Prediction of starry stonewort invasion risks in Minnesota and Wisconsin based on lake level habitat suitability

Where is starry stonewort going?

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July. 13, 2017
A comparison of eigenvalue decomposition and machine learning approaches for estimating distribution of a non-equilibrium species

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Figure 2.14. Public Waters in the Shingle Creek and West Mississippi watersheds.
Collaborators

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• Megan Weber
Starry stonewort working group

• MN DNR
• University of Wisconsin
  • Paul Skawiski
• Central Michigan University
• New York Botanical garden
  • Ken Karol and Robin Sleith
• University of Geneva
Starry Stonewort

Scott Brown

Starry stonewort
Photo by Paul Skawinski
Starry stonewort

*Nitellopsis obtusa*

- Green alga

Three domains of living organisms
(Gogarten, Taiz et al. 2015)
Starry stonewort

- Charophyte
- Closely related to stoneworts / muskgrasses native to Minnesota
- Ecologically important
  - Water quality
  - Habitat

McCourt et al. 1996

Chara
Lamprothamnium
Nitellopsis
Lychnothamnus
Nitella
Tolypella (sec. Rothia)
Tolypella (sec. Tolypella)
Coleochaete

Chara aspera  C. contraria  Nitella flexilis
Invasion history

- Relatively new invader
- Quickly gaining ground
- Increasing concern for AIS management
- Currently in 9 lakes in MN
Present distribution

Where will it go?
Ecological niche modeling

• Species distribution models
• Habitat suitability models
• Bioclimatic models
• MaxEnt
Ecological niche modeling
Ecological niche modeling
Ecological niche modeling

- pH
- Conductance
- N
- P
- Secchi
- ChlA
Determining the niche

Information from the current distribution
Determining the niche

Information from the current distribution

Conductance (µS)
Determining the niche

Information from the current distribution

Total N (mg/L)
Determining the niche

Information from the current distribution

pH
8.14
8.51
7.08
7.56
7.50
7.78
6.88
8.96
7.75
8.68
8.20
8.75
7.75
8.15
Challenges for predicting risk

- Is the current range all of the suitable habitat?
- Have you measured all the important factors?
- Biotic vs Abiotic constraints

DATA!
Environmental data
Environmental data

Realized niche shift associated with the Eurasian charophyte *Nitellopsis obtusa* becoming invasive in North America

Luis E. Escobar,1,2, Huijie Qiao,1, Nicholas B. Larkin,1,2,3 Daniel J. Jaffe,1,4

*Nitellopsis obtusa* (starry stonewort) is a dioecious species that is now an aquatic invasive in North America. Correspondence and requests for materials should be addressed to L.E.E. (email: lescobar@umn.edu)

Understanding how certain species experience great success outside of their native ranges, or become invasive in new areas, is of primary interest to ecologists and conservationists alike. It is true that many invasive species occupy niches very similar to those in their native ranges, with little evidence for evolutionary change. However, for some species, niche shifts have been documented that may play a role in their ability to successfully establish in areas where they were previously absent. These changes could include shifts in phenology, morphology, physiology, or behavior, and may result from natural selection or from human-mediated introduction. Understanding the causes of niche shifts and their implications for invasion risk is an important goal in ecology.

In the case of *Nitellopsis obtusa*, an aquatic invasive in North America with origins in the Eurasian region, we have investigated environmental variables associated with invasion risk. Using species records, climate and land surface temperature data, and remotely sensed environmental variables, we have found that *N. obtusa* is exploiting novel ecological niche space in its introduced range, which may help explain its invasiveness. While there appears to have been a shift in its realized niche associated with invasion in North America, there is still a shift in realized niche associated with invasion in its native range. Large portions of the United States are predicted to constitute highly suitable habitat for *N. obtusa*, leading to the potential for future expansion. Understanding how certain species experience great success outside of their native ranges, or become invasive in new areas, is of primary interest to ecologists and conservationists alike. It is true that many invasive species occupy niches very similar to those in their native ranges, with little evidence for evolutionary change. However, for some species, niche shifts have been documented that may play a role in their ability to successfully establish in areas where they were previously absent. These changes could include shifts in phenology, morphology, physiology, or behavior, and may result from natural selection or from human-mediated introduction. Understanding the causes of niche shifts and their implications for invasion risk is an important goal in ecology.

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Environmental data
Environmental data
Environmental data
Estimating the niche
Estimating the niche

Sampled lakes

- Dissolved oxygen
- Dissolved oxygen saturation
- pH
- Alkalinity
- Hardness
- Conductance
- Nitrate
- P
- Ortho-P
- Temp
- Secchi depth
- Chlorophyll A
- Color
- Salinity
- S
- Lead
- Ammonia
Estimating the niche

Sampled lakes

Nitrate
P
Ortho-P
Secchi depth
Chlorophyll A
Color
Salinity
S

pH
Alkalinity
Hardness
Conductance
N
Ammonia
Estimating the niche

Sampled lakes

P

Secchi depth

Chlorophyll A

pH

Conductance

N
Estimating the niche
Estimating the niche

Env 1

Env 2

Env 3
Predicting suitable habitat

• Three approaches
  - Random forests
  - Boosted regression trees
  - Ecological niche factor analysis (presence only)
Predicting suitable habitat

Low risk

High risk

Random forest

Boosted regression tree

ENFA
Predicting suitable habitat

Low risk

High risk

Random forest

Boosted regression tree

ENFA
Expanding what we know

Boosted

Random forest  Regression trees  ENFA
Expanding what we know

- Field sampling → Spatial interpolation
Expanding what we know

Random forest

Boosted regression tree

ENFA
Expanding what we know

Connectivity
Compare prediction methods
More samples

Regression networks
Expanding what we know

Keep looking!
Starry trek - How you can help

• Minnesota & Wisconsin
• Statewide, coordinated shoreline searches

Saturday, Aug. 5\textsuperscript{th}, 2017

\textit{University of Minnesota | extension}

in partnership with the

\textit{Minnesota Aquatic Invasive Species Research Center}

\textit{University of Wisconsin-Extension}

Photo: Dave Hansen
Final thoughts

• “All models are wrong; some are useful”

• Models give the impression of precision

• More levels of extrapolation or interpolation mean more sources of error

• Use models for planning and prioritization
Questions?