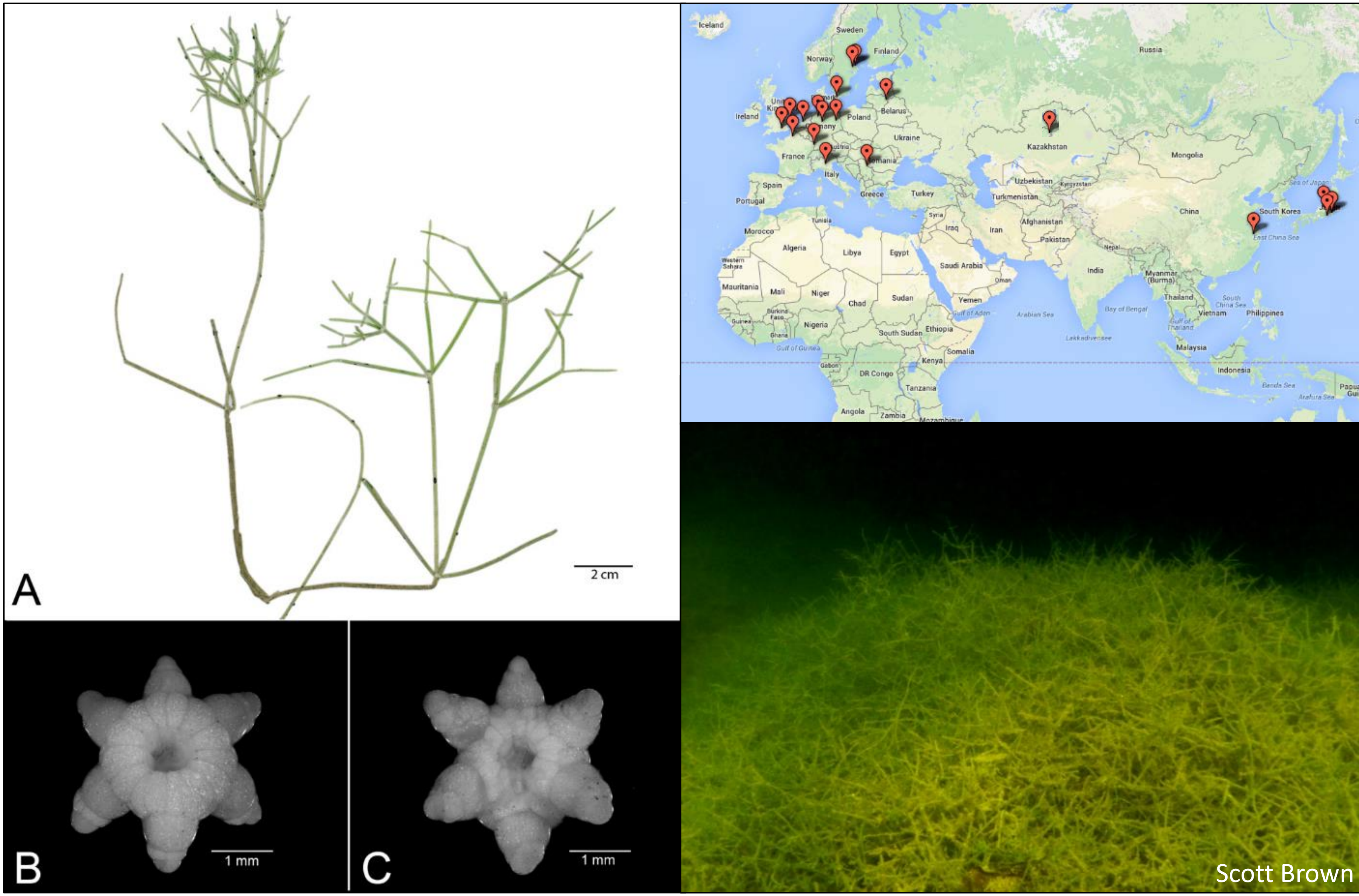
NYBG

Tracing the Movement of the Invasive Alga *Nitellopsis obtusa* (Starry Stonewort)

Robin S. Sleith & Kenneth G. Karol
Lewis B. and Dorothy Cullman Program for Molecular Systematics,
The New York Botanical Garden
19 April 2018

Nitellopsis obtusa (Desv. in Loisel.) J. Groves



Human and Ecological Impacts

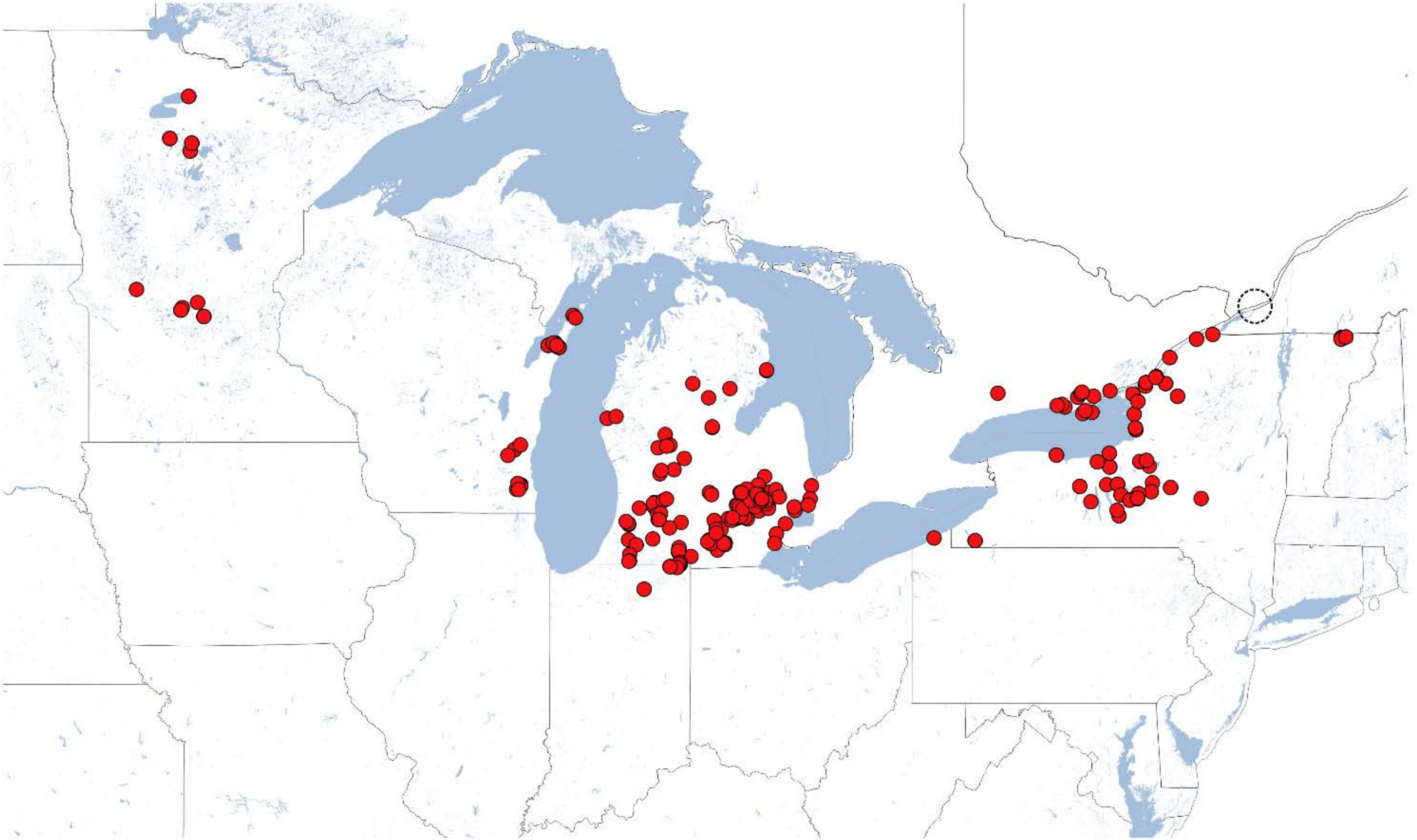
1974: St. Lawrence River, Quebec

1983: St. Lawrence River, Detroit River

2005: St. Lawrence River, Detroit River, New York

2013: Indiana, Michigan, New York, Pennsylvania

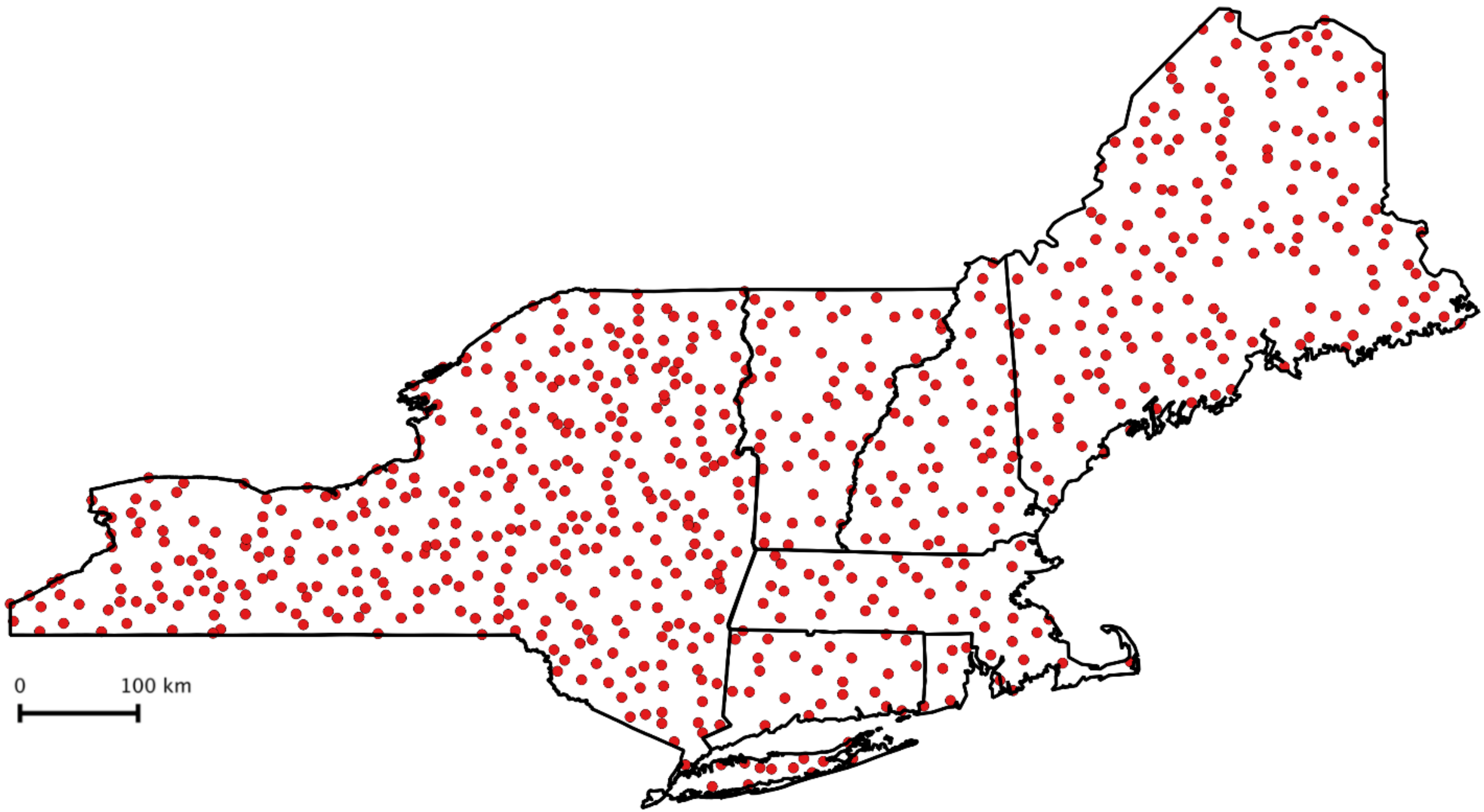
2017: Indiana, Michigan, Minnesota, New York, Ontario, Pennsylvania, Vermont, Wisconsin



Study Area

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

740 Sites

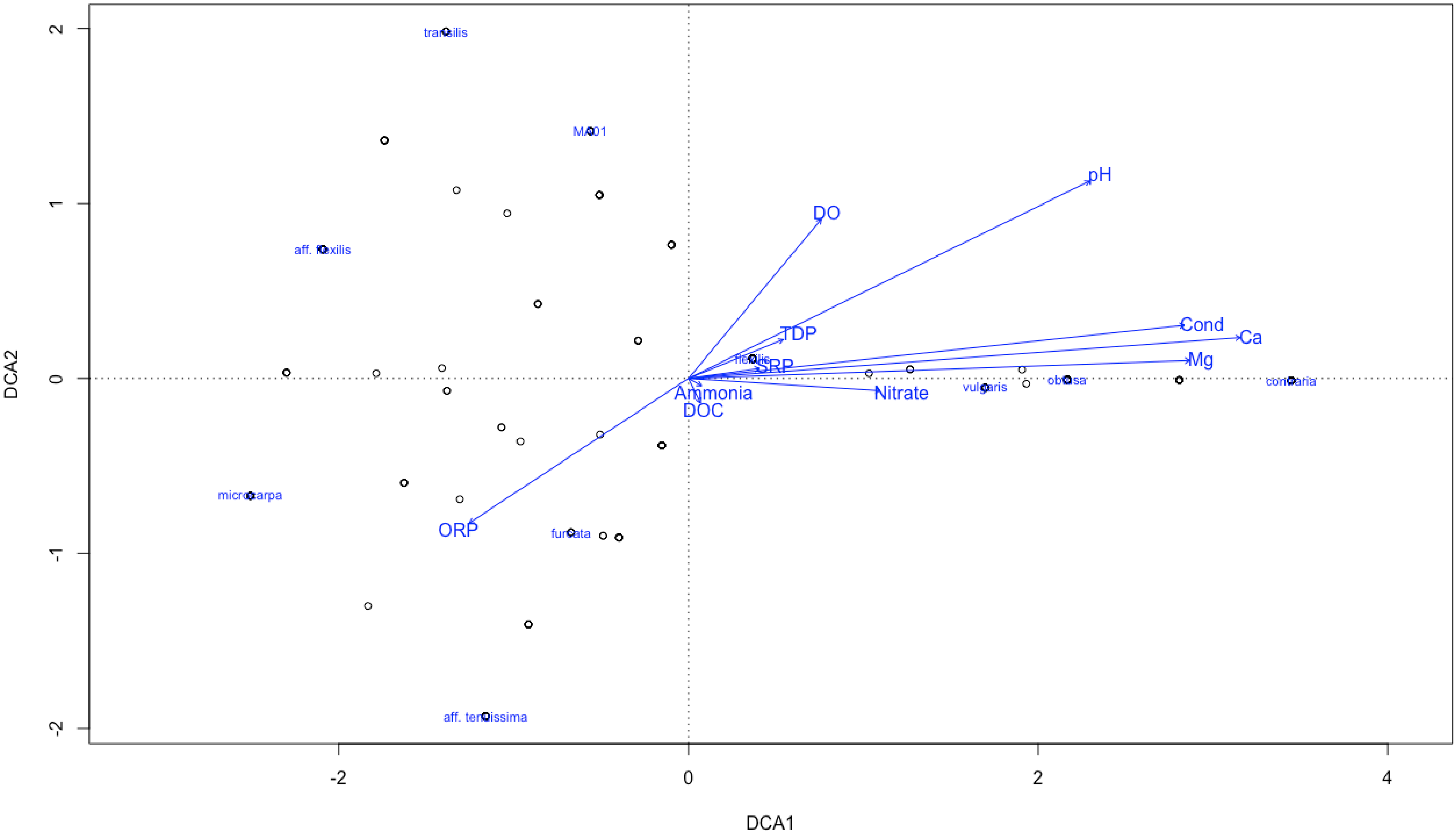


- 24,000 miles of driving = 1 trip around the equator

Water Chemistry

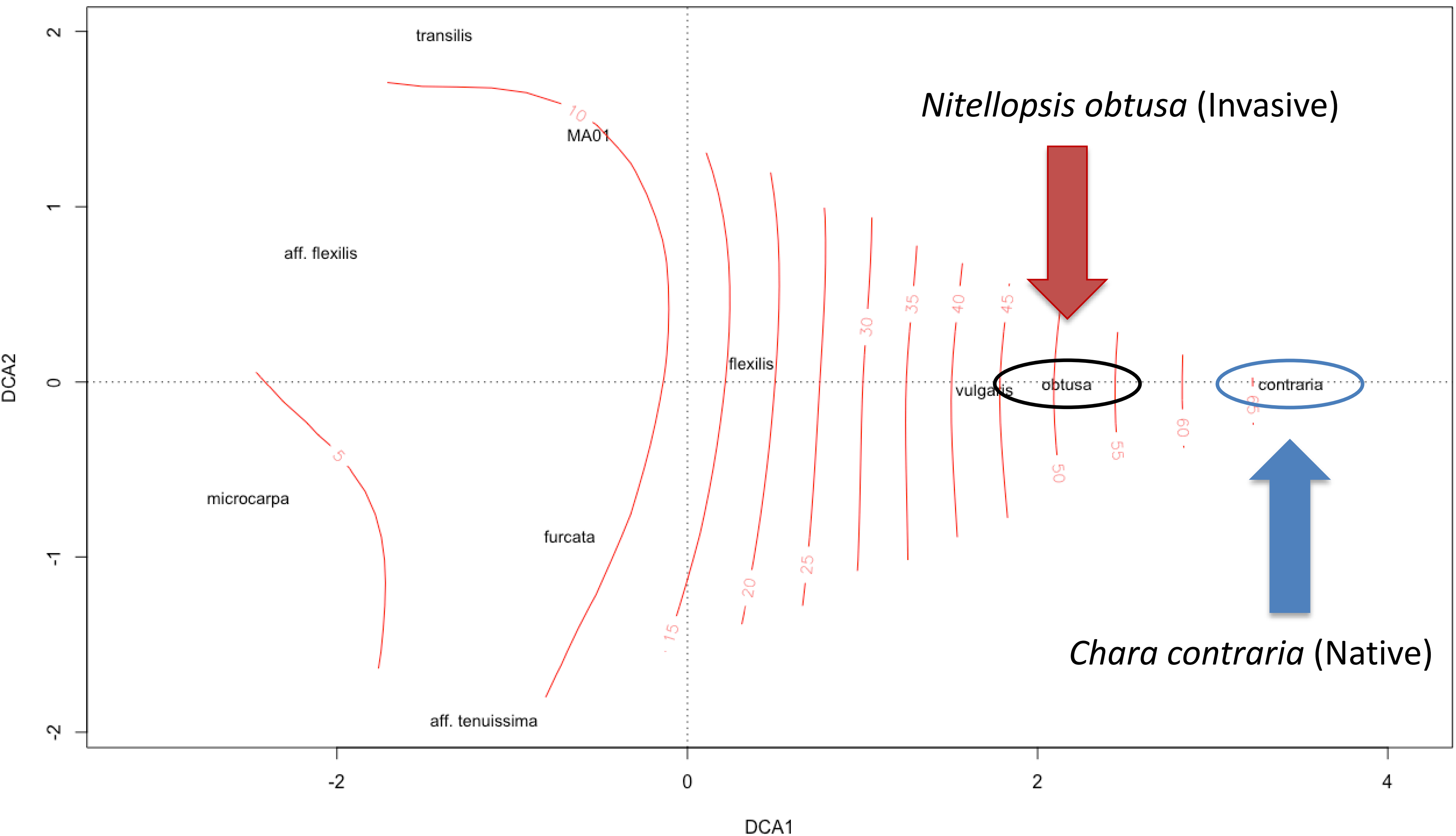
- Temperature (C)
- Dissolved Oxygen (mg/L)
- Oxidation Reduction Potential (mV)
- pH
- Conductivity (uS/cm)

- 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)

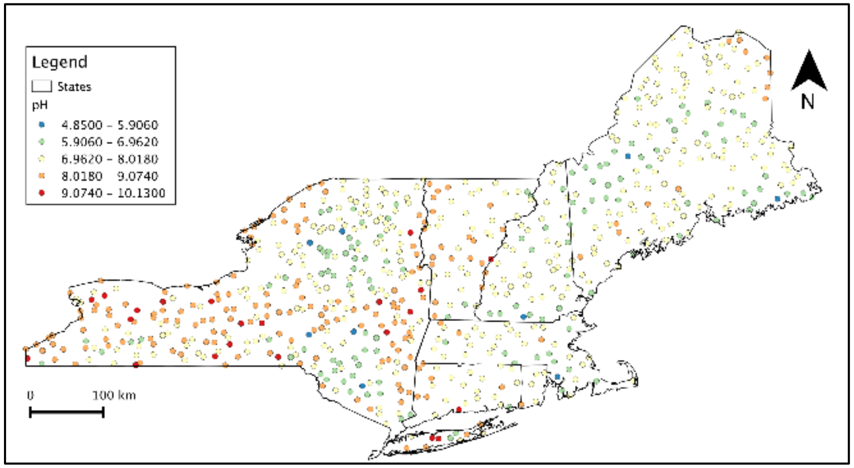


DCA2
DCA1
2
1
0
-1
-2
-2
0
2
4
pH
DO
Cond
Ca
Mg
TDP
SRP
Nitrate
Ammonia
DOC
ORP

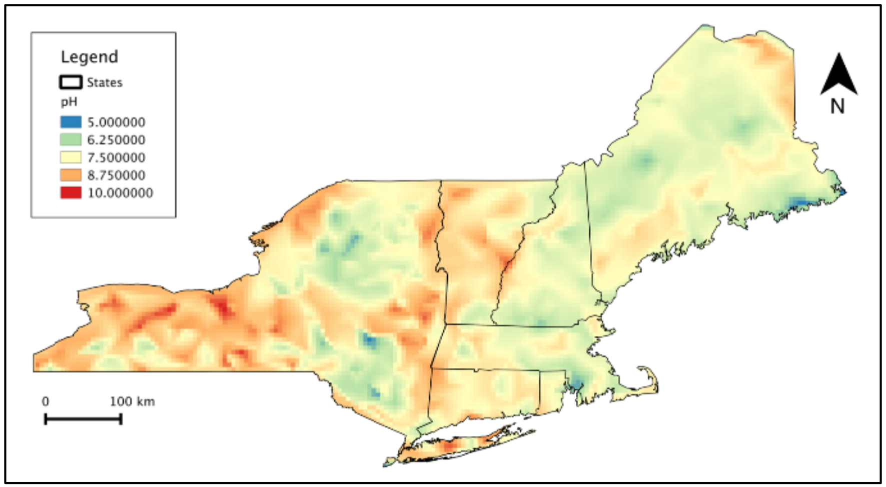
Calcium Spline



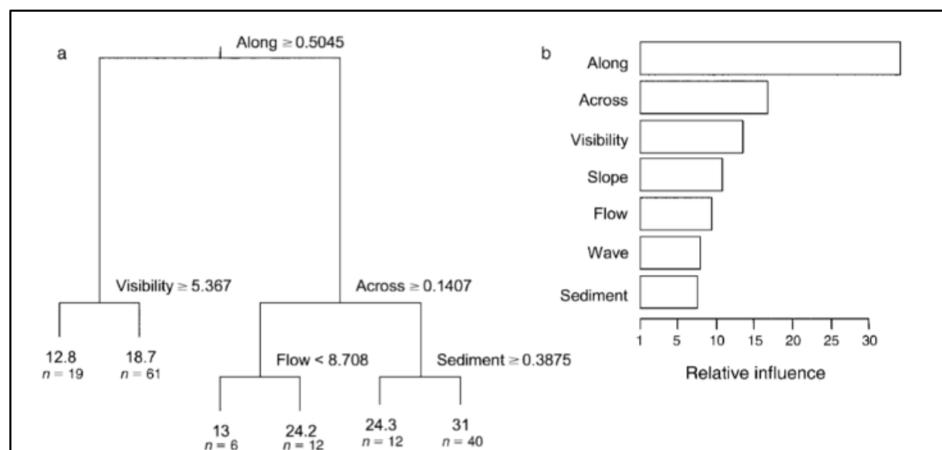
Modeling Methods



Chemistry Point Data

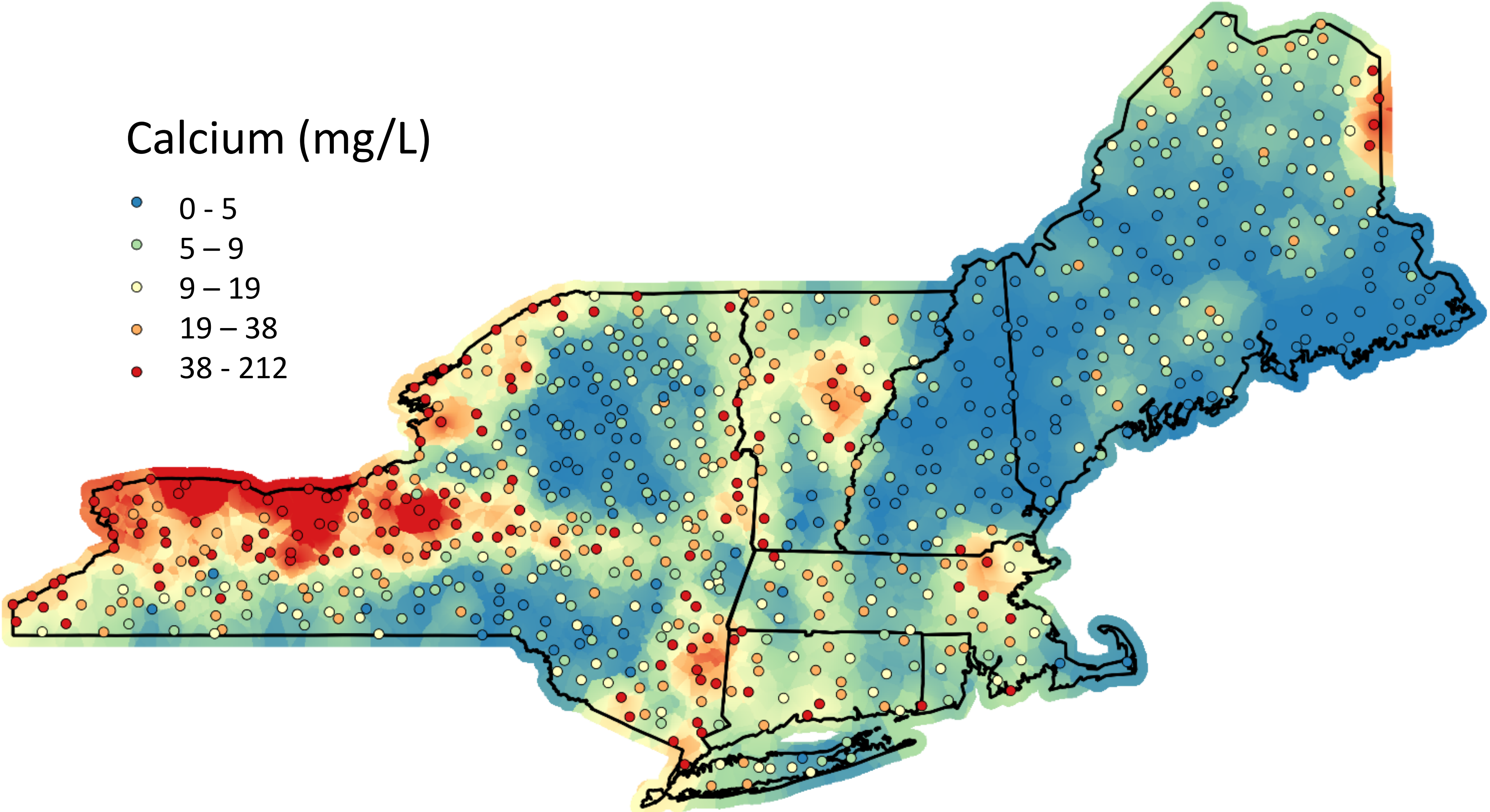


Interpolated Chemistry Raster

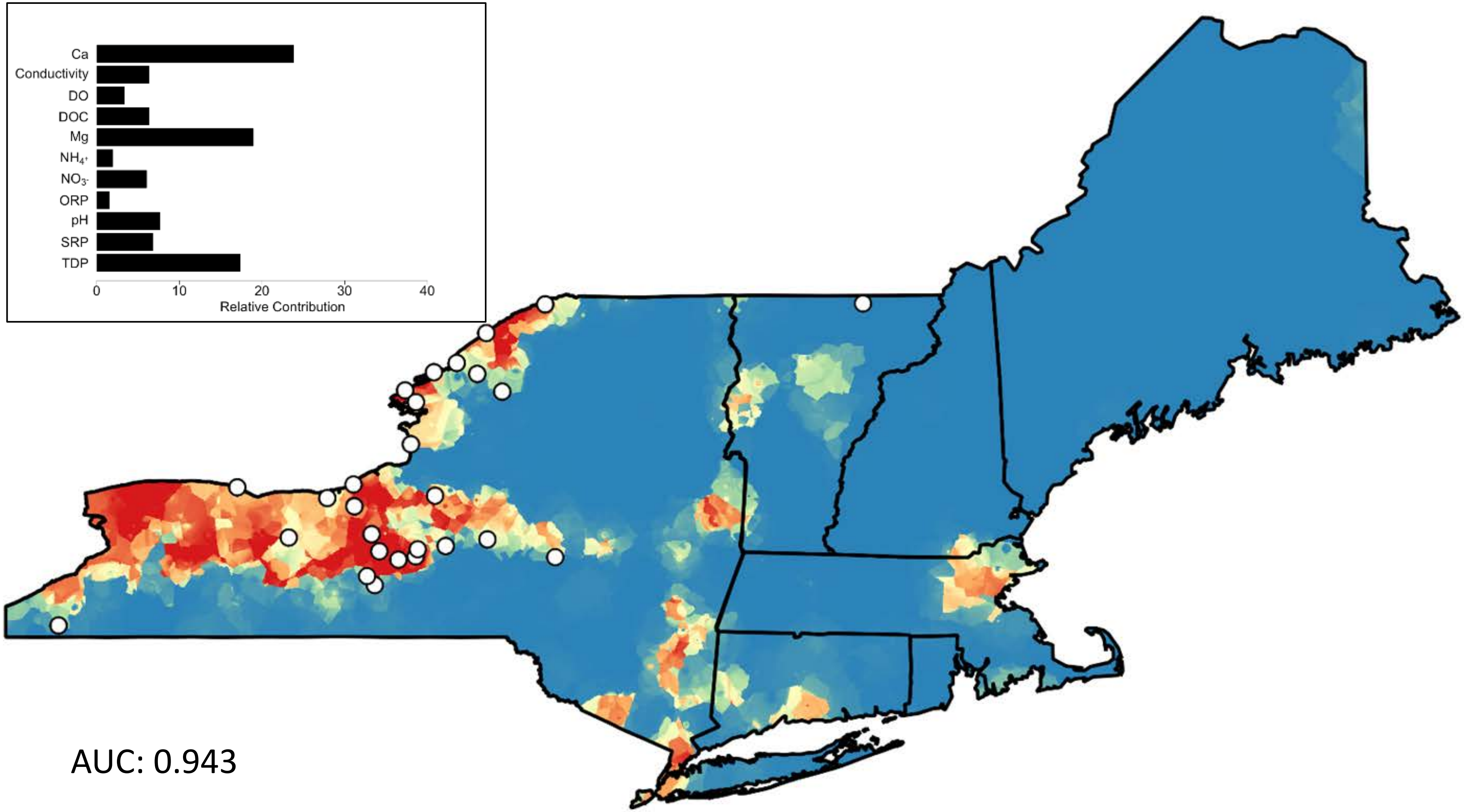


Boosted Regression Trees for ecological modeling
Elith & Leathwick 2016

Interpolation



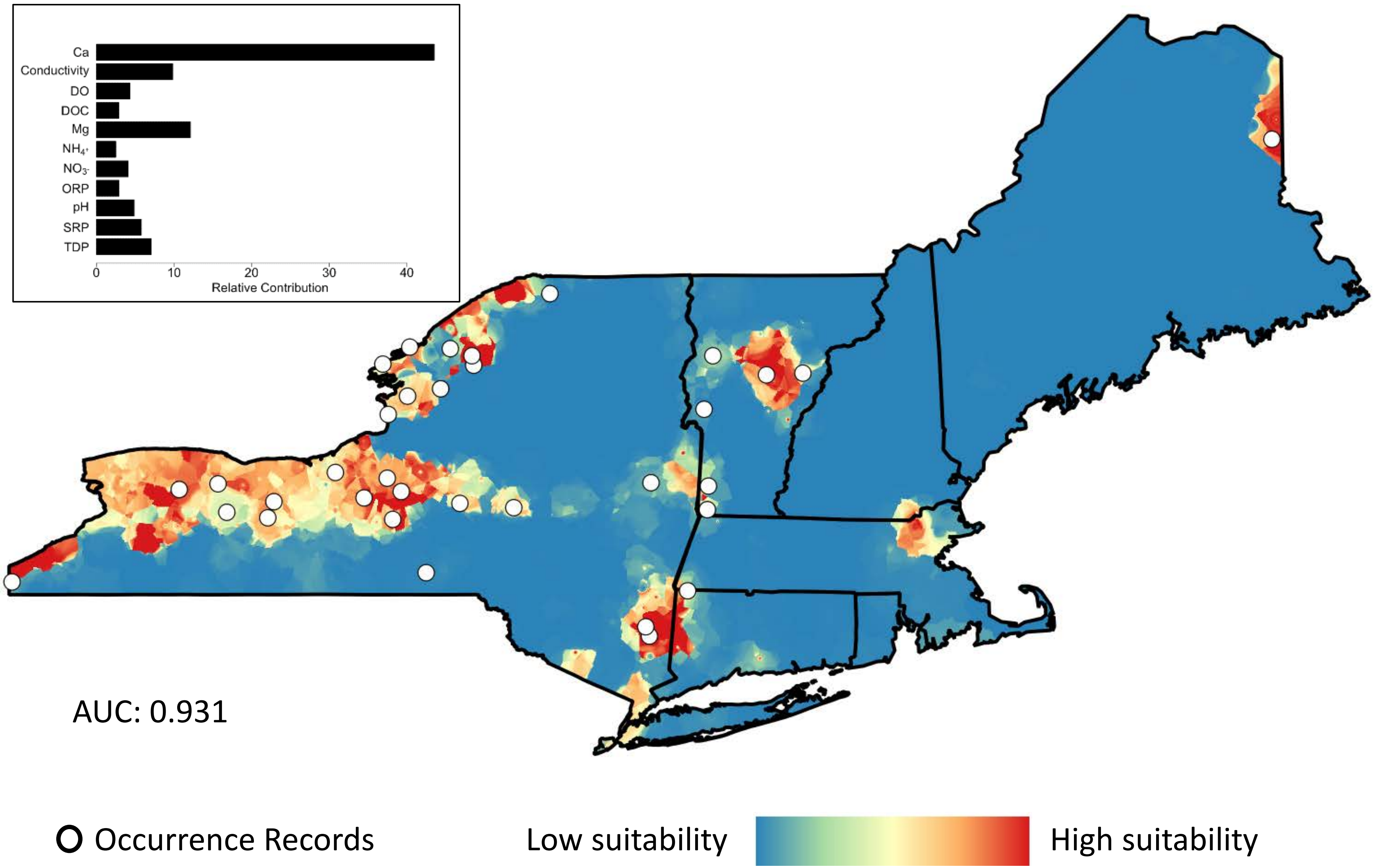
Nitellopsis obtusa



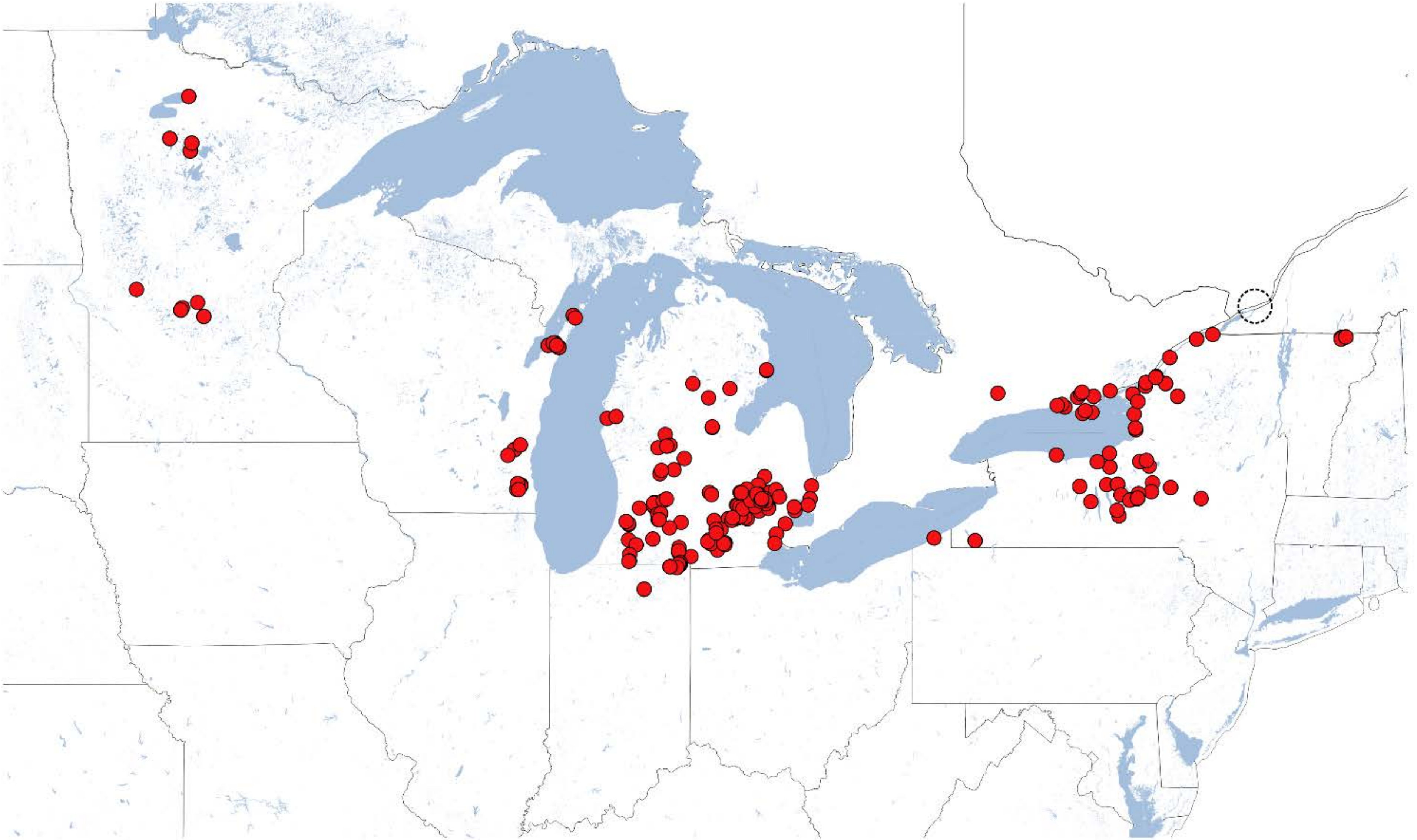
AUC: 0.943

O Occurrence Records   Low suitability   High suitability

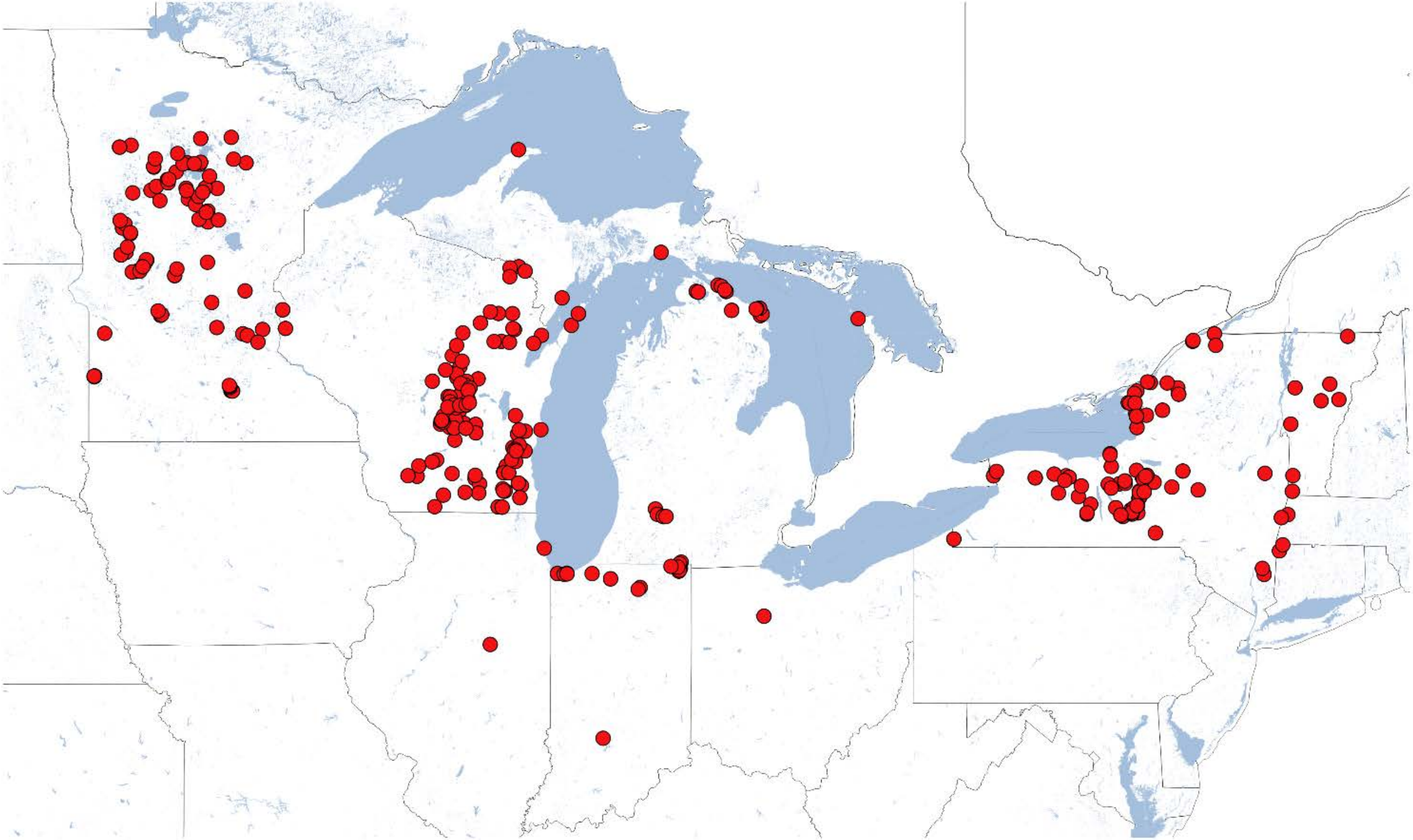
Chara contraria



Nitellopsis obtusa



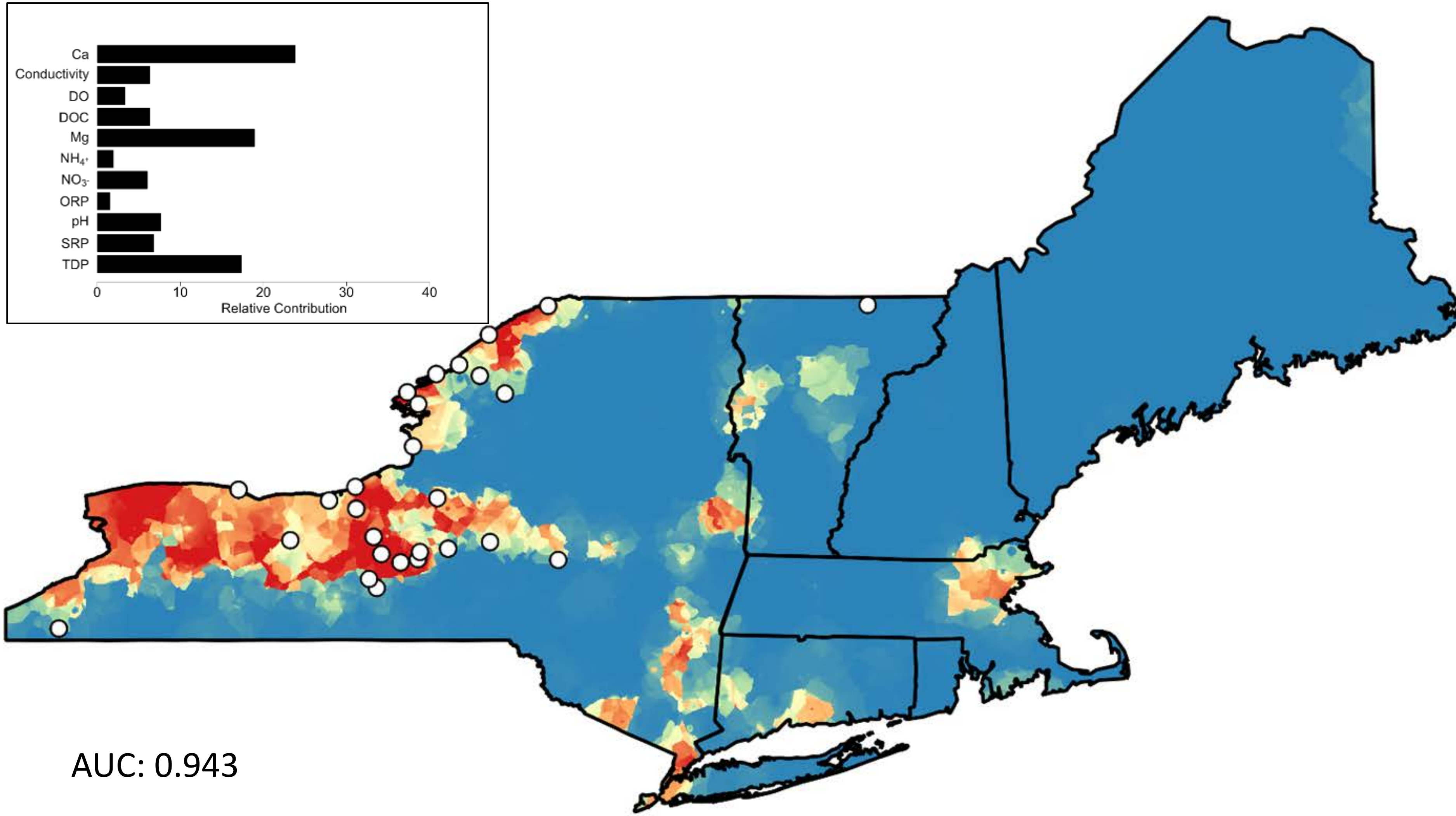
Chara contraria



Predicting changes in distributions under environmental change scenarios

- Scenario 1: Road salt use increases conductivity and leaching of cations
  - Incrementally increase Ca, Cond, Mg in concert to see how distributions change
- Scenario 2 (not shown): Farm and septic leaching increases nutrients
  - Incrementally increase Ammonia, Nitrate, TDP, SRP in concert to see how distributions change

Nitellopsis obtusa

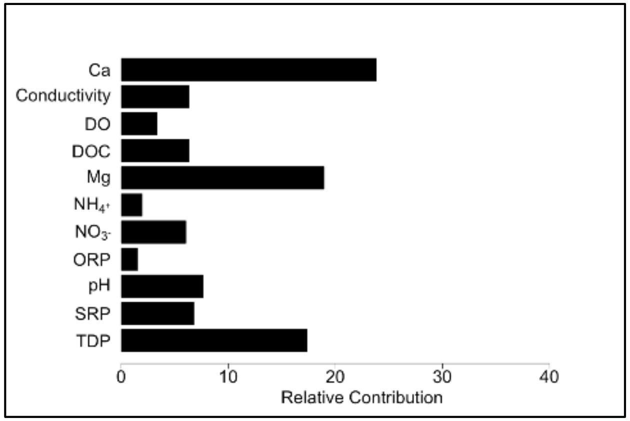


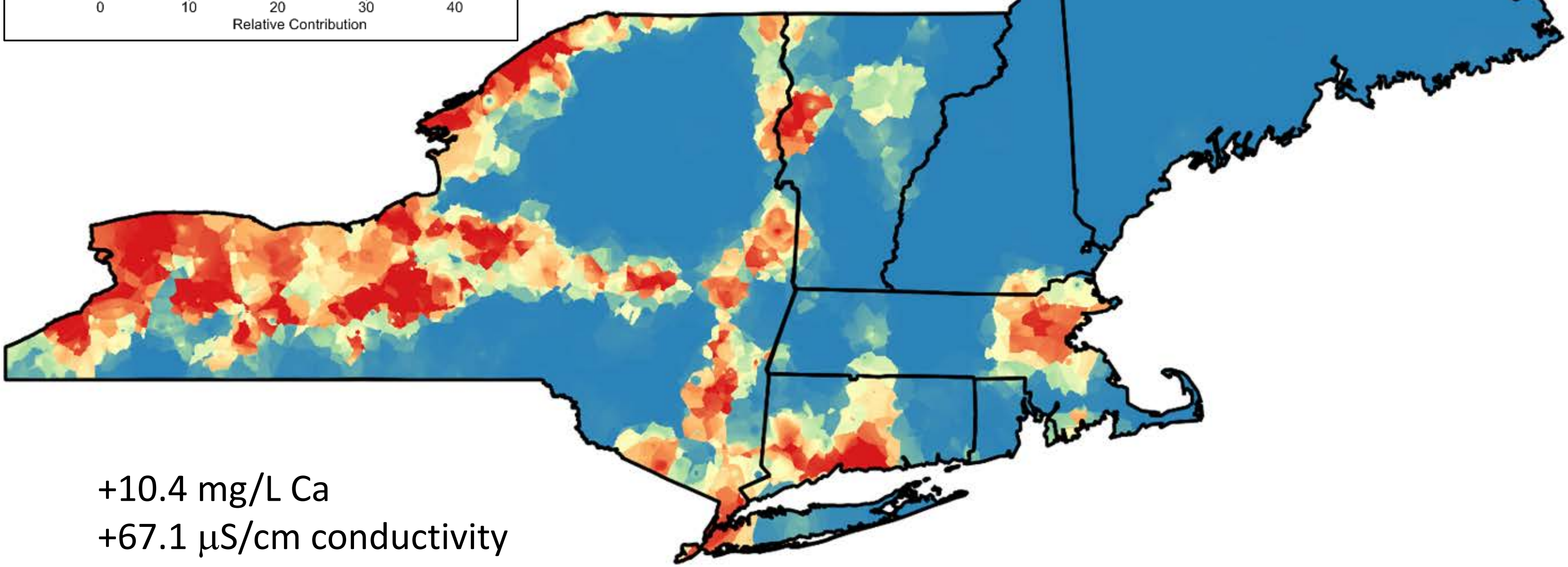
AUC: 0.943

O Occurrence Records

Low suitability High suitability

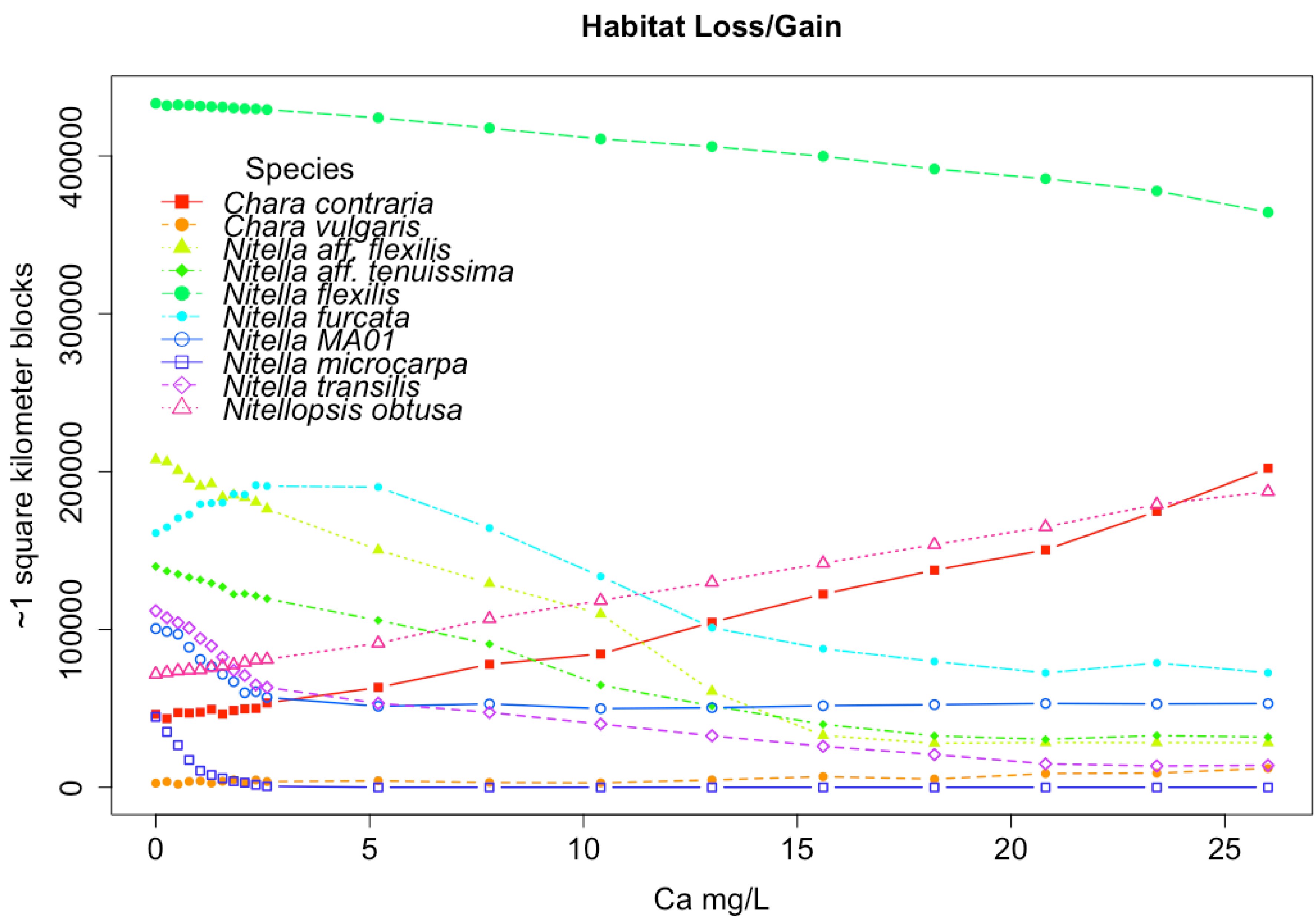
Nitellopsis obtusa





+10.4 mg/L Ca
+67.1 μS/cm conductivity
+2.1 mg/L Mg

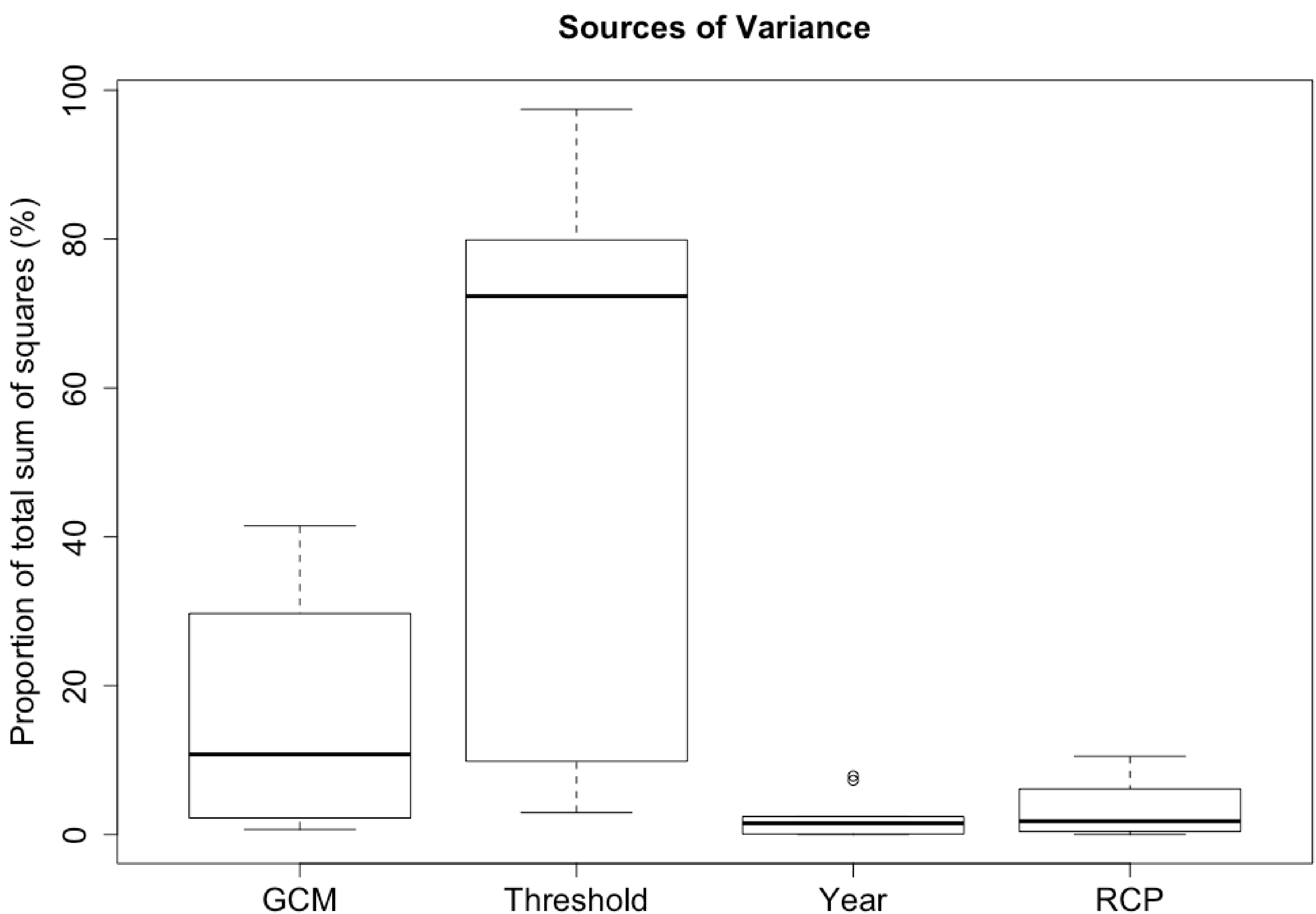
Low suitability — High suitability



Habitat Loss/Gain
~1 square kilometer blocks
0
100000
200000
300000
400000
Ca mg/L
0
5
10
15
20
25
Species
Chara contraria
Chara vulgaris
Nitella aff. flexilis
Nitella aff. tenuissima
Nitella flexilis
Nitella furcata
Nitella MA01
Nitella microcarpa
Nitella transilis
Nitellopsis obtusa

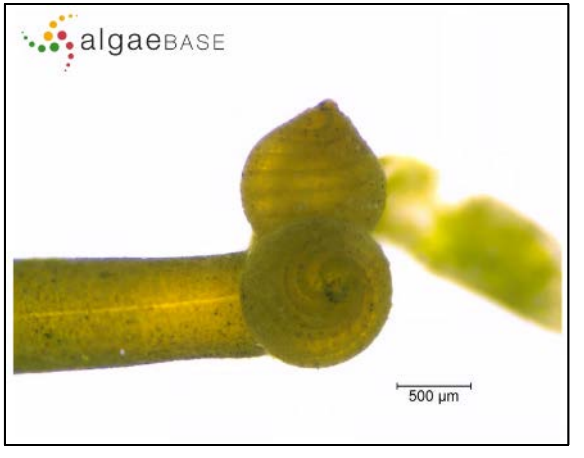
Predicting changes in distributions under climate change scenarios

- Models built using present WorldClim climate layers, forecasted to future climate scenarios
- 5 CMIP5 Global Climate Models (CCSM4, GISS-E2-R, HadGEM2-AO, MIROC5, NorESM1-M)
- 4 Representative Concentration Pathways (2.6, 4.5, 6.0, 8.5)
- 2 time points (2050, 2070)

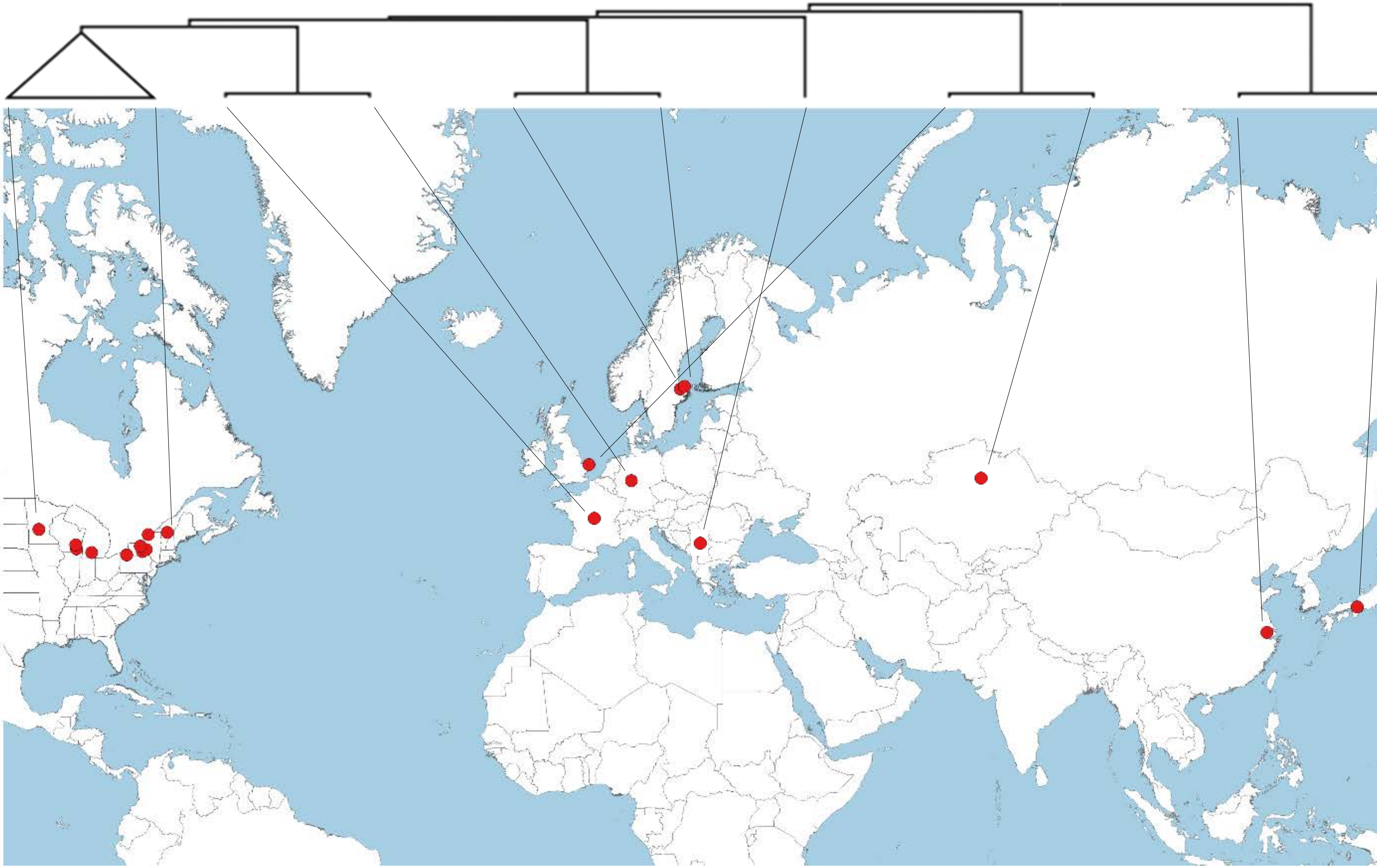

Sources of Variance
Proportion of total sum of squares (%)
0
20
40
60
80
100
GCM
Threshold
Year
RCP

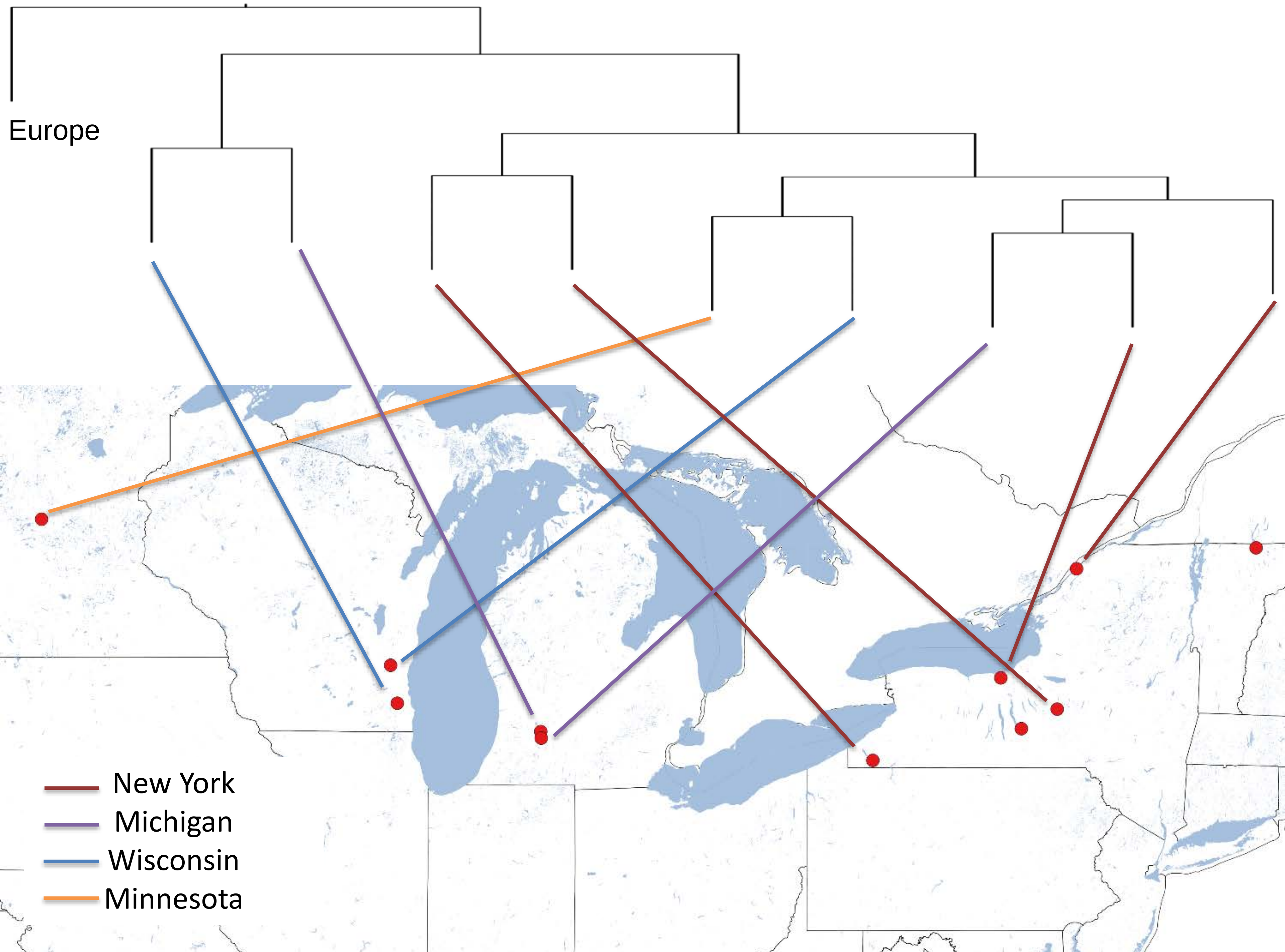
Phylogeography

- 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



European, not Asian origin



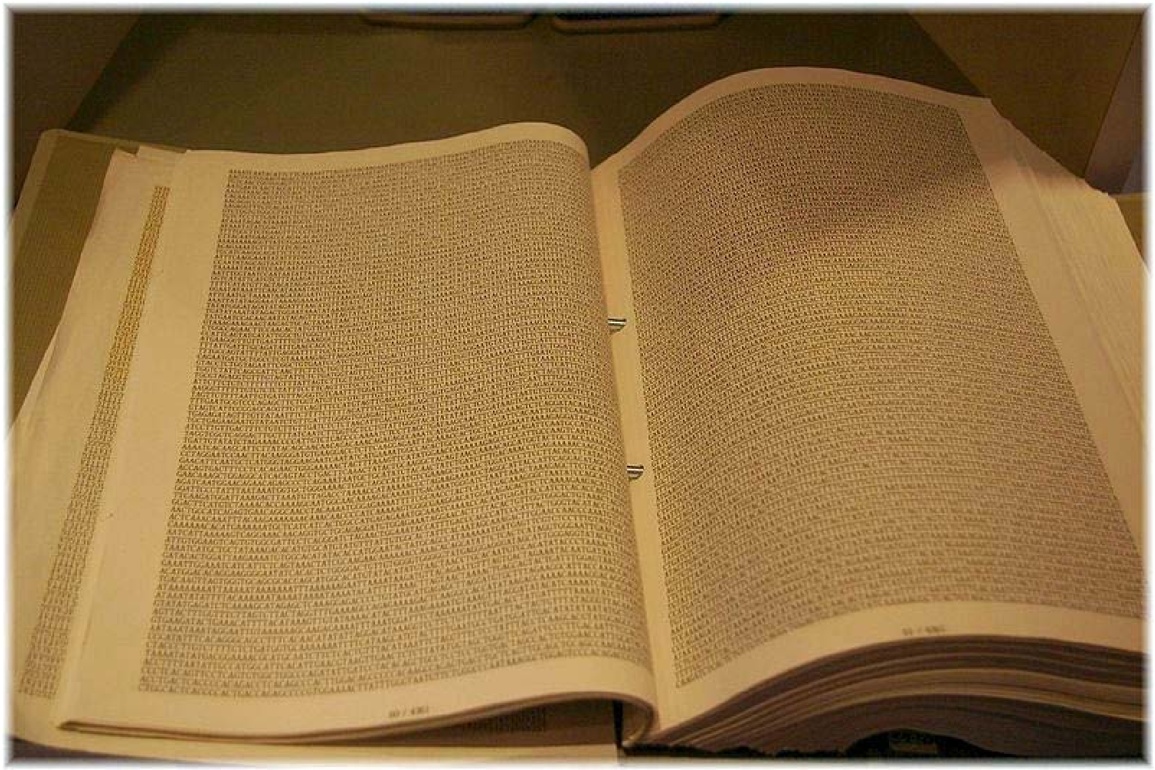


Europe
New York
Michigan
Wisconsin
Minnesota

Rapid Evolution

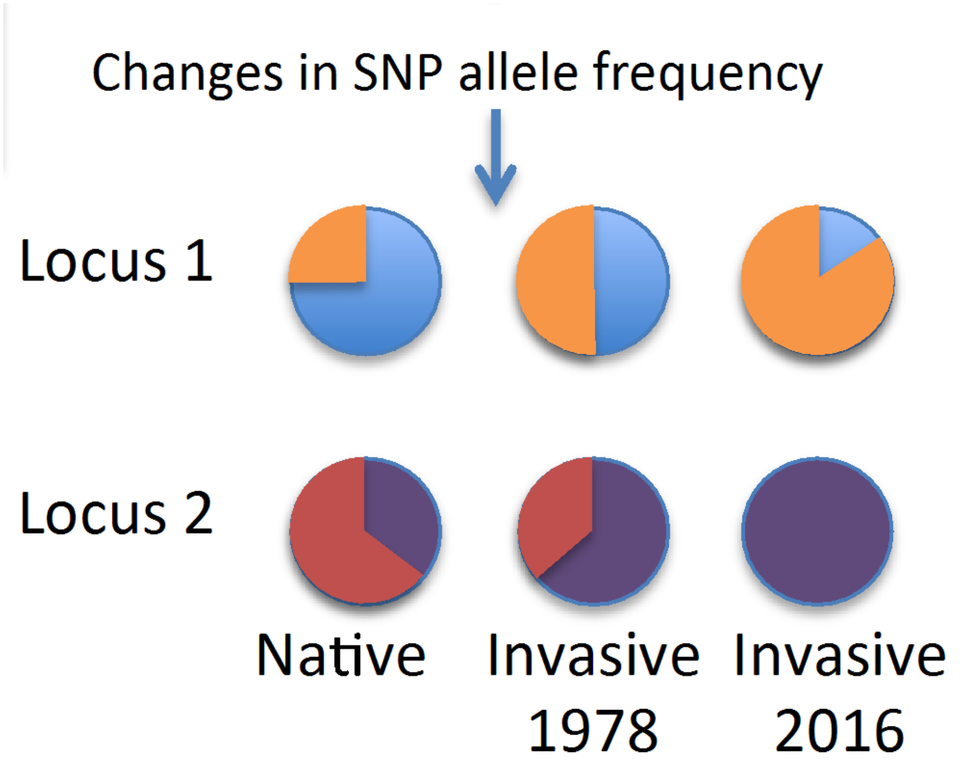
- Opportunity to explore the genetic basis of adaptive variation

Experimental Design



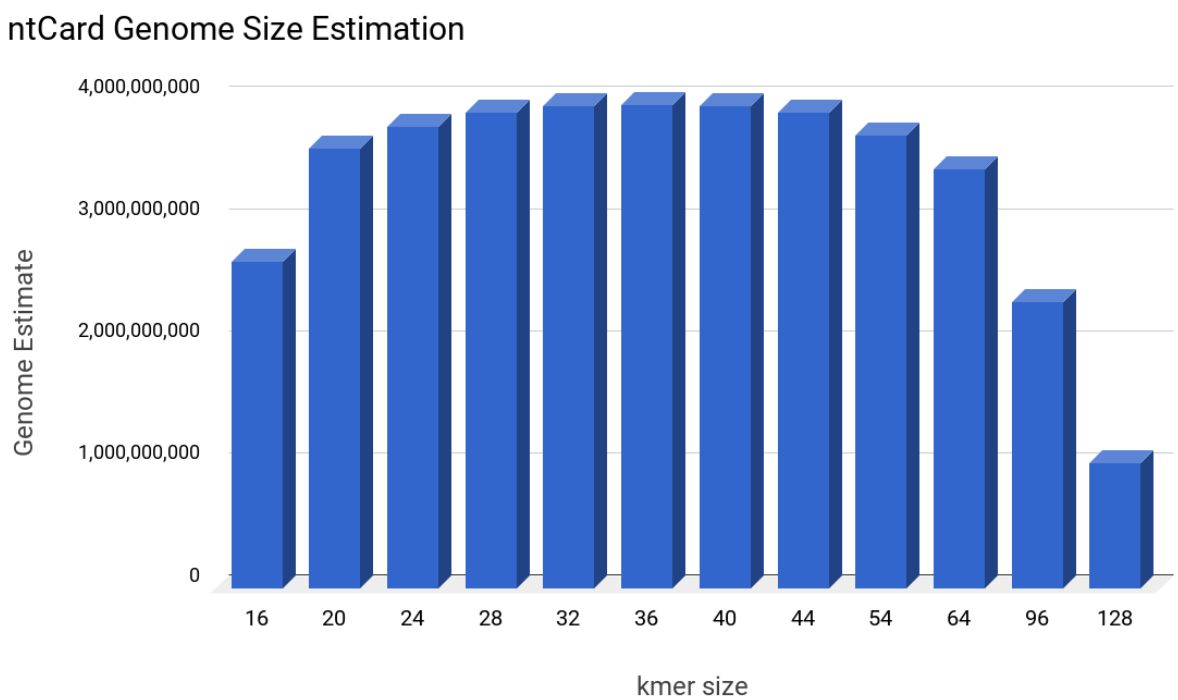
- Sequence genome
- Identify potentially adaptive loci
- Collect ddRADseq data from across space and time

Experimental Design



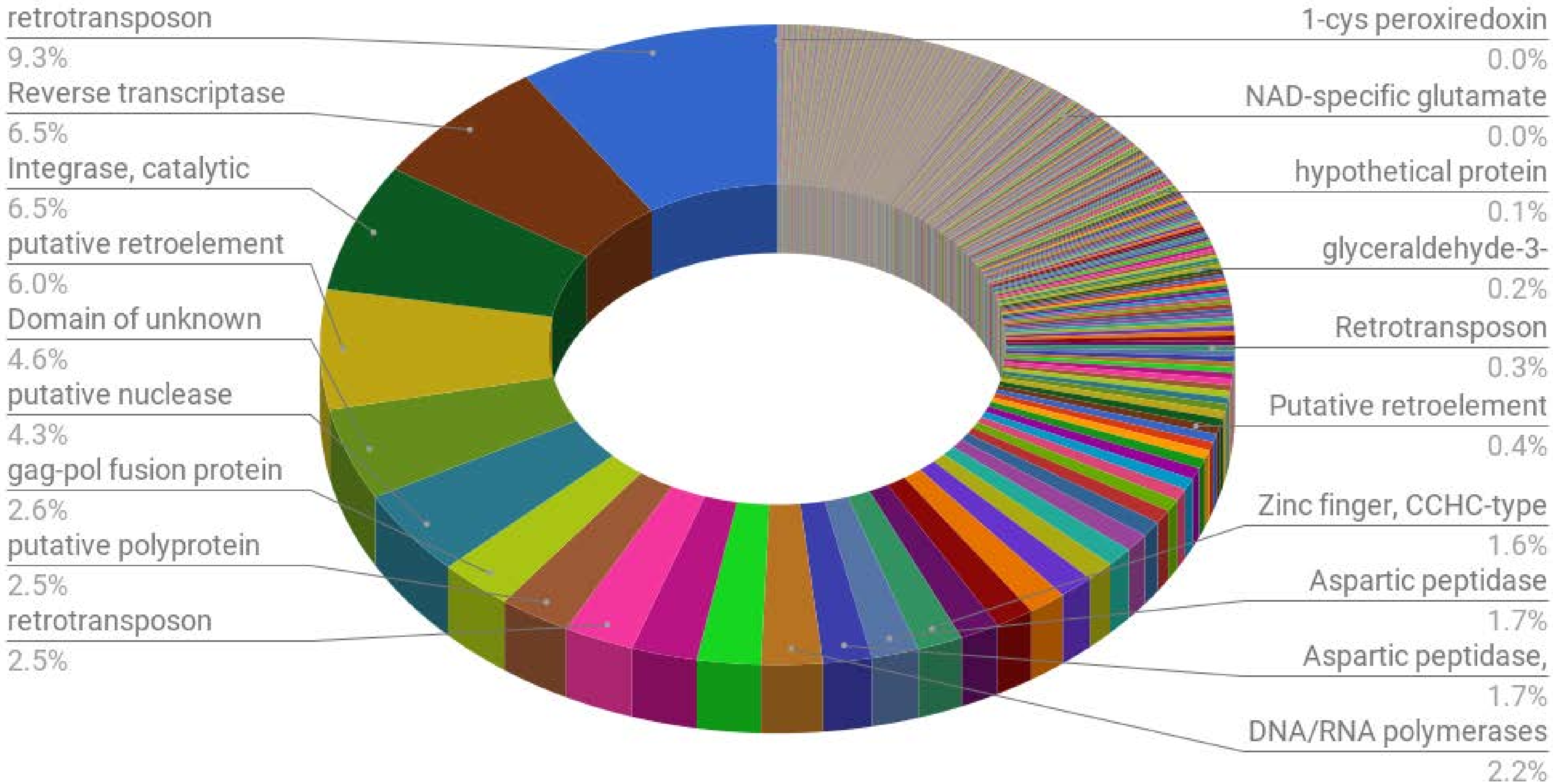
- Changes in adaptive allele frequencies indicate potential occurrence of rapid adaptation

ntCard – kmer counting



- Genome size estimates range from 1-5Gb
- Illumina coverage of 51,889,956,106bp
- 10-50x coverage

9,100 Gene Matches



Gene Ontology

Gene	Ontology	Number of contigs
peptide methionine sulfoxide reductase A1-like	Response to oxidative stress	2
peptide methionine sulfoxide reductase B1, chloroplastic	Response to oxidative stress	3
Zinc finger, CCHC-type	Cation transport	21
retrotransposon ty3-gypsy subclass	Cation transport	35
OSJNBb0049I21.5	Cation transport	121
SLC41 divalent cation transporters, integral membrane domain	Cation transport	314
metal tolerance protein 1-like	Cation transport	385

Conclusions

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

Best Bets

- PREVENTION. Clean. Drain. Dry.
- *Nitellopsis* thrives in high nutrient sites
- Limit runoff and nutrient inputs = benefits for all levels of aquatic ecosystems

STOP AQUATIC HITCHHIKERS!™

CLEAN. DRAIN. DRY.

Shameless Self Promotion

Biology, ecology, and management of starry stonewort (*Nitellopsis obtusa*; Characeae): A Red-listed Eurasian green alga invasive in North America

Daniel J. Larkin[a,*], Anna K. Monfils[b], Aurélie Boissezon[c], Robin S. Sleith[d,e], Paul M. Skawinski[f], Charles H. Welling[g,1], Blake C. Cahill[b], Kenneth G. Karol[d]

[a] *Department of Fisheries, Wildlife, & Conservation Biology and the Minnesota Aquatic Invasive Species Research Center, University of Minnesota, Saint Paul, MN, USA*
[b] *Department of Biology and Institute of Great Lakes Research, Central Michigan University, Mount Pleasant, MI, USA*
[c] *Aquatic Ecology Group, F.A. Forel Institute and Institute of Environmental Sciences, University of Geneva, Geneva, Switzerland*
[d] *Lewis B. and Dorothy Cullman Program for Molecular Systematics, The New York Botanical Garden, Bronx, NY, USA*
[e] *The Graduate Center, City University of New York, New York, NY, USA*
[f] *UW-Extension Lakes, University of Wisconsin, Stevens Point, WI, USA*
[g] *Invasive Species Program, Division of Ecological and Water Resources, Minnesota Department of Natural Resources, Saint Paul, MN, USA*

A R T I C L E I N F O

Keywords:
Charophycean
Invasion biology
Macrophytes
Plant diversity
Water chemistry

A B S T R A C T

Nitellopsis obtusa (starry stonewort) is a green macroalga (family Characeae) native to Europe and Asia that is of conservation concern in its native range but expanding in North America. We synthesize current science on *N. obtusa* and identify key knowledge gaps. *Nitellopsis obtusa* is able to reproduce sexually or asexually via fragments and bulbils. Native populations reproduce primarily asexually; sexual fertility increases with longer growing seasons and in shallower waters. In North America, only males have been observed. *Nitellopsis obtusa* has been known from North America for four decades and confirmed in seven U.S. states and two Canadian provinces. It is typically associated with low-flow areas of lakes with alkaline to neutral pH and elevated conductivity. *Nitellopsis obtusa* has ecological benefits in its native range, contributing to food webs and water clarity. In its invaded range, *N. obtusa* could negatively influence native macrophytes and habitat quality, but there has been little research on impacts. There have been many efforts to control *N. obtusa* through physical removal or chemical treatments, but little systematic evaluation of outcomes. Substantial areas of uncertainty regarding *N. obtusa* include controls on reproduction, full distribution in North America, ecological impacts, and control strategies.

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NSF

	Native range [1,2,3,4]			Introduced range [5]		
Parameter	Min.	Max.	Mean	Min.	Max.	Mean
Depth (m)	0.4	31	3.9	—	—	—
Summer temperature (C)	14.0	28	16.1	18.2	25.4	23.0
Dissolved oxygen (mg/L)	—	—	—	3.4	13.5	9.3
Oxidation reduction potential (mV)	—	—	—	46.3	277.1	98.4
pH	3.8	9.8	8.0	7.3	9.2	8.5
Conductivity (µS/cm)	32	2880	228.3	160.7	499.2	301.3
Nitrogen—ammonia (µg/L)	0	494	218.0	9.7	171.6	56.0
Nitrogen—nitrate (µg/L)	0	660	177.7	2.4	1732	230.9
Total nitrogen (µg/L)	0	7800	873.9	—	—	—
Soluble reactive phosphate (µg/L)	0	1015	12.0	0.6	110.7	11.9
Total dissolved phosphorus (µg/L)	2	430	50.2	6.6	172.2	24.6
Dissolved organic carbon (mg/L)	—	—	—	3.6	50.2	10.3
Calcium (mg/L)	5.2	172	92.5	28.8	107.1	50.8
Magnesium (mg/L)	3.4	17.5	10.7	1.2	20	9

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