Potential Spread of Great Lakes Invasive Species Under Climate Change

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Abstract

Invasive species are the greatest driver of environmental change in the Great Lakes. As the climate changes, the range and impacts of existing invaders will alter and new species may become established. In this study we created models for how suitable habitat may change for 30 different invasive species. We compared climates where the species currently lives and predicted climate conditions of the Great Lakes region in 2050 and 2070. We compared three different approaches to modeling; Boosted Regression Trees (BRT), Maximum Entropy (Maxent) and the new Risk Assessment Mapping Program (RAMP). A full analysis of results required us to quantitatively determine how species ranges may change. To do this I developed a method using the *countcolors* package in *RStudio*, which can be calibrated to calculate the number of climate suitable pixels in a given map. The results allow us to show how some species will greatly expand in their range over time, others will see their range contract, and some will find habitats in the Great Lakes suitable for the first time. We conclude that patterns and impacts of invasive species in the Great Lakes will remain dynamic for decades to come.

Introduction

- Invasive freshwater species damage ecosystems and economies across the Great Lakes. Climate change will have largely unknown effects on the range and impacts of invasive species already in the Great Lakes, and may allow new species to become established.

- Map models allow us to predict how certain species will react to projections of future climate change.

Objective: Create map models for a range of established invasive species and species that may become invasive in the future to determine how climate change will affect overall impacts of invasive species in the Great Lakes.

Methods

- For BRT and Maxent we used 19 bioclimatic variables from worldclim.org to estimate the climate similarity of each species' current distribution to that of the Great Lakes region. RAMP uses 16 variables from the same source.

- Each model was run for two time horizons (2050 & 2070) and with assumptions of moderate (RCP 4.5) and high (RCP 8.5) levels of climate change.

- Data for each species current range obtained from Global Biodiversity Information Facility (GBIF, https://gbif.org/).

- The program *RStudio* and the *countcolors* package were used to calculate the number of climate suitable pixels in each.

Results

Yabby crayfish (*Cherax destructor*)

Current Climate
Suitable pixels: 12,599

2070 RCP 8.5
Suitable pixels: 5,269

Water lettuce (*Pistia stratiotes*)

Current Climate
Suitable pixels: 1

2070 RCP 8.5
Suitable pixels: 278

Bighead carp (*Hypophthalmichthys nobilis*)

Current Climate
Suitable pixels: 727

2070 RCP 8.5
Suitable pixels: 17,094

Cane toad (*Rhinella marina*)

Current Climate
Suitable pixels: 0
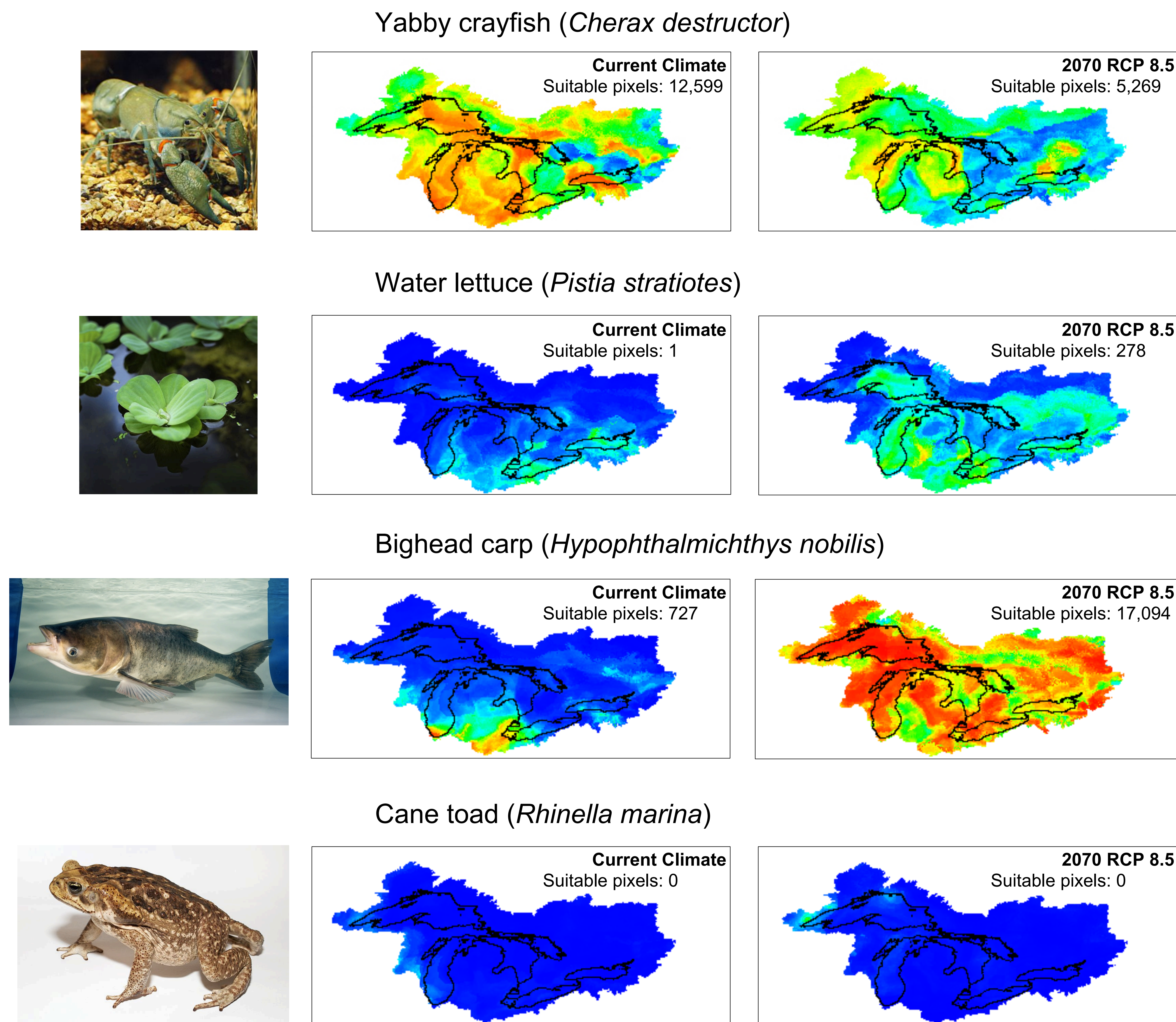
2070 RCP 8.5
Suitable pixels: 0

Figure 1: Models for four species across different taxa, comparing current climate suitability and climate suitability in the year 2070 under strong levels of climate change (RCP 8.5) in the Great Lakes region.

We assessed the potential current and future ranges for 30 invasive species that are either already established in the Great Lakes or that are considered high risk for future establishment. The four species shown above are indicative of our overall results that some species will see their range expand over time, others will contract, and some will move northward. All species will see changes in the size and location of their potential range, indicating that the situation for invasive species in the Great Lakes will remain dynamic for the foreseeable future.

The spreadsheet table for the total number of climate suitable pixels as well as the percentage of climate suitable pixels for all the maps and species can be viewed here.
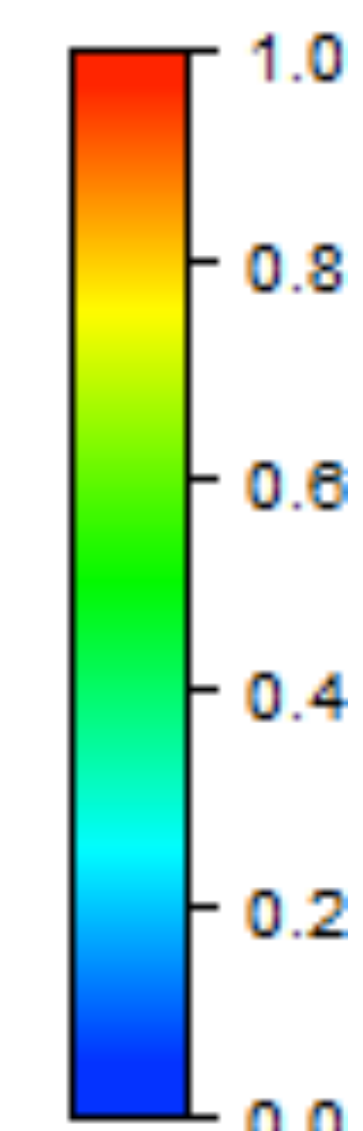
Conclusions and Implications

- Invasive species already established in the Great Lakes will see dynamic changes to their ranges. Some will grow, others will shrink, and all will move north.

- Invasions and their impacts are species-specific and driven by differing responses to changes in climate across the Great Lakes.

- Successful management and monitoring of invaders in the Great Lakes depends on accurate predictions developed from robust models.

- Management resources should be allocated to specific species of concern. Our results clearly show how the ranges of some high-impact species may change in the future. Spread of existing species and arrival of new ones means that the impacts of invasive species will remain dynamic over the coming century.

Citations

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