Tracing the movement of the invasive alga *Nitellopsis obtusa* using genetic analyses

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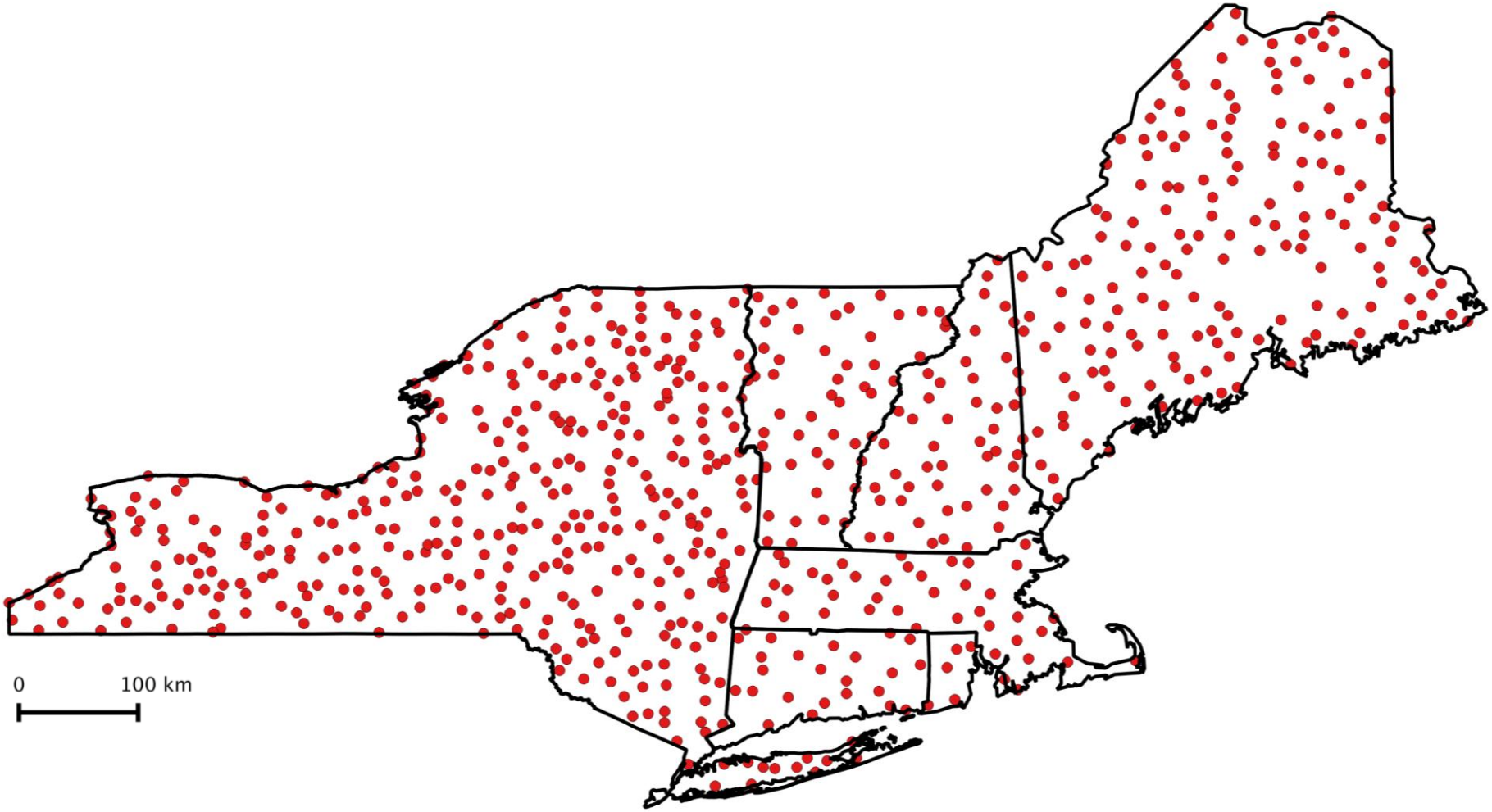
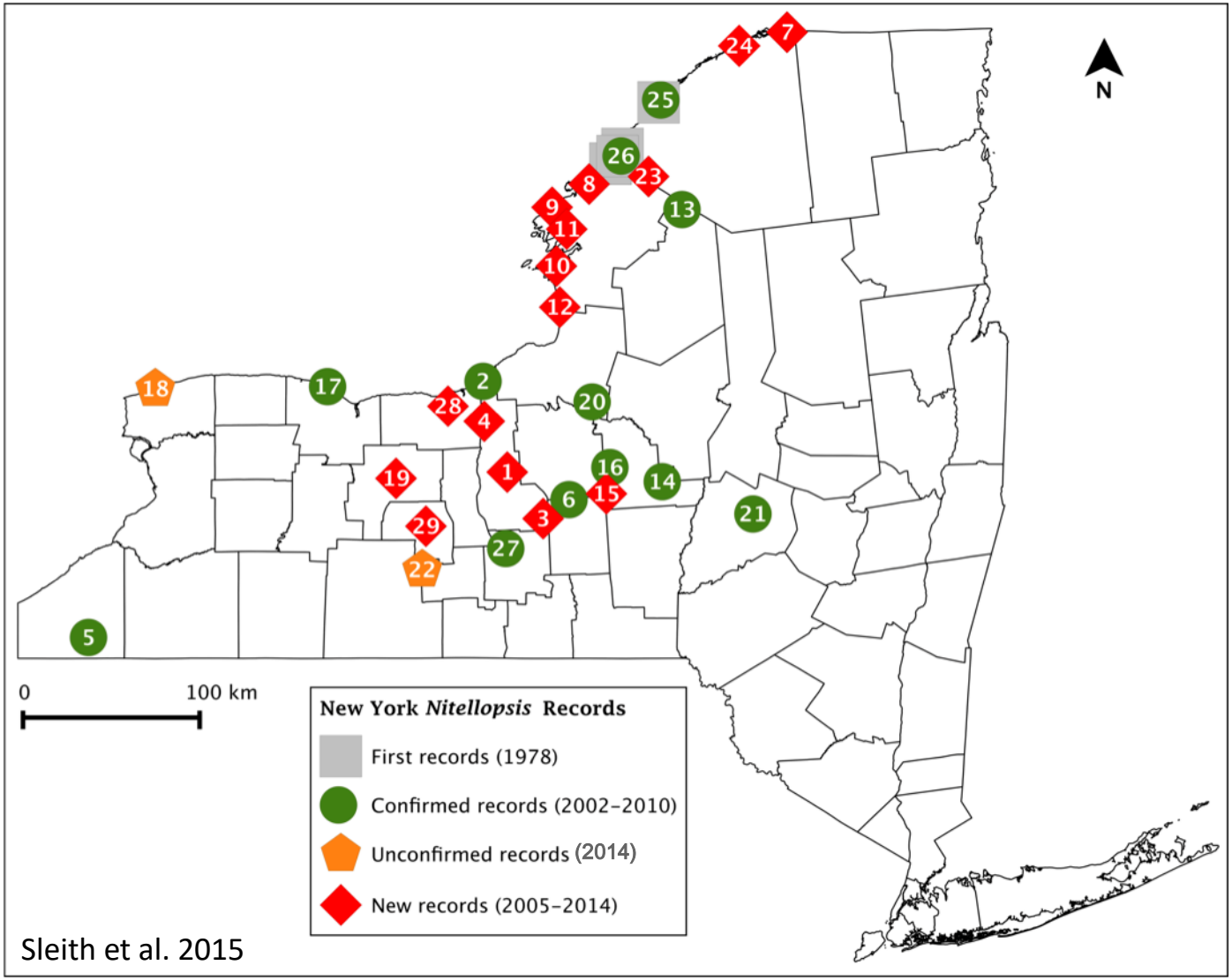
Study Area

- 327,758 km^2 (a bit smaller than Germany)
- >15 ecoregions
- Barrier islands to alpine tundra

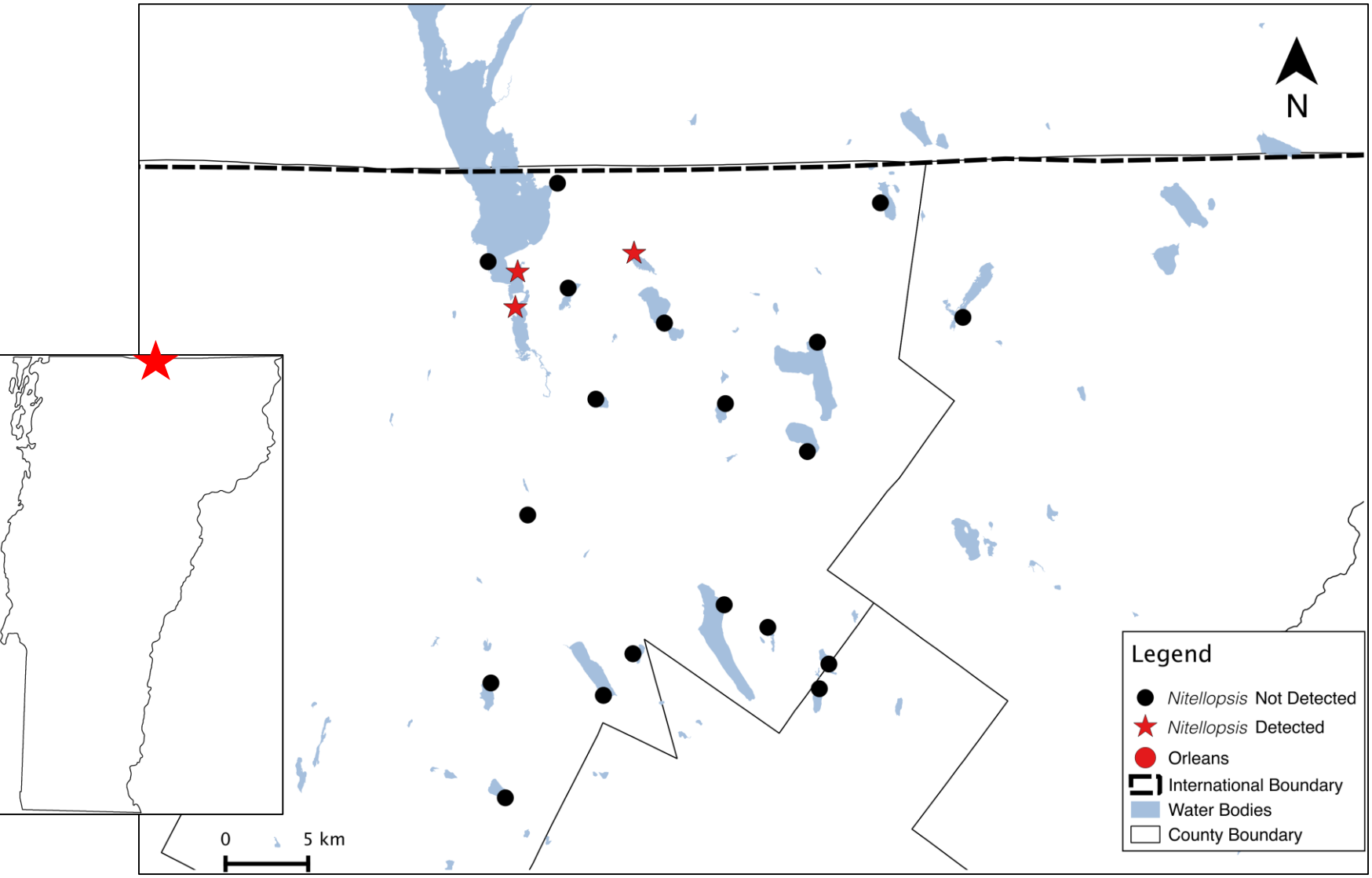
740 Sites



- 24,000 miles of driving = 1 trip around the equator



Starry Stonewort in 31 sites across 17 counties, 18 new records (red diamonds)



Starry Stonewort in 3 sites in Orleans County, Vermont

Water Chemistry

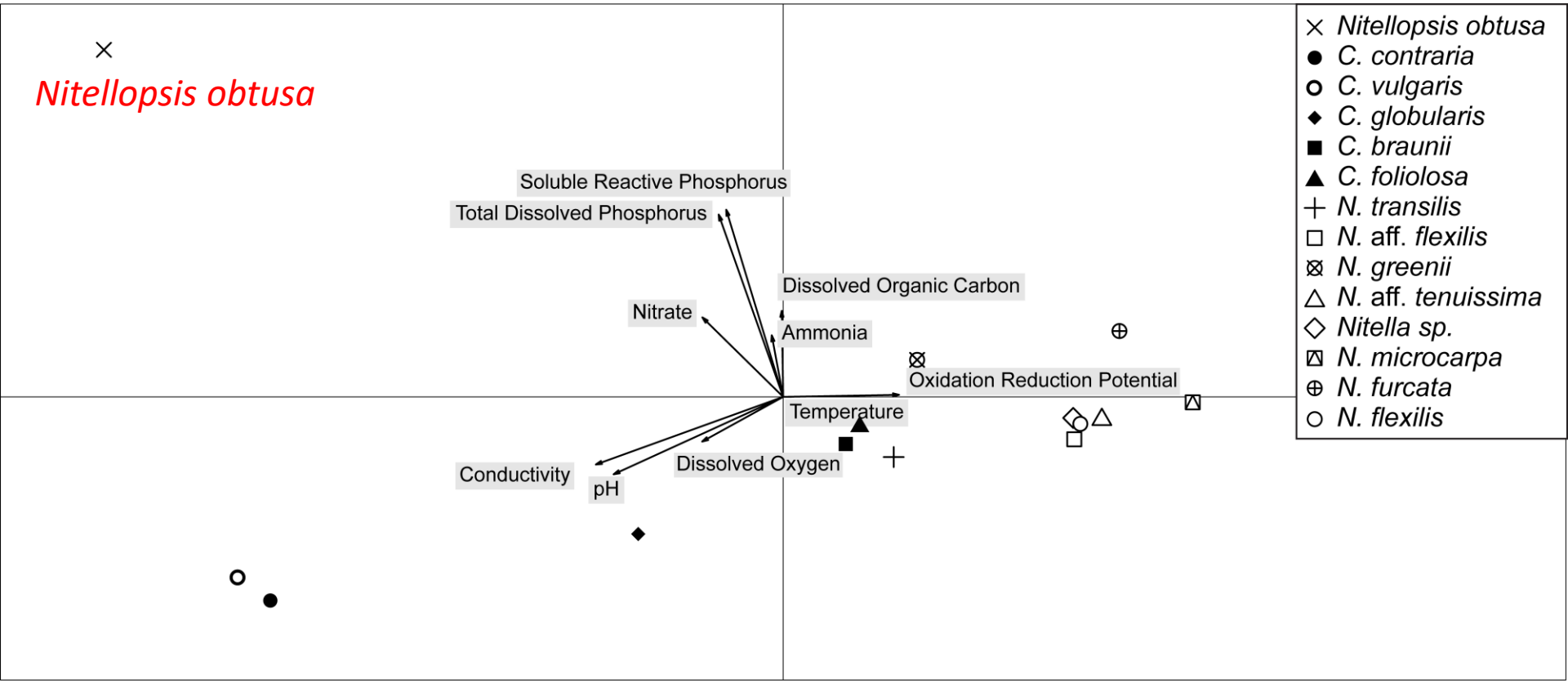
- Temperature (C)
- Dissolved Oxygen (mg/L)
- Oxidation Reduction Potential (mV)
- pH
- Conductivity (uS/cm)

- Nitrogen from Ammonia (ug/L)
- Nitrogen from Nitrate (ug/L)
- SRP- Soluble Reactive Phosphate (ug/L)
- TDP- Total Dissolved Phosphorus (ug/L)
- DOC- Dissolved Organic Carbon (mg/L)
- Calcium (mg/L)
- Magnesium (mg/L)

Species in OMI Space

High conductivity, basic,
high nutrients

Low conductivity, acidic,
high nutrients



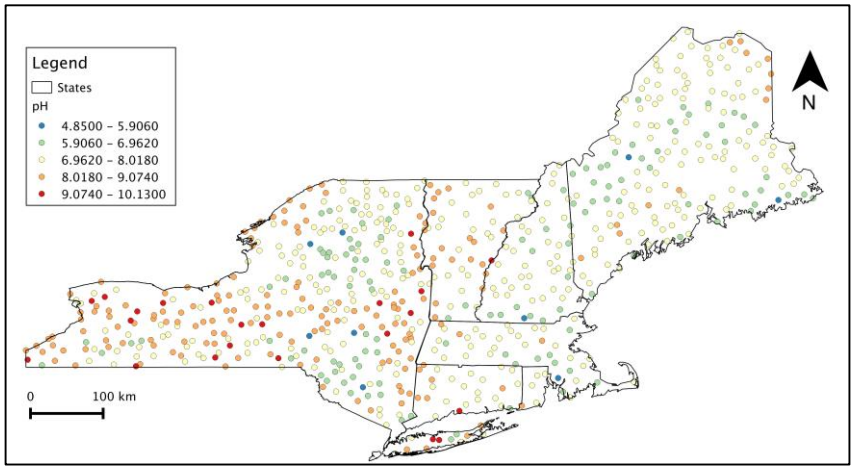
High conductivity, basic,
low nutrients

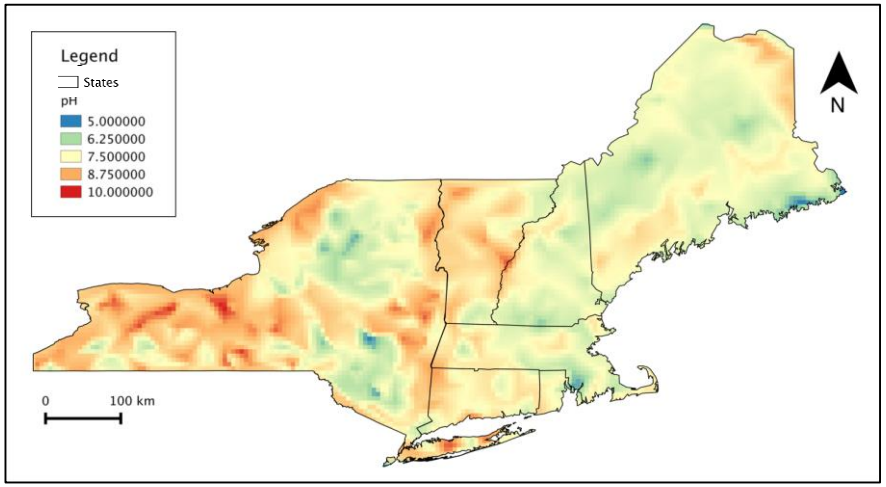
Low conductivity, acidic,
low nutrients

After Rey-Boissezon & Auderset Joye 2015

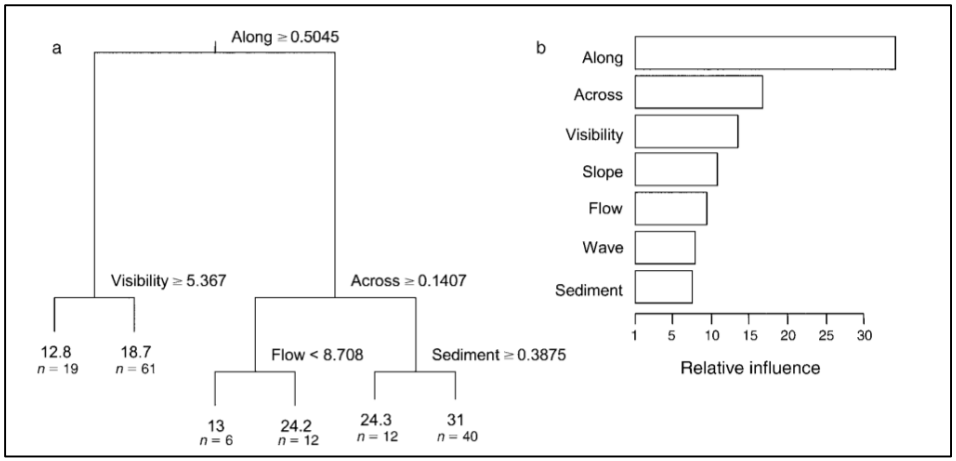
Modeling Methods

Chemistry Point Data



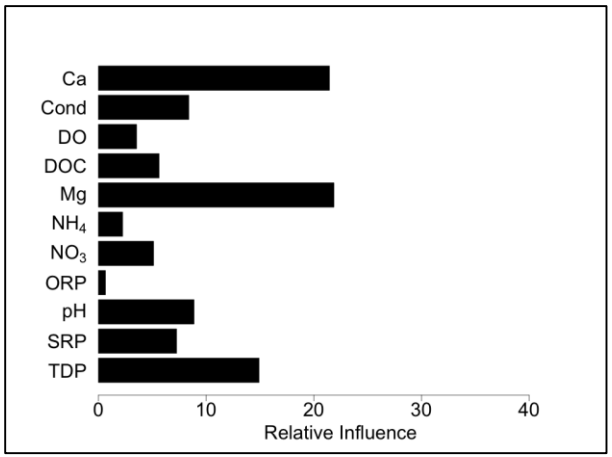


Interpolated Chemistry Raster



Boosted Regression Trees for ecological modeling
Elith & Leathwick 2016

Nitellopsis obtusa

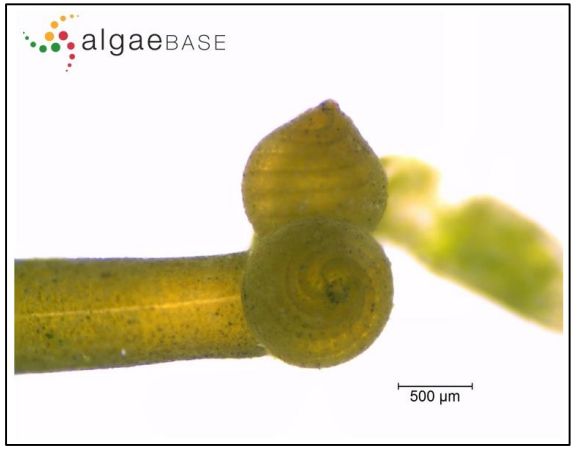


Low suitability — High suitability

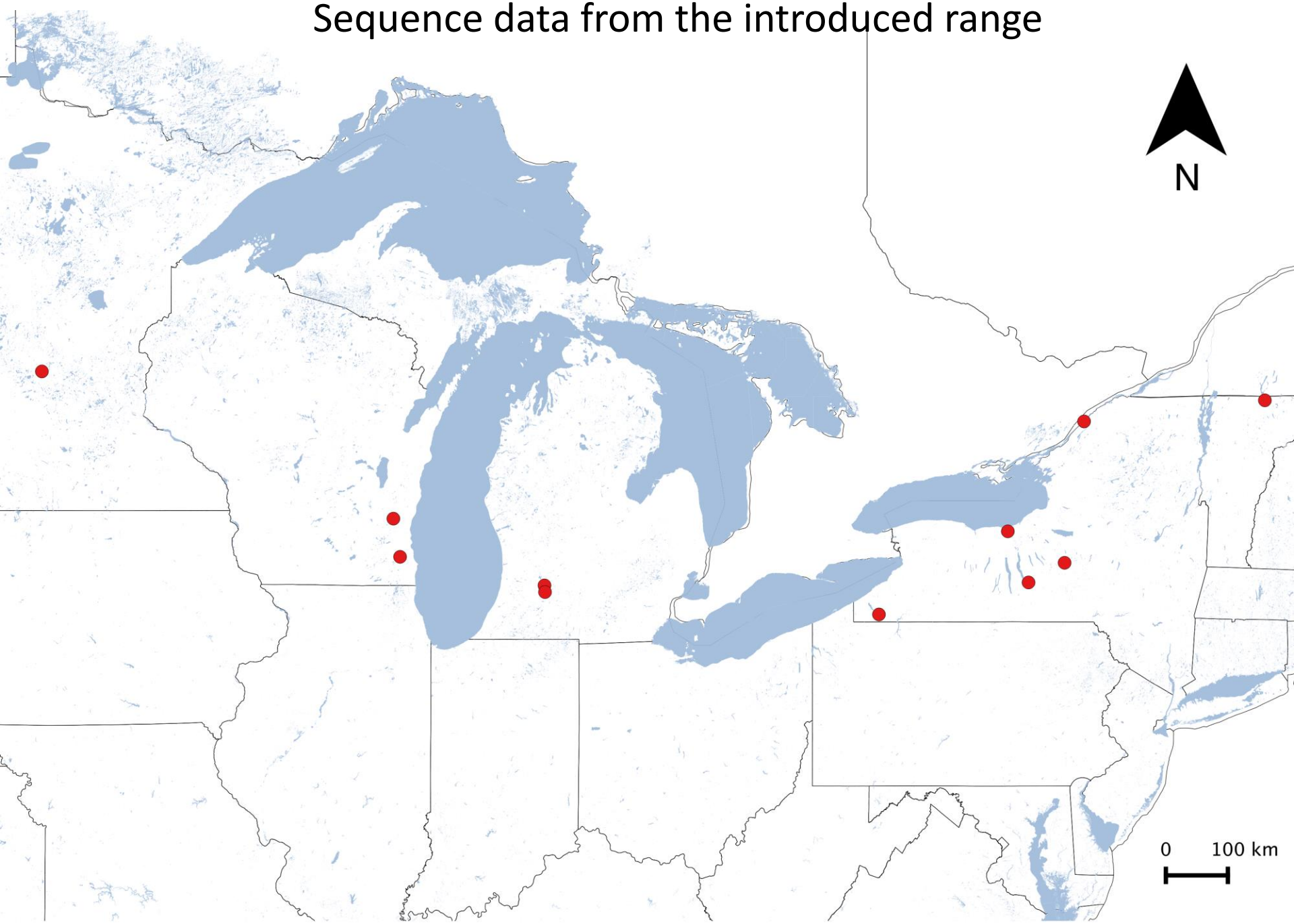
Occurrence Records

Phylogeography

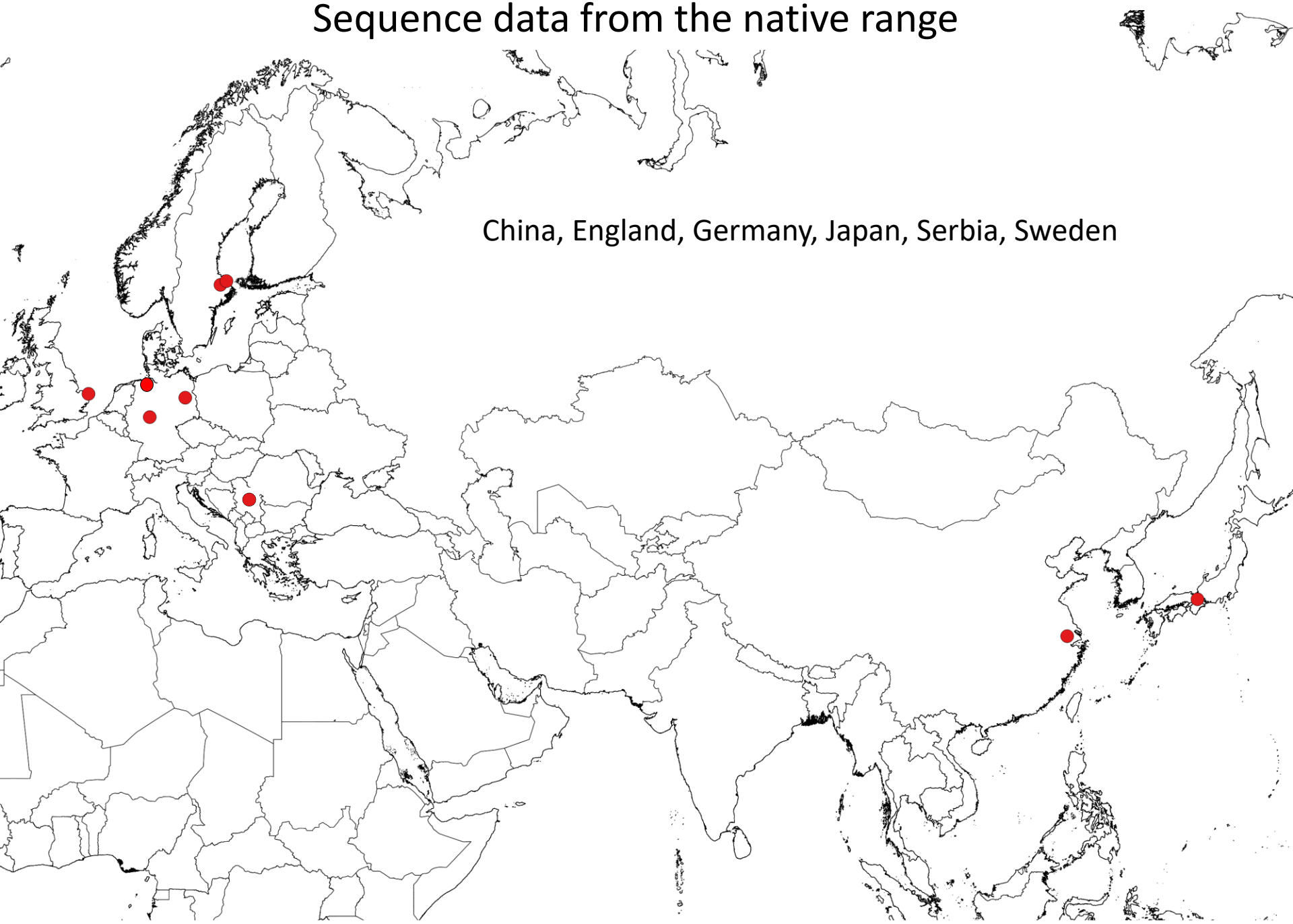
- Hypotheses
  - Introduced from Europe not Asia
  - Single introduction to North America with subsequent spread
  - Spread in North America is incremental in East to West direction



Sequence data from the introduced range



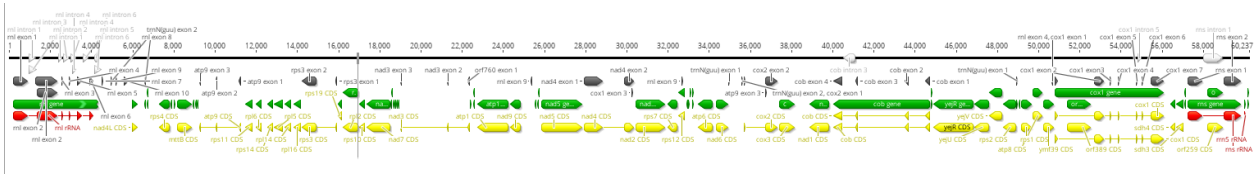
Sequence data from the native range



Organellar Genome Sequencing

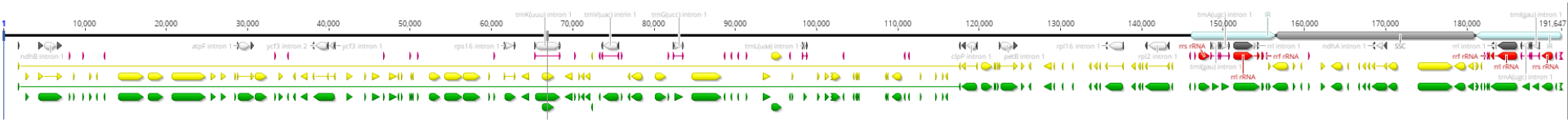
- Mitochondrial and plastid genomes
- Illumina whole genome approach
- Assemble *de novo* and annotate in Geneious

MT



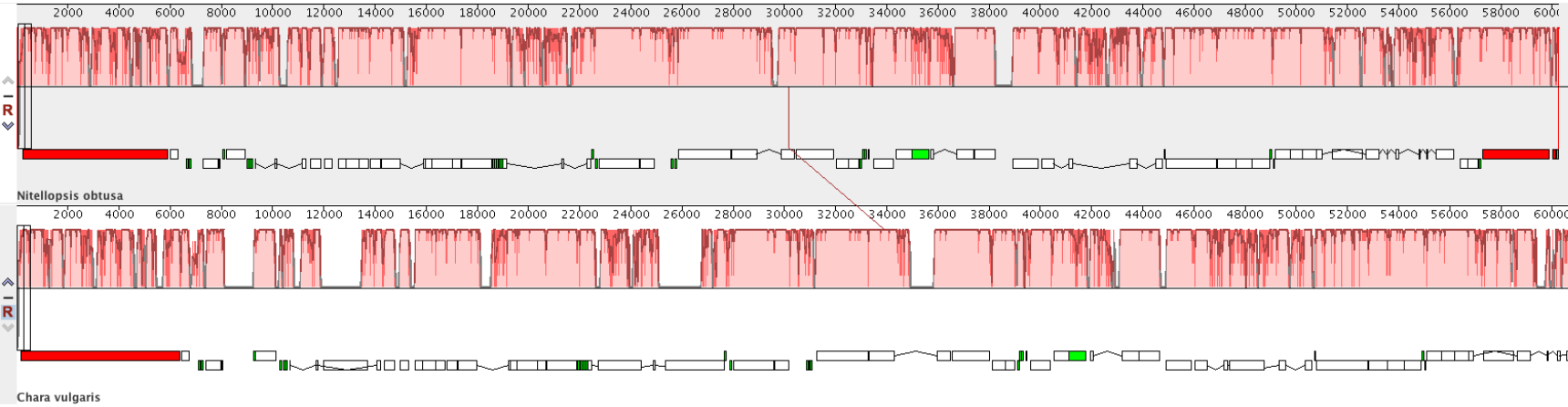
- 60,237 bp
- 70 genes
- 24 introns

CP



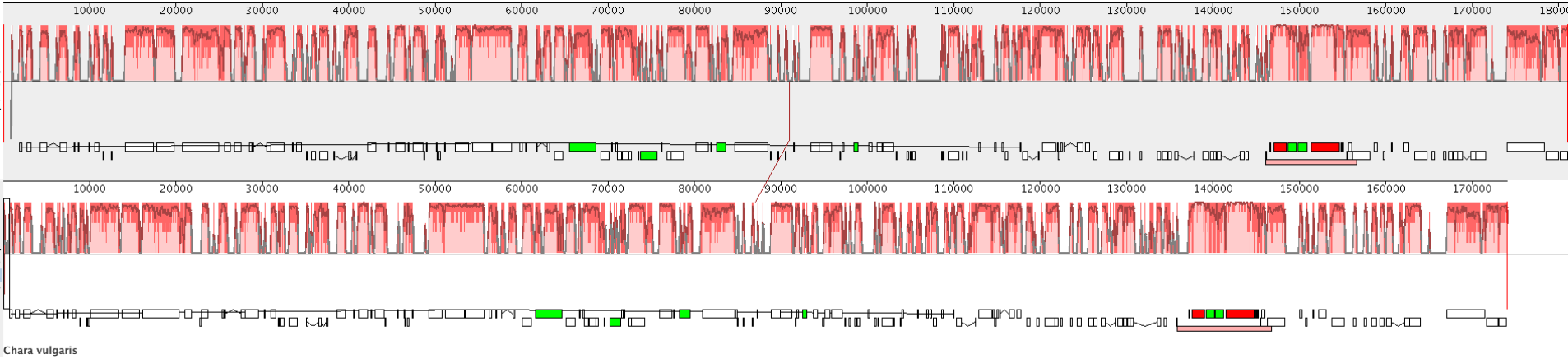
- 191,647 bp
- 2 inverted repeat regions
- 97 genes
- 20 introns

Nitellopsis obtusa



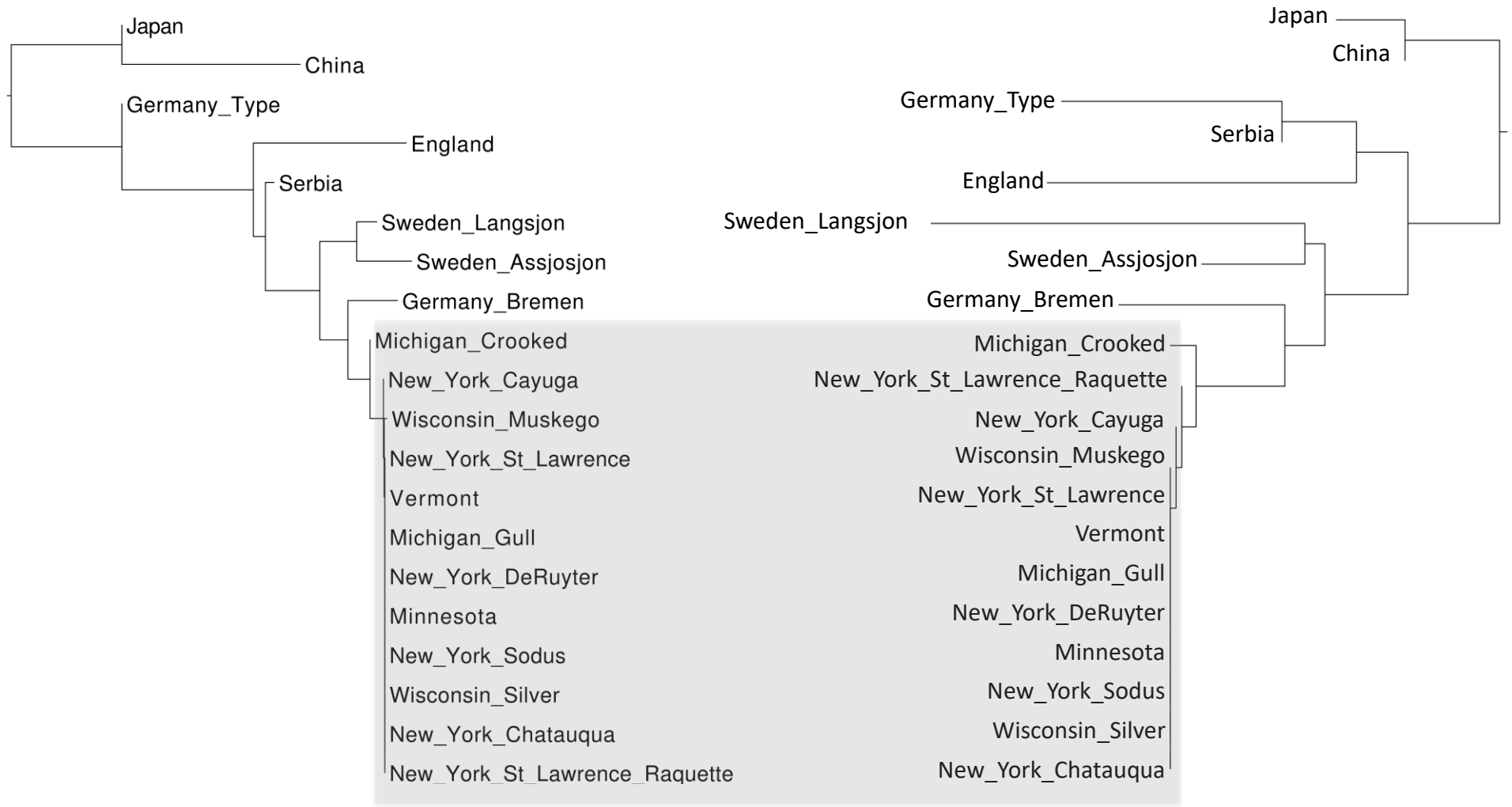
Chara vulgaris

Nitellopsis obtusa



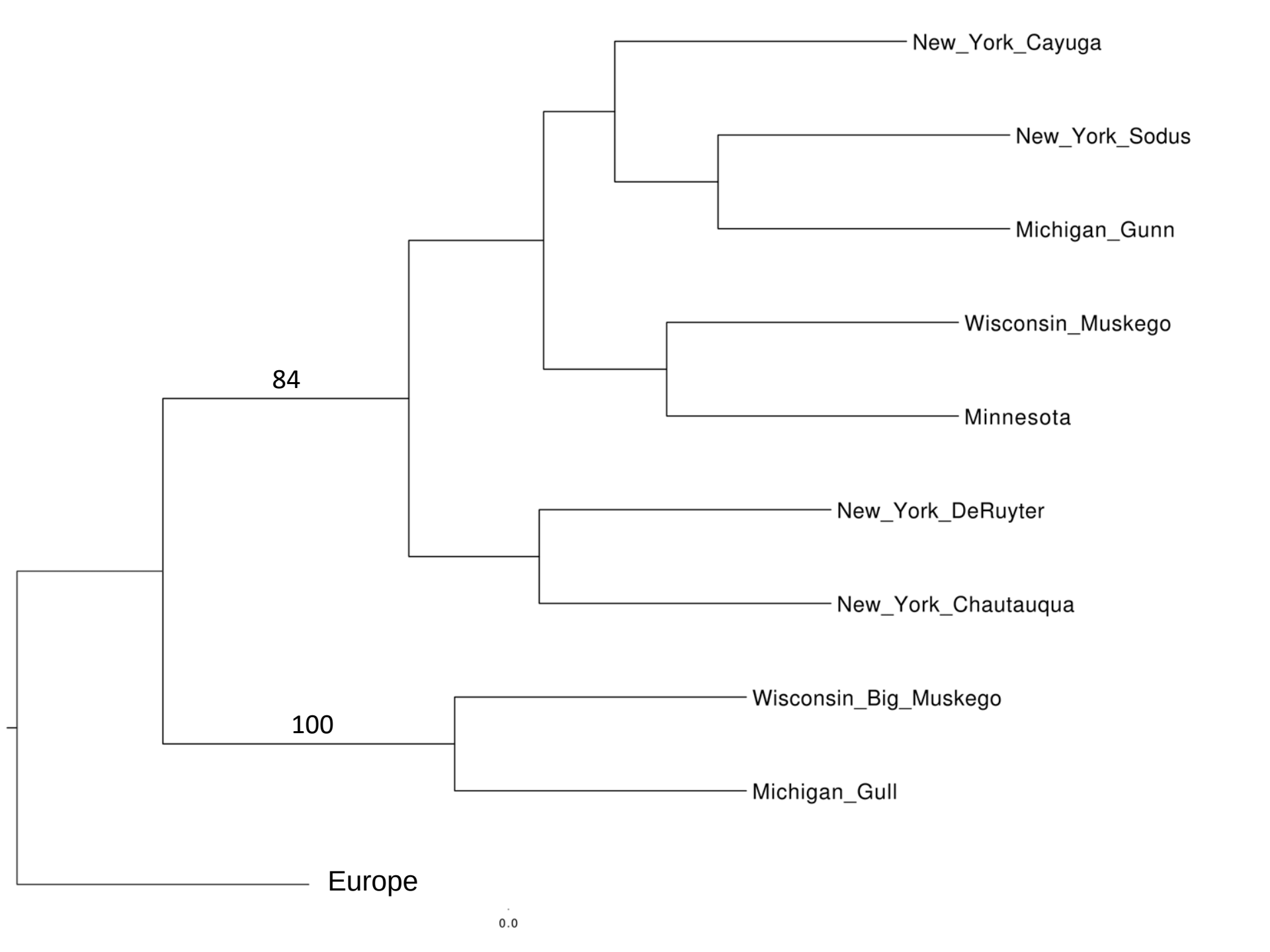
Chara vulgaris

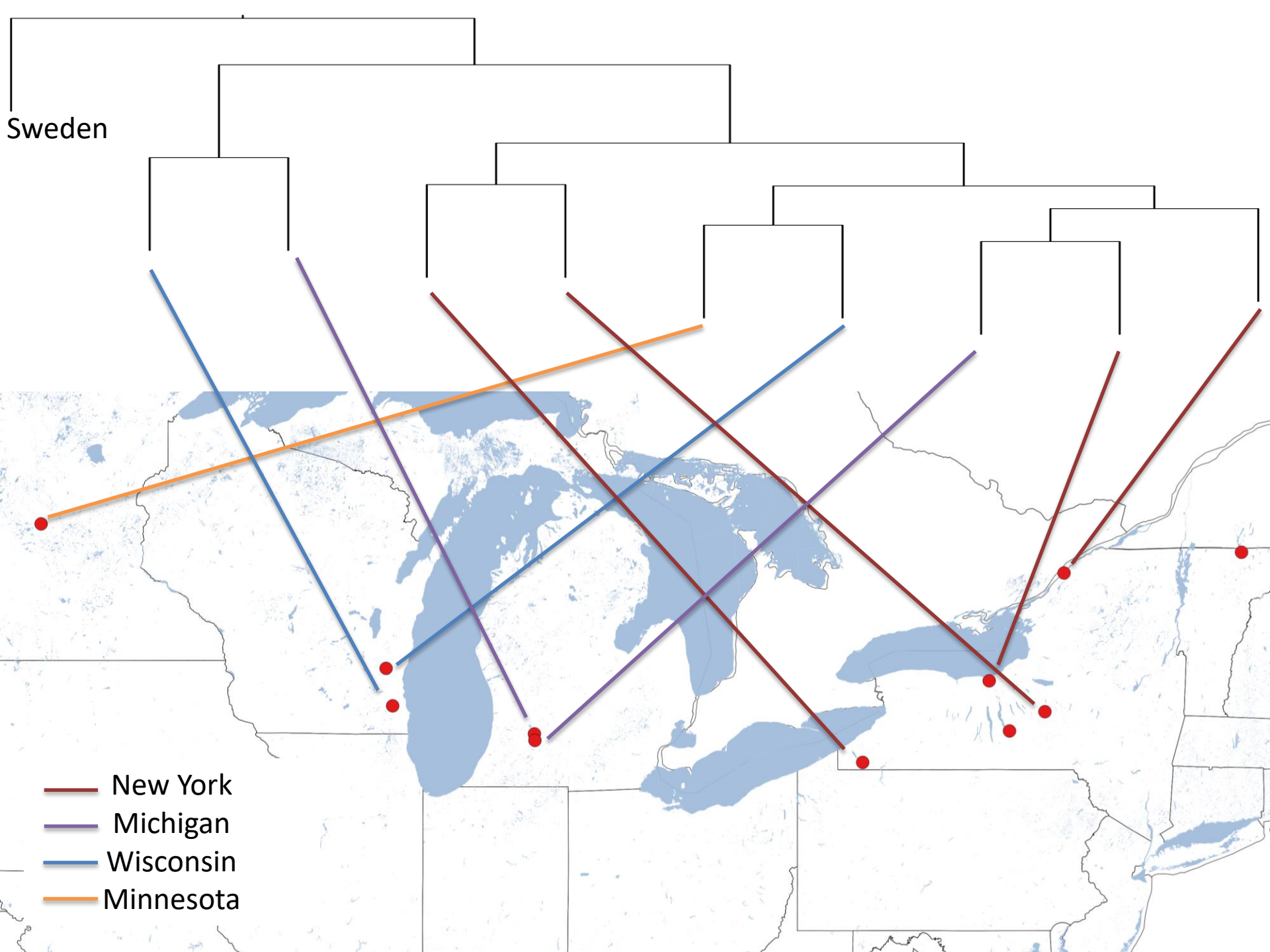
- Strict map to reference
- MAFFT Alignment
- Neighbor-Joining (Tamura-Nei)



Genotyping by Sequencing

- Sequences flanking areas of restriction sites
- Reduces complexity of genome
- More variable than organellar sequencing
- Identified single nucleotide polymorphisms (SNPs) across nuclear genome
- ipyrad pipeline used for processing data


New_York_Cayuga
New_York_Sodus
Michigan_Gunn
Wisconsin_Muskego
Minnesota
84
New_York_DeRuyter
New_York_Chautauqua
Wisconsin_Big_Muskego
100
Michigan_Gull
Europe
0.0


Sweden
New York
Michigan
Wisconsin
Minnesota

Conclusions

- *Nitellopsis obtusa* is still being reported from new localities in North America
- Occurs in unique chemical environment
- Is associated with higher concentrations of calcium and magnesium
- Introduced from Europe
- Complicated pattern of spread

Acknowledgements

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