Investigating Spread Rates of Aquatic Invasive Plant Species in North America

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INTRODUCTION

Characterizing the patterns of invasion can help inform management decisions. Hussner et al.[5] defines three different management goals: containment, reduction, and eradication. Managers require knowledge of a site and what potential invasive species are in the area to determine the most effective management strategy. Invasions also cross borders, requiring information on patterns of invasion well in advance to coordinate inter-state and international collaborations.[5]

We focused on *Nitellopsis obtusa*, *Hydrilla verticillata*, and *Najas minor*, which are aquatic species invasive to North America.[2] *N. obtusa* is native to Europe and Asia.[4] Monoecious *H. verticillata* is native to Korea.[6] *N. minor* is native to Europe, North Africa, and Asia.[11] All three species create dense mats in lakes and streams and root in the sediment.[18,19,21] They all reproduce asexually through fragmentation, and are often transported to different lakes and streams by watercraft.[18,19,21] In order to determine invasional patterns for our species, we calculated each of their spread rates and comparison spread rates and estimated their ranges. Due to their similar morphologies, we expected the rates and ranges of *N. obtusa*, *H. verticillata*, and *N. minor* to be the same.

METHODS

Occurrence points within our study range of the Northeast US and Southeastern Canada were downloaded from GBIF[3], iDigBio[7], and iMapInvasives[8]. We estimated spread rates by using QGIS[16] to create polygons from the occurrence points. We represented change over time by generating polygons for each five-year interval cumulatively (e.g., 1940-1944, 1940-1949, etc.). Only areas overlapping with lake boundaries (LakeATLAS)[10] were used in our analysis. The R Programming Environment[17,20] was used to calculate the rates of spread for each individual species and comparison rates in pairs. The rates of *H. verticillata* and *N. minor* used a linear regression and *N. obtusa* used an exponential model to best fit the data.

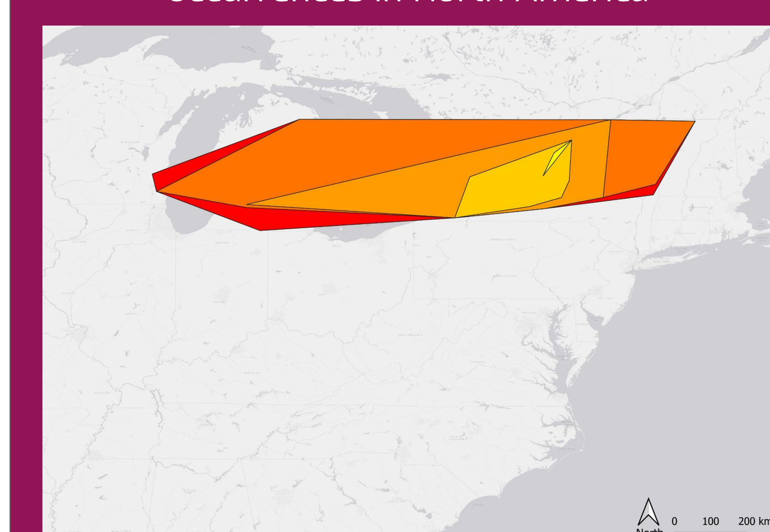
N. obtusa is spreading at a **higher rate** than *H. verticillata* and *N. minor* and may be overlooked as an **ecological threat**

Nitellopsis obtusa[12]

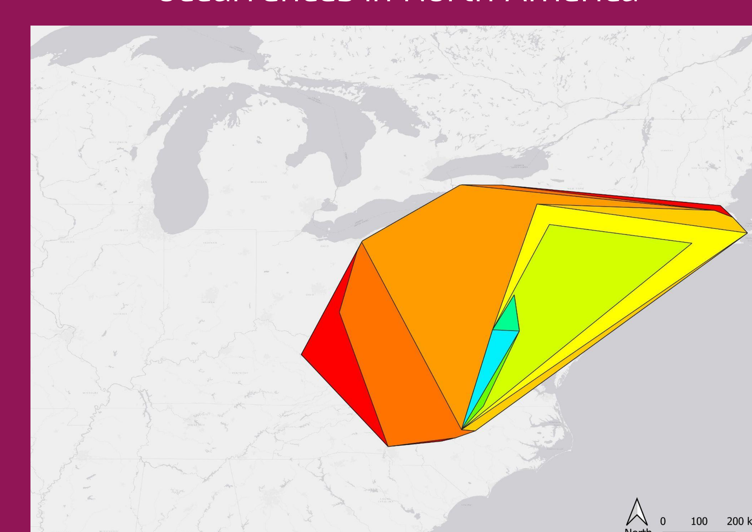
Hydrilla verticillata[14]

Najas minor[13]

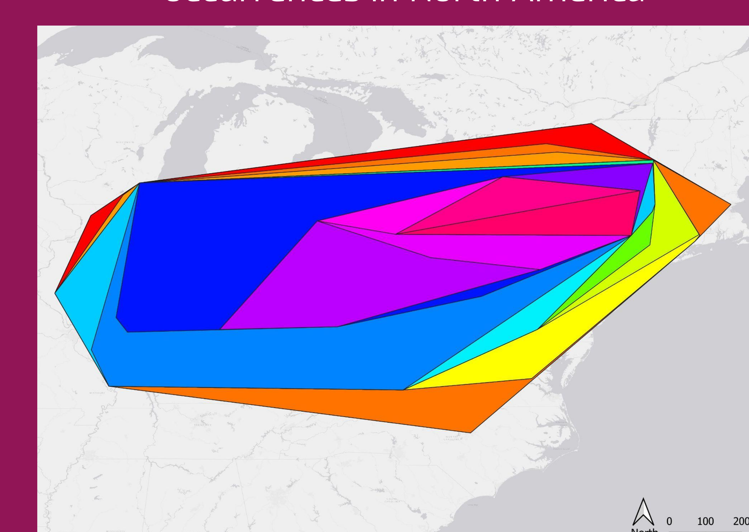
Geographic extent of *N. obtusa* occurrences in North America

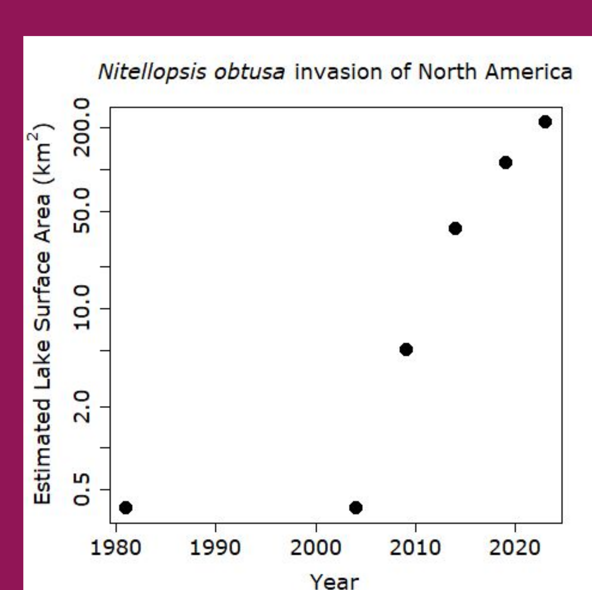


Geographic extent of *H. verticillata* occurrences in North America

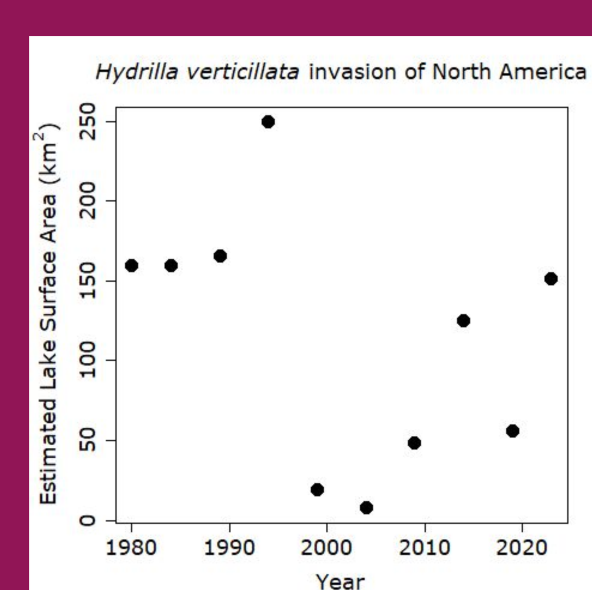


Geographic extent of *N. minor* occurrences in North America

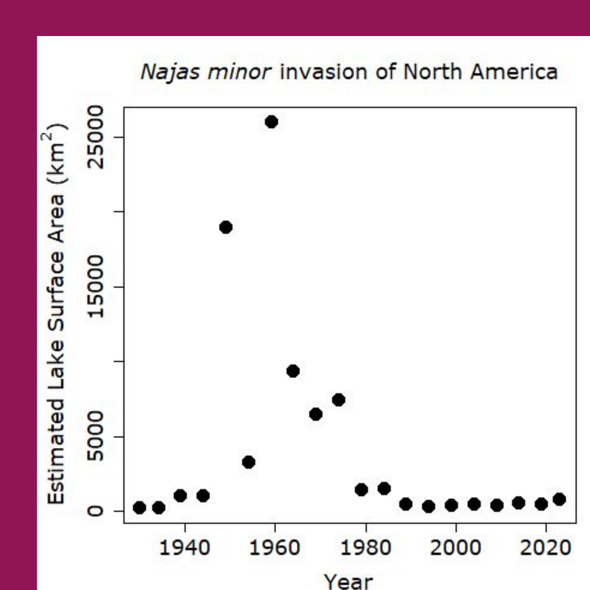




- Estimated current area: 219.35 km^2
- Spread rate: 0.16 ± 0.046 km^2/year (t = 3.48, p = 0.025, R^2 = 0.75)
- *N. obtusa* is spreading faster than both *H. verticillata* and *N. minor*.
  - *N. obtusa* & *H. verticillata*: -5.77 ± 1.51 km^2/year (t = -3.82, p = 0.0051, df = 8, R^2 = 0.65)
  - *N. obtusa* & *N. minor*: -19.55 ± 8.29 km^2/year (t = -2.36, p = 0.046, *df* = 8, R^2 = 0.41)



- Estimated current area: 151.24 km^2
- Spread rate: -2.05 ± 1.71 km^2/year (t = -1.20, p = 0.27, R^2 = 0.15)
- *H. verticillata* is spreading slower than *N. obtusa*, but the same as *N. minor*.
  - *H. verticillata* & *N. obtusa*: -5.77 ± 1.51 km^2/year (t = -3.82, p = 0.0051, df = 8, R^2 = 0.65)
  - *H. verticillata* & *N. minor*: -6.67 ± 9.51 km^2/year (t = -0.70, p = 0.51, *df* = 7, R^2 = 0.066)



- Estimated current area: 819.79 km^2
- Spread rate: -72.26 ± 52.75 km^2/year (t = -1.37, p = 0.19, R^2 = 0.094)
- *N. minor* is spreading slower than *N. obtusa*, but the same as *H. verticillata*.
  - *N. minor* & *N. obtusa*: -19.55 ± 8.29 km^2/year (t = -2.36, p = 0.046, *df* = 8, R^2 = 0.41)
  - *N. minor* & *H. verticillata*: -6.67 ± 9.51 km^2/year (t = -0.70, p = 0.51, *df* = 7, R^2 = 0.066)

DISCUSSION

H. verticillata and *N. minor* appear to be spreading at a similar rate, while *N. obtusa* appears to be spreading at a rate that is exponential and faster than the aforementioned species. The occurrence points suggest that *N. obtusa*'s pattern of spread is increasing its density more than its geographic range over time. Therefore, *N. obtusa* has a notably distinct invasional pattern. Another contributing factor may be the life history trait differences between the alga, *N. obtusa*, and the vascular plants, *H. verticillata* and *N. minor*.[18,19,21]

N. obtusa is beginning to spread to Minnesota and Vermont. The efficacy of invasional prevention and early stage removal is known[1], however eradication methods and their long-term effectiveness need more research.[9] We recommend lake managers in Minnesota and Vermont with known recreational boat use in their localities create prevention and early stage removal plans ahead of *N. obtusa* establishment.

LIMITATIONS & FUTURE WORK

We used the QGIS Concave Hull plugin to produce our polygons.[15] However, the plugin's algorithm did not always result in a distribution area that increased over time. This error led us to consider the rates in relation to each other instead of the actual values themselves. In addition, our analyses used historical occurrence data, which inherently contain sampling biases.

Our future work includes using species distribution models to compare environmental niches between the three species. Looking at the invasional patterns and the niches together can help us determine if competition between the species is occurring.

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