NYBG/125

INVASIVE SPECIES SUMMIT: CHALLENGES, STRATEGIES, AND PERSPECTIVES

FRI, NOV 6, 2015

Co-presented with Lower Hudson Partnership for Regional Invasive Species Management

LOWER HUDSON PRISM

NEW YORK BOTANICAL GARDEN

Lower Hudson Emerging Invasive Species

Linda Rohleder, Ph.D.

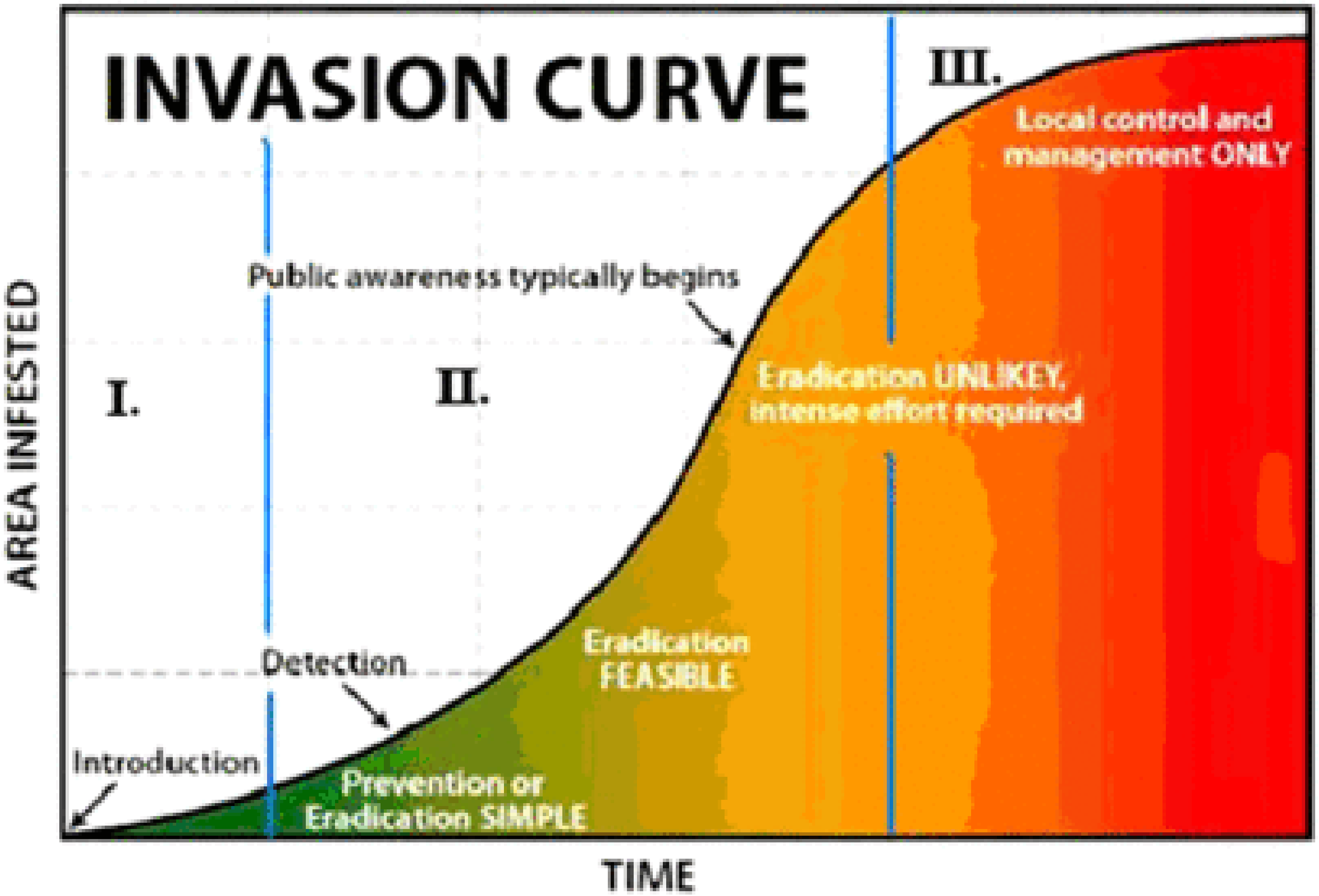
Coordinator, Lower Hudson PRISM

November 6, 2015

LOWER HUDSON PRISM

Linda Rohleder, Director of Land Stewardship, New York – New Jersey Trail Conference
600 Ramapo Valley Rd, Mahwah, NJ 07430   201-512-9348 x 21 lrohleder@nynjtc.org

What do we mean by “Emerging”?



- Image from Southwest Montana Science Partnership

Selecting species to focus on…

- In a 15 minute talk

- Currently present in the Lower Hudson PRISM region
- Low numbers of *reported* locations
- High impact or potential impact, High Invasiveness rank
  - NY State invasiveness ranks at: http://nyis.info
- Representative sample from different habitats, taxa

- There are **many others** to watch out for.

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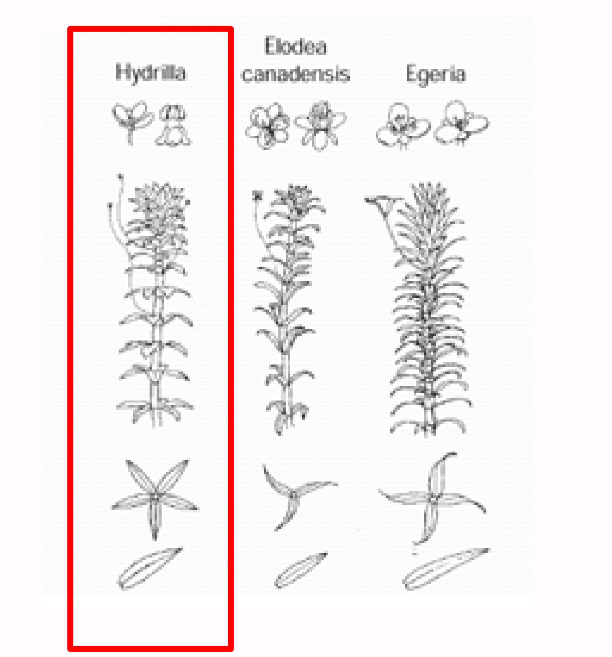
Hydrilla

- New York State Priority Invasive Species
- One location in the Croton River - Croton Reservoir
- Very Highly invasive

- Leaves in whorl around stem, edges serrated
- 3-8 (typically 5) leaves per whorl
- Tubers and turions



Photos: Samantha Epstein

Chinese mitten crab

- *Eriocheir sinensis*
- NY State Prohibited Species, Federally regulated
- Found in the Hudson River in 2007
- Very aggressive scavenger, Fresh water and salt water

http://www.dec.ny.gov/animals/35888.html

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Amur corktree

- *Phellodendron amurense*
- NYS Prohibited Invasive species, also Prohibited in Massachusetts
- When not in fruit, looks similar to an ash tree
- Deeply ridged corky bark, clusters of black berries
- 3 reports in NY – 2 in Westchester, 1 in Bronx
- Escapes into forested areas

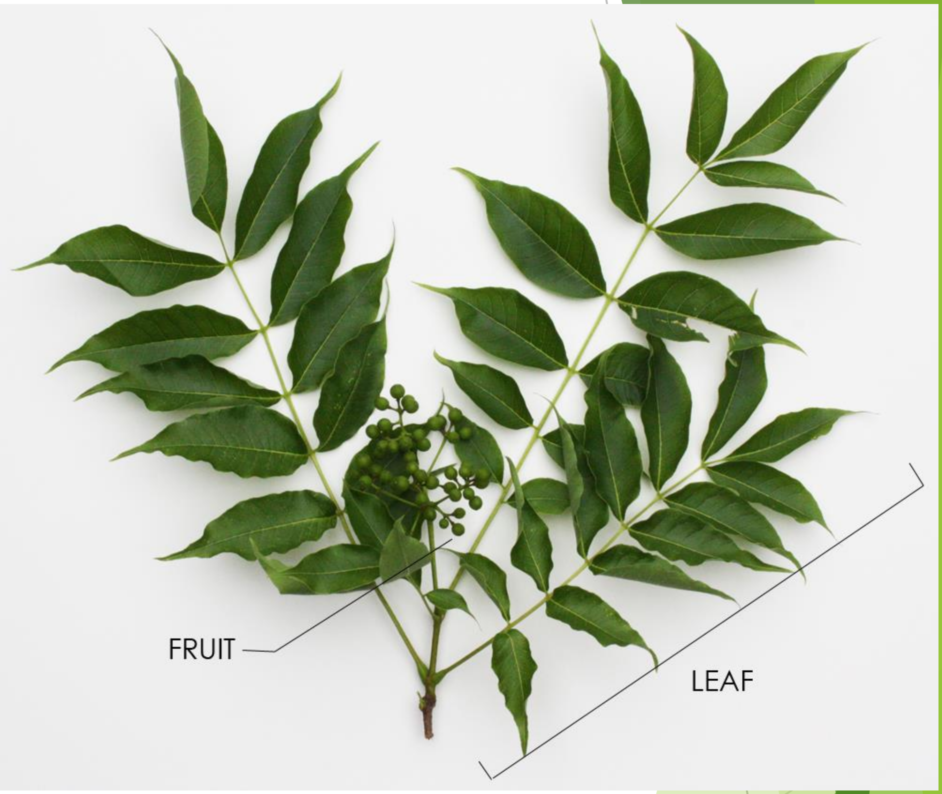

Photo: http://eabguelph.com

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Hardy kiwi, silver vine

- *Actinidia arguta*

  Actinidia polygama
- Woody vines, produce edible fruit

Photos: Massachusetts Audubon Fact Sheet

Scotch Broom

- *Cytisus scoparius*
- Highly invasive in the Pacific Northwest
- Nitrogen-fixer
- Spreading in Orange and Rockland co.

Photos: Shelby Timm

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Linden Viburnum

- *Viburnum dilatatum*
- Bird-dispersed, shade-tolerant forest understory shrub
- Similar to native *Viburnum dentatum*

Photo: Missouri Botanical Garden

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Jetbead (*Rhodotypos scandens*)

- Extensive populations found in Westchester, Orange

Photos: (flw) http://www.omcseeds.com; (leaf) John M. Randall, The Nature Conservancy; (fruit) Leslie J. Mehrhoff, University of Connecticut, Bugwood.org

Lesser celandine, Fig buttercup

- *Ficaria verna*, aka *Ranunculus ficaria*
- NY State Prohibited Species, Very Highly invasive
- Spring ephemeral wildflower
- Blankets floodplains, stream corridors, wet meadows
- Similar to native marsh marigold

Photo: Duke Farms, NJ

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Small carpetgrass

- *Arthraxon hispidus*
- Annual grass, native to Asia
- Sunny, moist habitats
- Similar to native Deertongue
- One location in Westchester

Hairs on edge of leaves

LOWER HUDSON PRISM

Photos: Leslie J. Mehrhoff, University of Connecticut, bugwood.org

Southern Pine Beetle

- *Dendroctonus frontalis*
- Confirmed in Orange County
- A southern pest expanding its range northward

- Attacks *Pinus* sp. Especially shortleaf and loblolly but also pitch pine

Photo: Ronald F. Billings, Texas Forest Service, bugwood.org

Photo: David T. Almquist, University of Florida, bugwood.org

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Spotted Wing Drosophila

- *Drosophila suzukii*
- Attacks soft-skinned ripening and ripe fruits: blueberries, raspberries, strawberries, peaches, plums, cherry, grapes …
- Natural areas hosts include: barberry, honeysuckle, pokeweed, blackberry, raspberry, black cherry, elderberry, dogwood, …
- Reported for Orange and Dutchess counties

Photo: Michigan State University Fact Sheet

Photo: Tim Martinson, Horticulture, Cornell University

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Many other species…

- See list of 15 New York early detection plants at
  - **http://bit.ly/1WiWF9z** (Excel spreadsheet)
- Invasive Species distributions in New York
  - **http://nyimapinvasives.org**
  - Report your findings here!
- NY State Invasive Species Assessments
  - **http://nyis.info** Resources tab
- Species categorizations based on current knowledge for the Lower Hudson region
  - **http://lhprism.org/content/strategy**

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LOWER HUDSON PRISM

NEW YORK BOTANICAL GARDEN

Incised Fumewort (*Corydalis incisa*) Invasive in North America

Daniel E. Atha
Conservation Program Manager,
Associate Editor, *Brittonia*
New York Botanical Garden
Bronx, NY 10458
Tel: 718-817-8896
Email: datha@nybg.org

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- Globally, invasive species cause 1.4 trillion dollars in damage each year[1]

- Montana, North and South Dakota and Wyoming together spend approximately $144 million per year on leafy spurge control [2]

- Controlling Palmer amaranth costs Georgia cotton growers more than $110 million each year, making it the most economically destructive weed in the southeastern United States[3]

- The state of Florida spends $56 million annually to control one invasive plant species - Hydrilla[4]

- In 2008, the Adirondack town of Inlet, New York (pop. 333) allocated $2,500 for control of Japanese Knotweed[5].

1. Pimentel, D., McNair, S., Janecka, J., Wightman, J., Simmonds, C., O'Connell, C., Wong, E., Russel, L., Zern, J., Aquino, T. and Tsomondo, T. 2001. Economic and environmental threats of alien plant, animal, and microbe invasions. Agriculture, Ecosystems and Environment 84: 1-20.

2. Montana Weed Control Association. 2015. http://mtweed.org/weed-of-the-week-series-leafy-spurge/. Accessed 6 February 2015.

3. Webster, T. M. & T. L. Grey. 2015. Glyphosate-Resistant Palmer Amaranth (*Amaranthus palmeri*) Morphology, Growth, and Seed Production in Georgia. Weed Science 63: 264-272.

4. Economic Impacts of Invasive Species in the Pacific Northwest Economic Region. 2012. (http://www.aquaticnuisance.org/wordpress/wp-content/uploads/2010/06/economicimpacts_pnwer_2012.pdf). Accessed 6 February 2015.

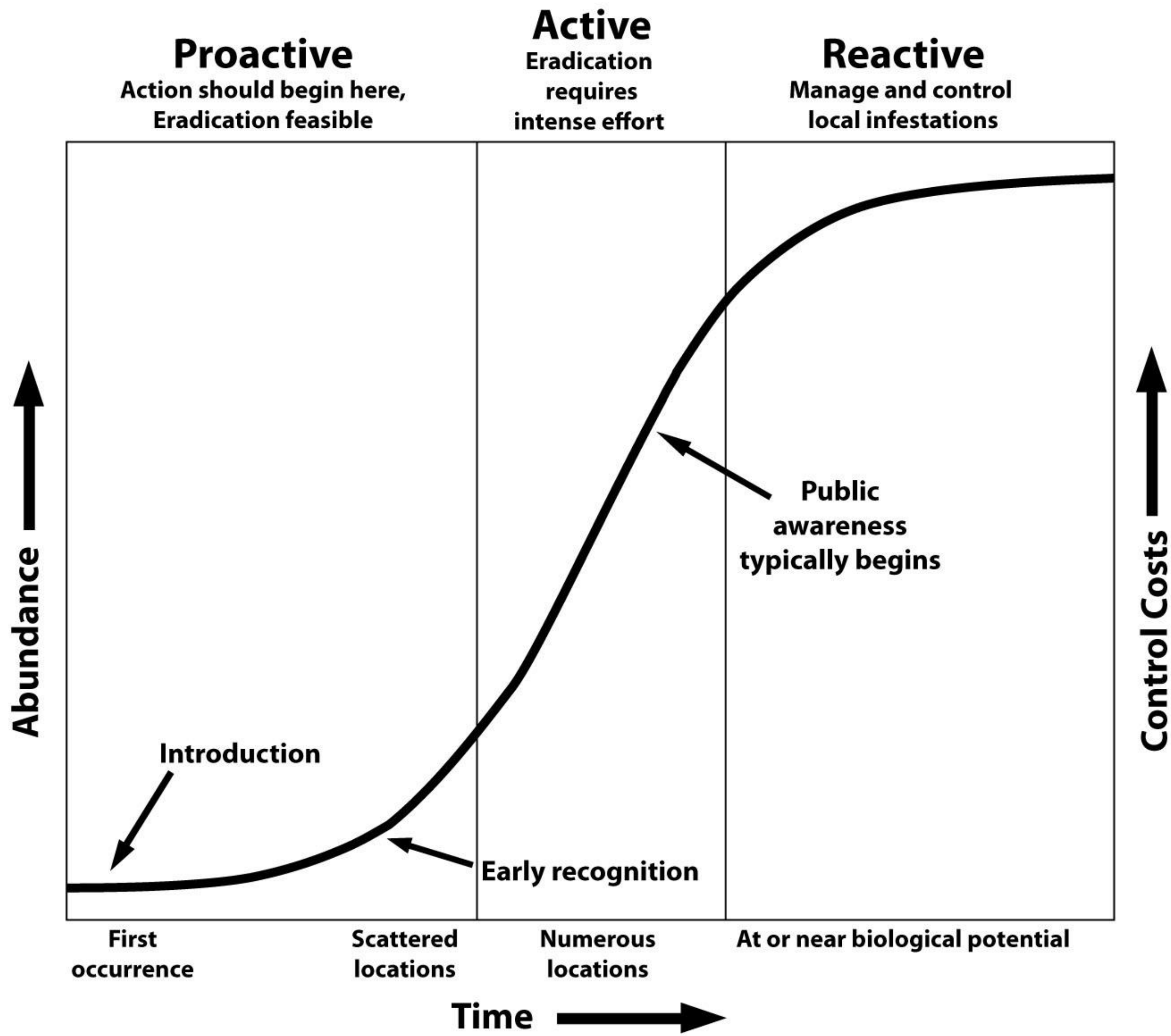
5. Adirondack Life. 2013. http://www.adirondacklifemag.com/blogs/2013/04/15/the-knotweed-factor/. Accessed 6 February 2015.

Economic Impacts

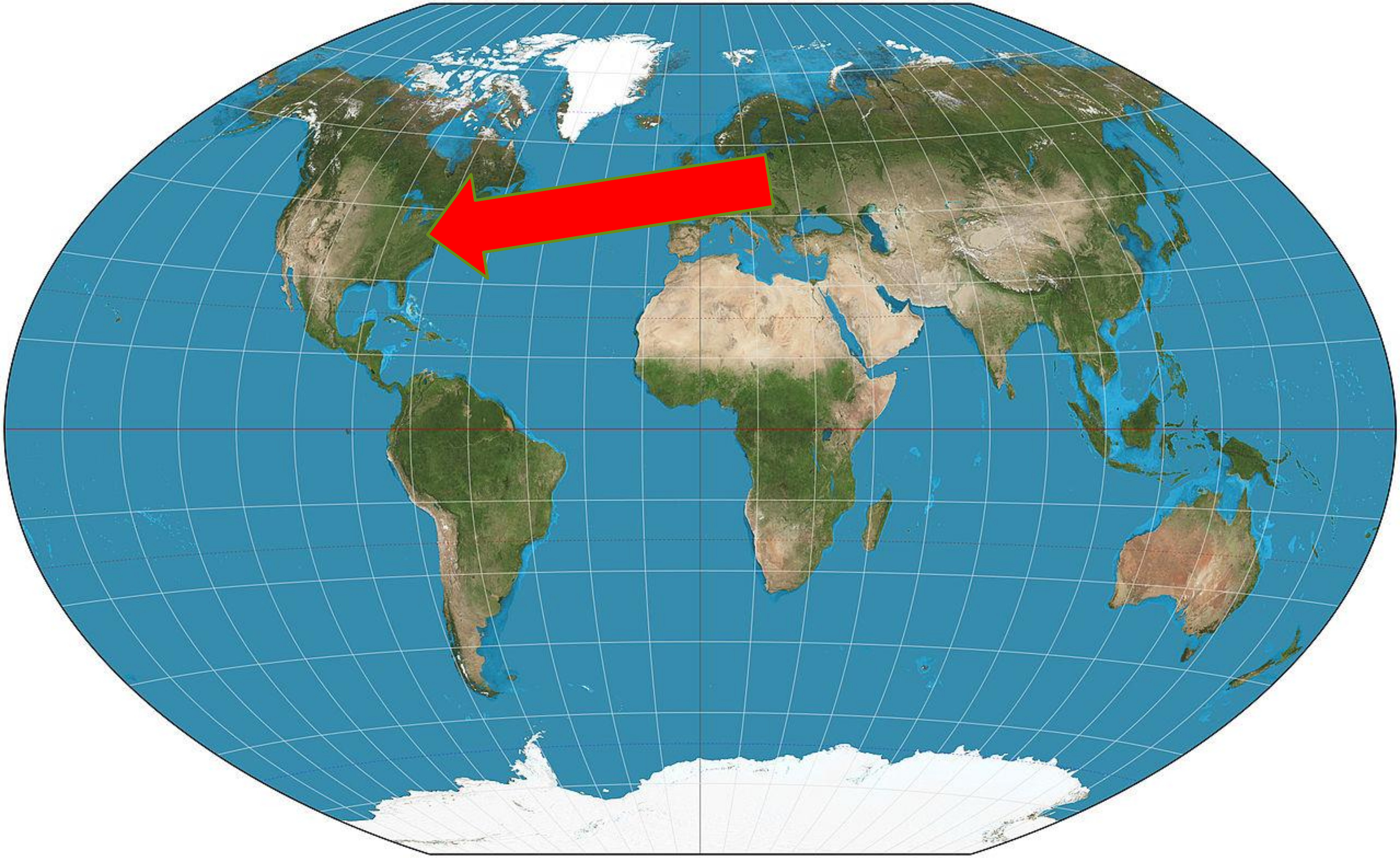
Five Levels of Invasion*

1. casual alien plants
2. naturalized plants
3. invasive plants
4. noxious plants
5. transformers

*Richardson, D. M., P. Pysek, M. Rejmanek, M. G. Barbour, F. D. Panetta and C. J. West. 2000. Naturalization and invasion of alien plants: concepts and definitions. Diversity and Distributions. 6: 93–107.



Invasion Process



https://en.wikipedia.org/wiki/World_map#/media/File:Winkel_triple_projection_SW.jpg

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Alien Plant Introduction to North America before 1860

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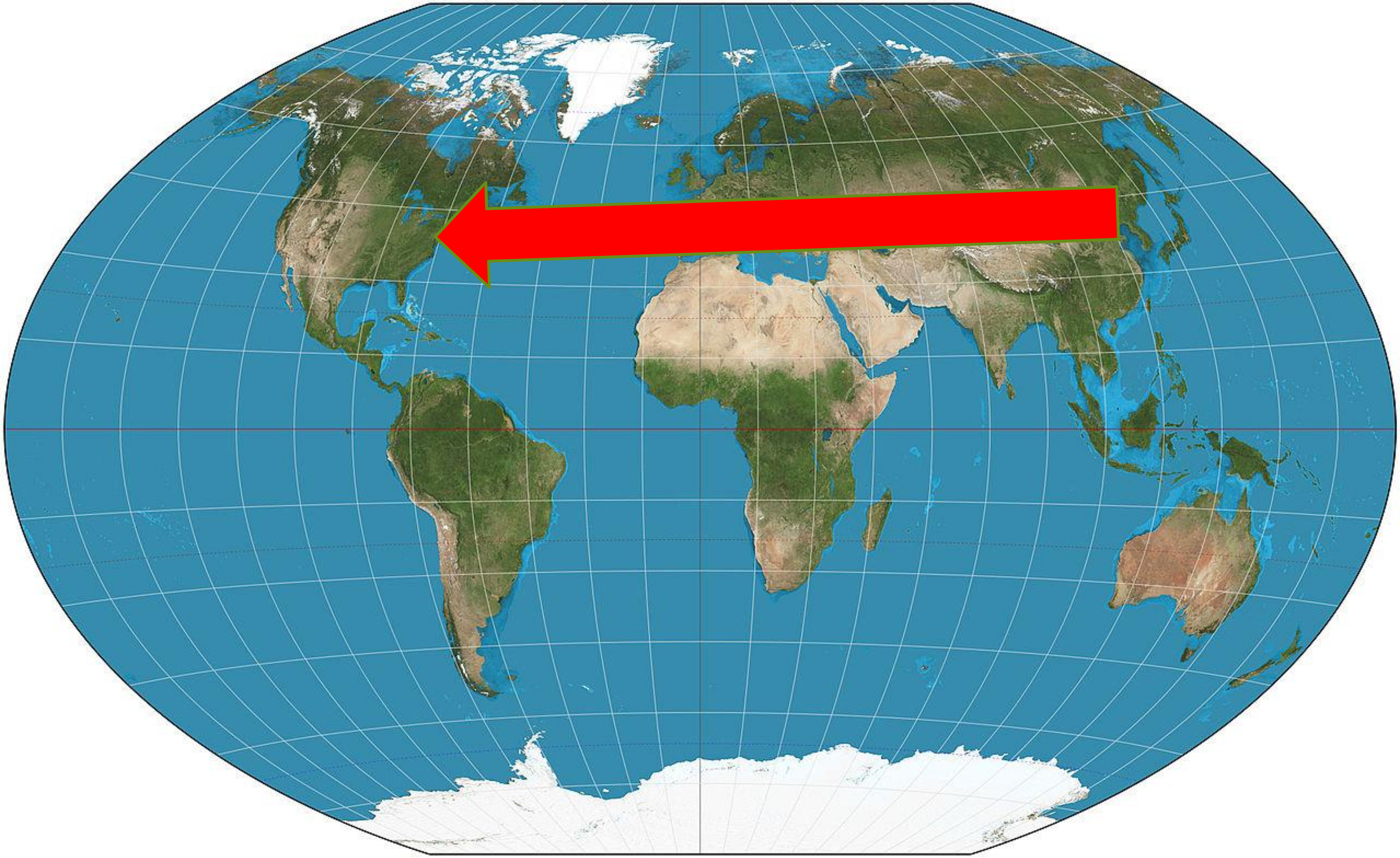
Alien Plant Introductions to North America before 1860



https://en.wikipedia.org/wiki/World_map#/media/File:Winkel_triple_projection_SW.jpg

Alien Plant Introduction to North America After 1860

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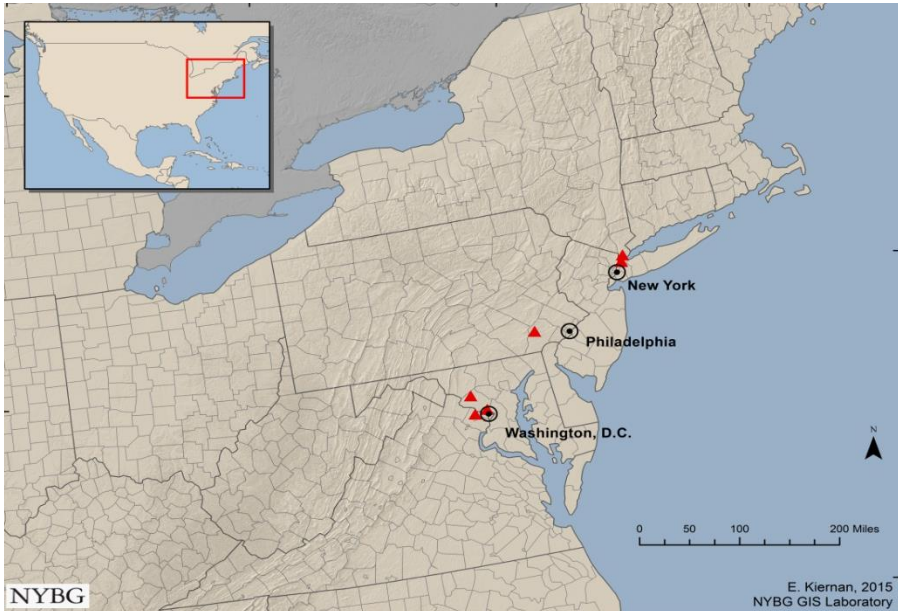
Alien Plant Introduction to North America After 1860



Description: Biennial or winter annual herb, 4 to 40 cm tall, seedlings growing from swollen roots. Mature plants with several stems from the base. Leaves highly divided, 2–12 cm long, segments sharply toothed. Inflorescences with 10–16 flowers. Fruits about 2 cm long, opening explosively. Seeds <1 mm diam, black and lustrous; flowering April to May.
Distribution and habitat: Native of Eastern China, Korea, Taiwan and Japan; currently known from New York, Pennsylvania, Maryland, Virginia, District of Columbia in gardens, wetlands and forests.
Reproduction: seeds are explosively ejected, float in water, attractive to ants.
Threats: Outcompetes other vegetation; can form dense stands.
Control: Hand pulling mature plants before fruit set; seedlings can be very numerous, but easy to pull.
Note: The species was first found in North America in 2005. The seeds are ejected up to 9 feet, float in water and have an oily body (elaiosome) attractive to ants. The swollen roots may serve as additional dispersal agents.

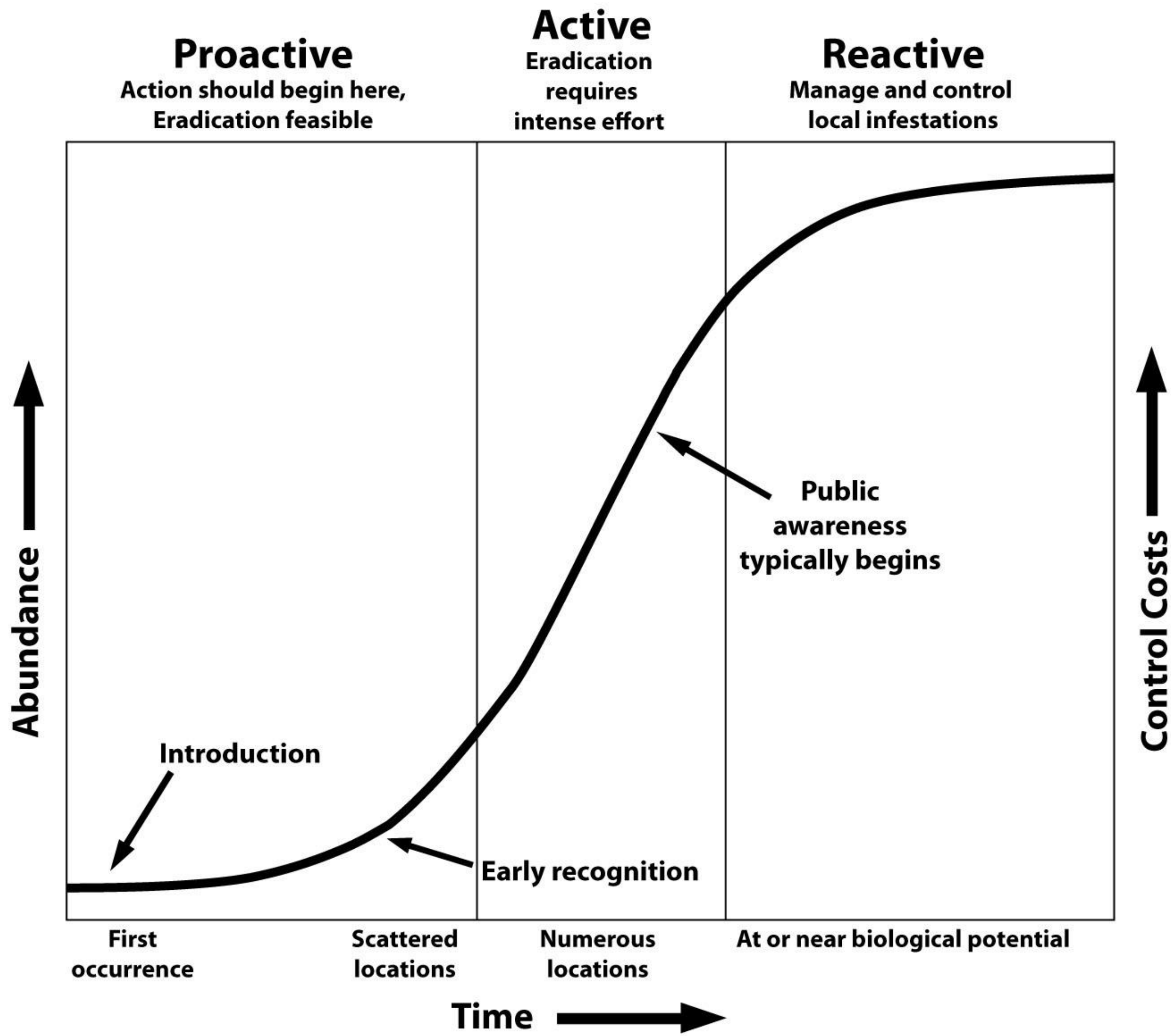
 Corydalis incisa **(Thunb.) Pers. – Incised Fumewort (Fumariaceae)**

NYBG/125 *Corydalis incisa* – Incised Fumewort (Fumariaceae)

Corydalis incisa **- flower and fruit**

Stop the spread before it’s too late!!

Ongoing Research



Invasion Process

- **Larry Haller**, chief economist, Poultry Programs, USDA Agricultural Marketing Service
- **Mary Farrah**, board member, Mid-Atlantic Invasive Plant Council
- **Debra Dreger**, Medical writer
- **Sarah Lumban Tobing**, formerly of NYC Parks
- **Danielle Bissett**, Ecological Restoration Project Manager, Wetlands and Riparian Restoration Forestry, Horticulture, and Natural Resources (NYC Parks)
- **Bobbi Angell**, artist
- **Jessica Arcate Schuler**, director of the Thain Family Forest, NYBG
- **Damon Little**, Informatics Manager, NYBG
- **Brenda Bates**, Westchester County Parks
- **Allison Granberry**, teacher, and students from Hostos-Lincoln Academy of Science

NYC Parks

NATIONALLY ACCREDITED PARKS WESTCHESTER COUNTY

LOWER HUDSON PRISM

BRONX river alliance

MID-ATLANTIC INVASIVE PLANT COUNCIL

Thank You!!

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NEW YORK BOTANICAL GARDEN

Distribution of *Nitellopsis obtusa* in New York, U.S.A.

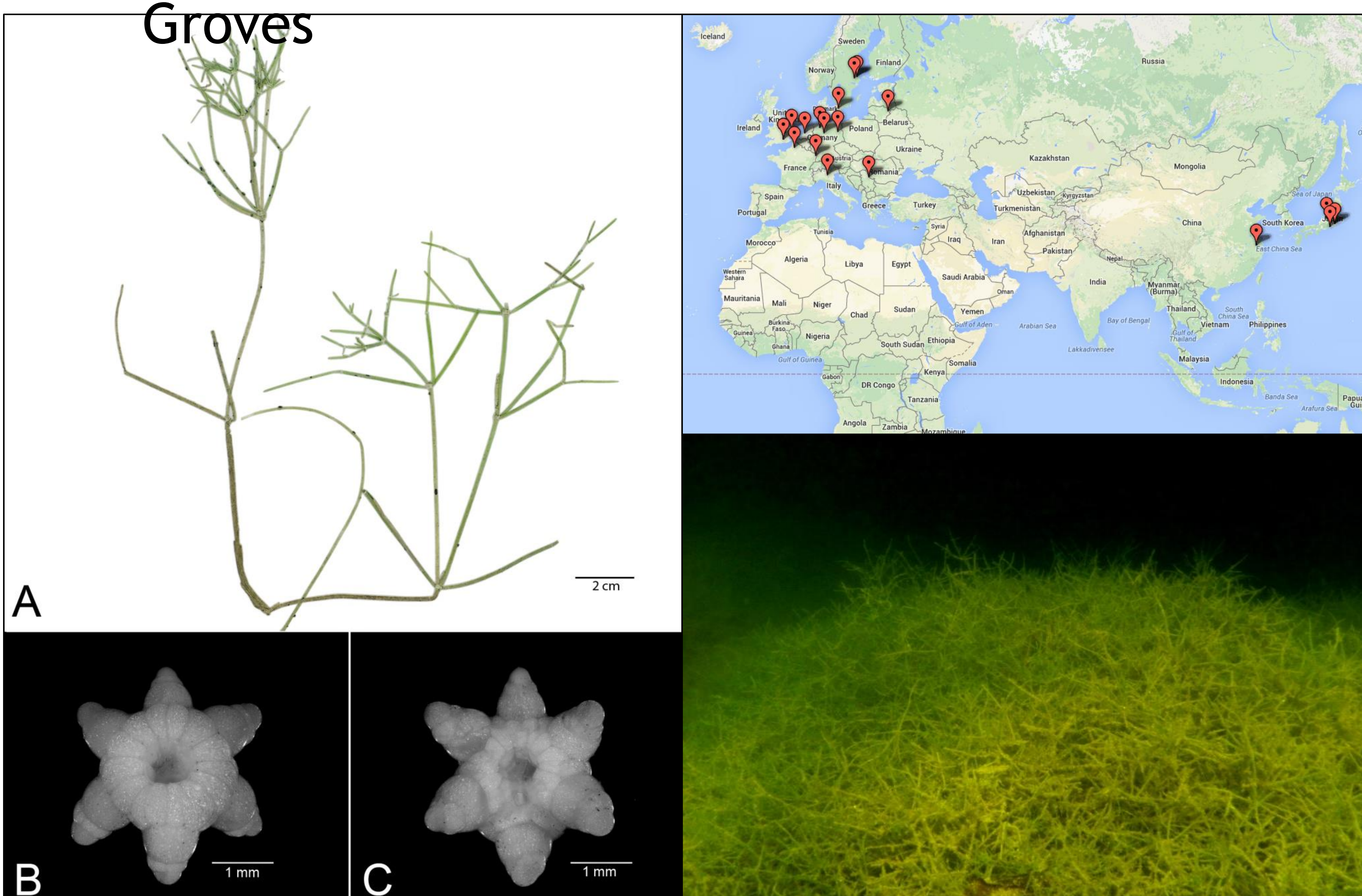
Robin S. Sleith

Lewis B. and Dorothy Cullman Program for Molecular Systematics, The New York Botanical Garden, Bronx, New York 10458, U.S.A.; [2]The Graduate Center, CUNY, 365 Fifth Avenue, New York, NY 10016 U.S.A.

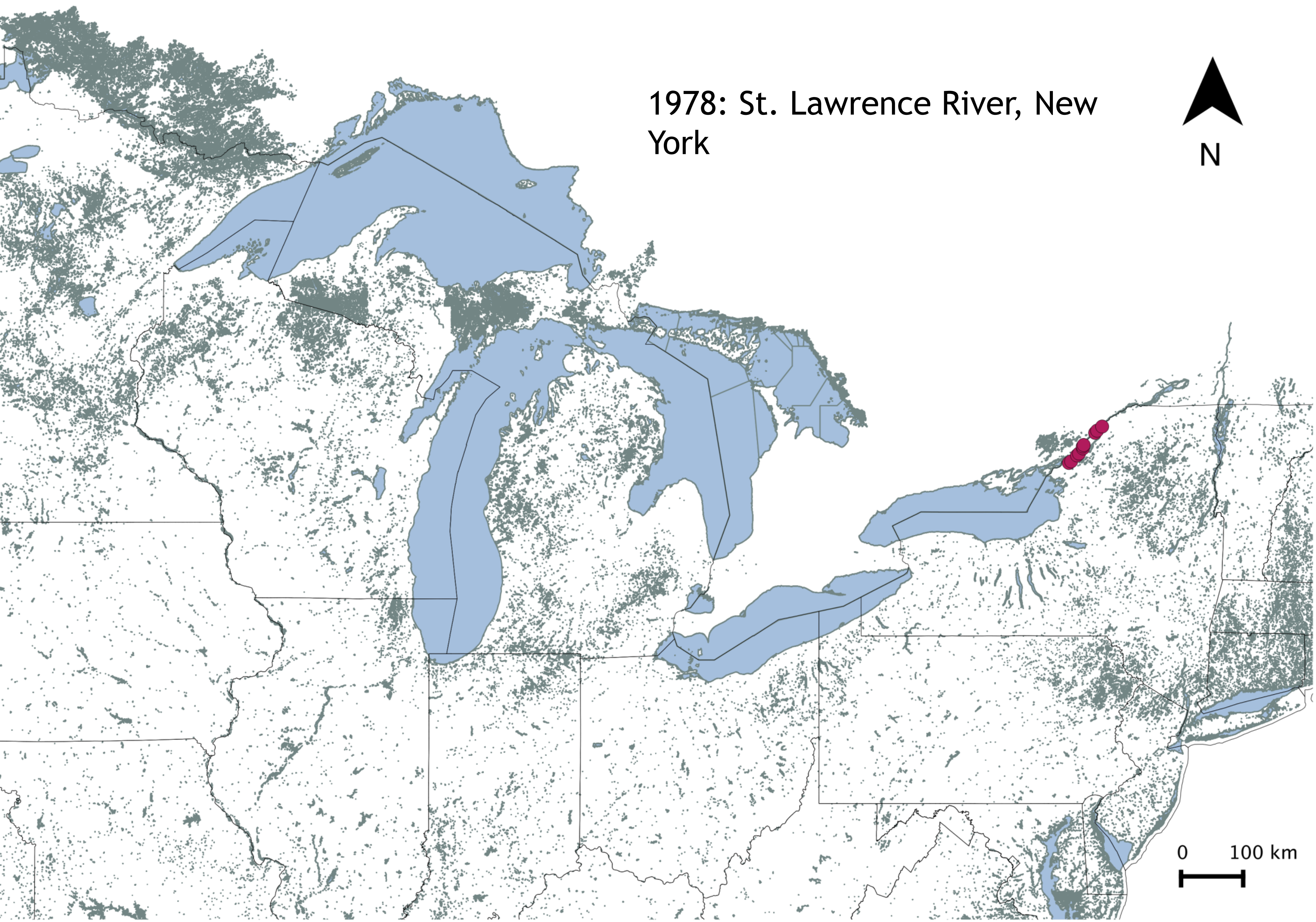
Aquatic Invasive Species

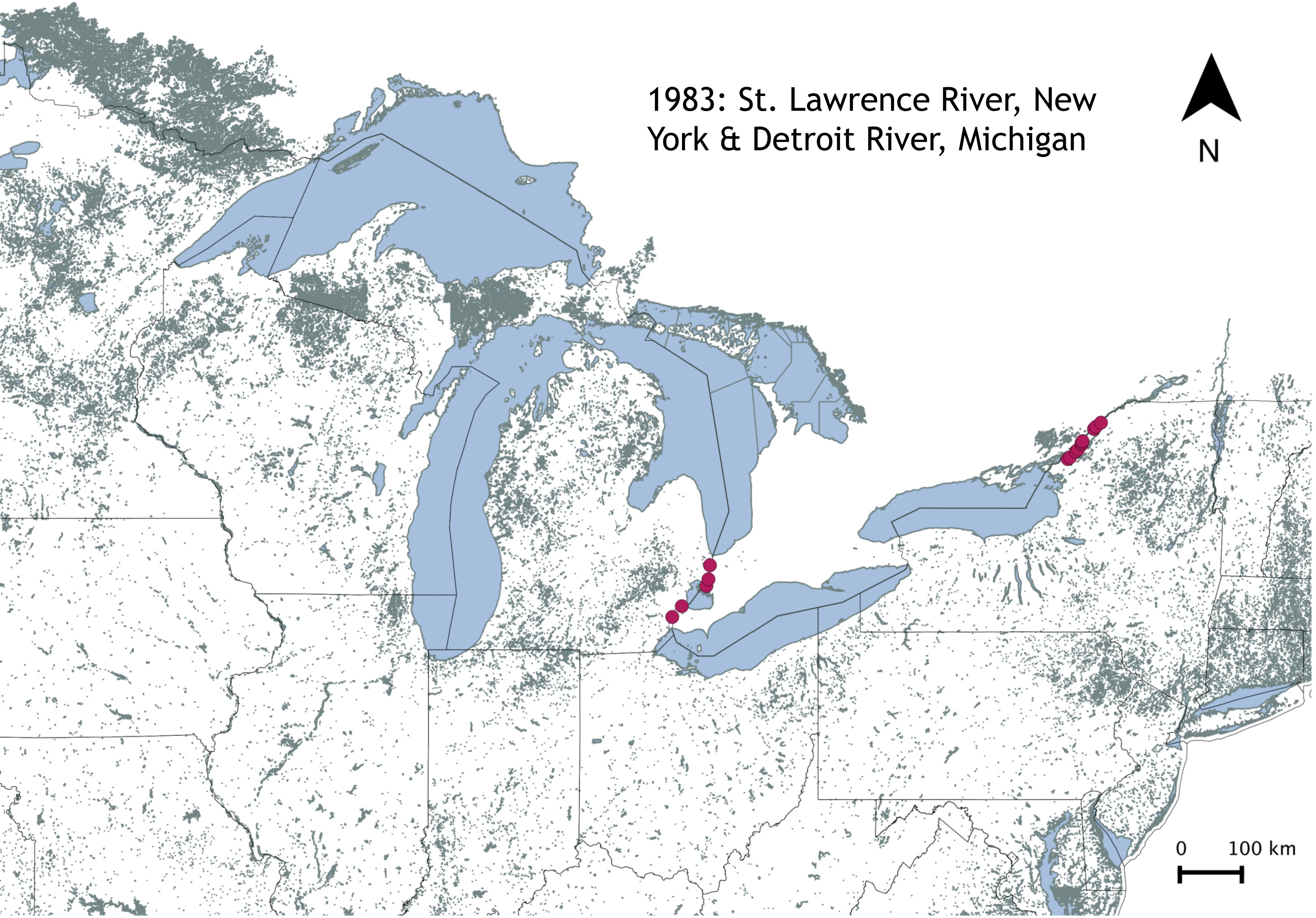
- Annual Damages: Billions of Dollars
- Sources: International Shipping, Aquarium Trade, Intentional Introduction
- Preventing introduction is single most effective strategy

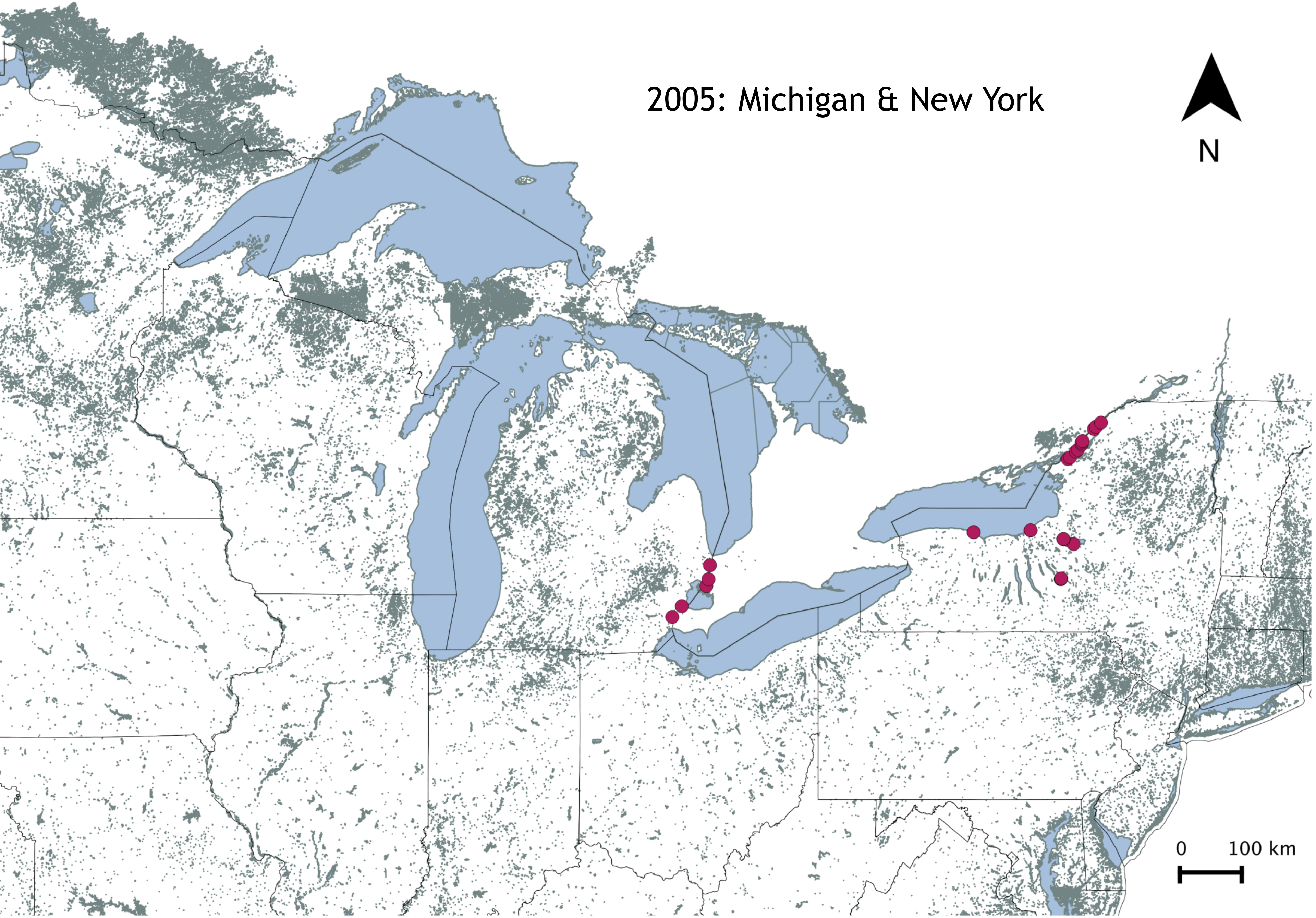
Nitellopsis obtusa (Desv. in Loisel.) J. Groves

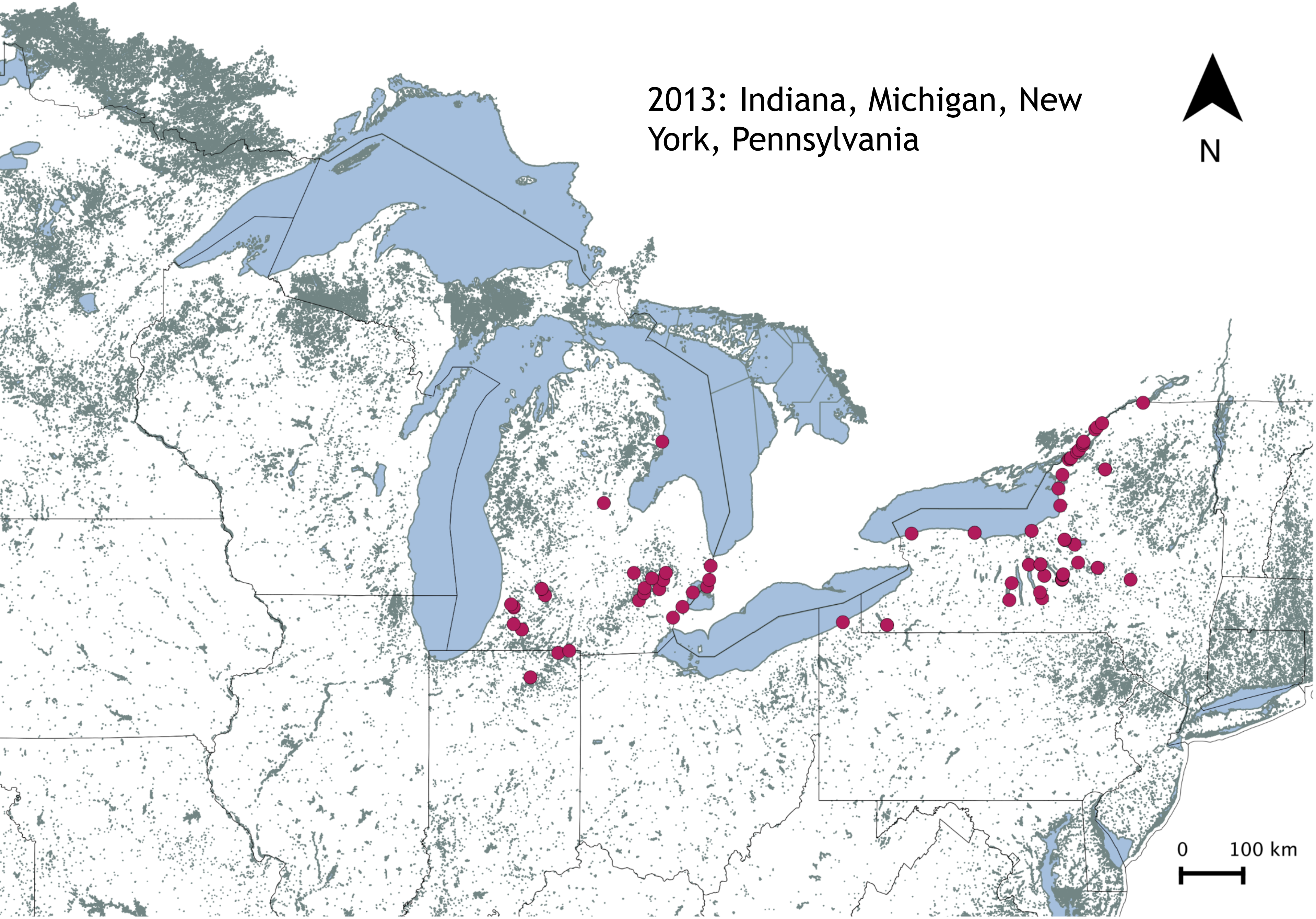


Impact

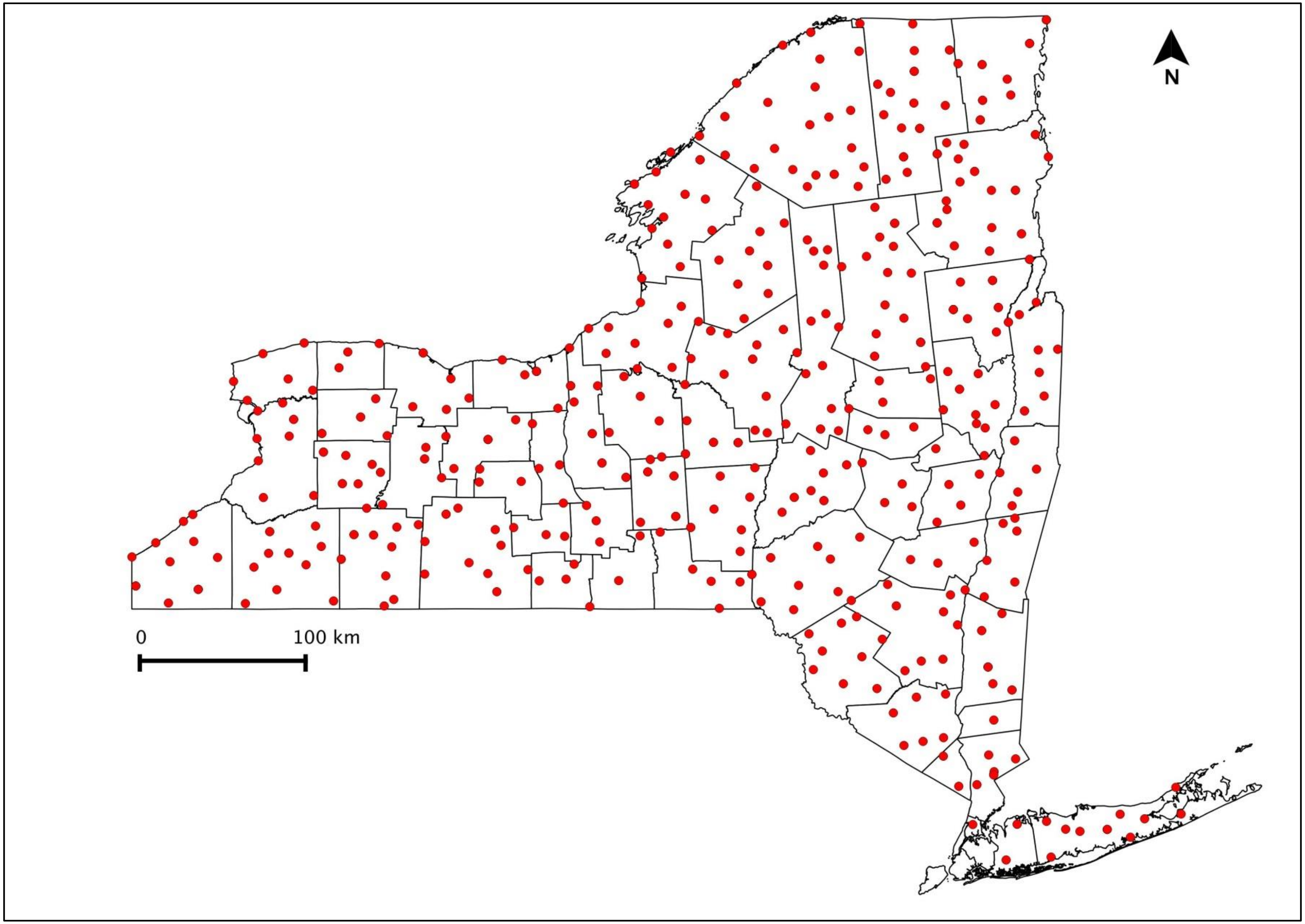

1978: St. Lawrence River, New York
N
0
100 km


1983: St. Lawrence River, New York & Detroit River, Michigan
N
0
100 km

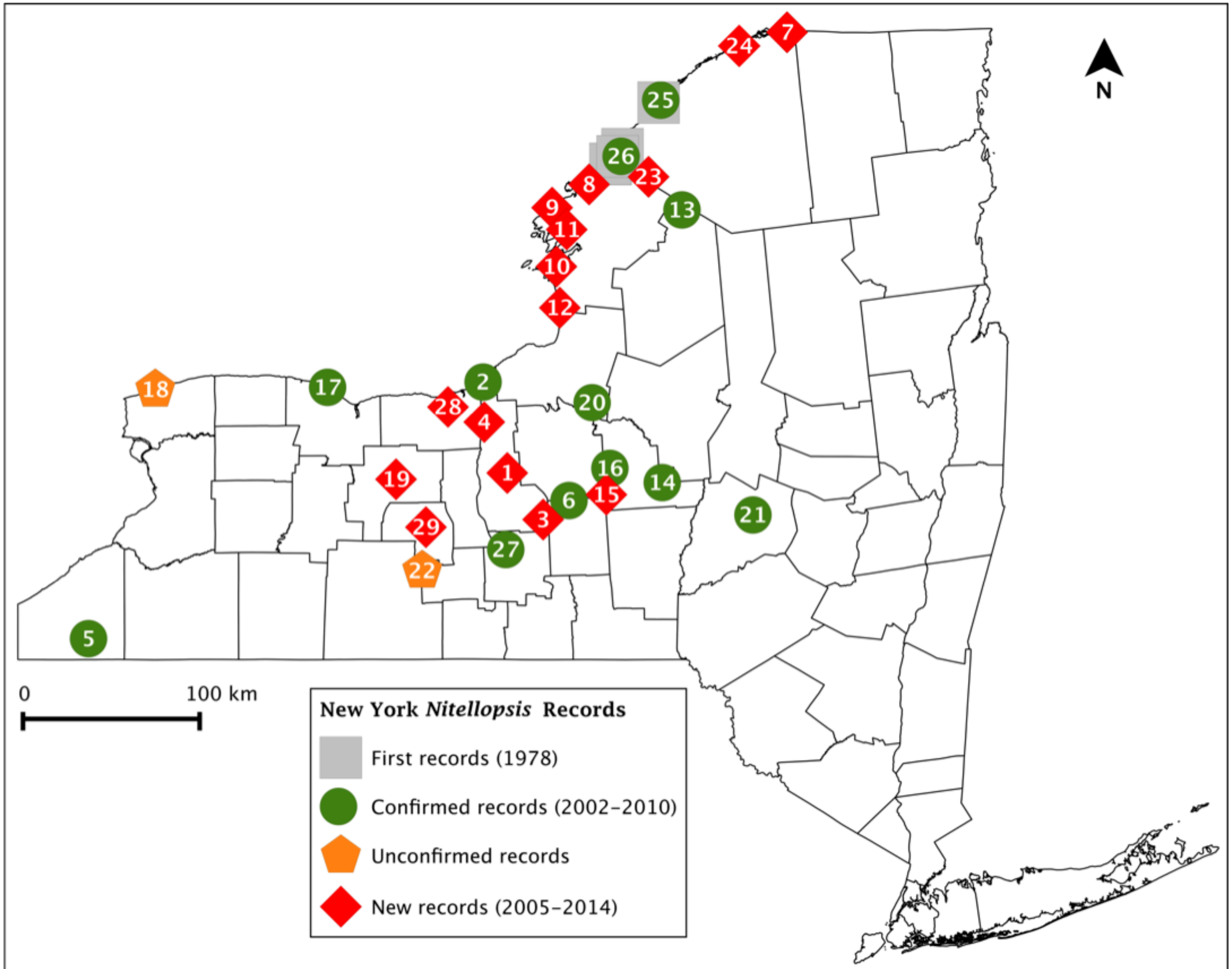

2005: Michigan & New York
N
0
100 km


2013: Indiana, Michigan, New York, Pennsylvania
N
0
100 km

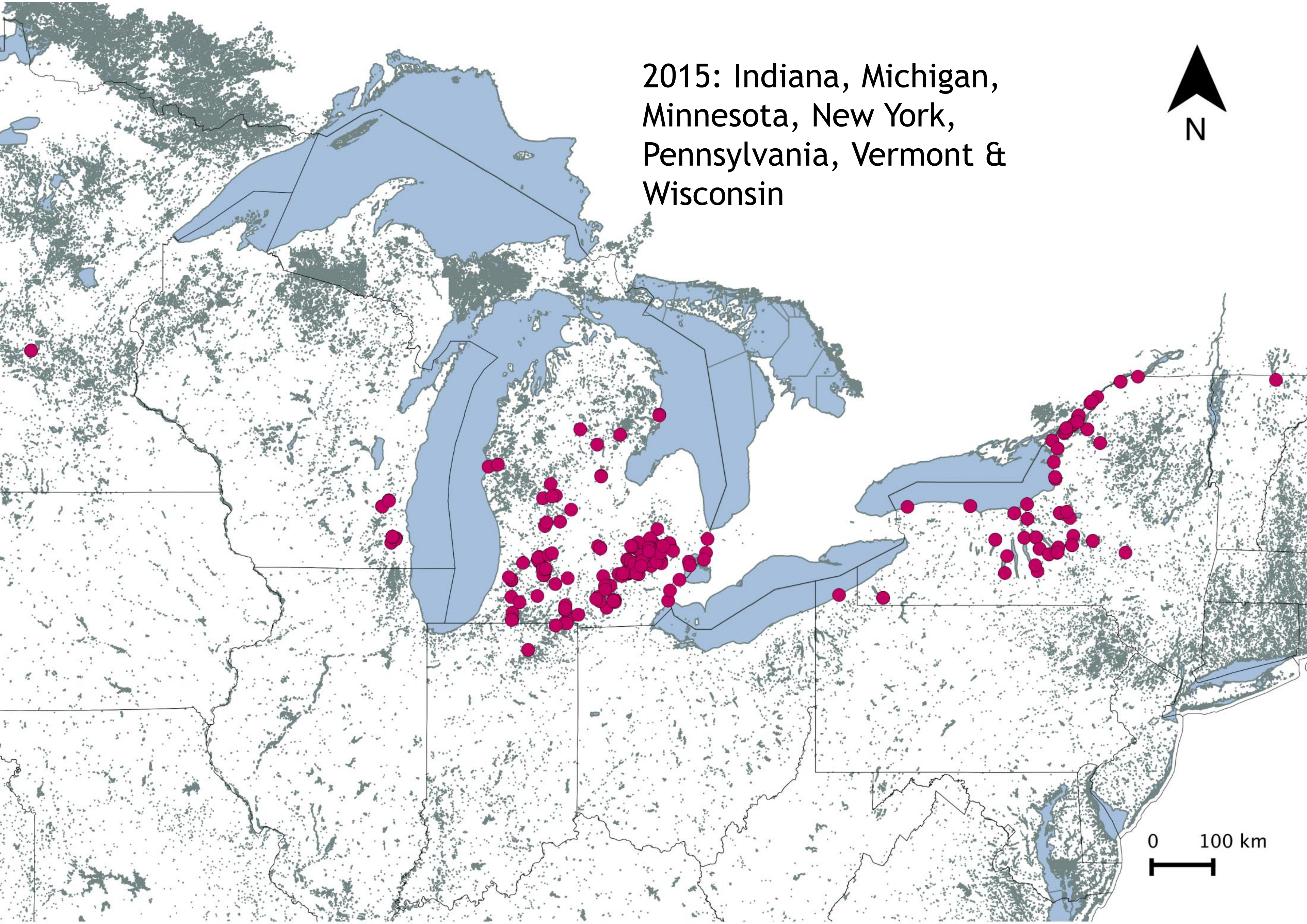
Summer 2014



- 390 waterbodies across New York
- Total Stonewort diversity



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


2015: Indiana, Michigan, Minnesota, New York, Pennsylvania, Vermont & Wisconsin
N
0
100 km

Water Chemistry

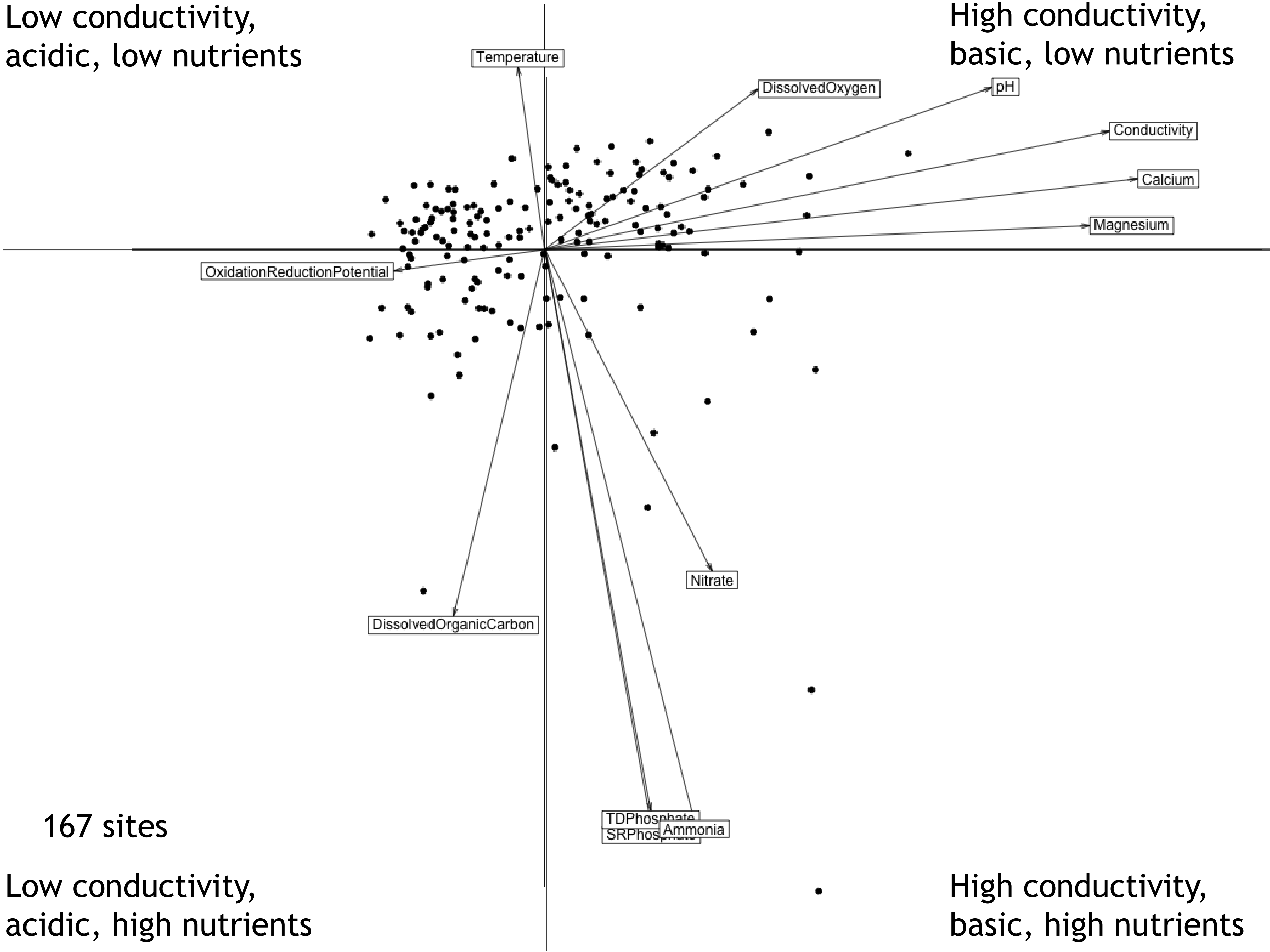
- Temperature (C)
- Dissolved Oxygen (mg/L)
- Oxidation Reduction Potential (mV)
- pH
- Conductivity (uS/cm)

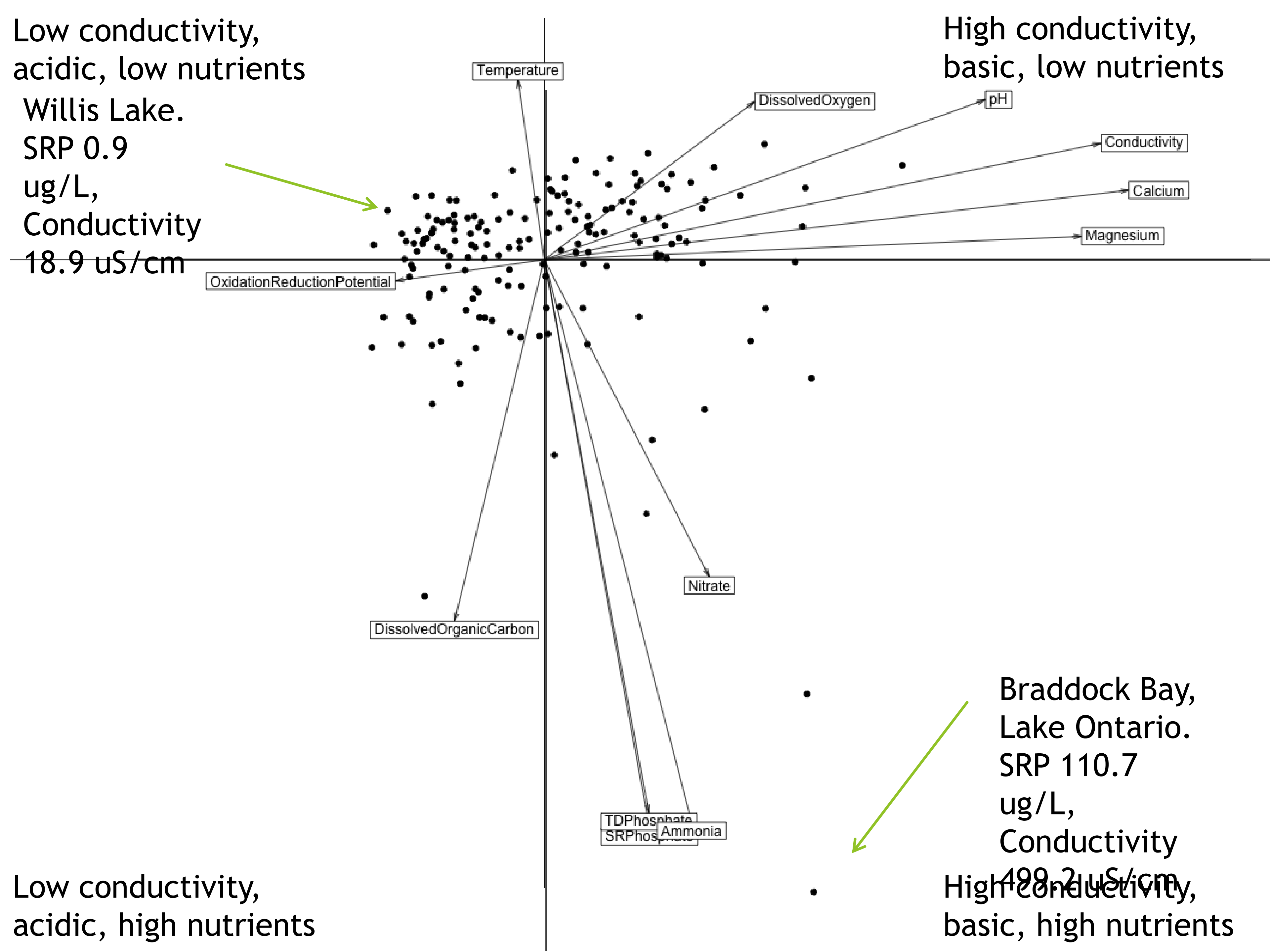
- ug/L of Nitrogen from Ammonia
- ug/L of Nitrogen from Nitrate
- ug/L of Phosphorus from Soluble Reactiv Phosphate (SRP)
- ug/L of Phosphorus from Total Dissolved Phosphorus (TDP)
- mg/L Dissolved Organic Carbon (DOC)

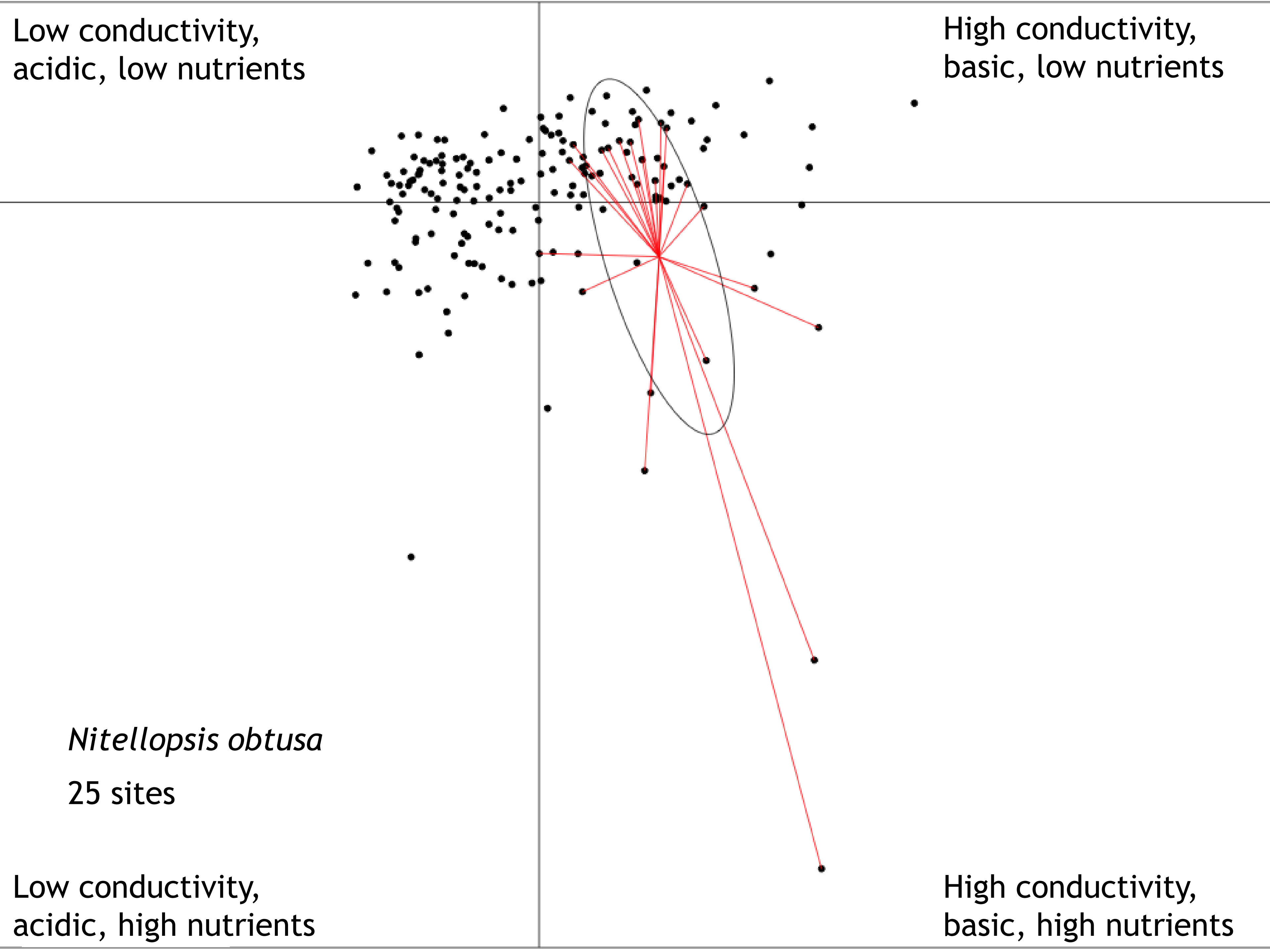
Outlying Mean Index
(Doledec et al., 2000)

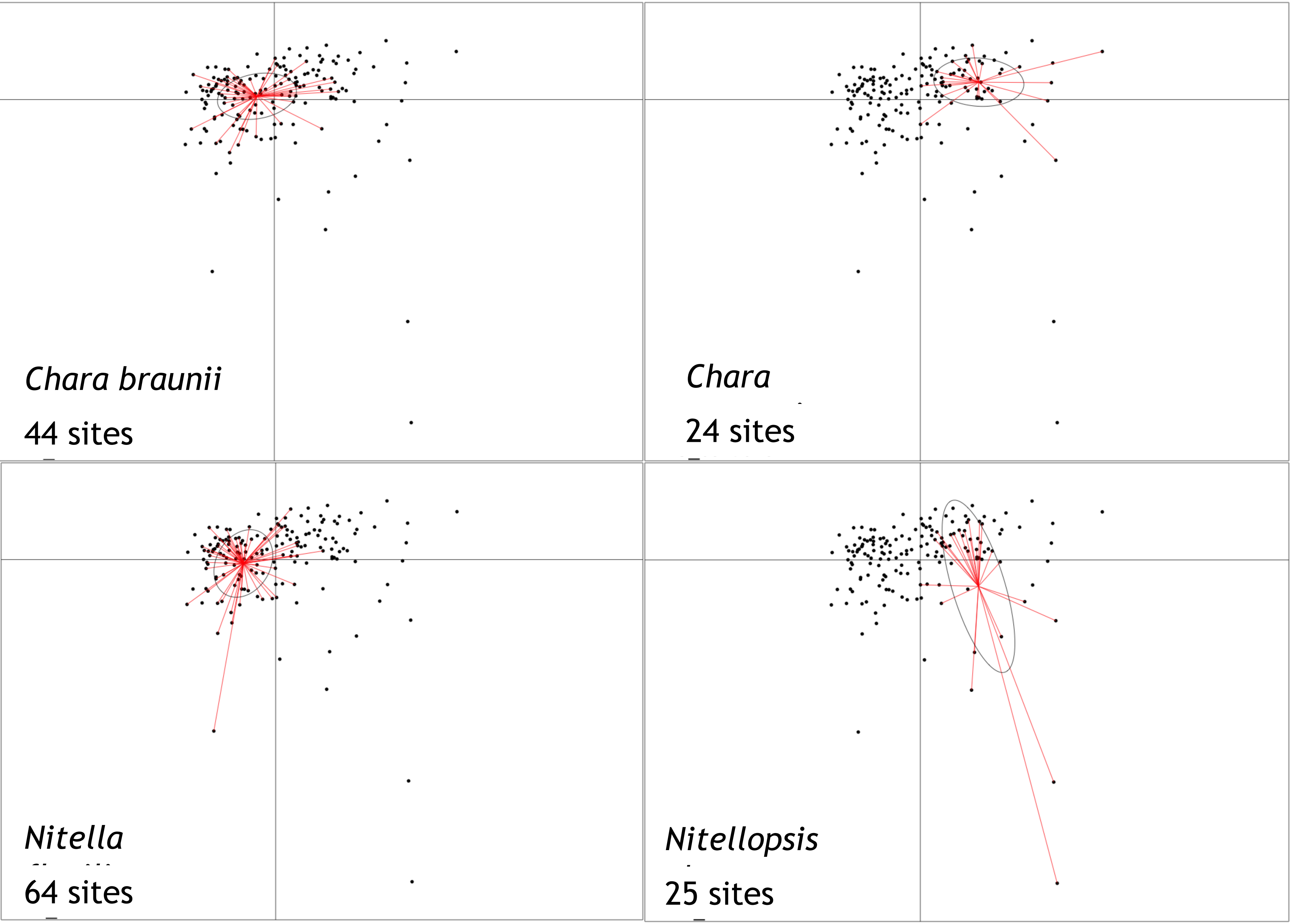
- OMI separates species based on their marginality

- 2 table approach
- No parameter transformations are needed
- No prior assumptions about the shape of the response curve
- Implemented with ade4 package in R


Low conductivity, acidic, low nutrients
High conductivity, basic, low nutrients
Temperature
DissolvedOxygen
pH
Conductivity
Calcium
Magnesium
OxidationReductionPotential
Nitrate
DissolvedOrganicCarbon
TDPhosphate
SRPhos
Ammonia
167 sites
Low conductivity, acidic, high nutrients
High conductivity, basic, high nutrients


Low conductivity, acidic, low nutrients
High conductivity, basic, low nutrients
Willis Lake. SRP 0.9 ug/L, Conductivity 18.9 uS/cm
Temperature
DissolvedOxygen
pH
Conductivity
Calcium
Magnesium
OxidationReductionPotential
Nitrate
DissolvedOrganicCarbon
TDPhosphate
Ammonia
Braddock Bay, Lake Ontario. SRP 110.7 ug/L, Conductivity 499.2 uS/cm
Low conductivity, acidic, high nutrients
High conductivity, basic, high nutrients


Low conductivity, acidic, low nutrients
High conductivity, basic, low nutrients
Nitellopsis obtusa
25 sites
Low conductivity, acidic, high nutrients
High conductivity, basic, high nutrients

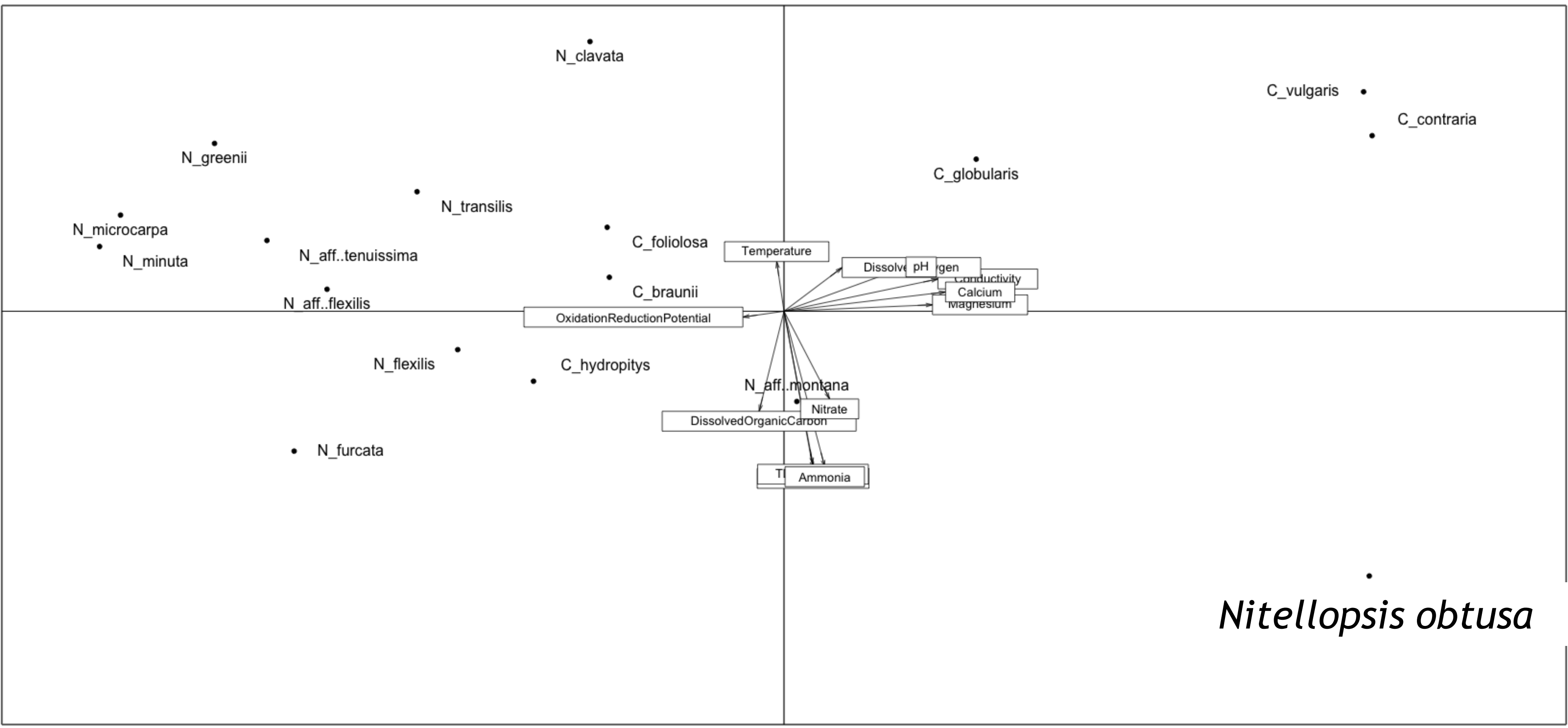


Chara braunii
44 sites
Chara
24 sites
Nitella
64 sites
Nitellopsis
25 sites

Low conductivity, acidic, low nutrients

High conductivity, basic, low nutrients

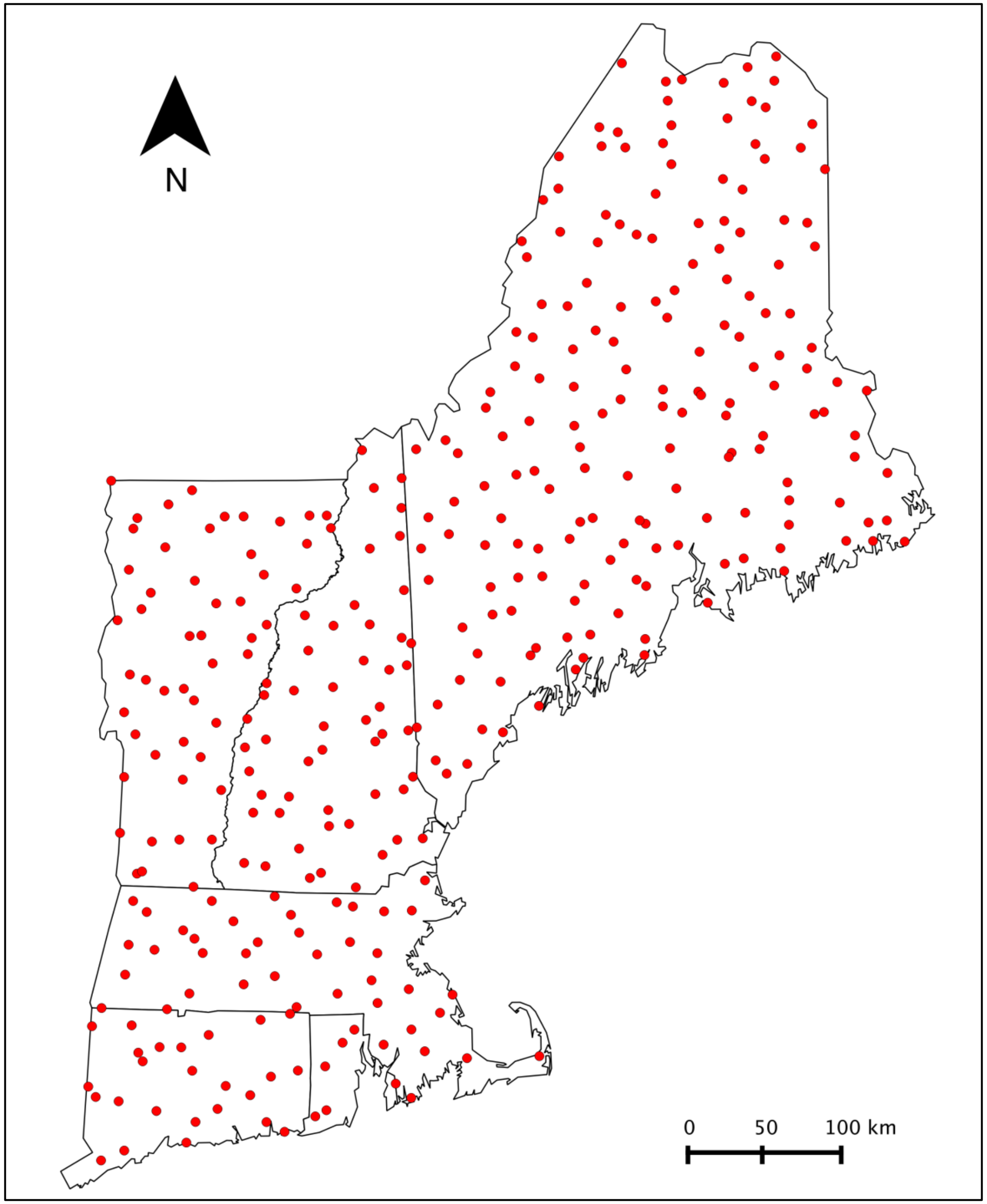
Species in OMI Space



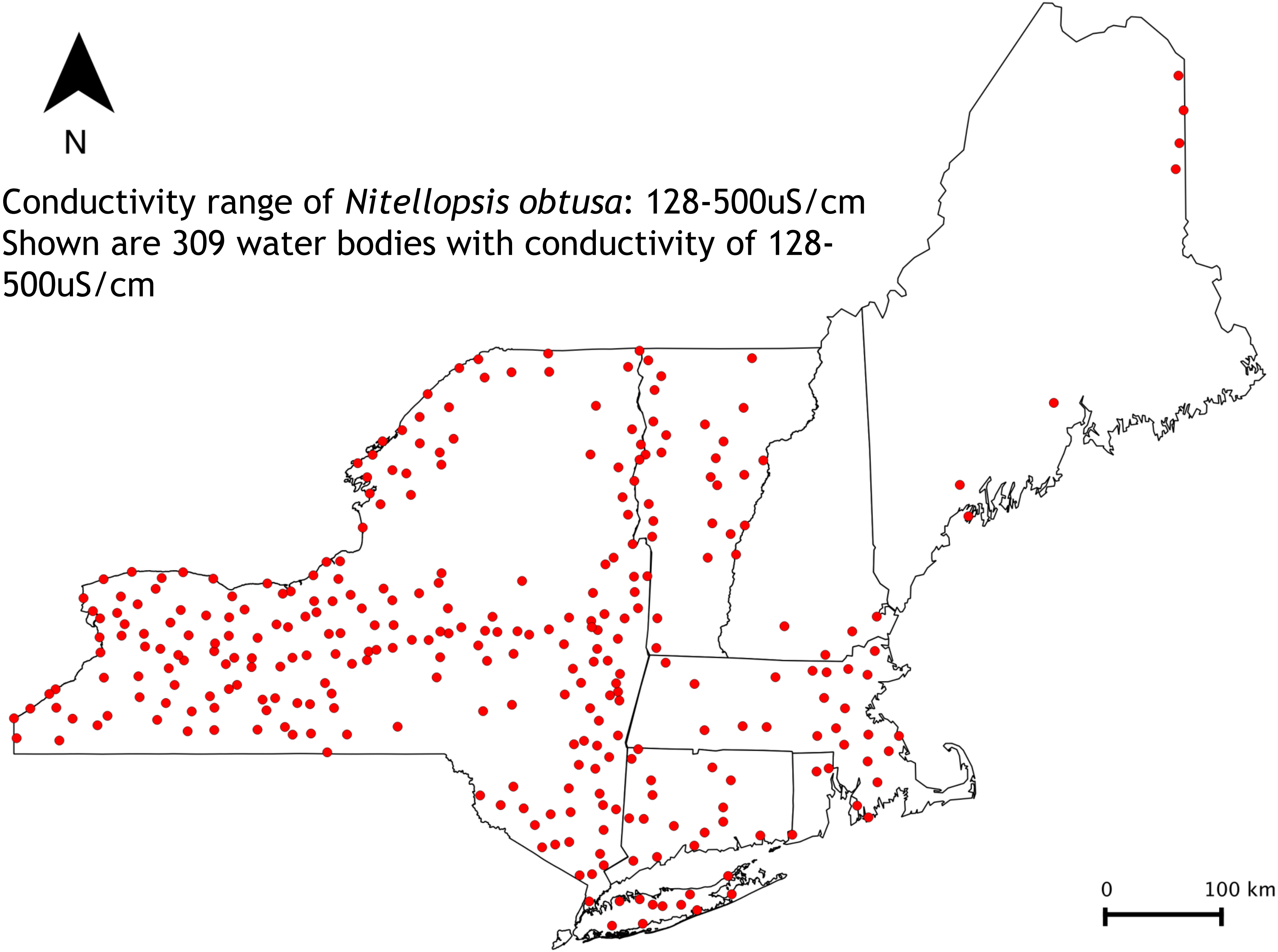
Low conductivity, acidic, high nutrients

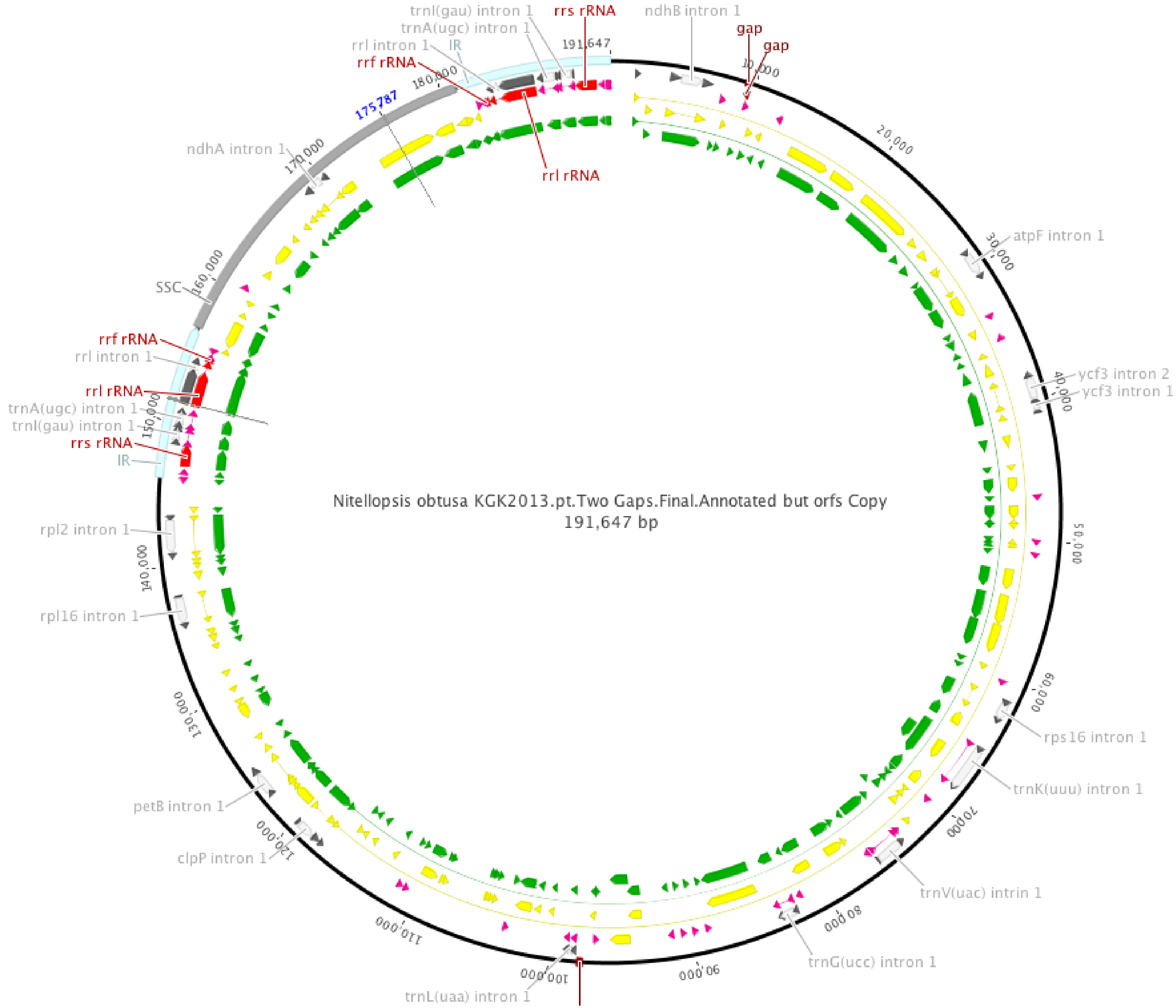
High conductivity, basic, high nutrients

2015 New England Survey



Conductivity range of *Nitellopsis obtusa*: 128-500uS/cm
Shown are 309 water bodies with conductivity of 128-500uS/cm




Nitellopsis obtusa KGK2013.pt.Two Gaps.Final.Annotated but orfs Copy
191,647 bp
trnI(gau) intron 1
trnA(ugc) intron 1
rrs rRNA
ndhB intron 1
gap
gap
rrl intron 1
IR
rrf rRNA
rrl rRNA
175787
ndhA intron 1
SSC
rrf rRNA
rrl intron 1
rrl rRNA
trnA(ugc) intron 1
trnI(gau) intron 1
rrs rRNA
IR
rpl2 intron 1
rpl16 intron 1
petB intron 1
clpP intron 1
trnL(uaa) intron 1
trnG(ucc) intron 1
trnV(uac) intrin 1
trnK(uuu) intron 1
rps16 intron 1
atpF intron 1
ycf3 intron 2
ycf3 intron 1

Acknowledgments

- Support provided by the Sarah K. de Coizart Article TENTH Perpetual Charitable Trust
- This material is based upon work supported by the National Science Foundation under grant numbers DEB-1020660 and DEB-1036466
- Dr. Kenneth G. Karol
- Amy J. Havens, Robert A. Stewart, Dario J. Cavaliere, Stephen D. Gottschalk
- Dr. John Wehr & Kam Truhn

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NEW YORK BOTANICAL GARDEN

Evidence for evolution of glyphosate tolerance, not resistance in Japanese knotweed

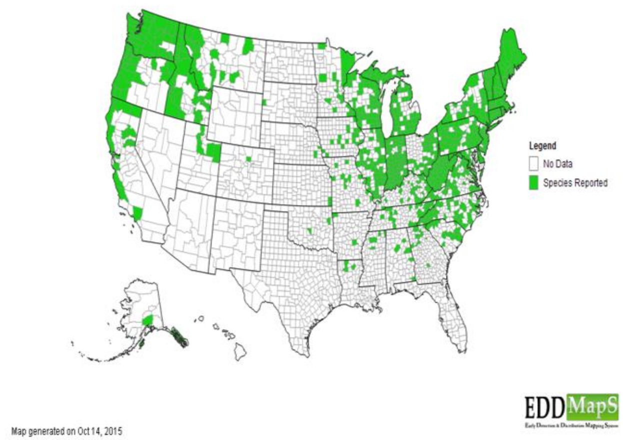
Acer VanWallendael, Henrique Valim, & Steven J. Franks
Fordham University

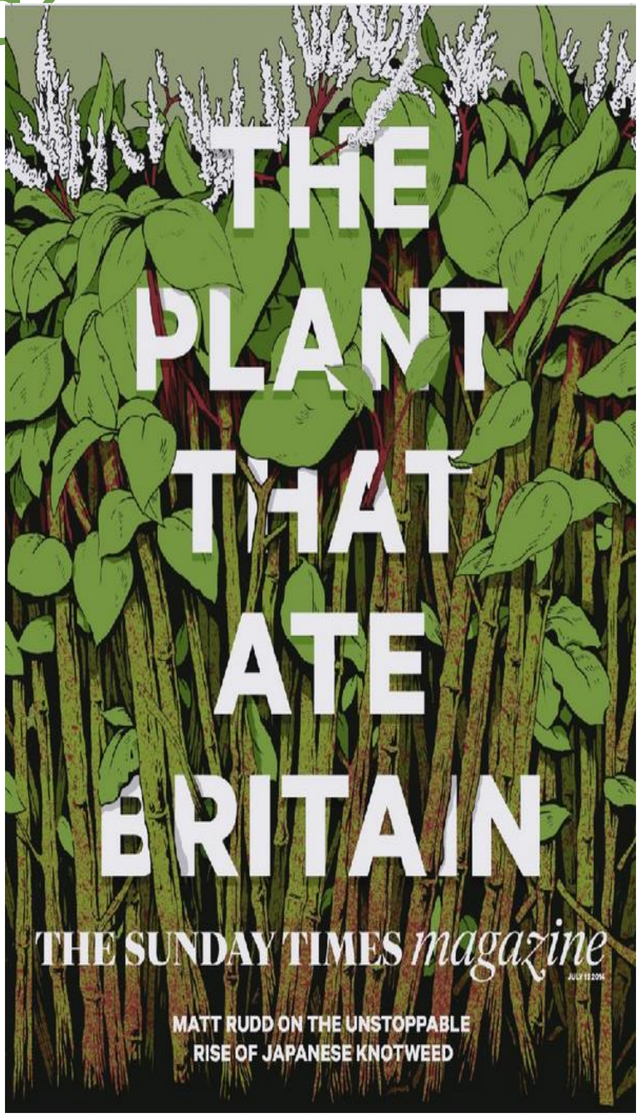
Outline

1. Background
2. Resistance vs. tolerance
3. Assaying for tolerance
4. Assaying for resistance
5. Results
6. Conclusions
7. Future Directions

What is Japanese knotweed?

Large, rhizomatous perennial
Fallopia japonica, Reynoutria japonica,
   Polygonum cuspidatum
Reproduces sexually and asexually, disputed
   which is predominant (Hollingsworth and Bailey 2000 vs Gammon et al. 2007)
Most effective treatment:
   stem injection

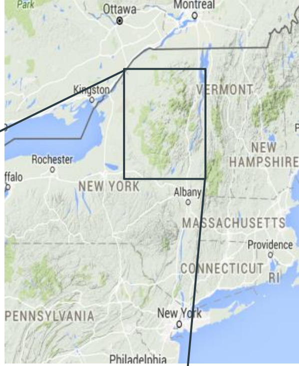


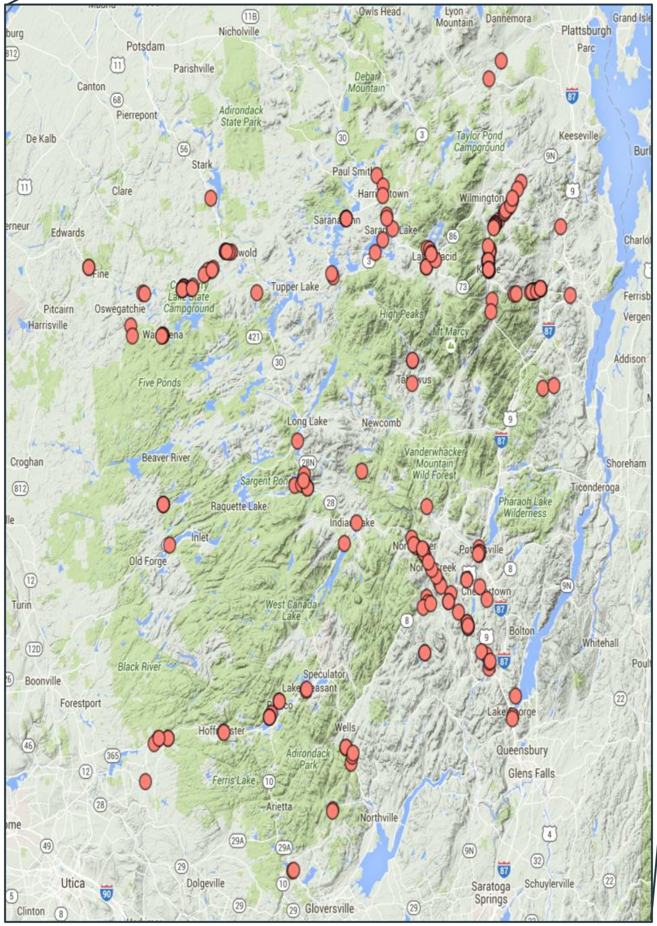


The Sunday Times

Background: Adirondack knotweed

- Since 2007, over 830 stands of knotweed have been treated, >100,000 canes
- Glyphosate-based herbicides (Roundup, Rodeo)
- At some locations, knotweed regrow following treatment
- Indication of **variation in response to herbicide**

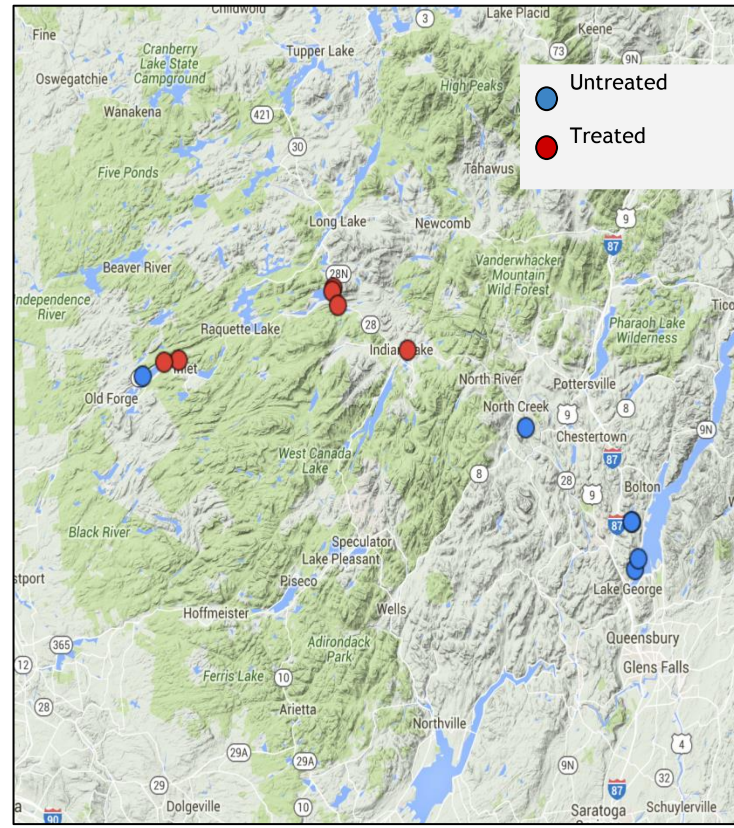




Selection for resistance or tolerance?

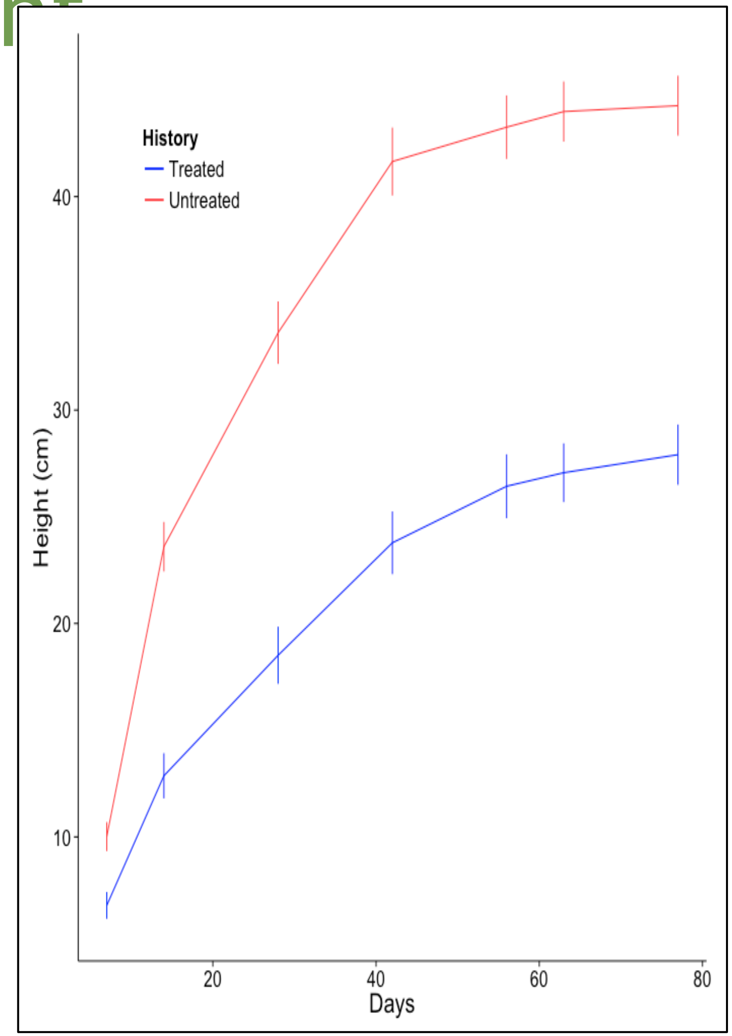
Do knotweed at historically treated sites show a difference in response to herbicide from those at historically untreated sites?

Rhizomes collected from six historically treated, six untreated



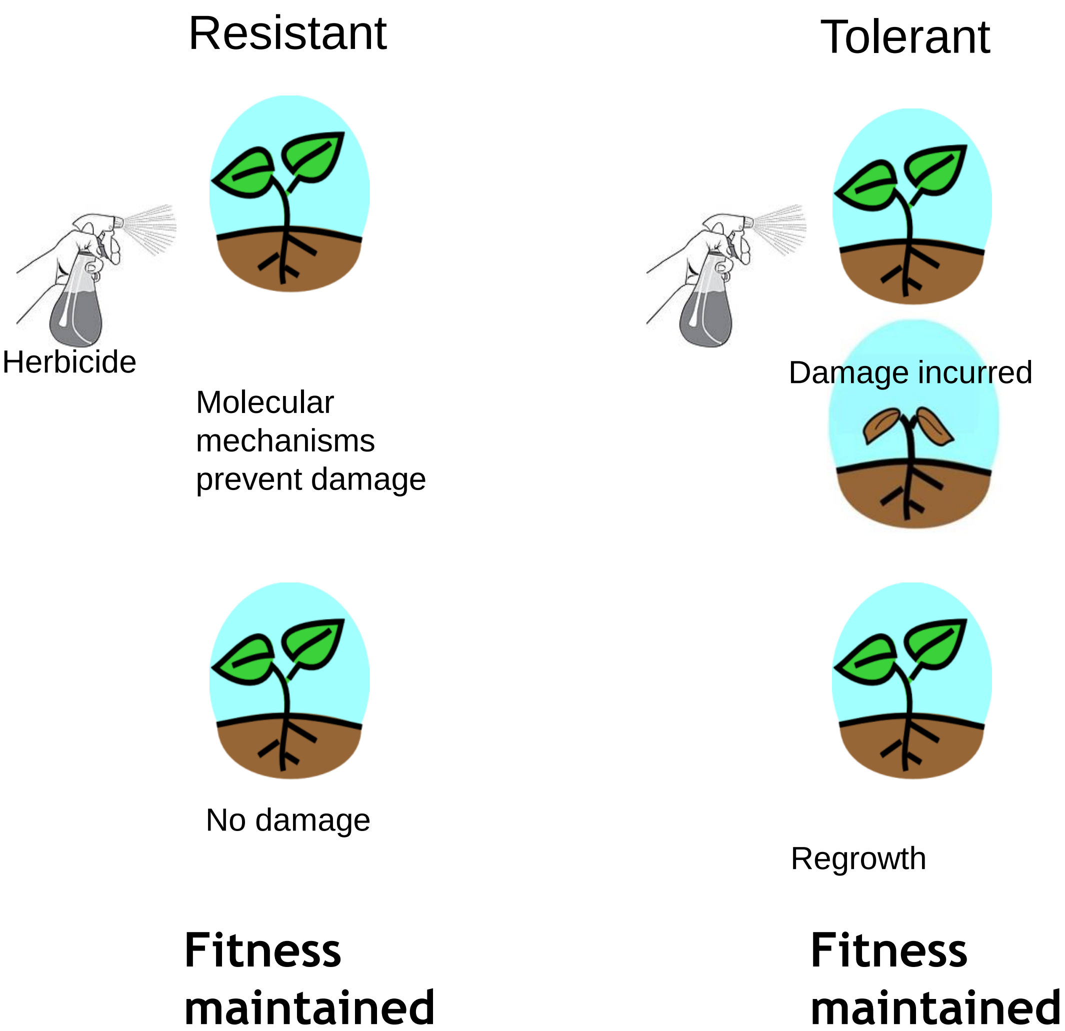
Are populations different

Growth in greenhouse over several months
Definite difference in growth between
historically treated and untreated
-Likely residual impact of glyphosate damage
-Indicates persistent difference based on treatment history



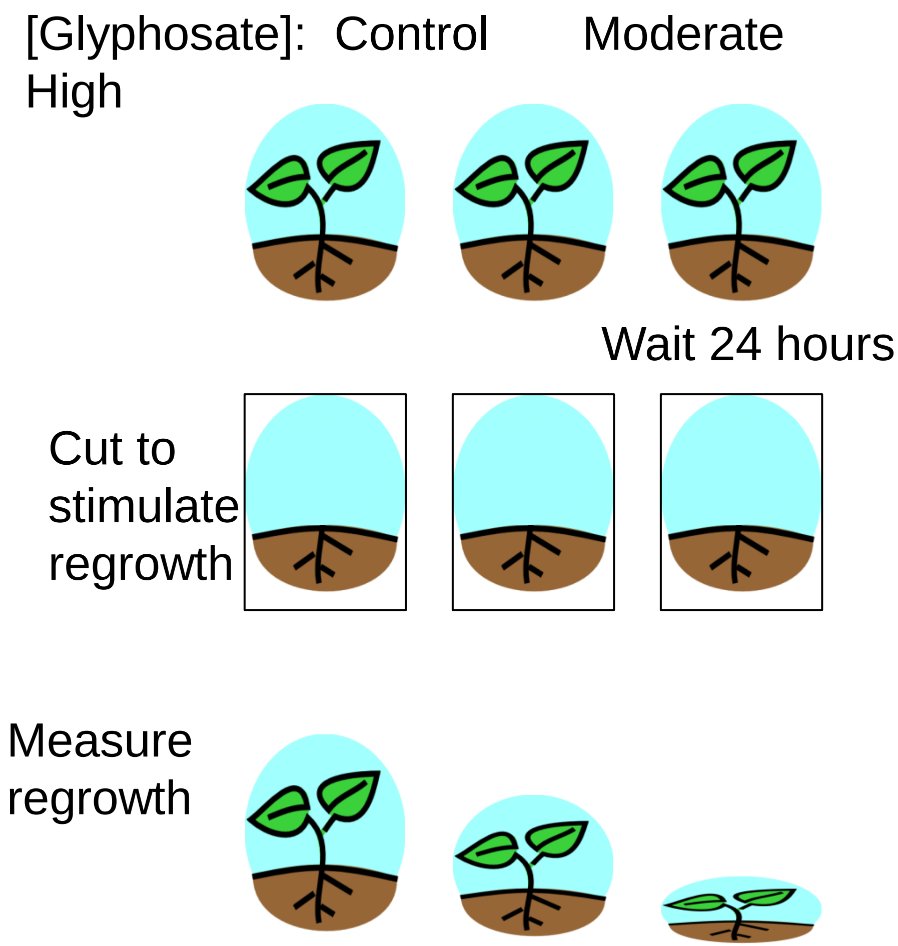
Error bars ±1 SE

Resistance versus tolerance (Baucom and Mauricio 2004)



- Resistant: biochemical mechanisms prevent damage from occurring
- Tolerant: growth after damage maintains fitness

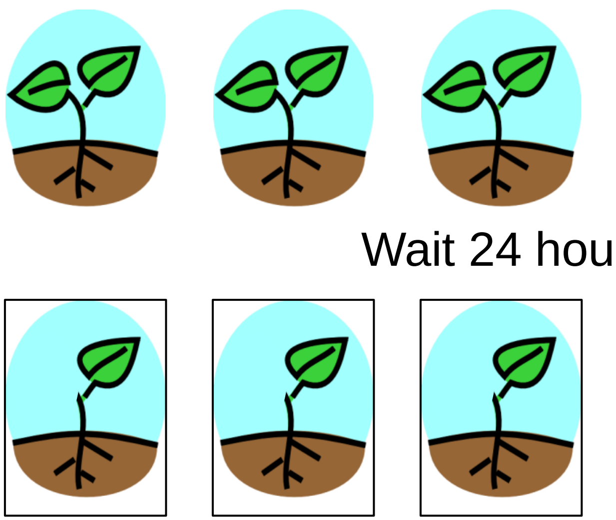
Assay for tolerance



- Glyphosate will damage plants
- **If tolerant: glyphosate concentration will have less impact on regrowth**
- **H_1: Historically untreated plants will have higher herbicide tolerance**

Assay for resistance

[Glyphosate]: Control | Moderate 0.5x dose | High 2x dose



Wait 24 hours

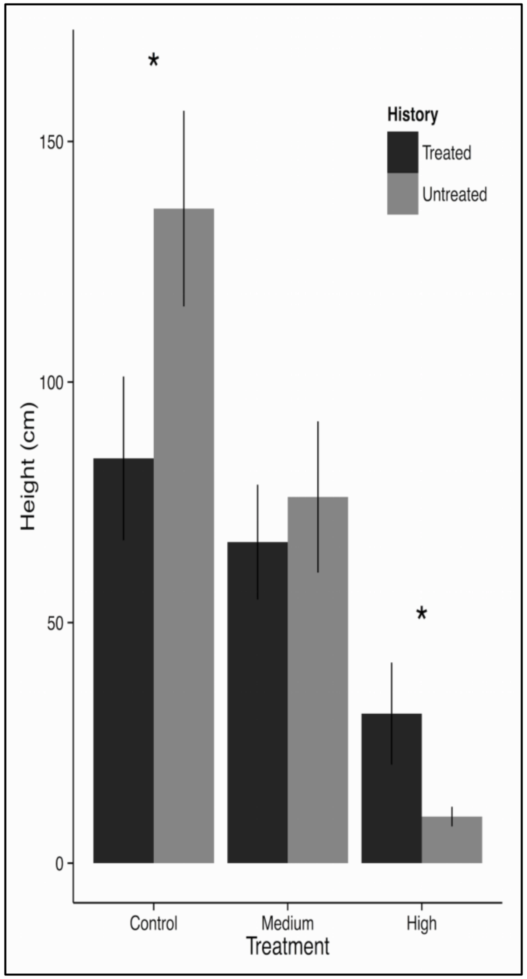
Harvest leaves

Extract and measure shikimate increase

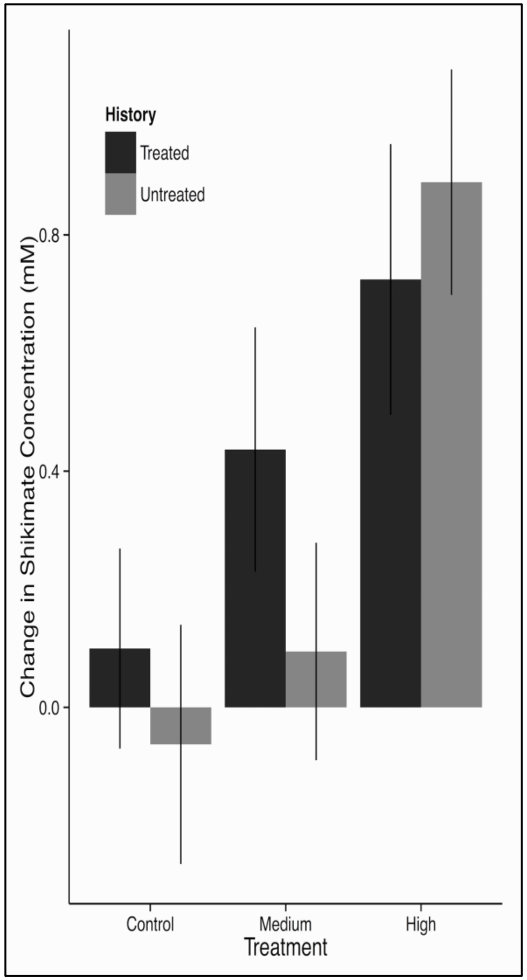
Control	Moderate 0.5x dose	High 2x dose
No Change	Small increase	Large increase

- Glyphosate blocks enzyme EPSPS - leads to shikimate accumulation
- **If resistant: no shikimate buildup**
- **H_2: Historically treated plants will have higher herbicide resistance**

Results: Yes tolerance, no resistance



Tolerance: Historically treated can re-grow following high glyphosate, untreated cannot. Error bars ±1 SE



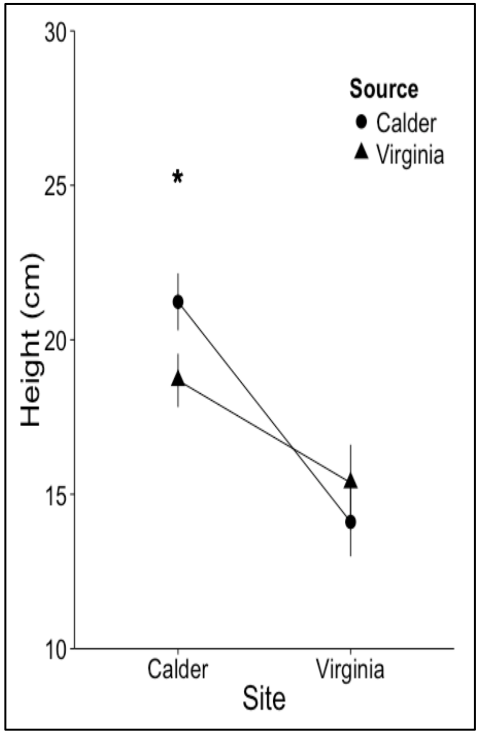
Resistance: no detectable difference between historically treated and untreated. Error bars ±1 SE

Conclusions

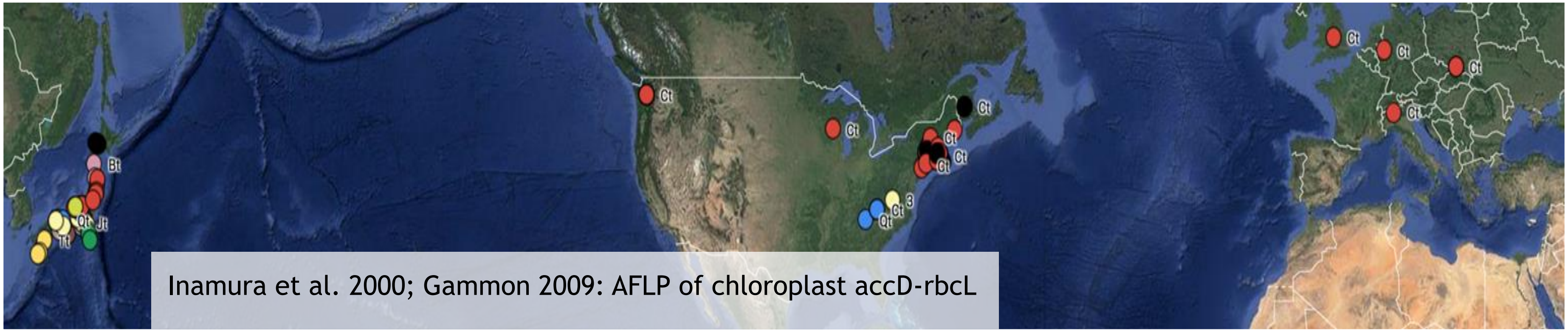
- Stands that have historically survived glyphosate treatment show increased tolerance to herbicide
- Evidence for either:
  - Selection for tolerance by herbicide treatment
  - Plastic response in tolerance to herbicide
- No evidence of resistance
- Managers should consider variance in tolerance to herbicides when attempting knotweed removal

Future directions

1. Local adaptation in Japanese knotweed



2. Genetic composition of US knotweed



Inamura et al. 2000; Gammon 2009: AFLP of chloroplast accD-rbcL

Acknowledgements

Assistance

Dr. Steven Franks and Henrique Valim

Douglas Johnson and Brendan Quirion

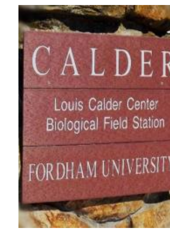
APIPP: Adirondack Park Invasive Plant Program

Dr. John Wehr

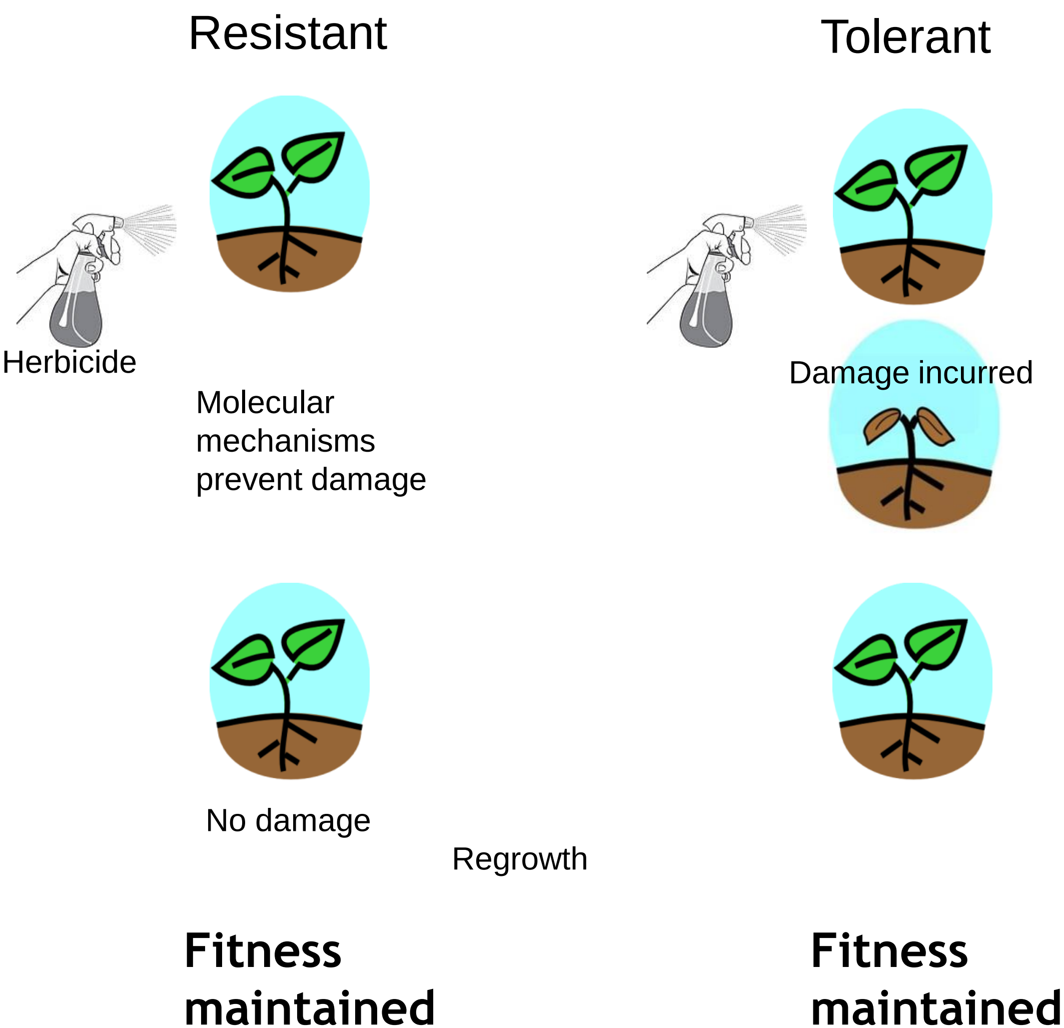
Funding

Fordham's Calder Center

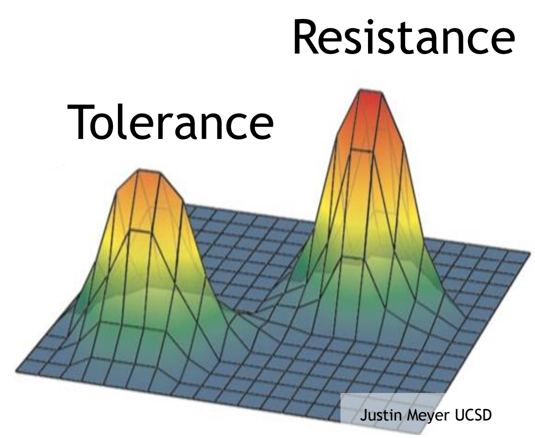
Fordham McCloskey Grant



Resistance versus tolerance (Baucom and Mauricio 2004)



- Resistant: biochemical mechanisms prevent damage from occurring
- Tolerant: growth after damage maintains fitness



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