Conquering the Cold: Climate suitability predictions for the Asian clam in cold temperate North America

Morden AL, Ricciardi A
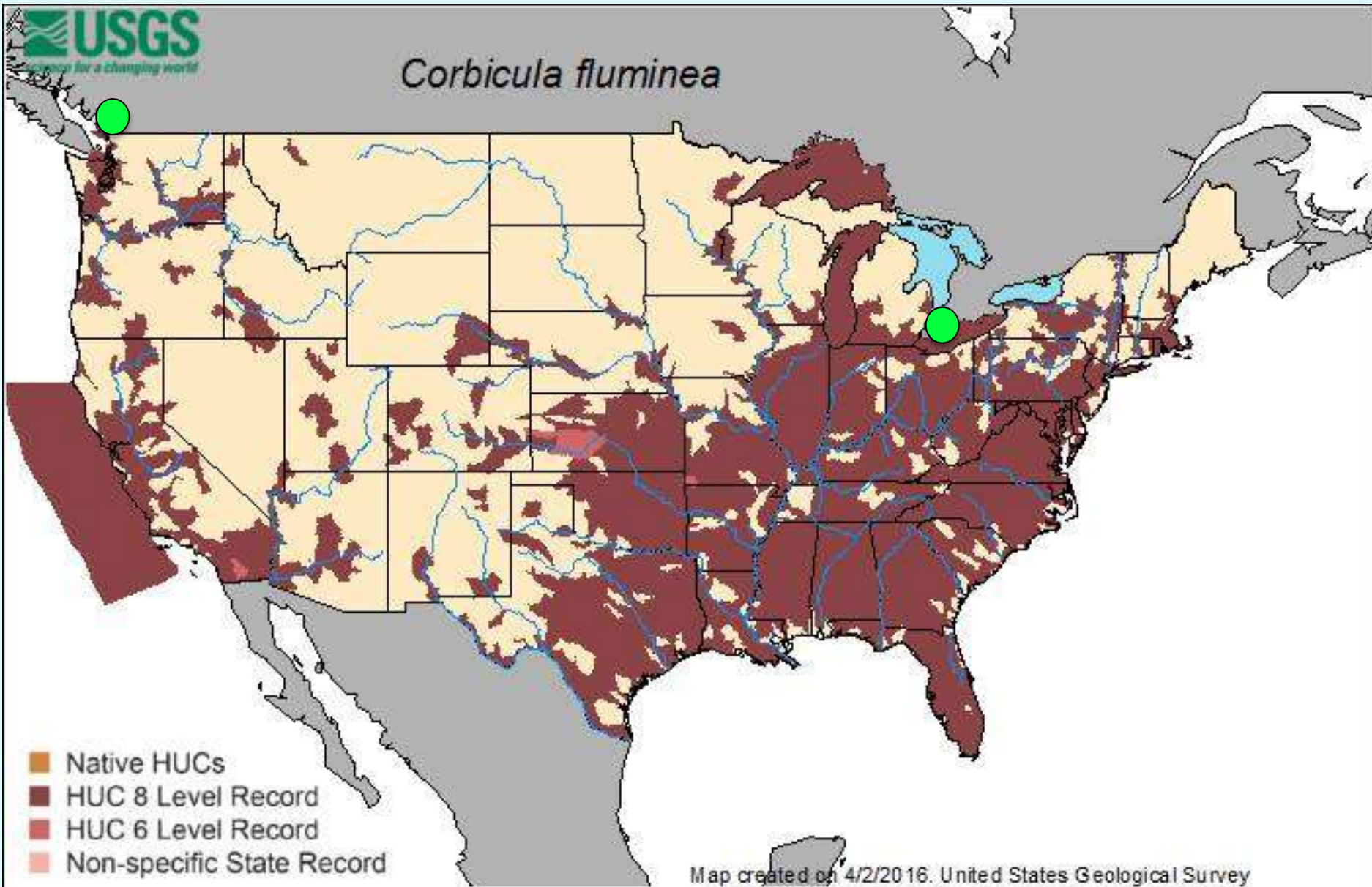**Redpath Museum**
McGill University

International Conference on Aquatic Invasive Species
14 April 2016 - Winnipeg, Canada

The Asian clam: a damaging invader

- Native to Asia, Australia and Africa; now has global range
- Widespread in USA water bodies
- Impacts include: altered nutrient cycling, habitat restructuring, biofouling

Northern Range Extension

Corbicula fluminea

Native HUCs
HUC 8 Level Record
HUC 6 Level Record
Non-specific State Record

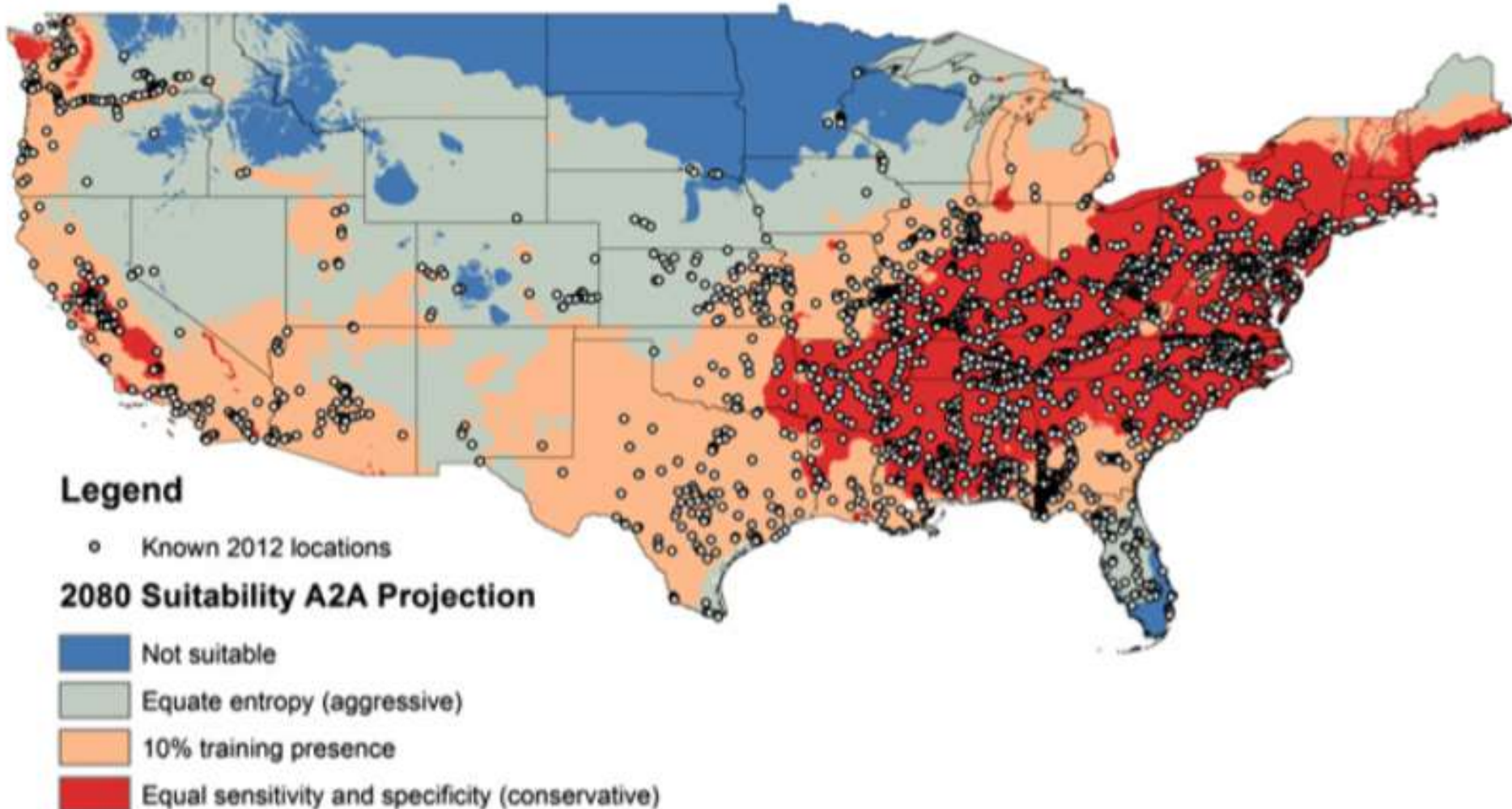Map created on 4/2/2016. United States Geological Survey

Given this recent northern range extension, what cold temperate regions of North America, including Canada, are vulnerable to invasion?

Can climate suitability modeling techniques inform Asian clam risk assessment?

Projected climate suitability for the Asian clam in the continental USA

(d)

Legend

○ Known 2012 locations

2080 Suitability A2A Projection

- Not suitable
- Equate entropy (aggressive)
- 10% training presence
- Equal sensitivity and specificity (conservative)

McDowell et al. 2014, *Freshwater Biology*

MaxEnt

- Presence-only habitat suitability modeling program (generative) (Phillips et al. 2006[1])

- Can be parameterized to model species undergoing range expansion (Elith et al. 2010[2])

- Assigns a probability distribution of maximum entropy across environmental/geographic space

- Very good performance compared to other presence-only SDM

[1]Ecological Modelling, [2]Methods in Ecology and Evolution

Data

- BioClim present and future climate data layers, 5 arc-minute resolution (Hijmans et al. 2005)

- USGS NAS Asian clam presence dataset + personal observation, state/provincial gov'ts

- ~ 6,795 valid presence records reduced to 2,585 after spatial rarefying to environmental grid

- Climate scenarios RCP 4.5 and 8.5 to 2050, GCMs selected based on past performance:
  - HadGEM-2ES
  - MIROC-ESM-CHEM
  - MRI CGCM3
  - MPI-ESM-LR

Model validation criteria

- Cannot conventionally validate model since there is no 'true' probability distribution to compare to, or independent validation dataset

- Model validation criteria (Elith et al. 2010[1], Jimenez-Valverde 2011[2]):

    1. Response curves are not overly complex, and therefore not overfitted to training data
    2. Current presence locations are identified
   3. Regions of unreliable prediction are identified

[1]*Methods in Ecology and Evolution,* [2]*Biological Invasions*

Model Output

- Used logistic output, assigned maximum sensitivity plus specificity threshold

- 10 replicate runs, train:test = 80:20, AUC = 0.79

Environmental predictor	Percent contribution (%)	Permutation importance (%)
Mean temperature (coldest quarter) *	82.1	71.8
Mean temperature (warmest quarter) *	14.8	16.4
Altitude	2.6	11.6
Annual temperature range	0.4	0.2
Mean precipitation (driest quarter)	0.1	0

Environmental response curves

Response to mean temp. in the warmest quarter
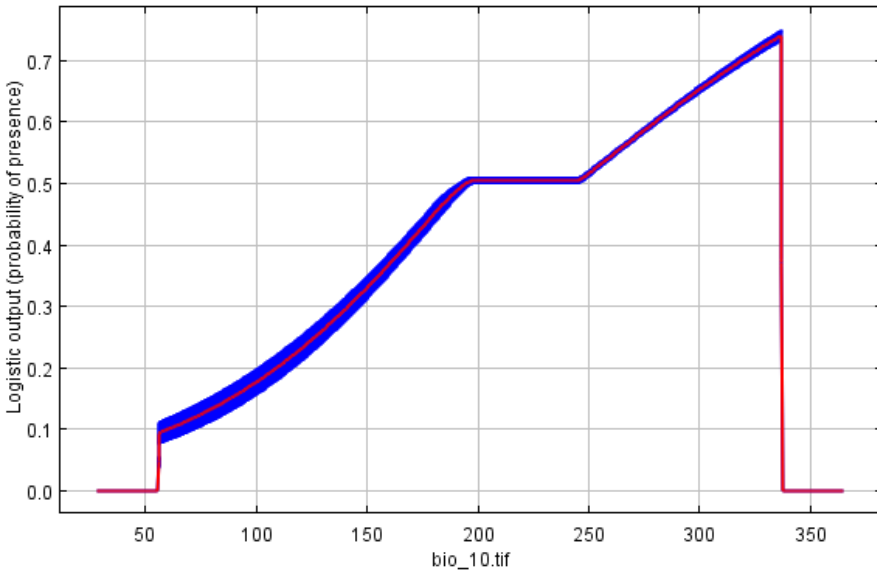
Response to altitude
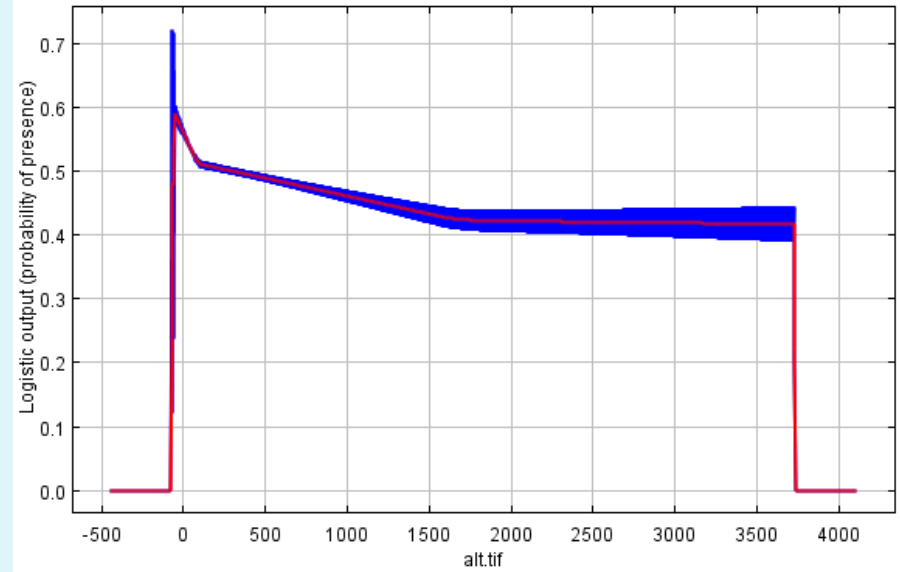
Response to mean temp. in the coldest quarter
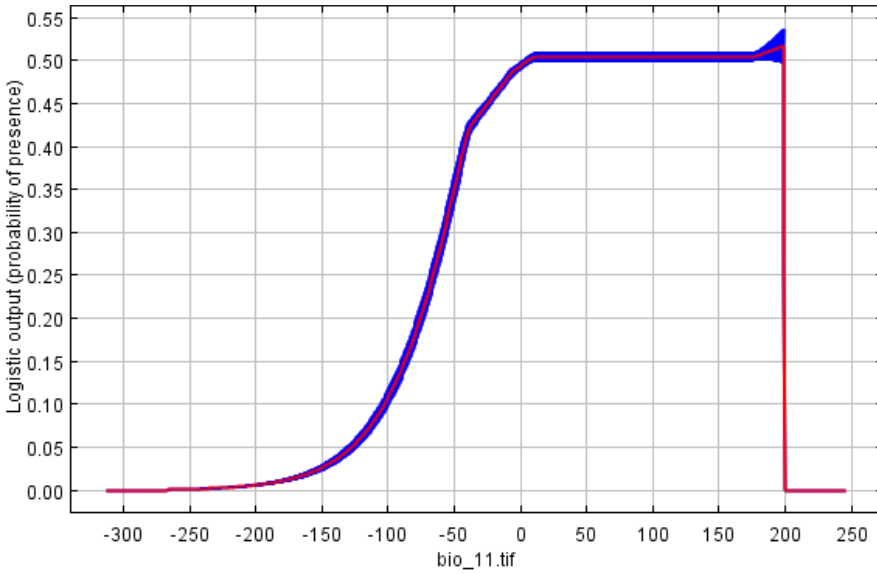
Response to precipitation in the driest quarter
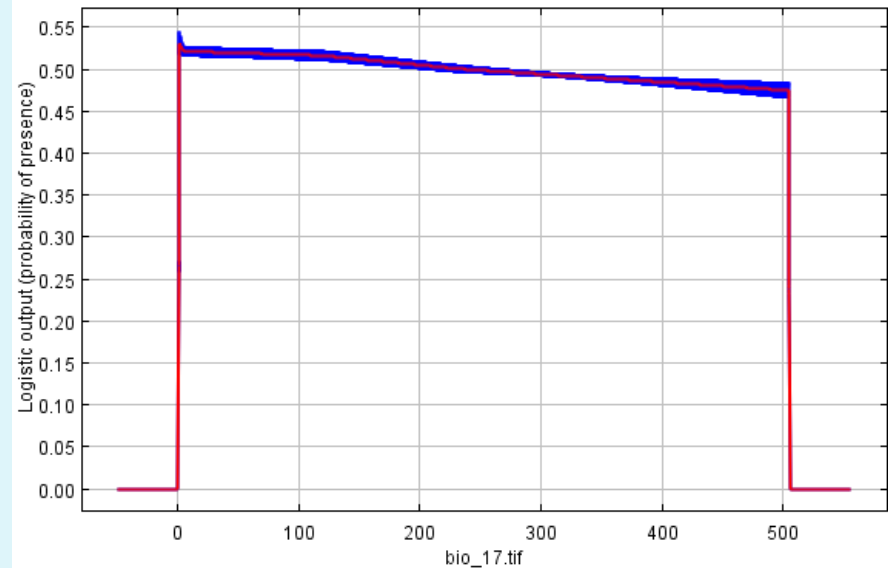
Response to precipitation in the driest quarter
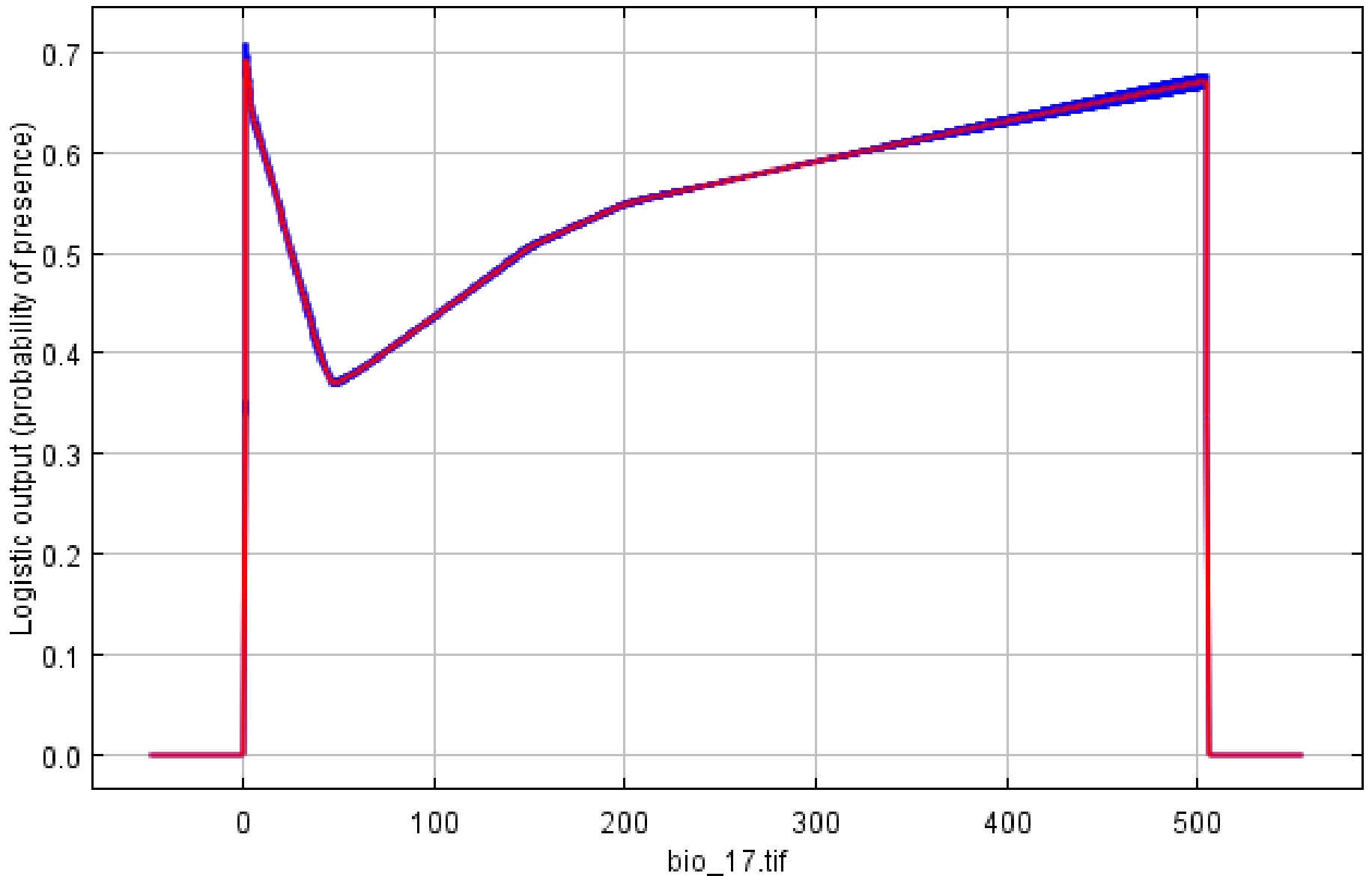
Current climate suitability for the Asian clam at a maximum sensitivity plus specificity threshold

Legend
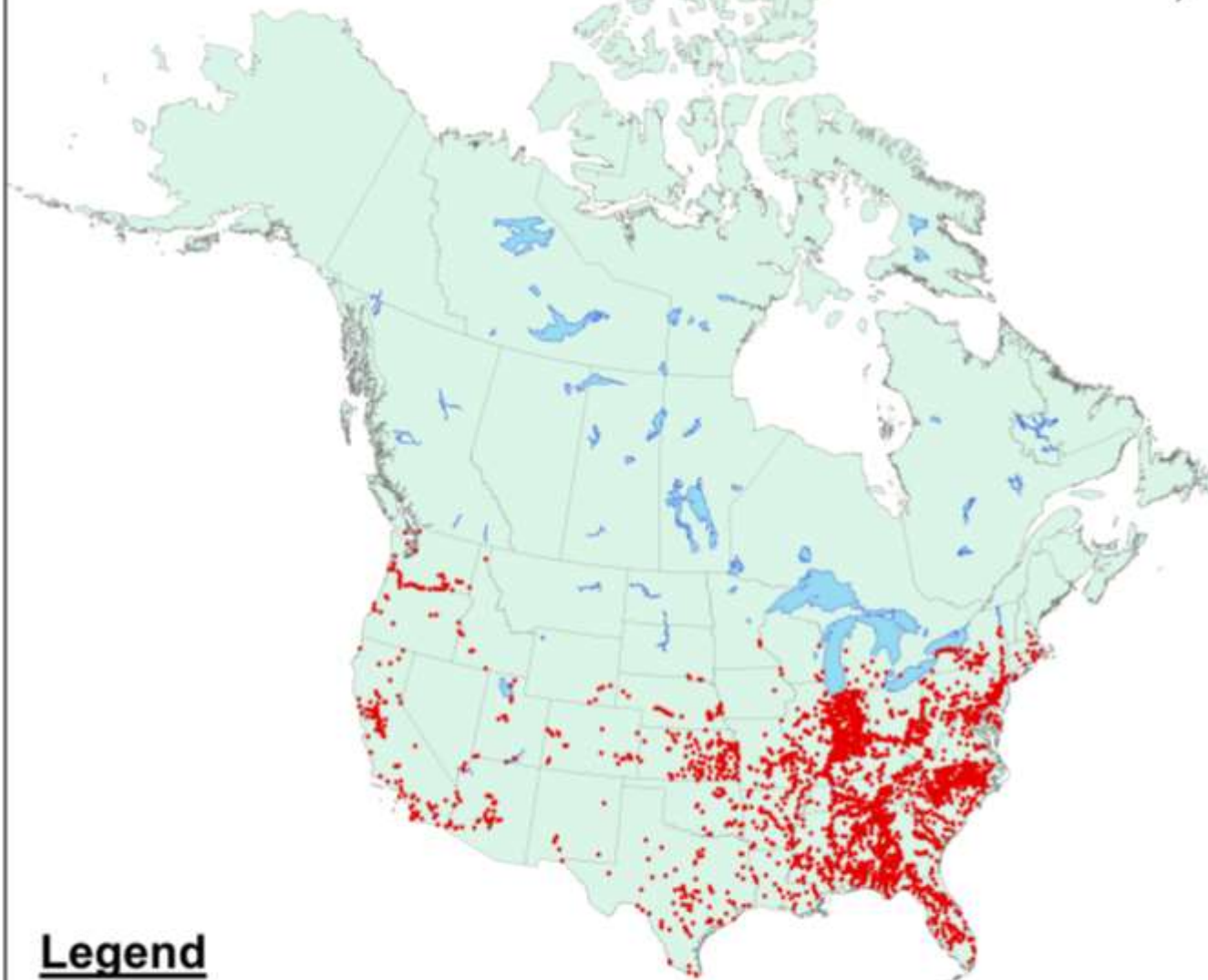
Major North American Lakes

Climate Suitability

Value

0 *Unsuitable*

1 *Suitable*

0   625   1,250   2,500 Kilometers

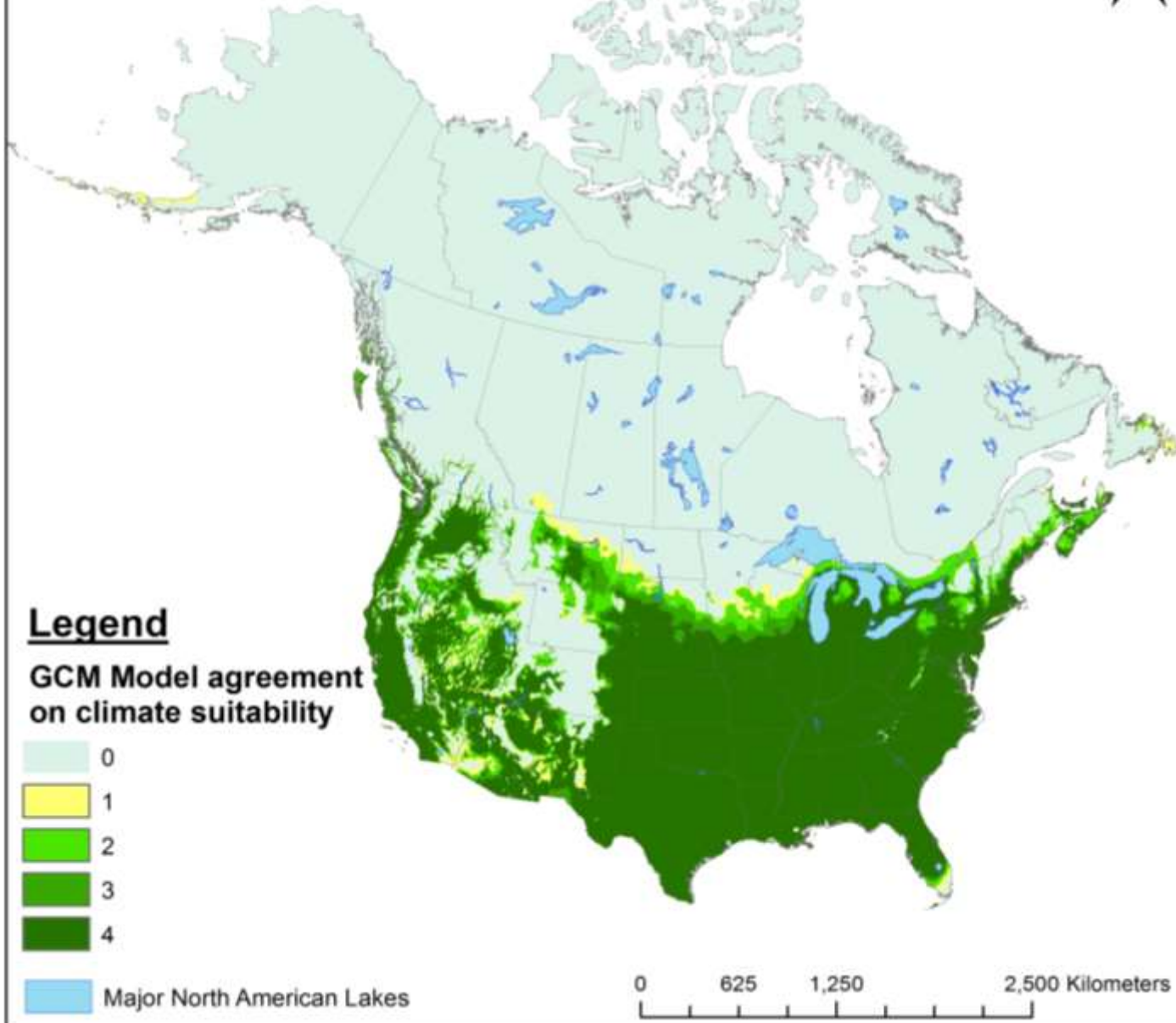**Spatially rarefied presence records (100km²) of the Asian clam in North America**
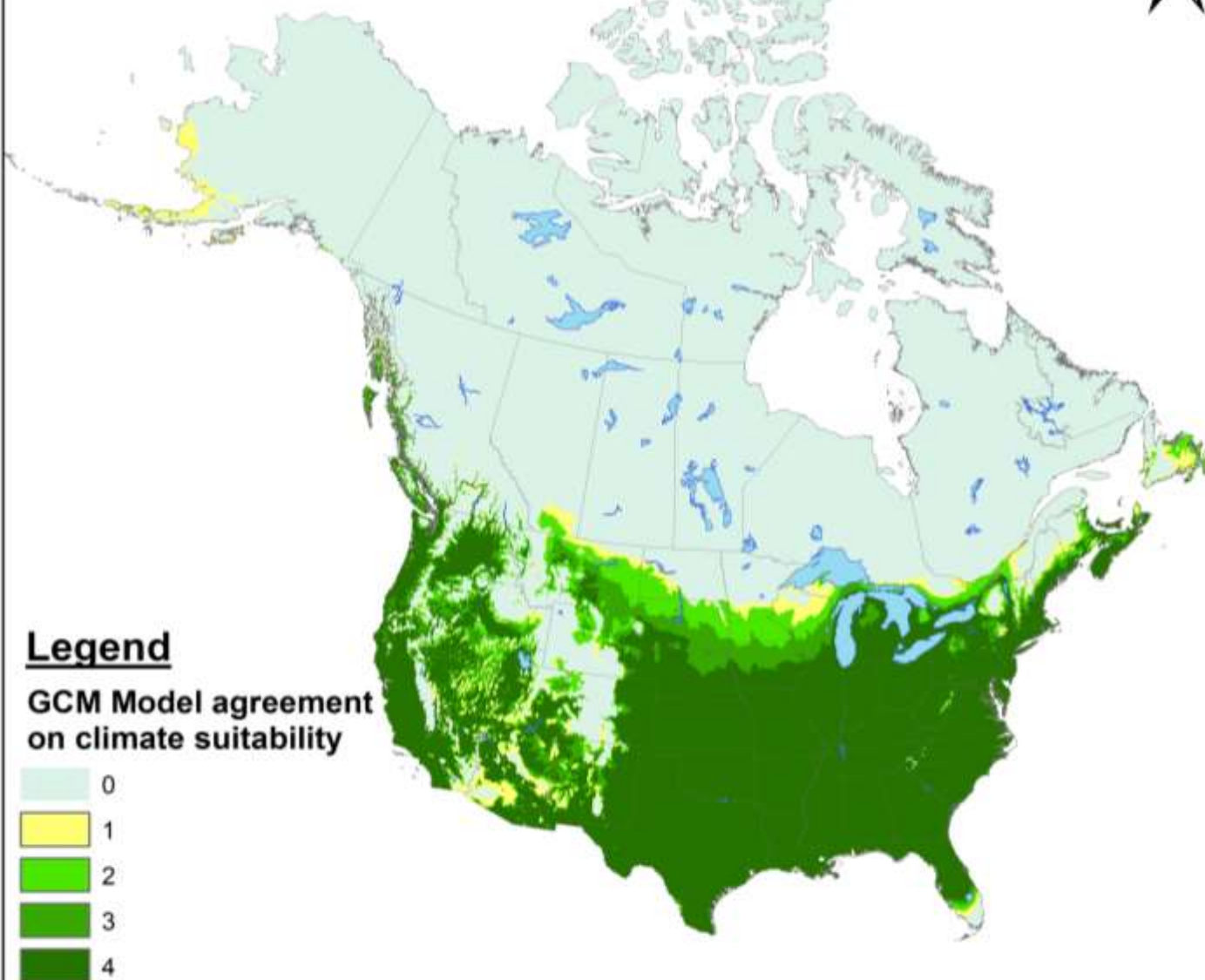
N

Legend

· Rarefied Asian clam presence records

Major North American Lakes

0   625   1,250   2,500 Kilometers

Asian clam climate suitability in 2050 along RCP 4.5

Legend

GCM Model agreement on climate suitability

- 0
- 1
- 2
- 3
- 4

Major North American Lakes

0   625   1,250   2,500 Kilometers

Asian clam climate suitability in 2050 along RCP 8.5

Legend

GCM Model agreement on climate suitability

- 0
- 1
- 2
- 3
- 4

Major North American Lakes

0   625   1,250   2,500 Kilometers

Concluding thoughts

- The Asian clam will likely continue its northward range expansion in North America
- Cold temperate water bodies at risk of invasion in the next 25-45 years
- No information about density, therefore does not predict impact
- Model outputs are only as valid as the assumptions they're based on!

Acknowledgements:

- Prof. Ricciardi, labmates, and Lidia Della Venezia
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- Dr. Mattias Herborg at the BC Ministry of Environment
- Midwest Invasive Species Information Center
- Brant Fisher, Indiana Dept. of Natural Resources
- And many more...

Model Settings and Selection

- Limited background to within 1,200km of known range limit
- Only permitted hinge responses
- Minimized artifacts in response curves (indicate of overfitting) using regularization parameter λ (increased from 1 to 2.5)
- Disabled extrapolation, enabled clamping
- Countered detection/time since invasion biases in presence data:
  - Gaussian kernel density bias file
  - Latitudinal bias file (WGS1984 projection)