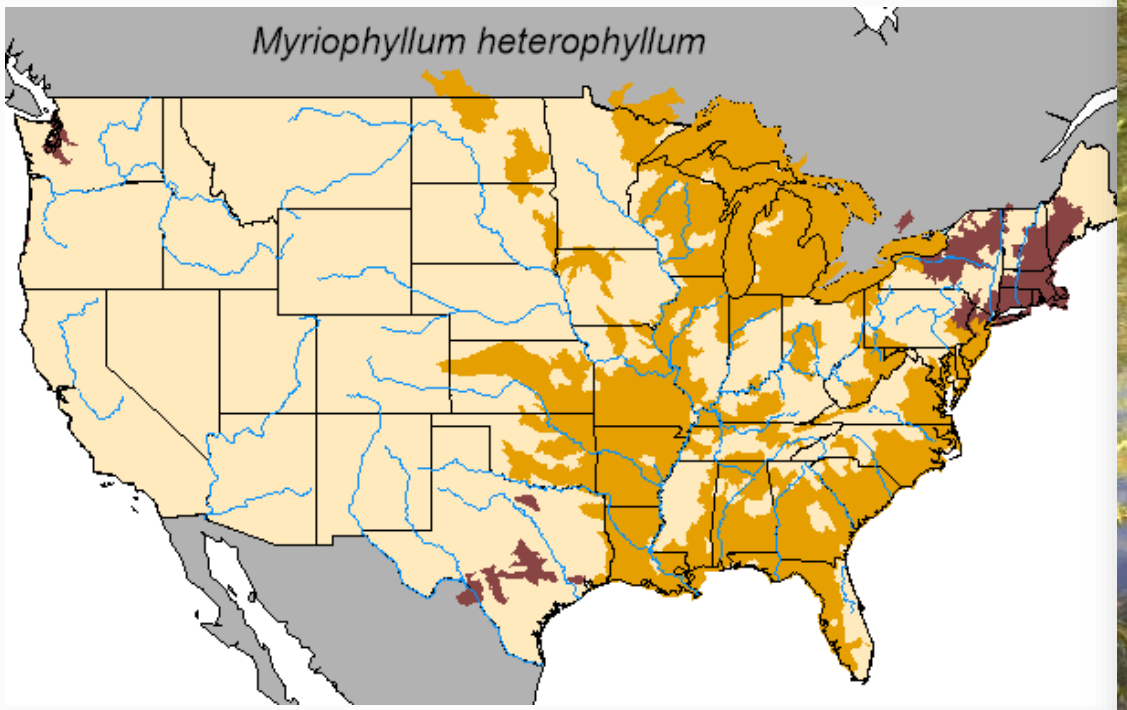


Variable-leaf watermilfoil (*M. heterophyllum*)

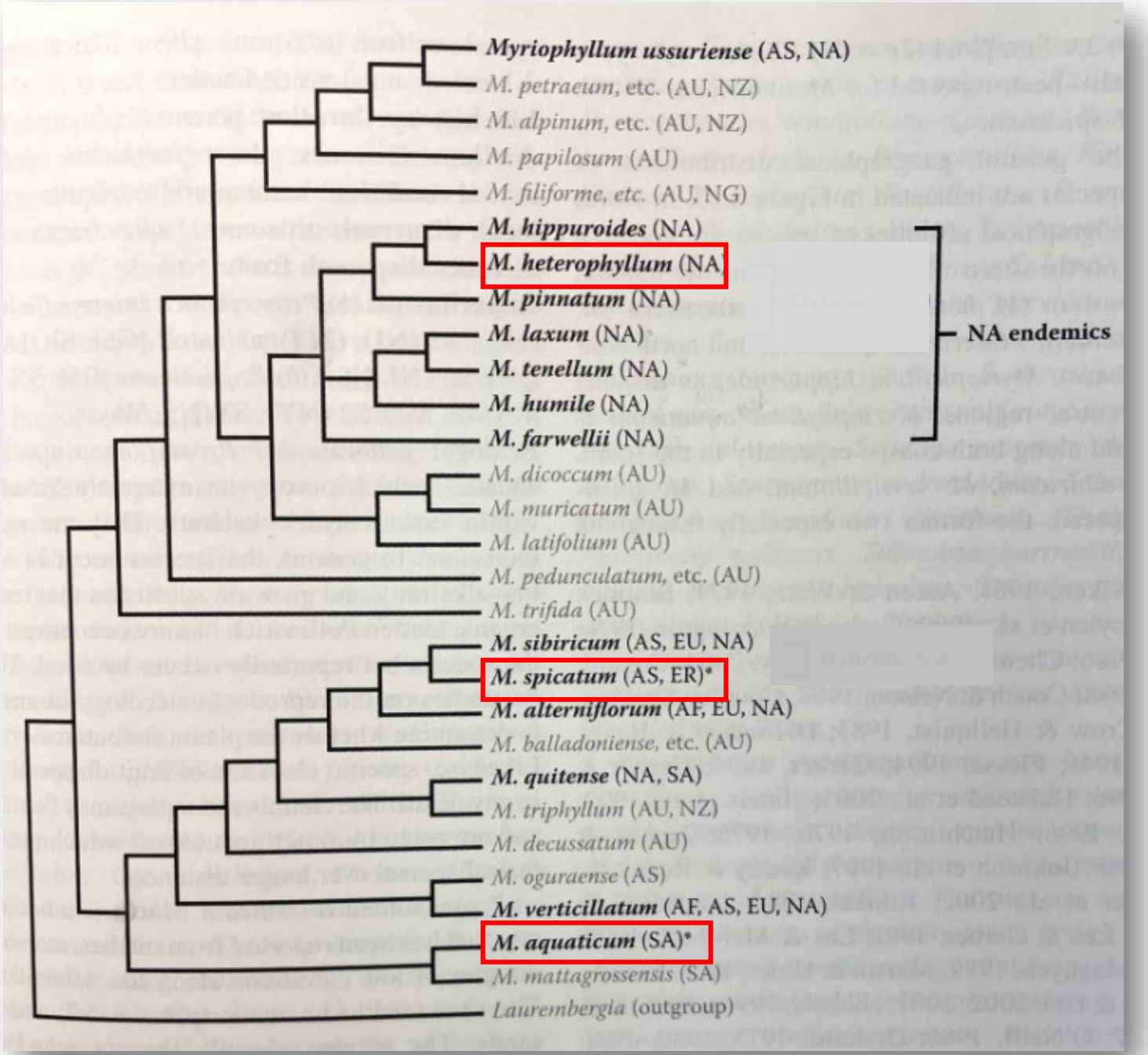
Variable-leaf watermilfoil (*M. heterophyllum*)



- Native to SE United States
- Popular in aquarium trade
- Invasive in NE U.S. and Europe
- Class A Noxious Weed (listed 2007)

Western watermilfoil (*M. hippuroides*)

Western watermilfoil (*M. hippuroides*)


Myriophyllum ussuriense (AS, NA)
M. petraeum, etc. (AU, NZ)
M. alpinum, etc. (AU, NZ)
M. papilosum (AU)
M. filiforme, etc. (AU, NG)
M. hippuroides (NA)
M. heterophyllum (NA)
M. pinnatum (NA)
M. laxum (NA)
M. tenellum (NA)
M. humile (NA)
M. farwellii (NA)
NA endemics
M. dicoccum (AU)
M. muricatum (AU)
M. latifolium (AU)
M. pedunculatum, etc. (AU)
M. trifida (AU)
M. sibiricum (AS, EU, NA)
M. spicatum (AS, ER)*
M. alterniflorum (AF, EU, NA)
M. balladoniense, etc. (AU)
M. quitense (NA, SA)
M. triphyllum (AU, NZ)
M. decussatum (AU)
M. oguraense (AS)
M. verticillatum (AF, AS, EU, NA)
M. aquaticum (SA)*
M. mattagrossensis (SA)
Laurembergia (outgroup)

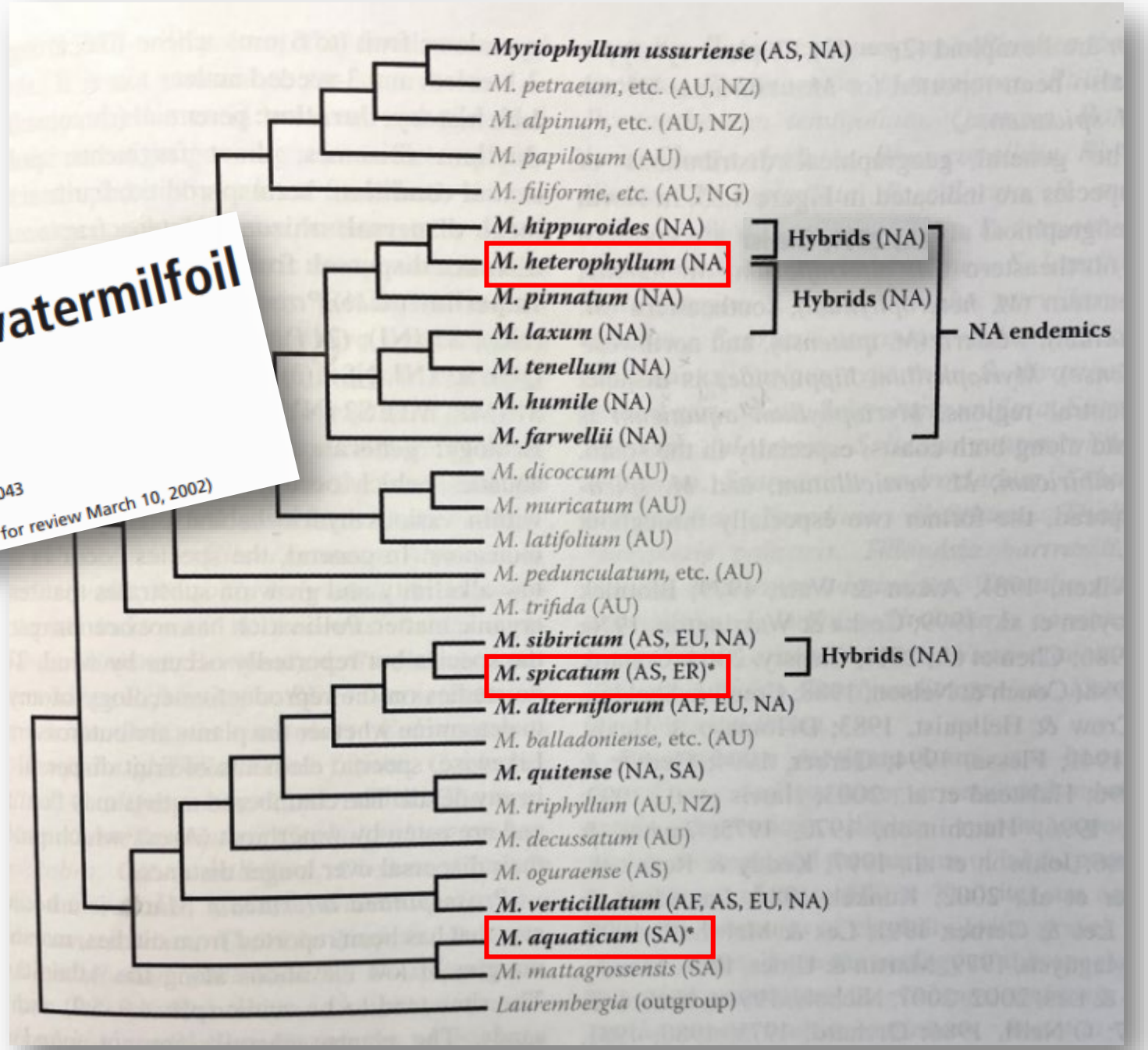
Watermilfoil hybridization

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. Dilcher, University of Florida, Gainesville, FL, July 2, 2002 (received for review March 10, 2002)



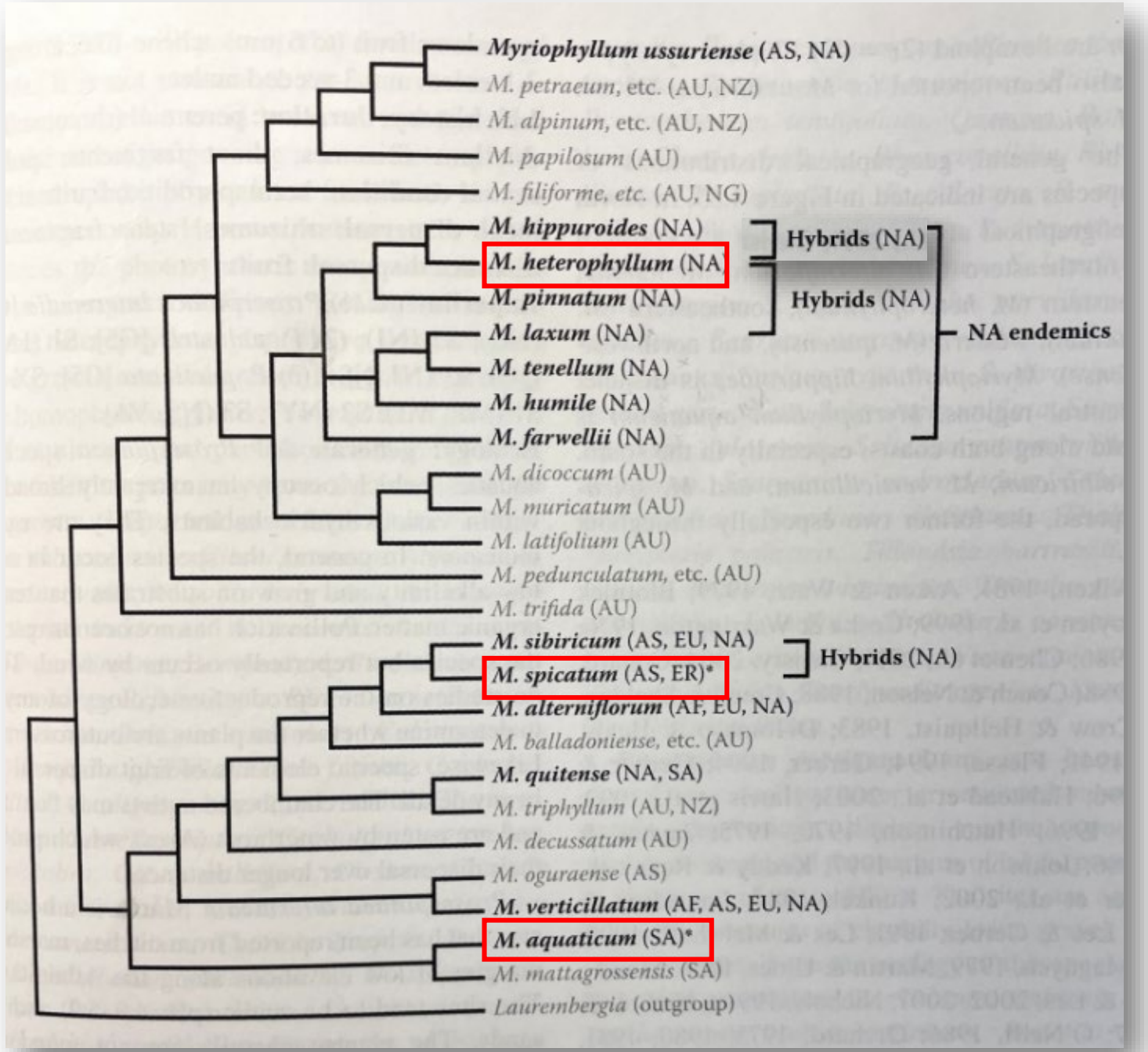
Moody and Les 2002 *PNAS*, Les, 2018

Watermilfoil hybridization

M. spicatum × *M sibiricum*

M. heterophyllum × *M. laxum*

M. heterophyllum × *M. hippuroides*

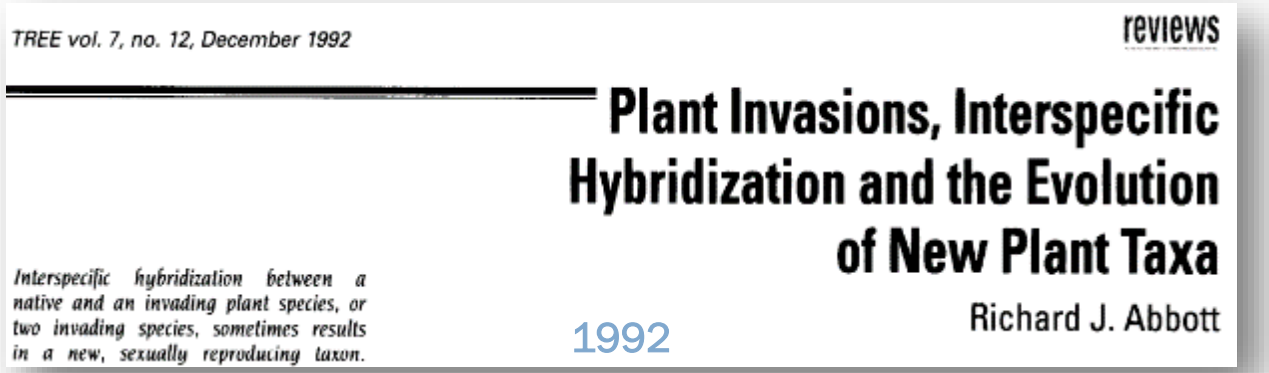


Moody and Les 2002 *PNAS*, Les, 2018

Watermilfoil hybridization

Why should we care?

Hybridization can lead to (increased) invasiveness



TREE vol. 7, no. 12, December 1992

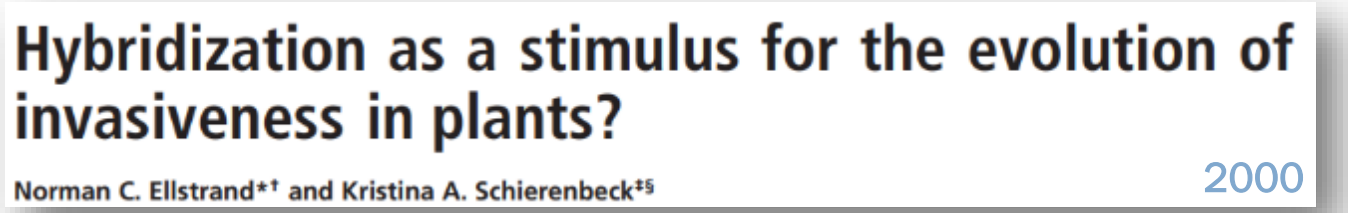
reviews

Plant Invasions, Interspecific Hybridization and the Evolution of New Plant Taxa

Richard J. Abbott

Interspecific hybridization between a native and an invading plant species, or two invading species, sometimes results in a new, sexually reproducing taxon.

1992



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

Norman C. Ellstrand*† and Kristina A. Schierenbeck‡§

2000

Biol Invasions (2009) 11:1093–1105
DOI 10.1007/s10530-008-9388-x

ORIGINAL PAPER

Hybridization and the evolution of invasiveness in plants and other organisms

Kristina A. Schierenbeck · Norman C. Ellstrand

2009

ECOLOGY LETTERS

Ecology Letters, (2014) 17: 1464–1477 doi: 10.1111/ele.12355

REVIEW AND SYNTHESIS

Hybridisation is associated with increased fecundity and size in invasive taxa: meta-analytic support for the hybridisation-invasion hypothesis

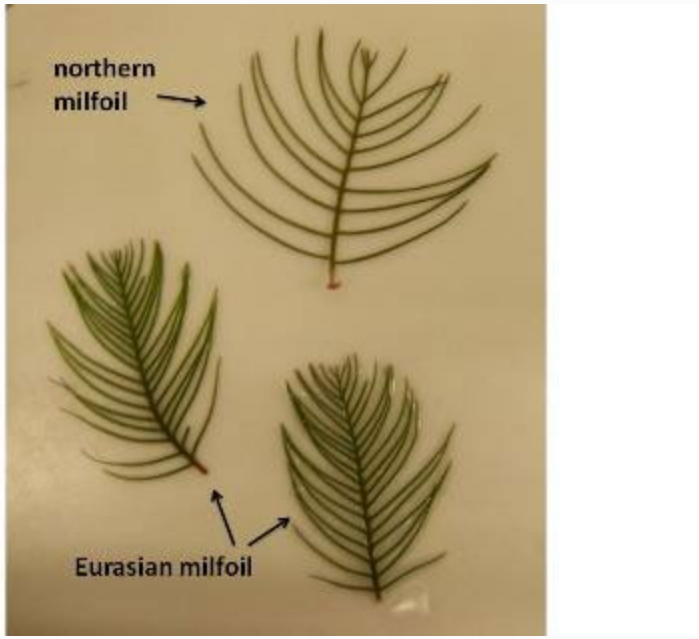
2014

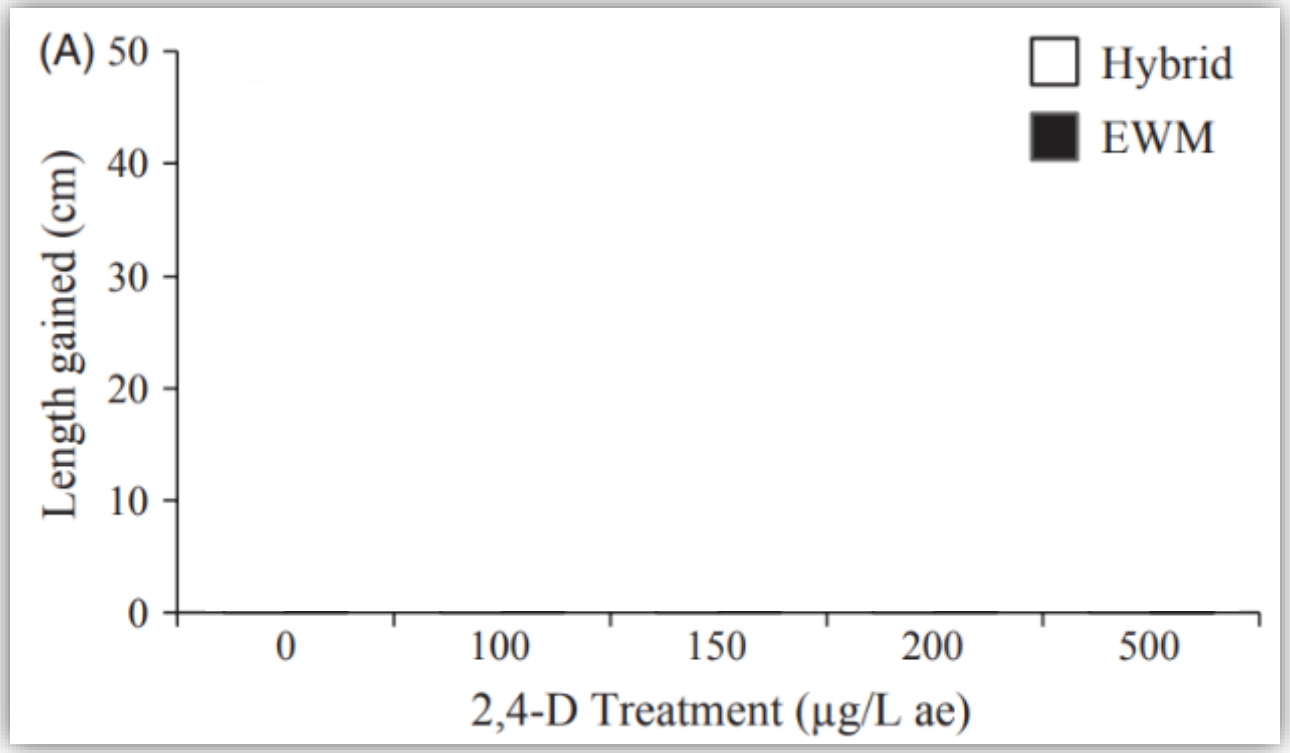
Watermilfoil hybridization

M. spicatum

×

M sibiricum





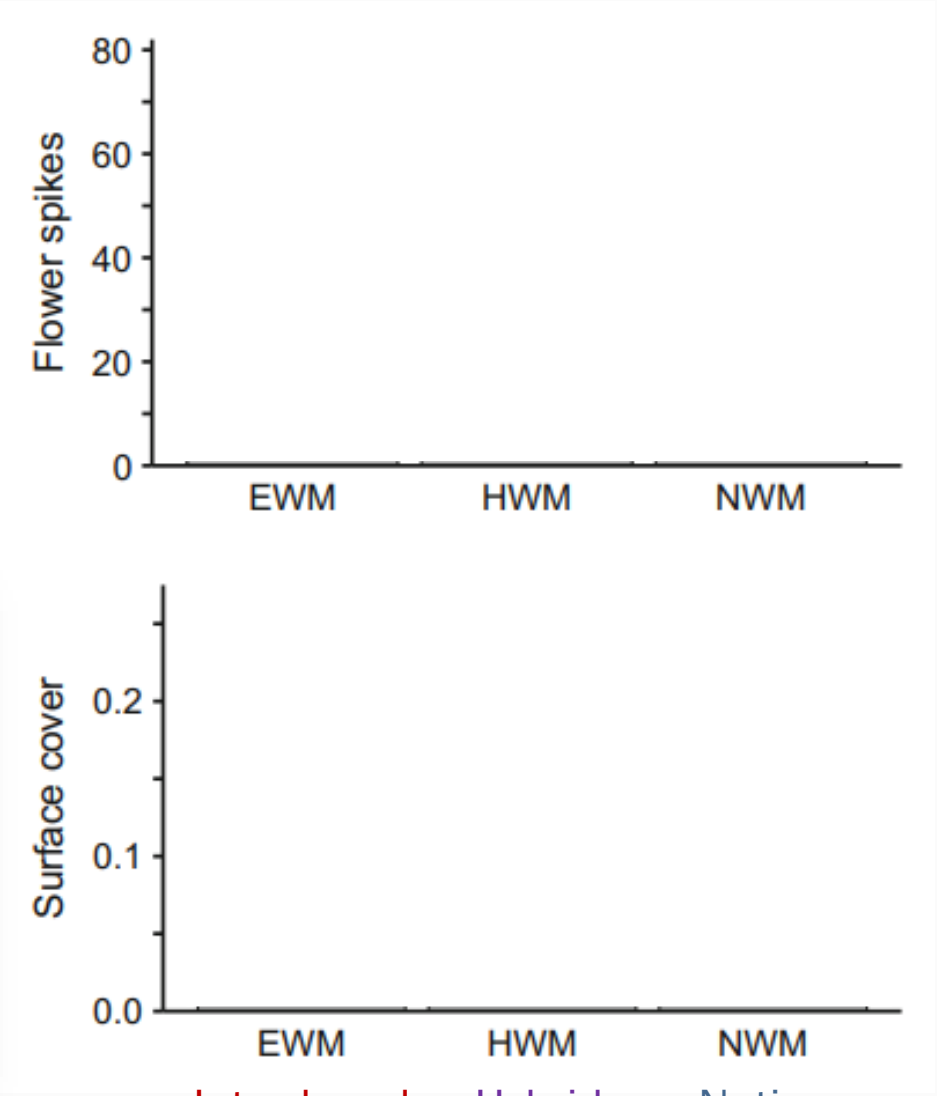
LaRue et al. 2012, *Evolutionary Applications*

Watermilfoil hybridization

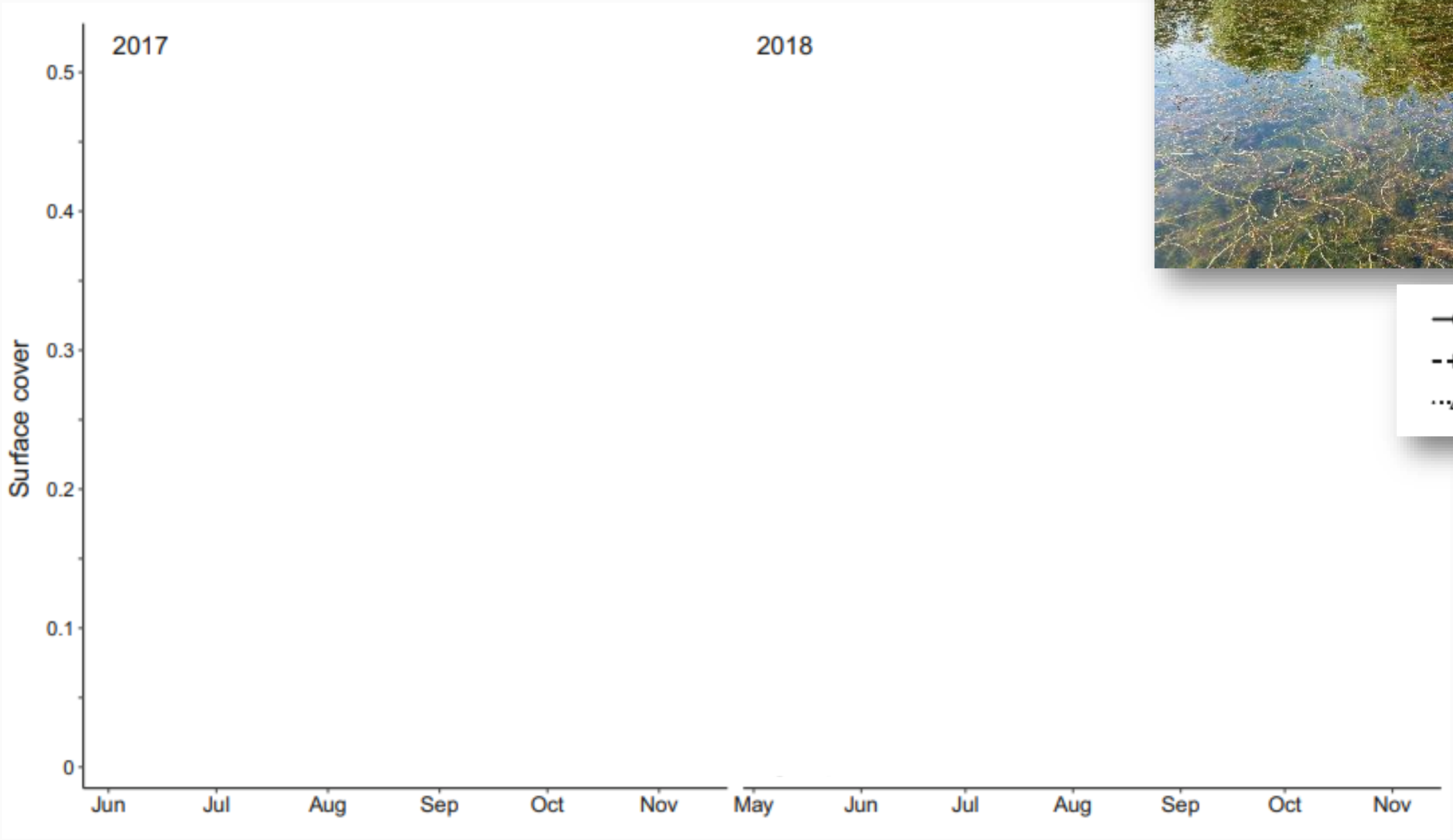
M. spicatum

×

M sibiricum



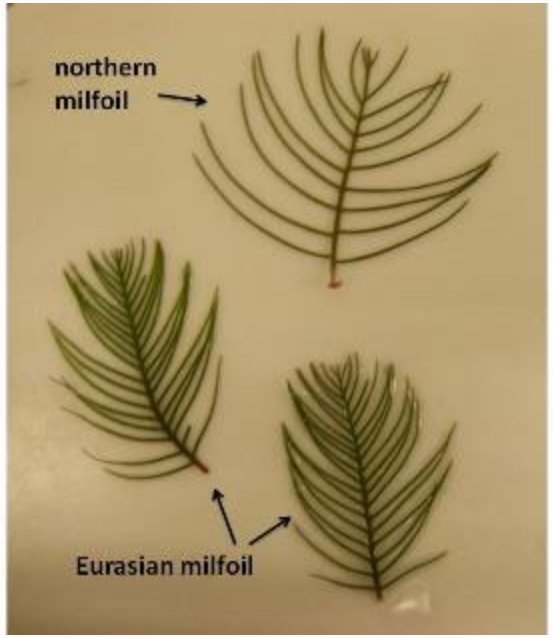
Glisson and Larkin 2021, *Biological Invasions*

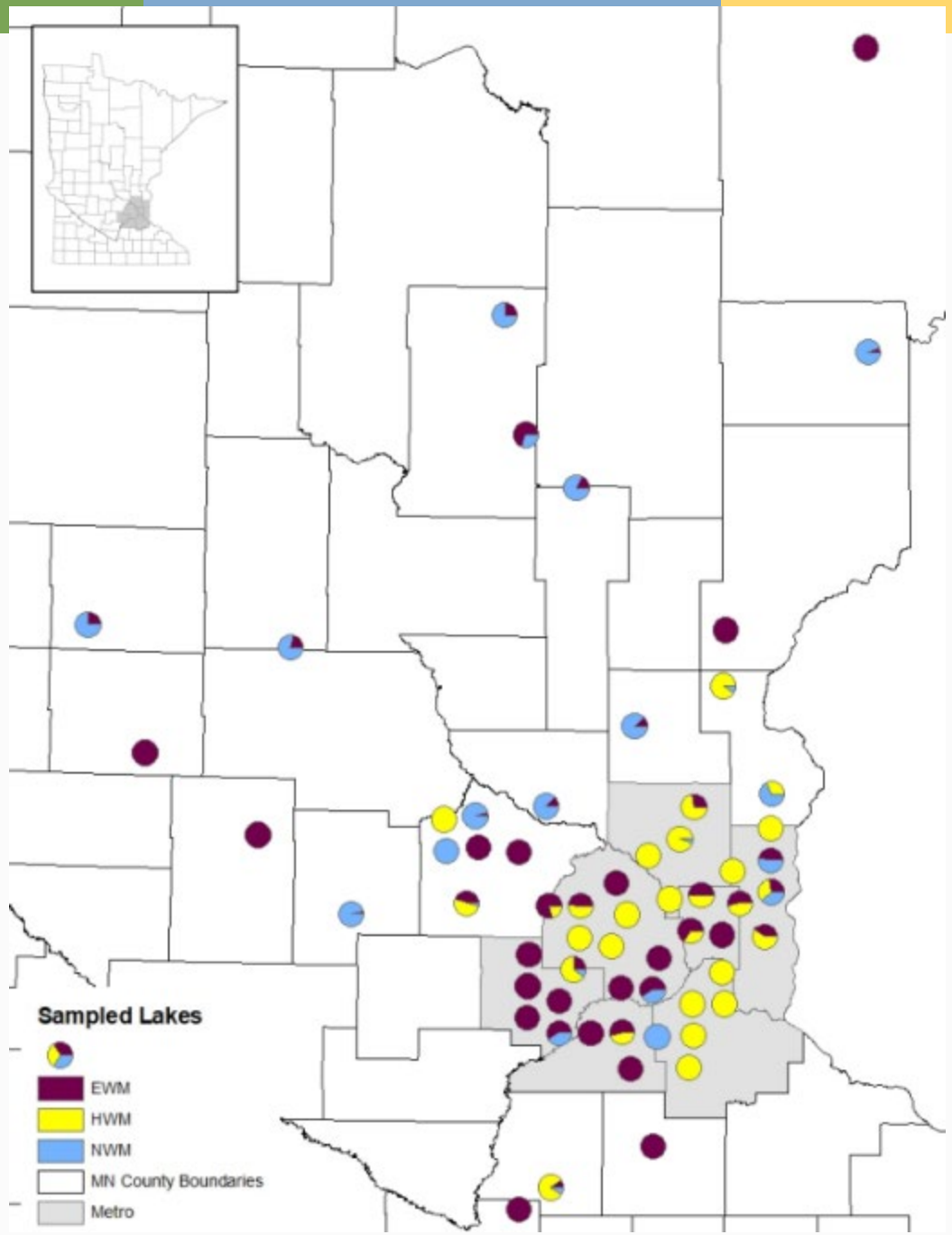

2017
2018
Surface cover
0.5
0.4
0.3
0.2
0.1
0
Jun
Jul
Aug
Sep
Oct
Nov
May
Jun
Jul
Aug
Sep
Oct
Nov
HWM
EWM
NWM

M. spicatum

×

M sibiricum





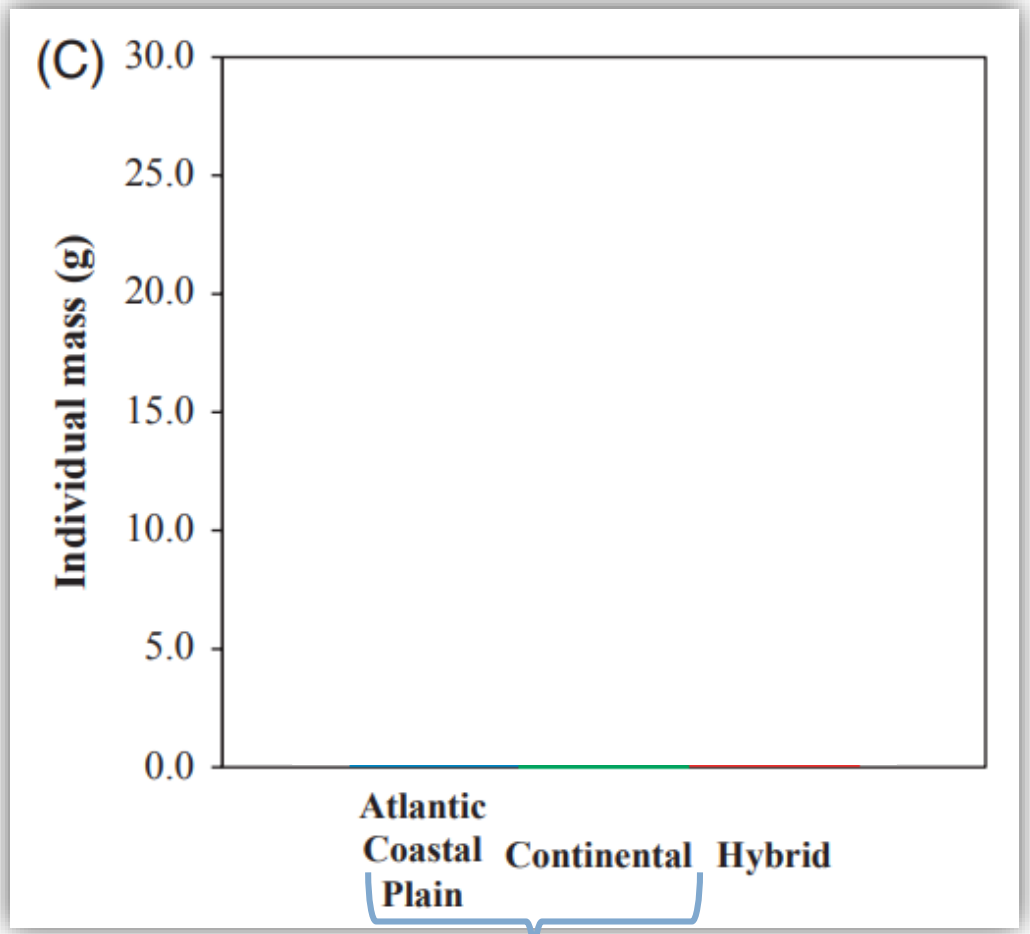
Eltawely et al. 2020, *Diversity*

Watermilfoil hybridization

M. heterophyllum

×

M. laxum



Tavalire et al. 2012, *Evolutionary Applications*

Watermilfoil hybridization

M. heterophyllum

×

M. hippuroides

Evidence from other *Myriophyllum* taxa:

- Greater invasiveness of hybrids
- Displacement of native parent taxon

Outline

1. Introduction to watermilfoils
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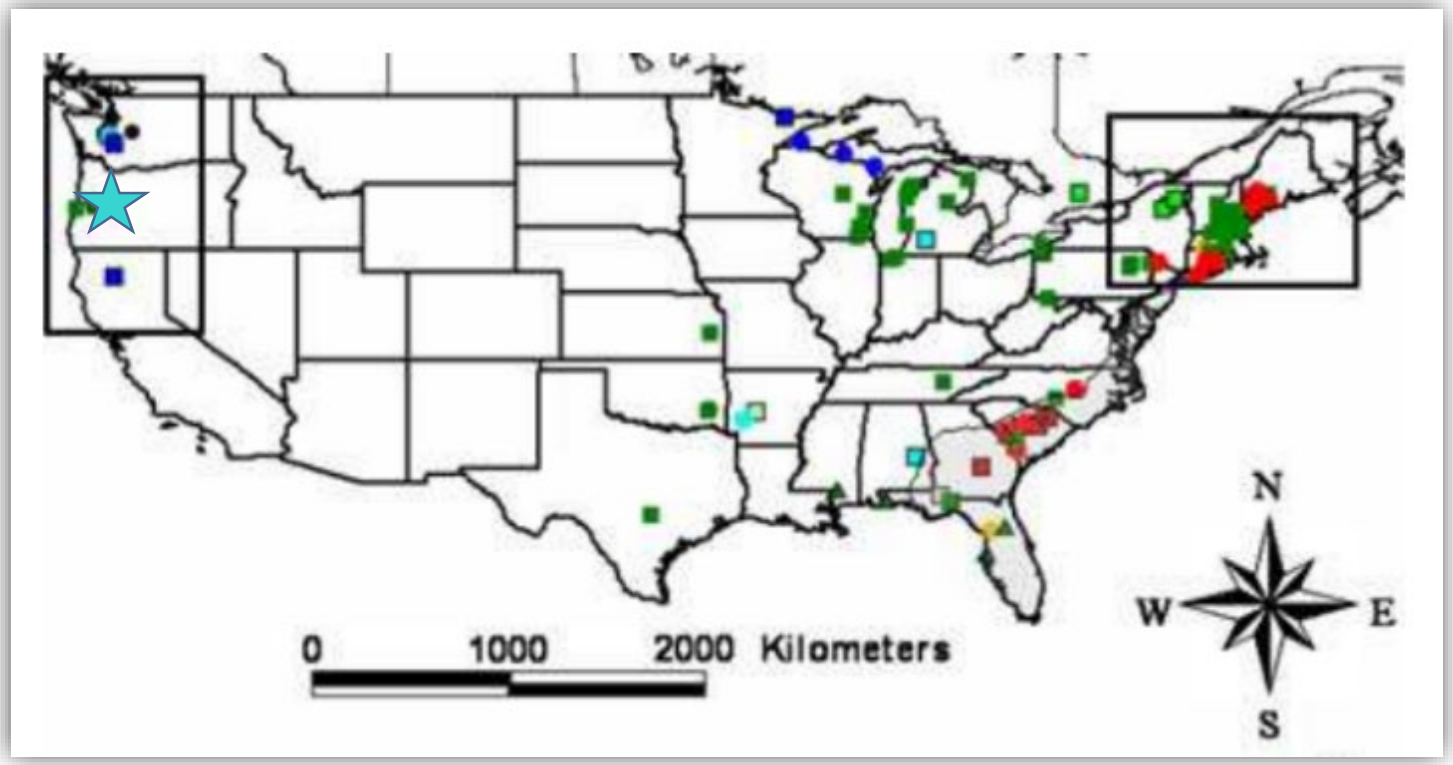
M. heterophyllum × *M. hippuroides*

M. heterophyllum × *M. hippuroides*

- First documented in 2011
- Fern Ridge Reservoir, OR
- No other known locations until…



Thum et al. 2011, *Biological Invasions*

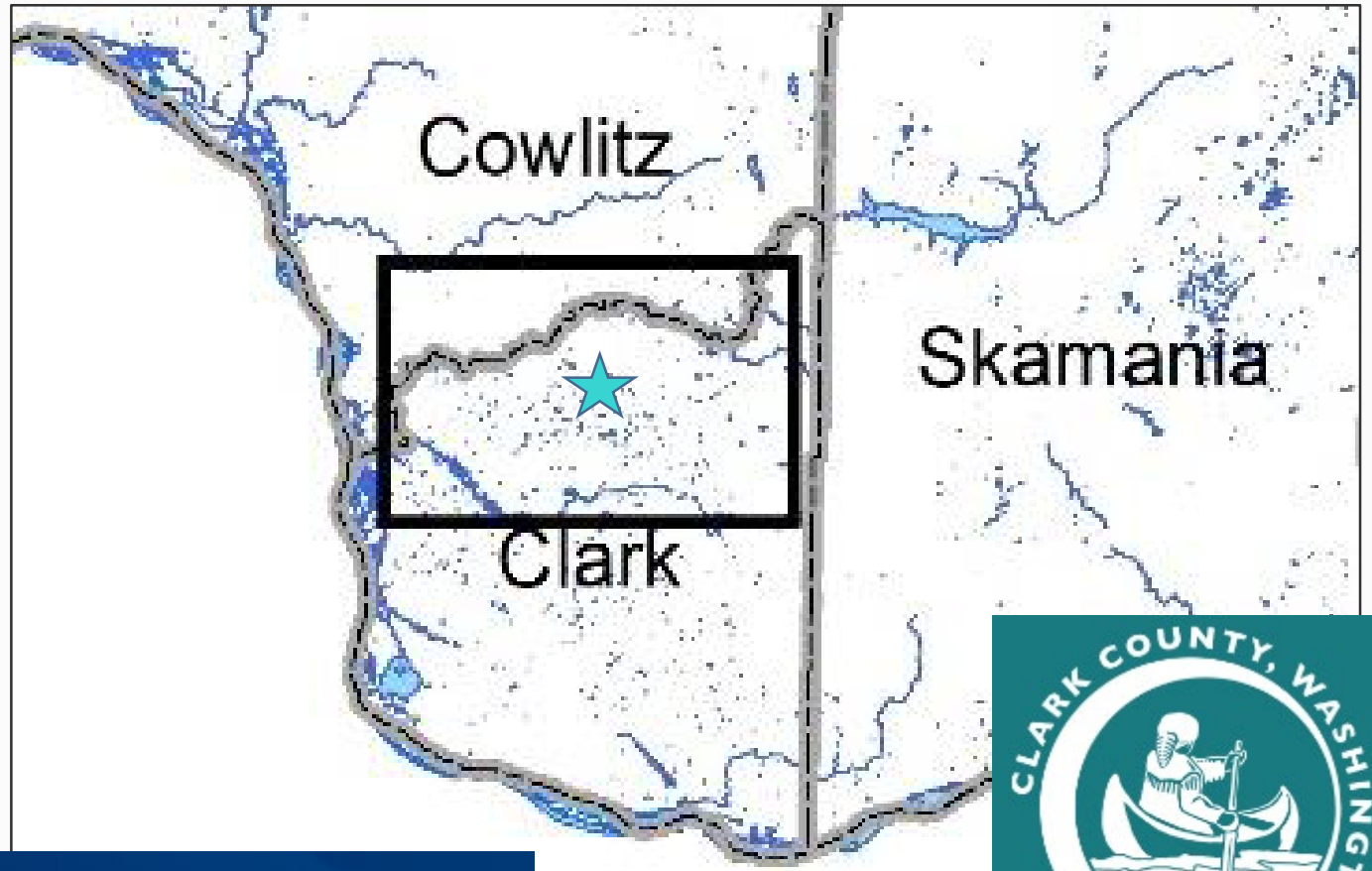
Clark County, 2021

- New suspected *M. heterophyllum* population in private reservoir
- Visit + genetic sample
- Sample sent to Thum Lab at Montana State University
- ID confirmed as *M. heterophyllum*

Clark County, 2022

Clark County, 2022

- Clark County surveys of nearby waterbodies
  - Lewis River watershed
- Genetic samples collected
  - Sent to Thum Lab at Montana State University

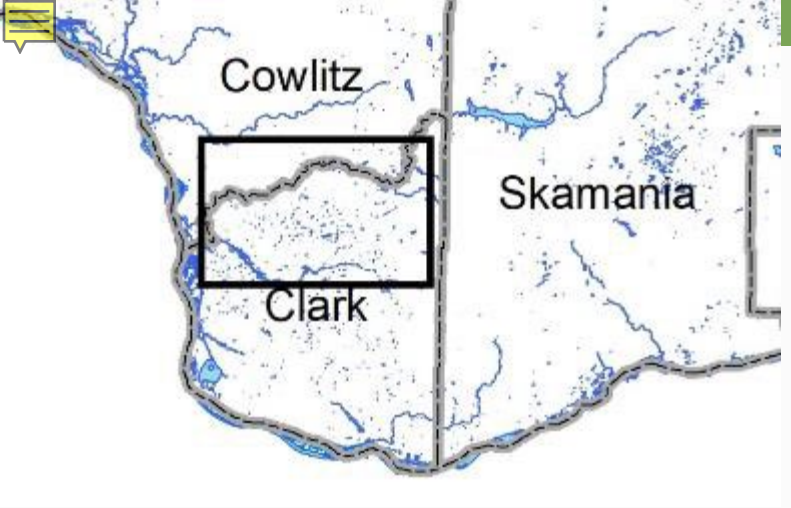


2022 Survey Results

2022 Survey Results

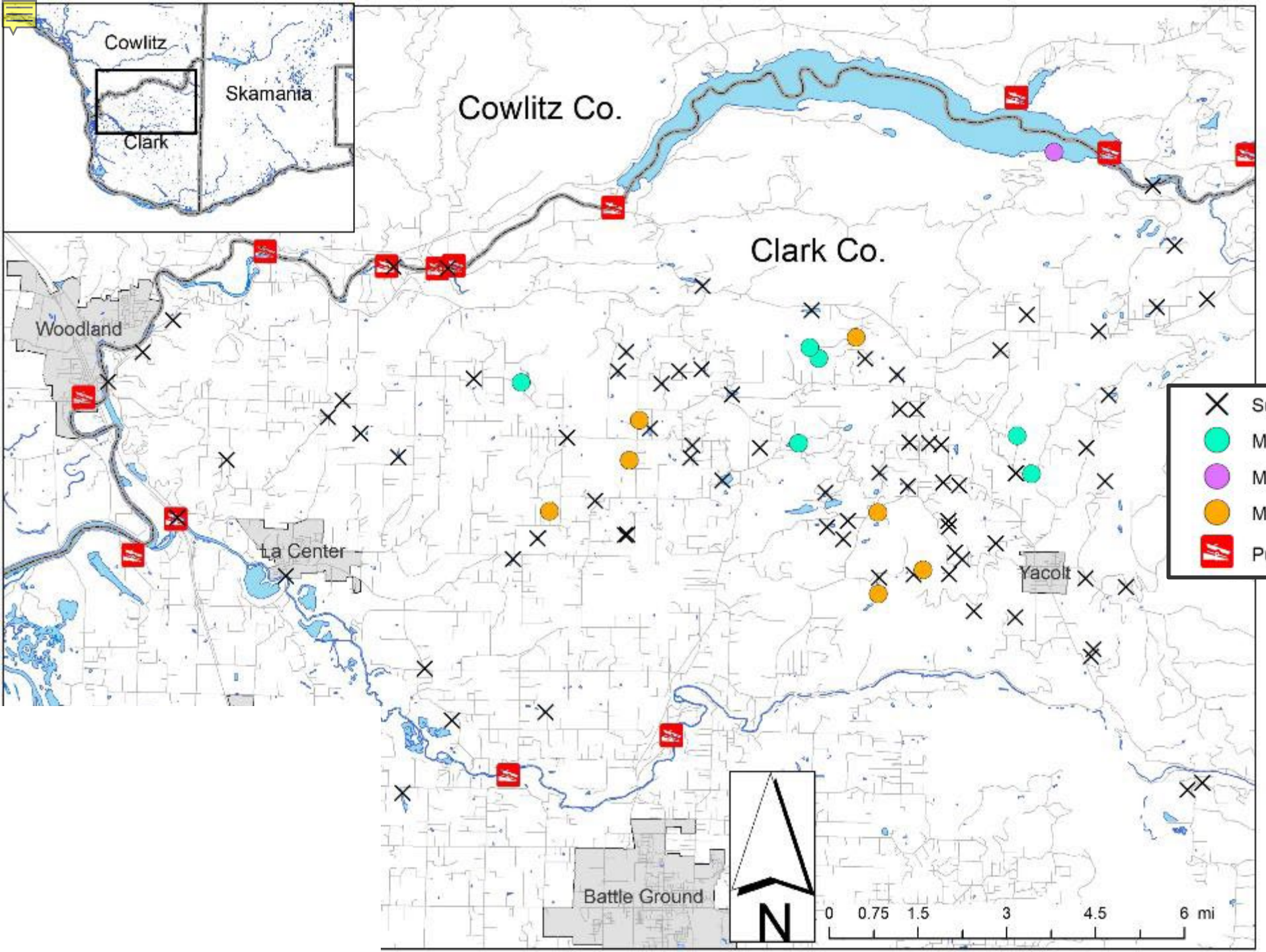
- 6 new *M. heterophyllum* waterbodies
  - 7, including initial discovery
- First documented *M. heterophyllum* × *M. hippuroides* hybrids in WA
  - 7 waterbodies
- All populations in small, private ponds

2022 Survey Results



- Survey location - M. heterophyllum unconfirmed
- M. heterophyllum
- M. heterophyllum and Hybrid
- M. heterophyllum x M. hippuroides
- Public Boat Launch

2022 Survey Results



2023 Response

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- Meetings with regional and state organizations

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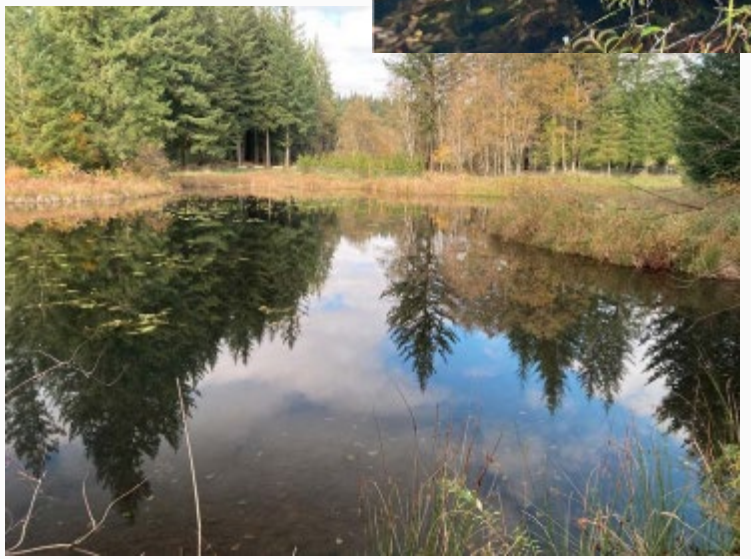
- Treatment of (most) known *M. heterophyllum* locations in Clark Co.
  - 5 waterbodies treated—ProcellaCOR
  - 2 unable to treat



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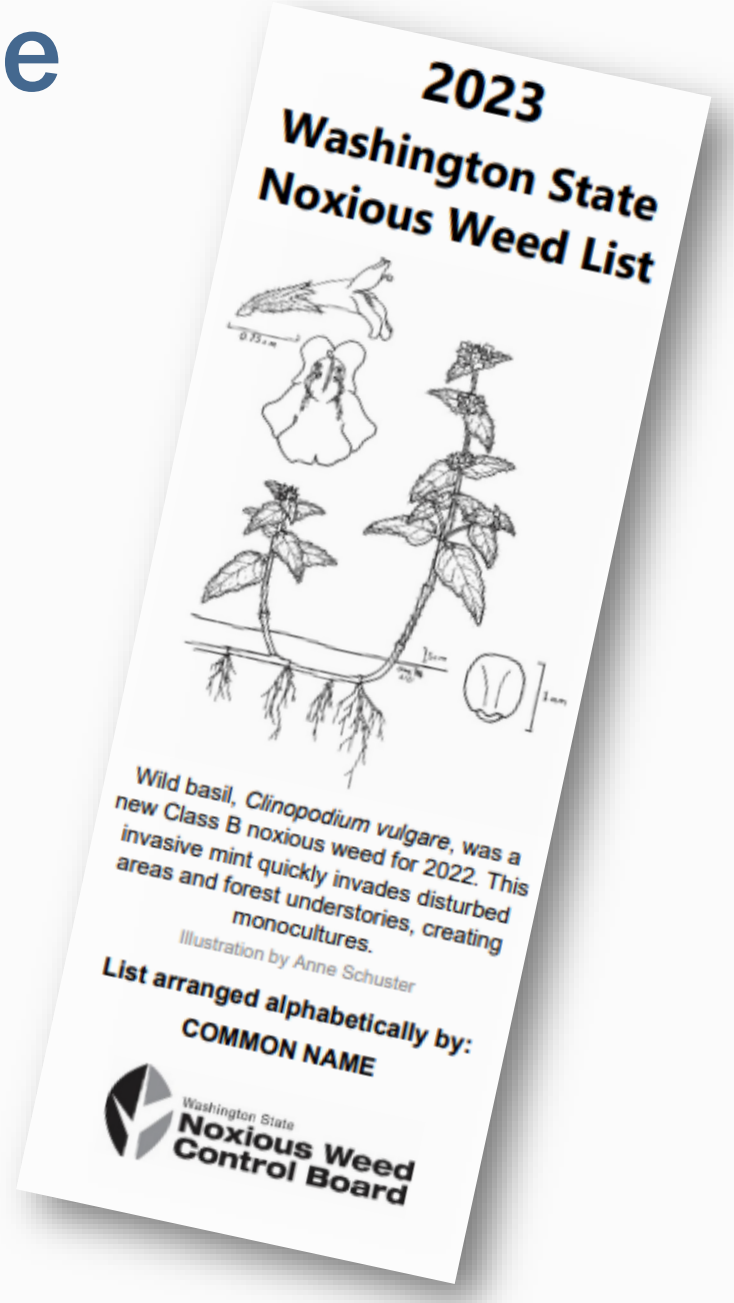
- Added *M. heterophyllum* × *M. hippuroides* to Noxious Weed List (effective 2024)



2023 Response

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  - 5 waterbodies treated—ProcellaCOR
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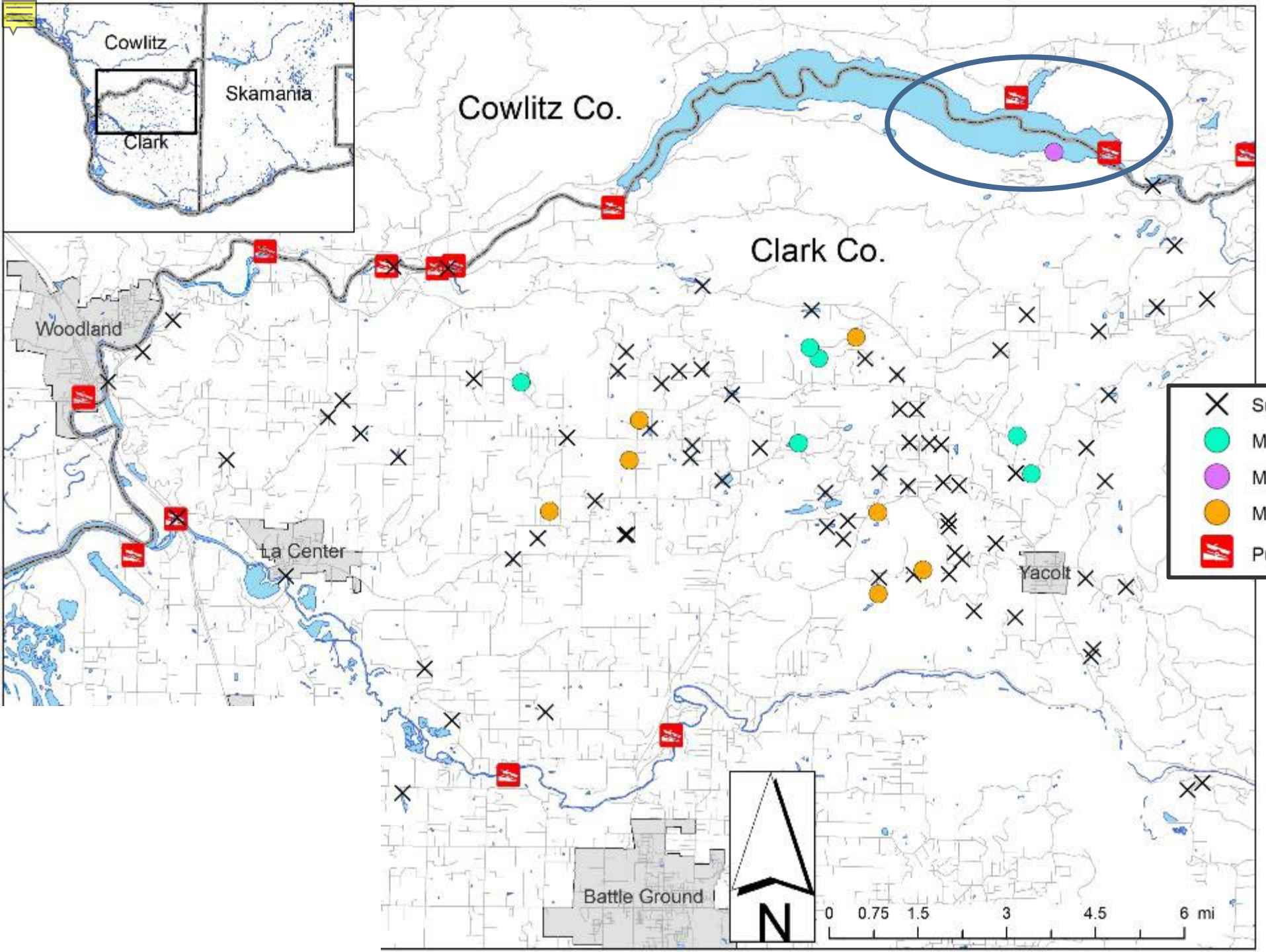
- Continued surveys

2023 Lake Merwin Survey



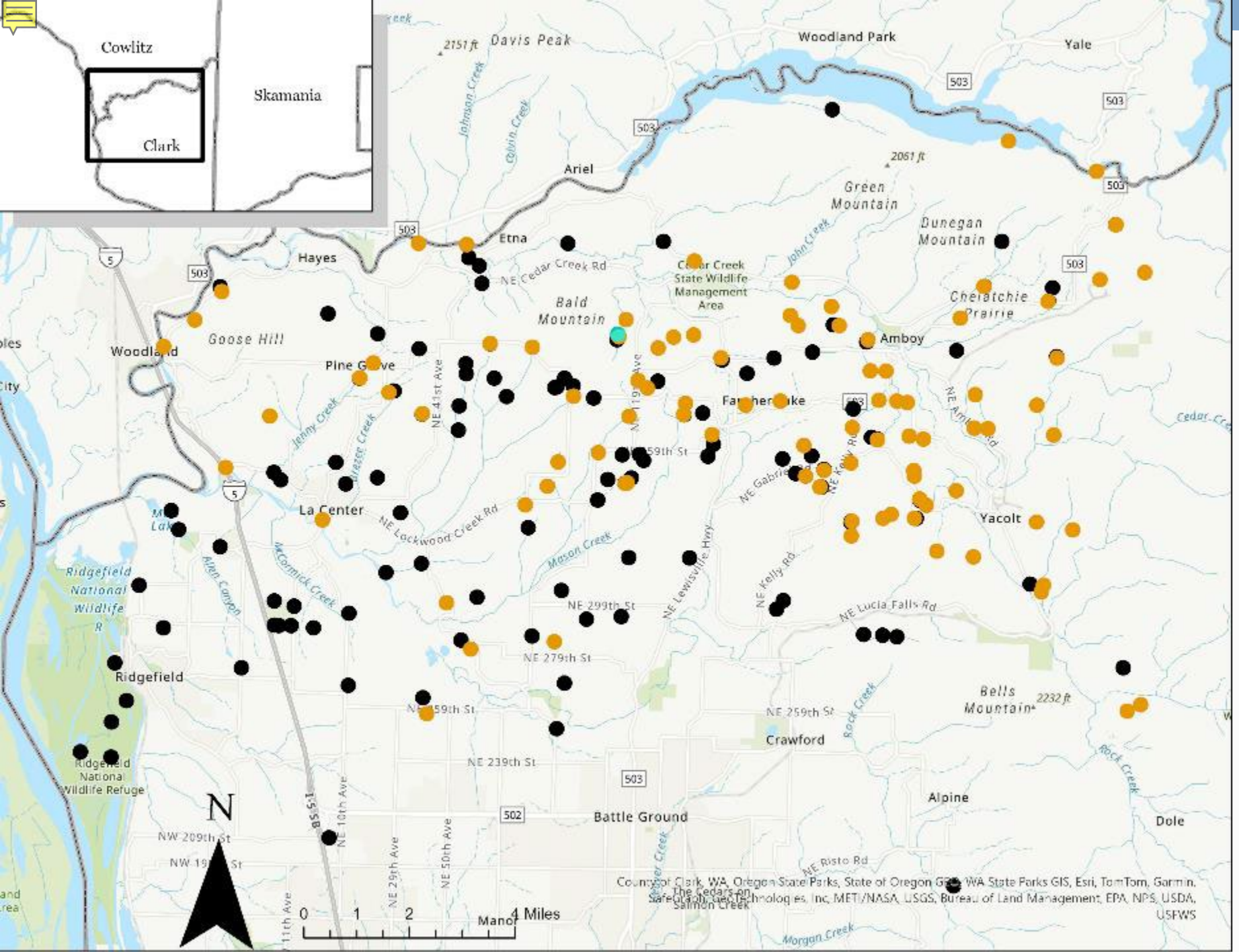
Cowlitz County Noxious Weed Control

CLARK COUNTY, WASHINGTON

PACIFICORP®

2022 + 2023 Surveys

- 2022
- 2023



2022 + 2023 Surveys

- 2022
- 2023

~ 100 locations each year!

CLARK COUNTY, WASHINGTON

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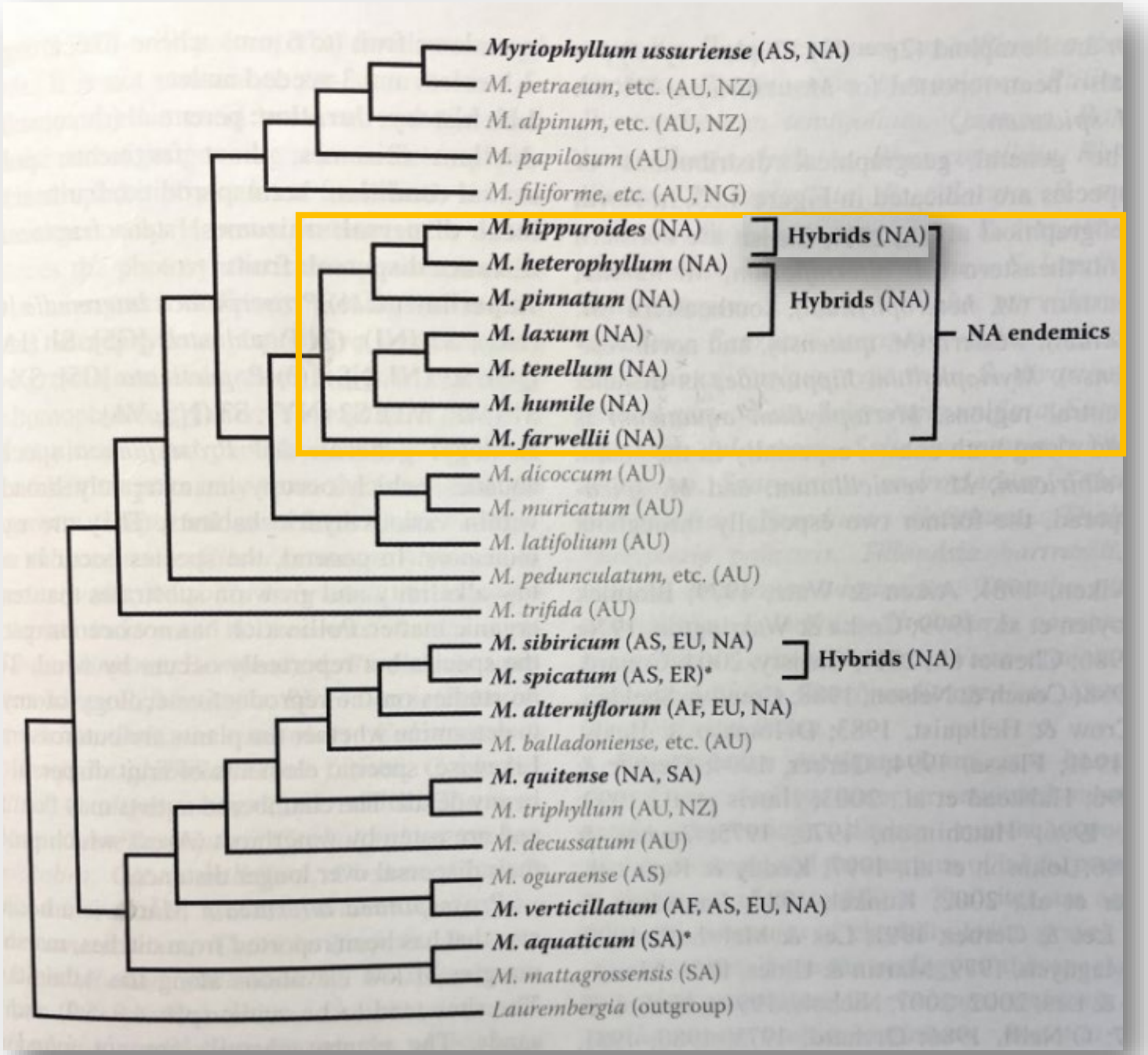
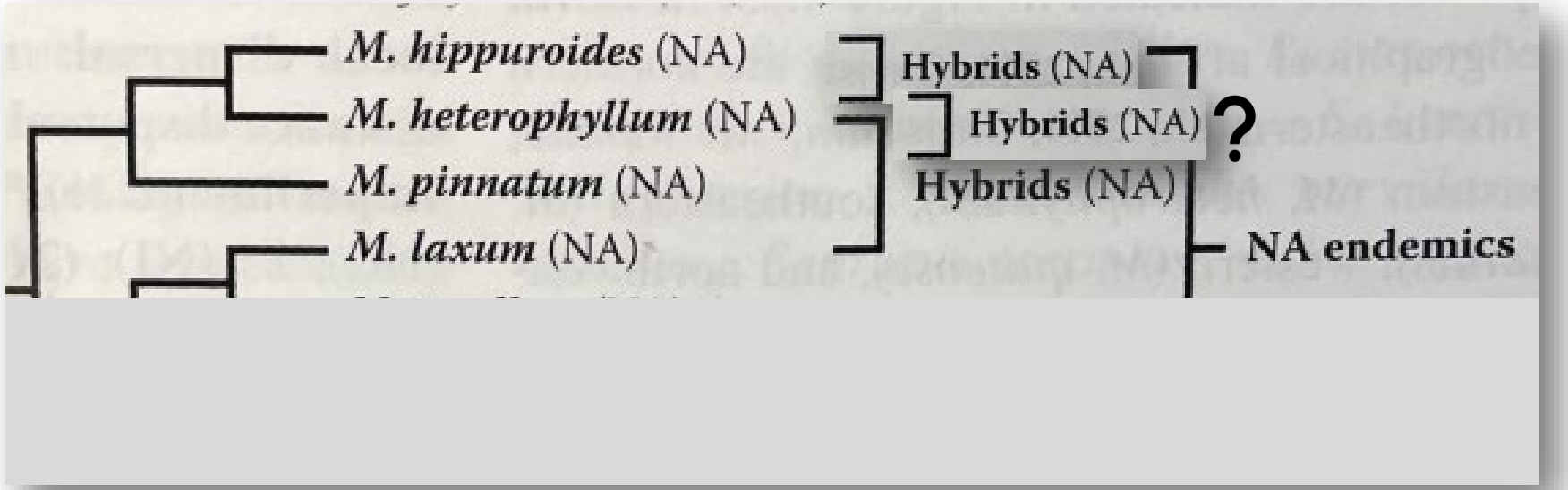
Watermilfoils in North America



Endemic watermilfoil diversity & hybridization



Biol Invasions (2011) 13:1687–1709
DOI 10.1007/s10530-010-9927-0

ORIGINAL PAPER

Molecular markers reconstruct the invasion history of variable leaf watermilfoil (*Myriophyllum heterophyllum*) and distinguish it from closely related species

Ryan A. Thum · Matthew P. Zuellig · Robert L. Johnson · Michael L. Moody · Charles Vossbrinck

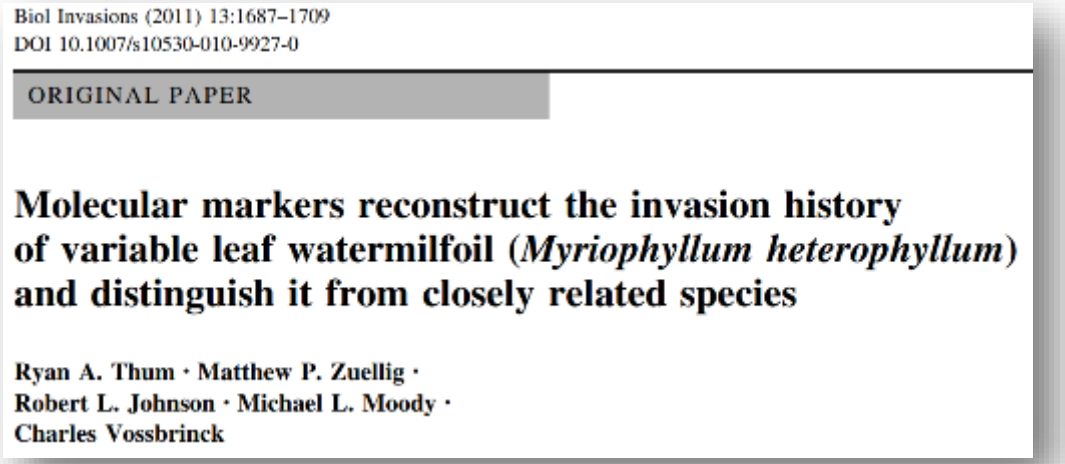
Conclusions

- These are (at least) 4 distinct species
- Hybridization is occurring
- 2 distinct lineages of *M. heterophyllum* present in WA (both found in Eastern U.S.)
  - These lineages may be cryptic species
- Possibly more taxonomic diversity and hybridization history than current methods show
- More + better genetic testing needed

New genetic testing techniques

New genetic testing techniques

- Traditional genetic techniques only go so far
  - Internal transcribed spacer (ITS) DNA
  - Chloroplast DNA (cpDNA)
- New techniques allow for more information to be used across whole genome
  - Restriction site-associated DNA sequencing (RADSeq)
- Need many samples from all three taxa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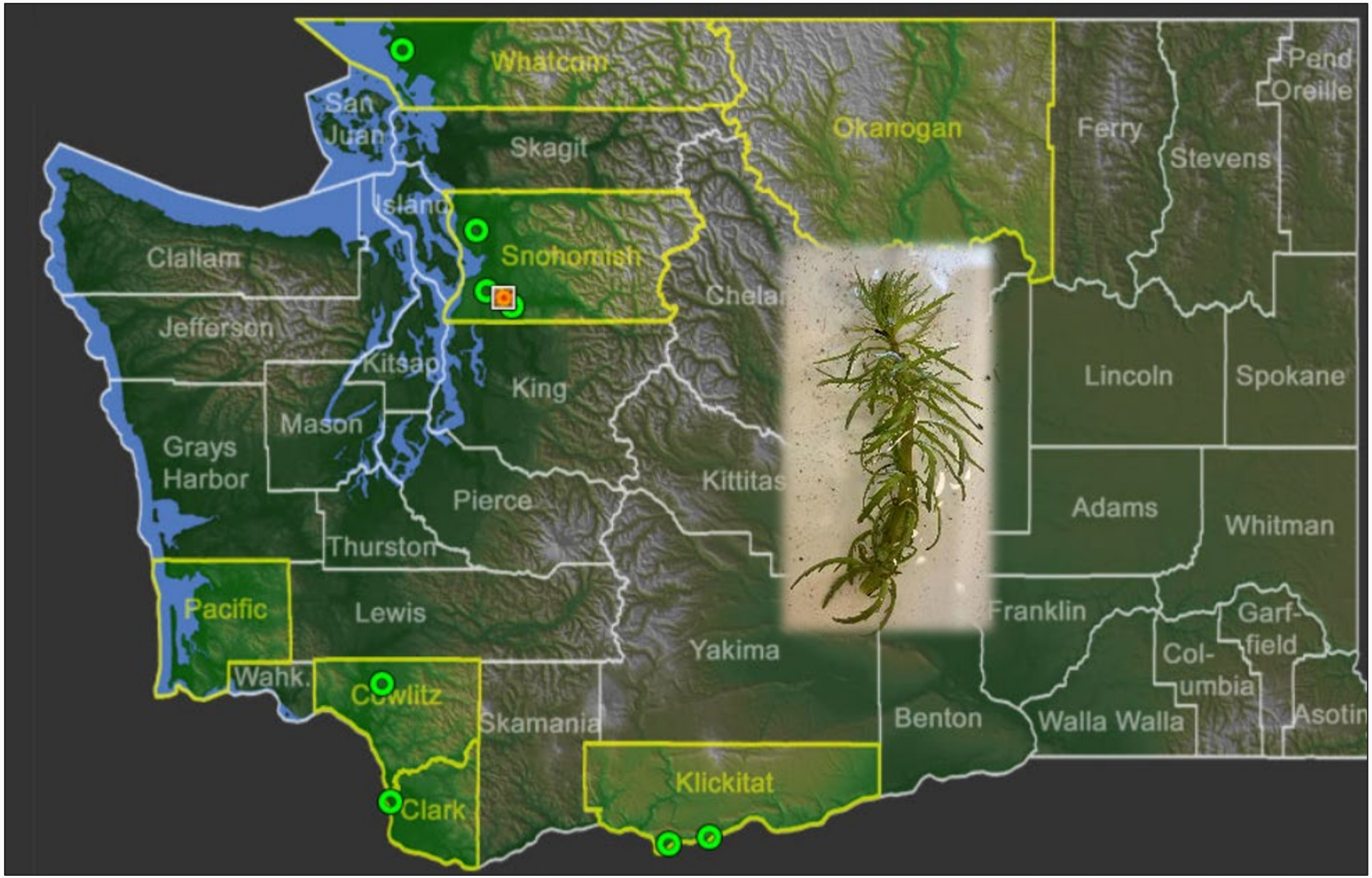
BRIEFINGS IN FUNCTIONAL GENOMICS. VOL 9 NO 5. 416–423 doi:10.1093/bfgp/elq031

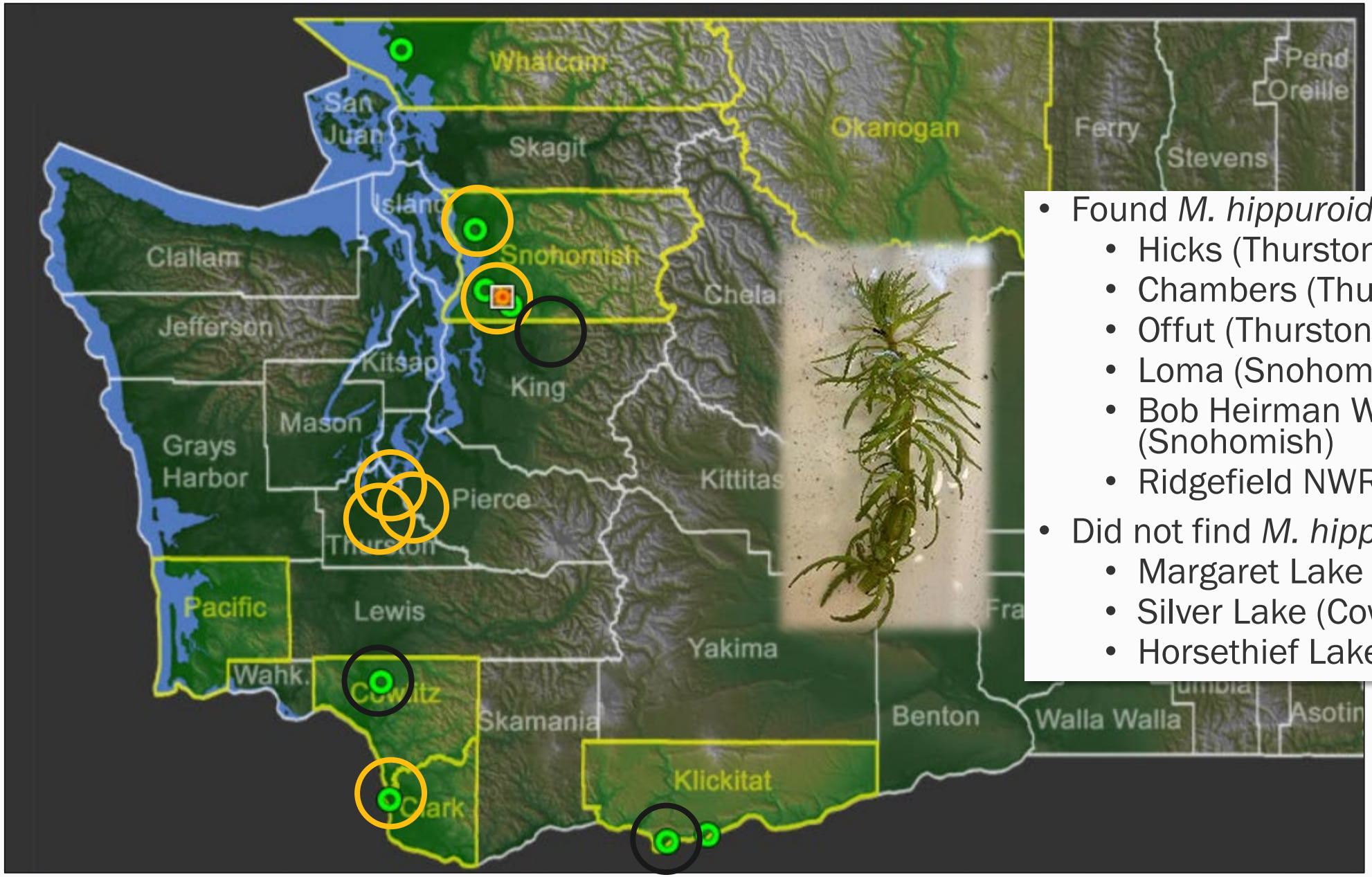
RADSeq: next-generation population genetics

John W. Davey and Mark L. Blaxter

M. hippuroides surveys 2023



M. hippuroides surveys 2023



- Found *M. hippuroides*
  - Hicks (Thurston)
  - Chambers (Thurston)
  - Offut (Thurston)
  - Loma (Snohomish)
  - Bob Heirman Wildlife Preserve (Snohomish)
  - Ridgefield NWR (Clark)
- Did not find *M. hippuroides*
  - Margaret Lake (King)
  - Silver Lake (Cowlitz)
  - Horsethief Lake (Klickitat)

M. hippuroides surveys 2023

Loma Lake (Snohomish Co.)

M. hippuroides surveys 2023

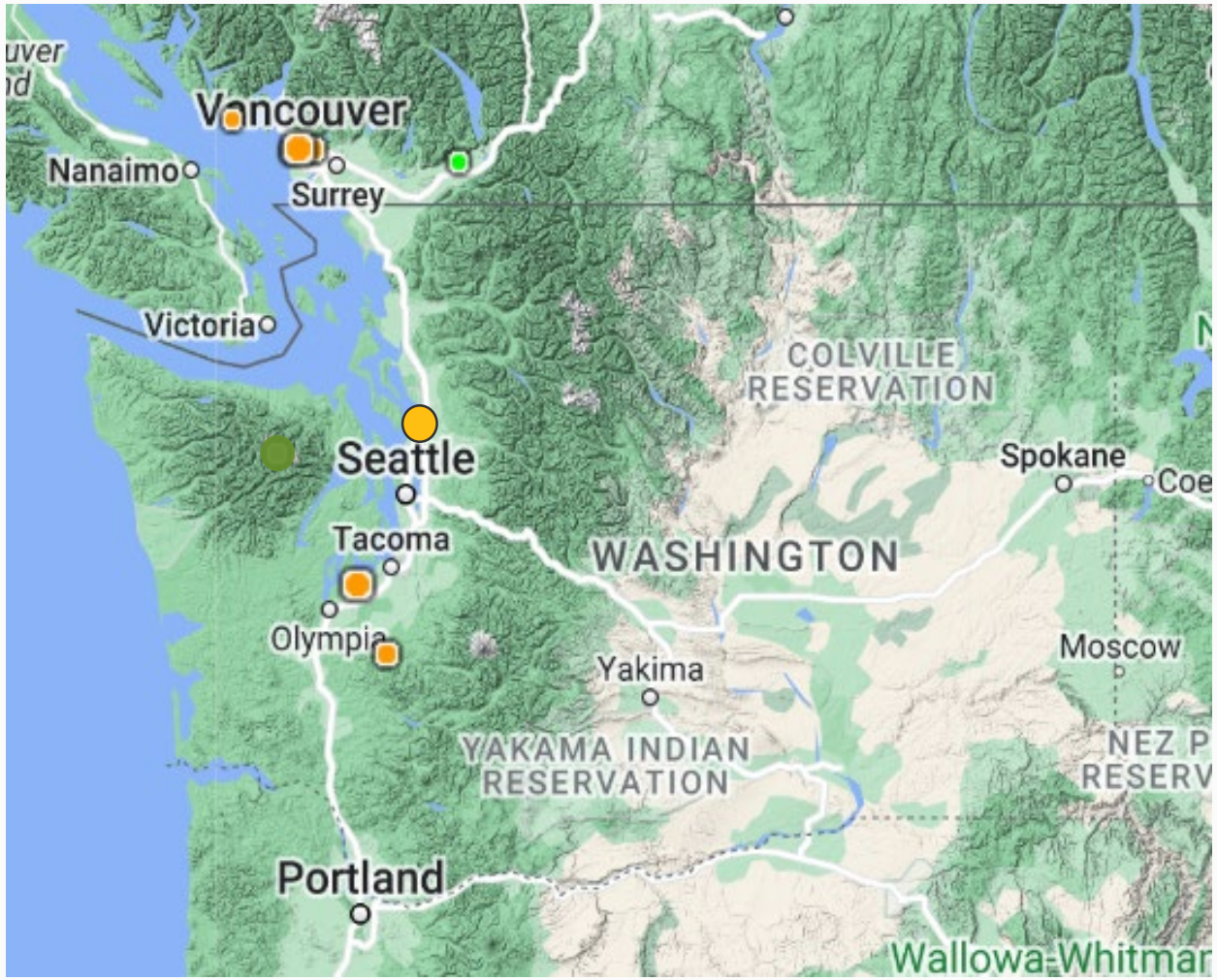
Bob Heirman Wildlife Preserve (Snohomish Co.)

M. hippuroides surveys 2023

Ridgefield NWR (Clark Co.)

M. heterophyllum surveys 2023

M. heterophyllum surveys 2023



Blue (Thurston)

Clear Lake (Thurston)

Clear Lake (Pierce)

Florence Lake (Pierce)

Josephine Lake (Pierce)

Hall Lake (Snohomish)

M. heterophyllum surveys 2023

Blue Lake (Thurston Co.)

Samples sent to lab at Montana State

Next Steps

1. Process genetic samples

2. Continue treatments of *M. heterophyllum* and *M. heterophyllum* × *M. hippuroides* populations
   - Treatments of 5 waterbodies planned for 2024

3. Continue surveying throughout the region

Acknowledgements

Thank you!

Wesley Glisson
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(360) 688-8811