The use of co-spatial modeling to inform aquatic invasive species management

Nick Phelps, Meggan Craft, Eva Enns, Luis Escobar, Kaushi Kanankege, Zoe Kao, Andres Perez, Huijie Qiao

Minnesota Aquatic Invasive Species Research Center
University of Minnesota
Driven to Discover℠

Institute of Zoology, CAS

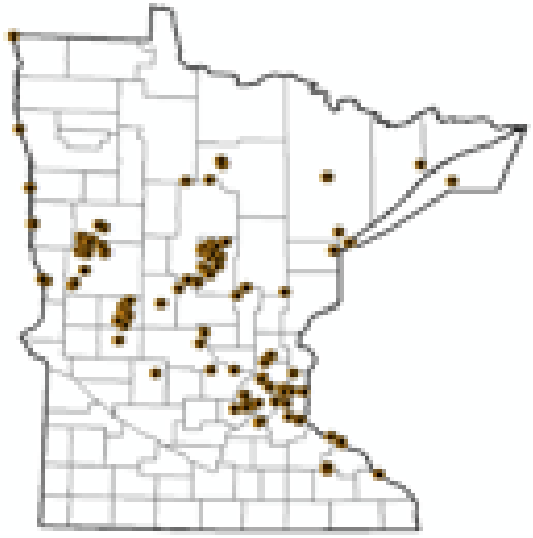
Virginia Tech

International Conference on Aquatic Invasive Species

October 25, 2017

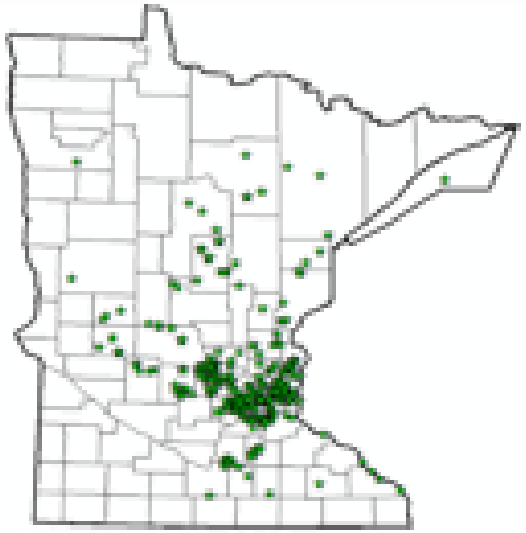
Is every lake at risk of AIS establishment?

Zebra mussels (n=125)

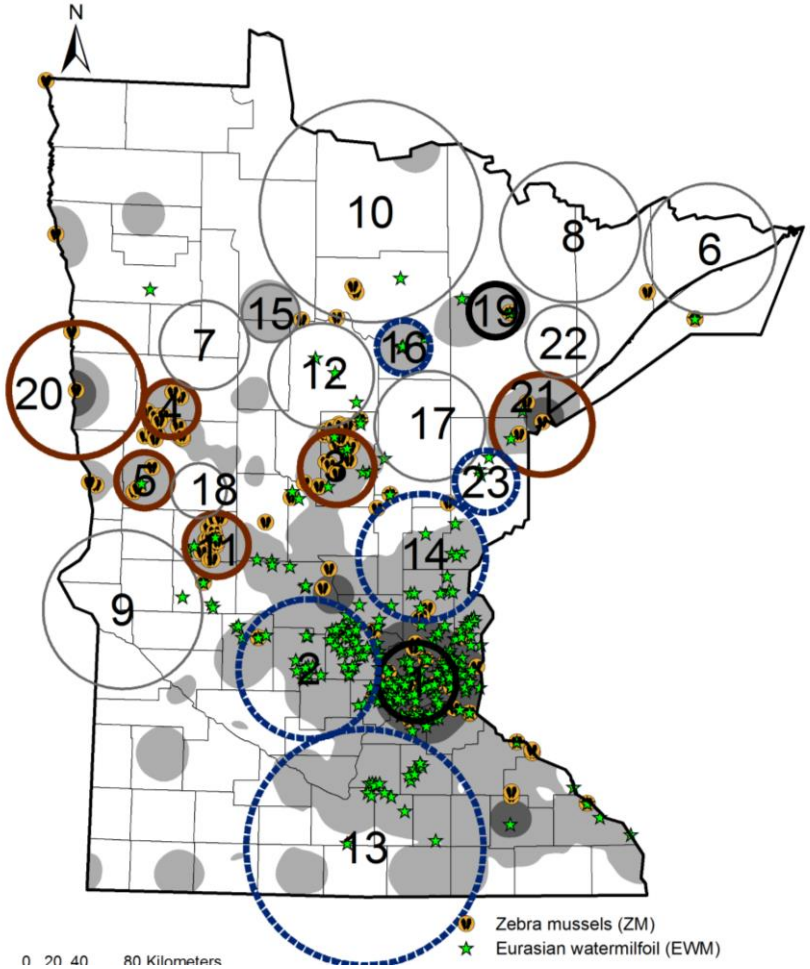


3. ZM 1989 - 2016

Eurasian watermilfoil (n=304)



6. EWM 1987 - 2016

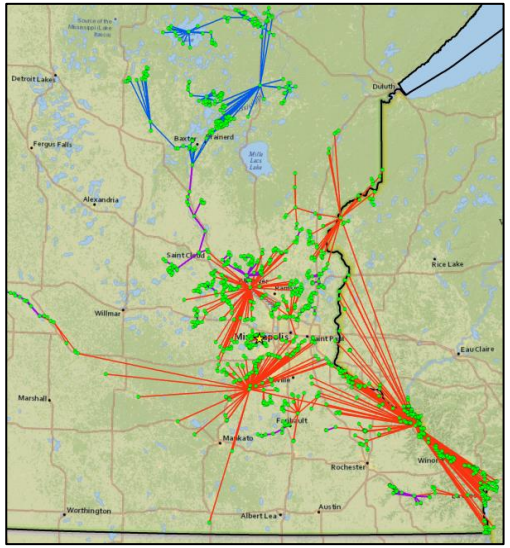


Which lakes are at risk?

Can the AIS get there?

Can the AIS survive?

Risk =



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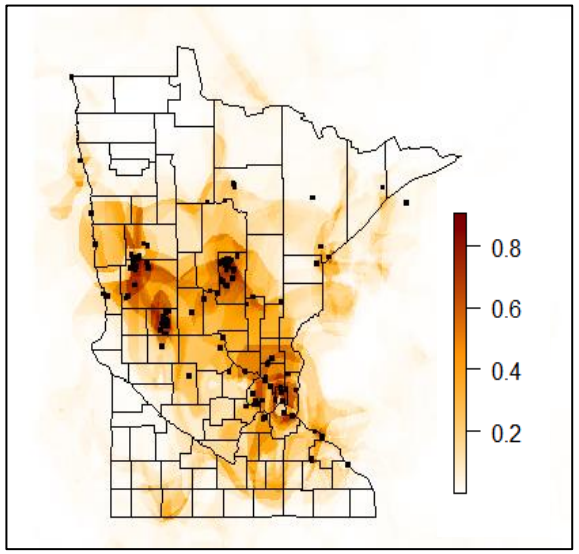
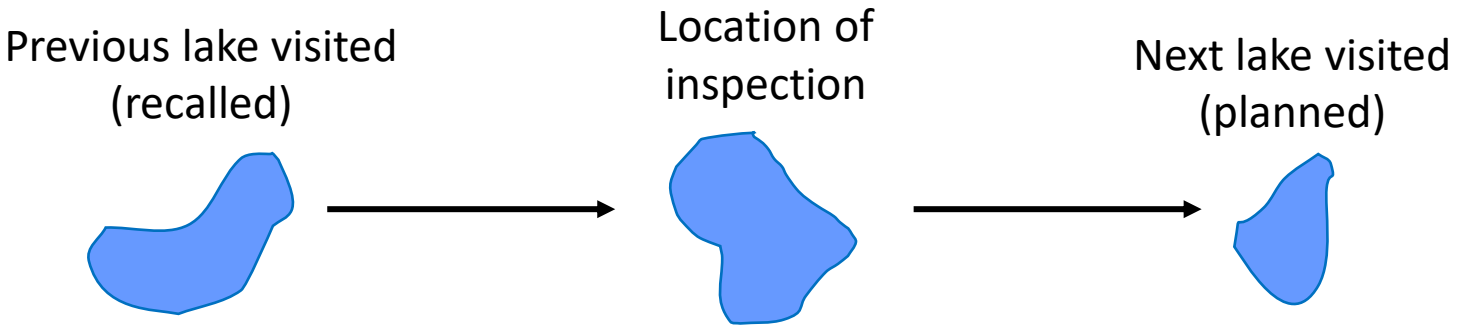


1. Boater movement
2. Natural connections
3. Geographic proximity

1. Zebra mussels
2. Starry stonewort
3. *Heterosporis sutherlandae*
4. Viral hemorrhagic septicemia virus

Networks of AIS spread: Boater movement

- MN DNR Watercraft Inspection survey (2014-2016)
  - Where was the LAST waterbody you visited?
  - Where is the NEXT waterbody you will visit?
- Aggregated over all responses to create a network



Networks of AIS spread: Boater movement

- 898,914 boat inspections conducted across 667 Minnesota lakes in 55 counties from 2014 – 2016
- 690,624 survey responses used to construct lake network
  - Exclusions
    - 3,395 had blank previous/next lake fields
    - 92,250 non-responses (“don’t know”, “refuse to answer”, “lake service provider”)
    - 112,645 were repeat enter/exit inspections

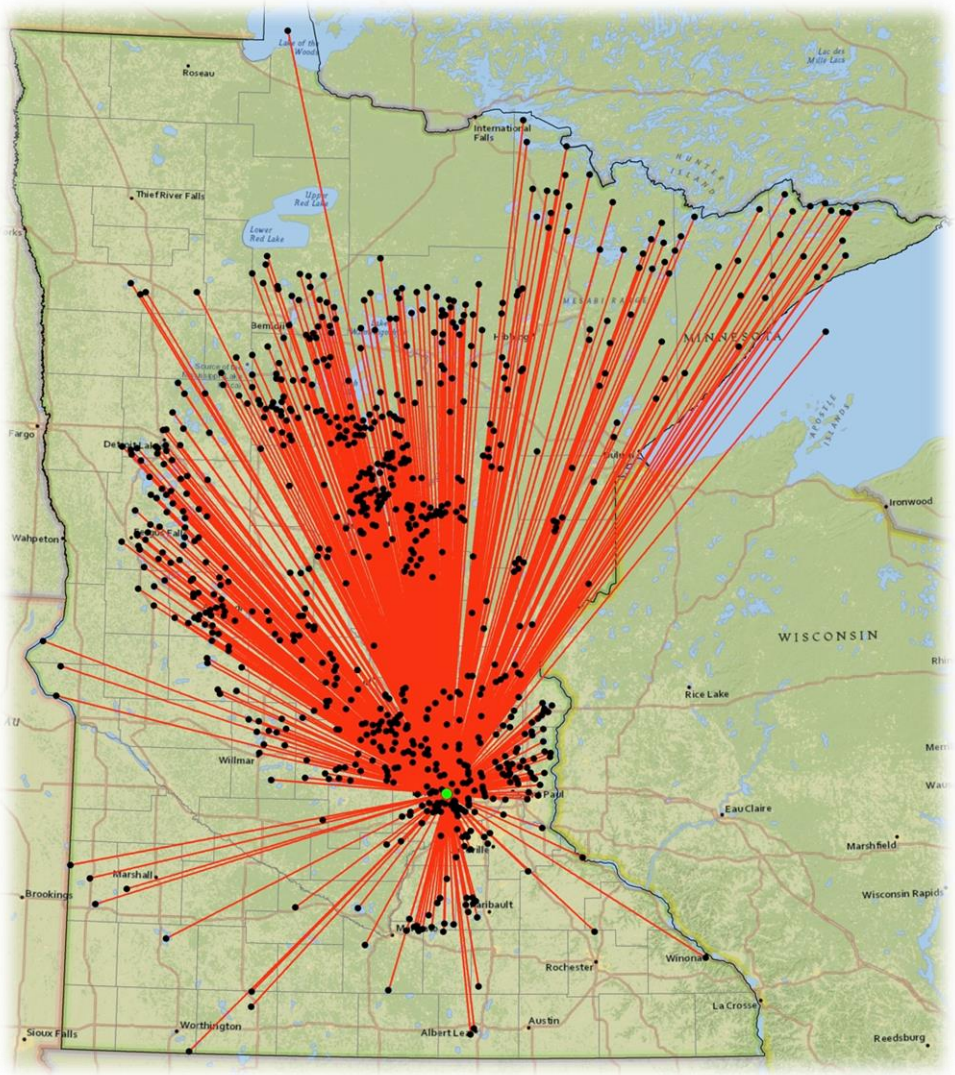
Networks of AIS spread: Boater movement

Lake Minnetonka

144,402 movements between 770 lakes

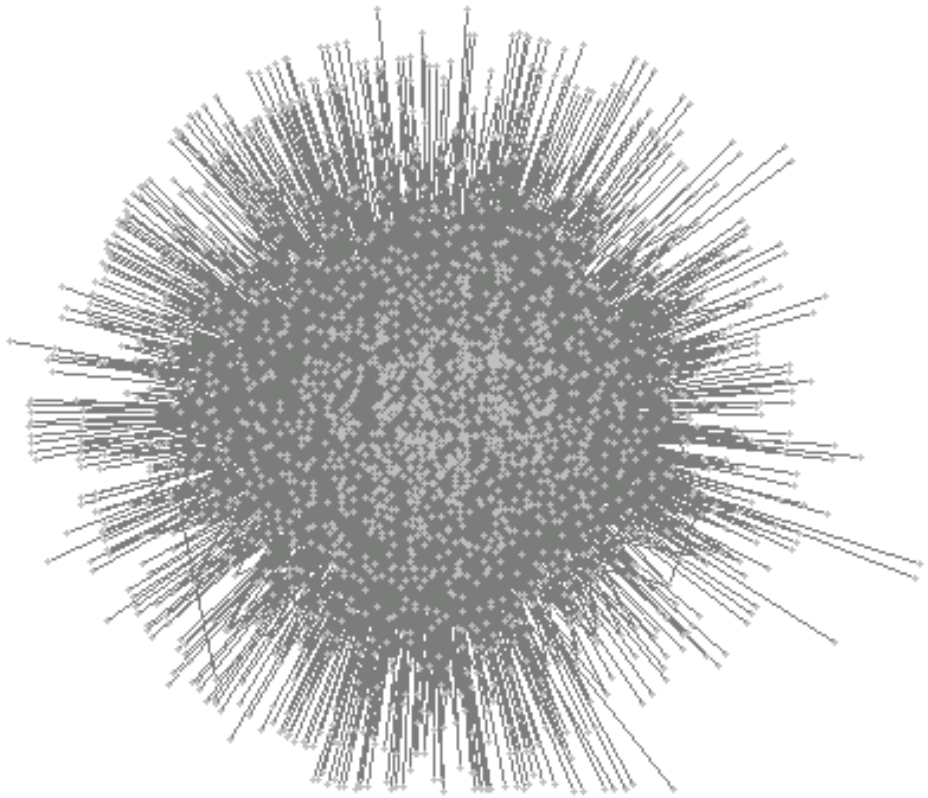
<u>Top connections:</u>

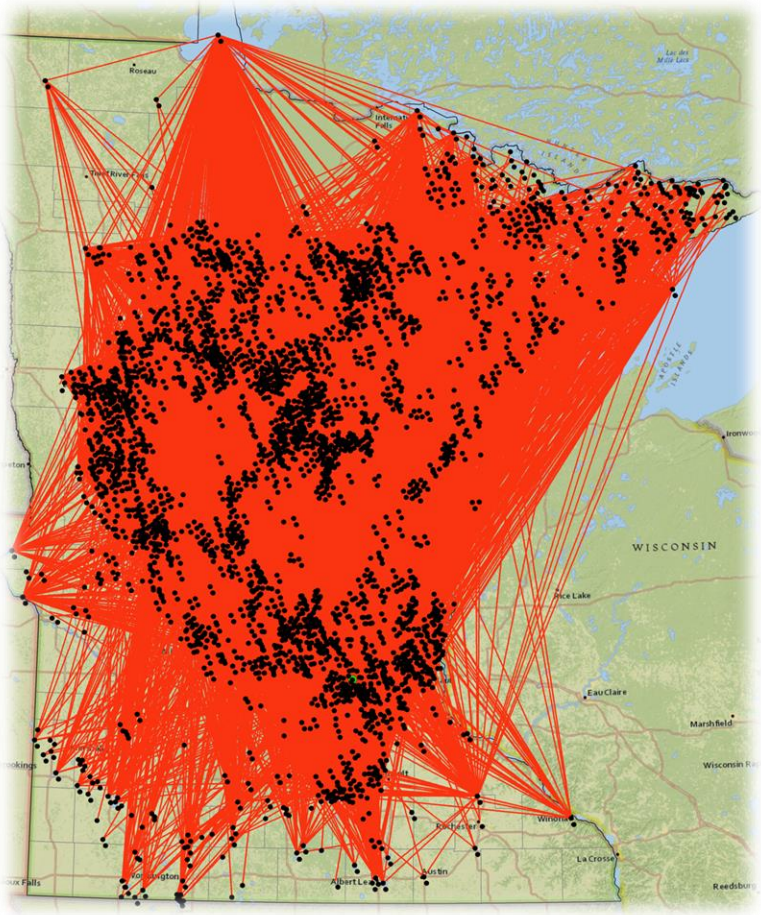
Minnetonka (Hennepin) – 79%
Waconia (Carver) – 3.1%
Independence (Hennepin) – 1.6%
Medicine (Hennepin) – 1.5%
Minnewashta (Carver) – 1.0%
Lotus (Carver) – 1.0%



Networks of AIS spread: Boater movement

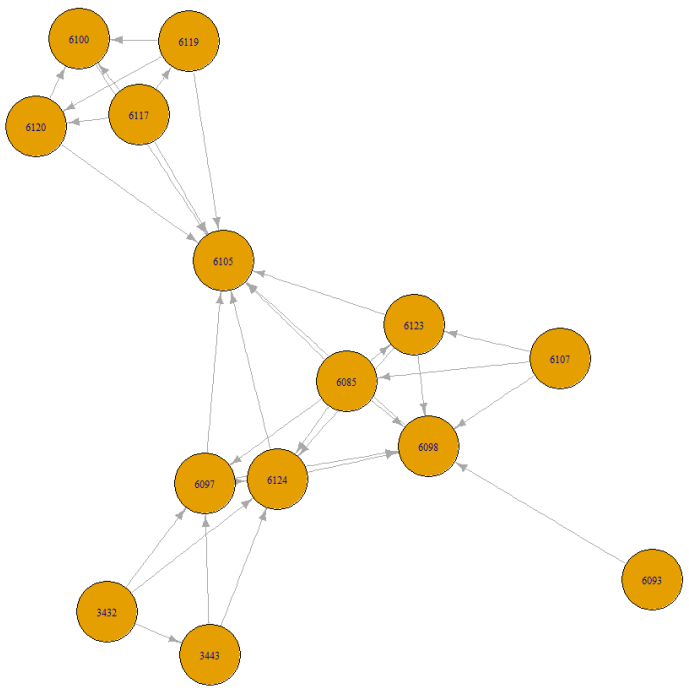
- Combined network consisted of 2,194 lakes and 34,288 edges





Networks of AIS spread: Water connectivity

- Identify all lakes (n=9,875)
- Calculate direction of water flow with lake elevations
- Calculate river distance between lakes
- Build the networks:
  - 1,944 unconnected lakes
  - 153 clusters of 2 lakes
  - 21 clusters of 3 lakes
  - 19 major lake clusters

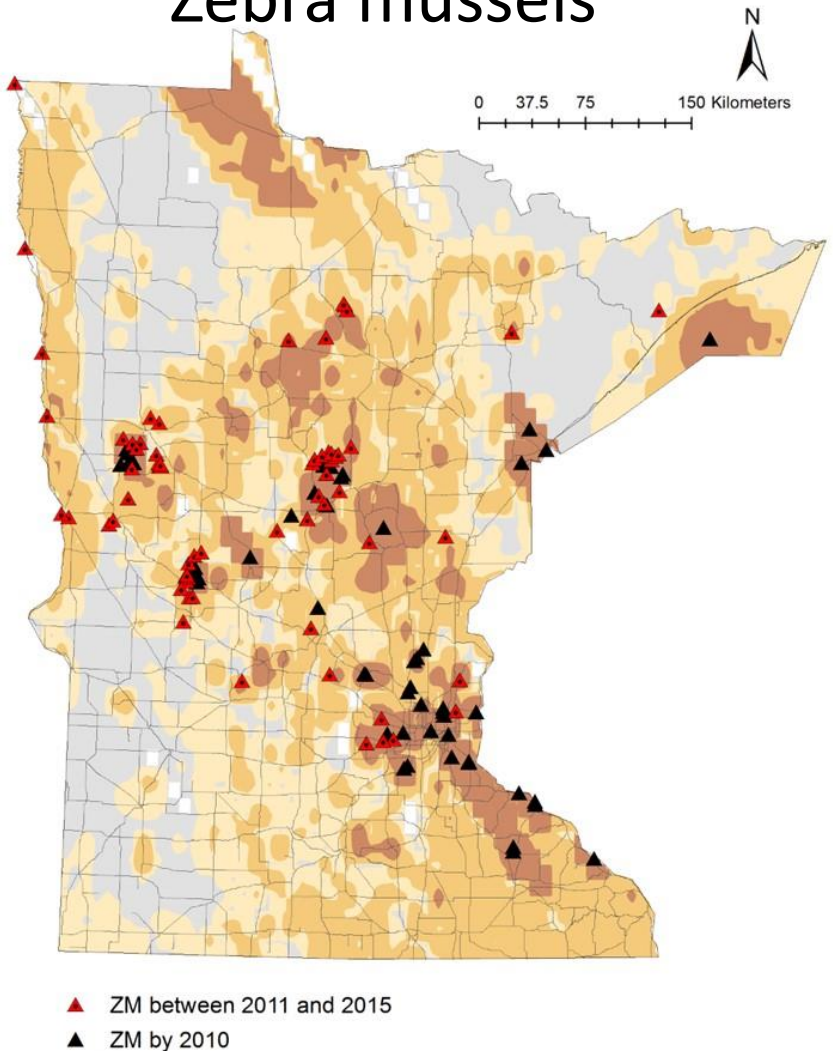


Networks of AIS spread: Proximity risk?

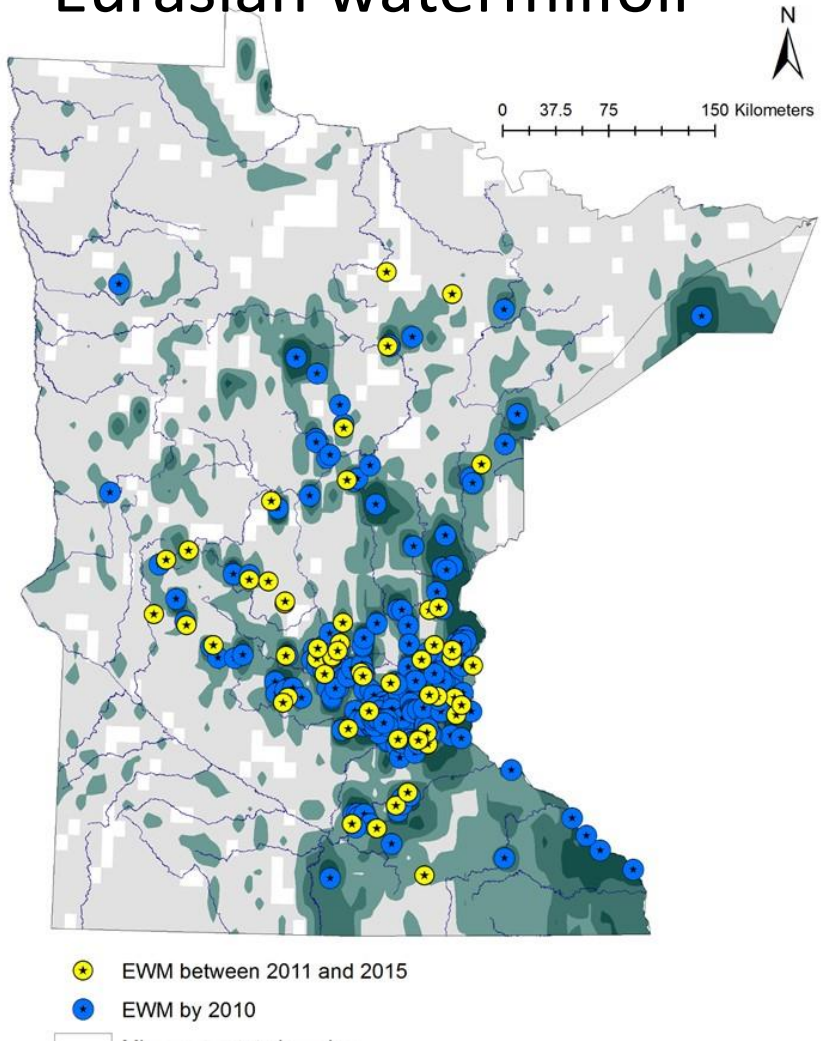
- Local spread risk factors?

Networks of AIS spread: Version 1.0

Zebra mussels



Eurasian watermilfoil



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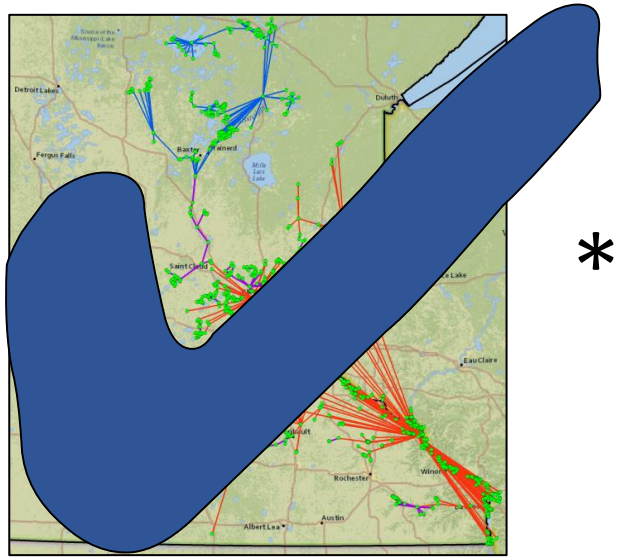

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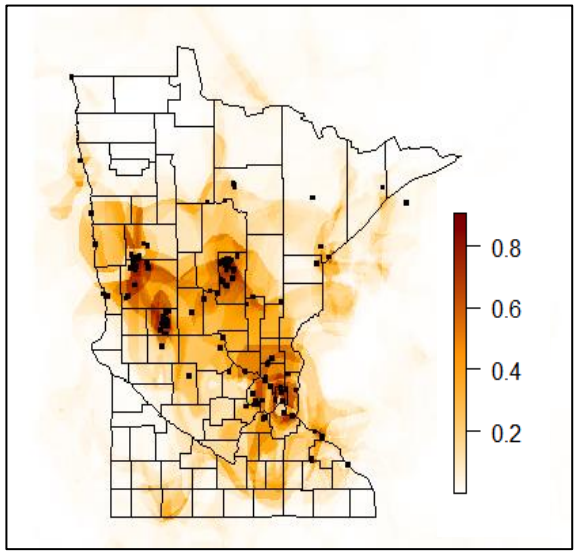
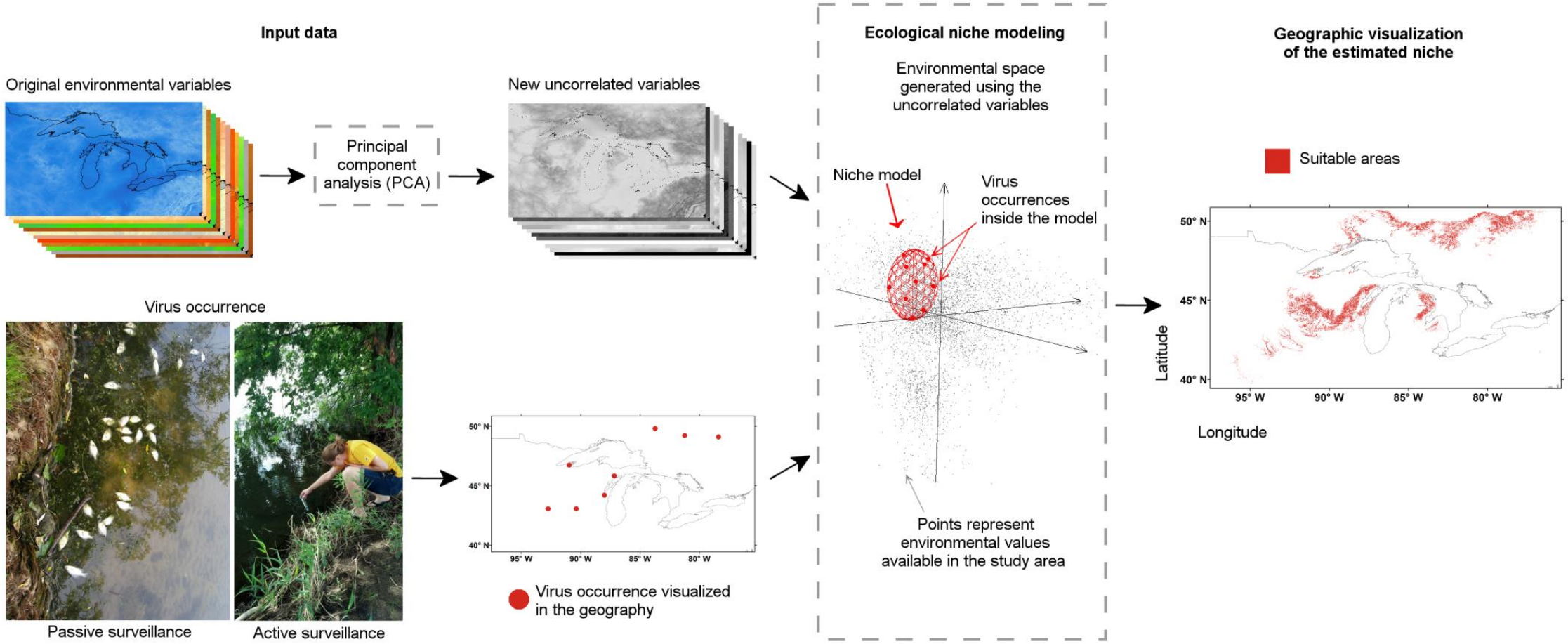


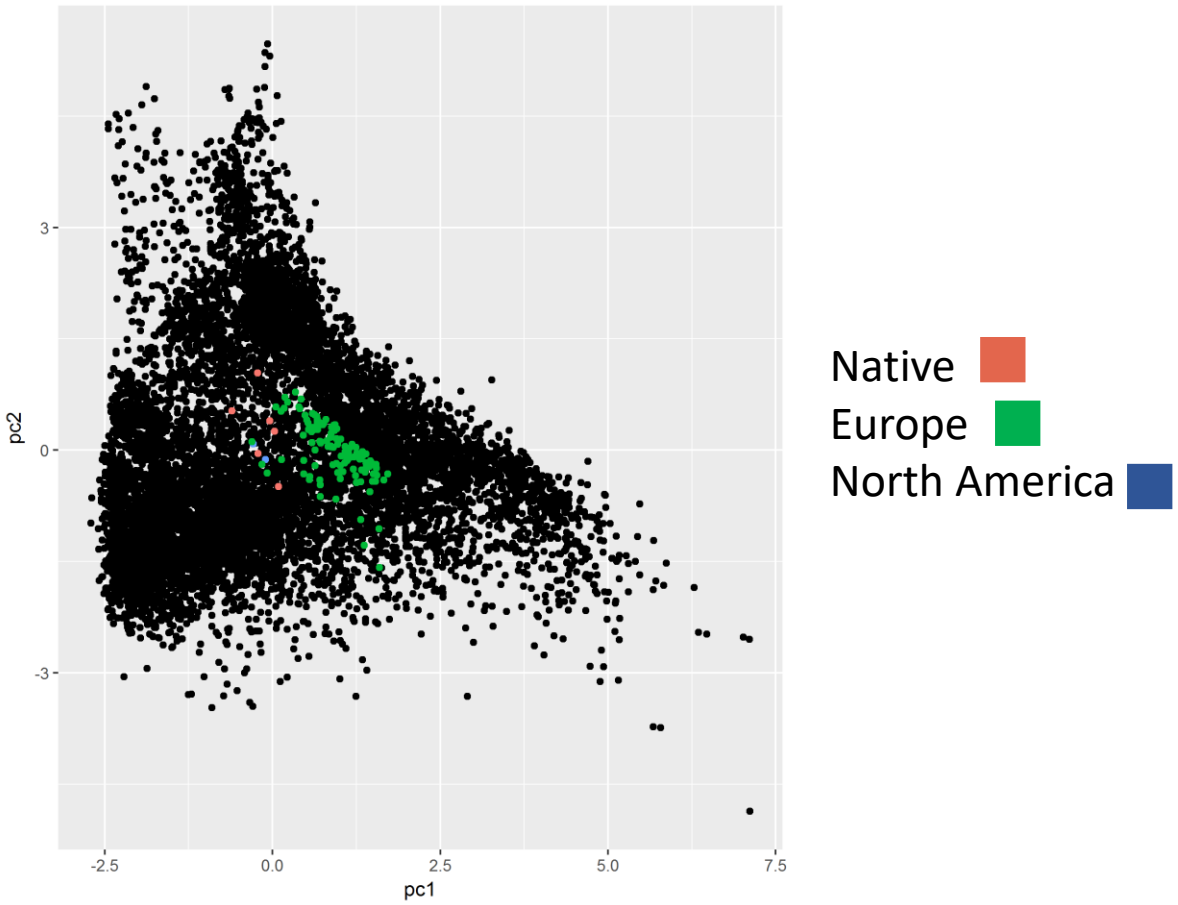
Suitability: Ecological niche modeling



Escobar et al. 2016. JFD.

Suitability: Zebra mussels

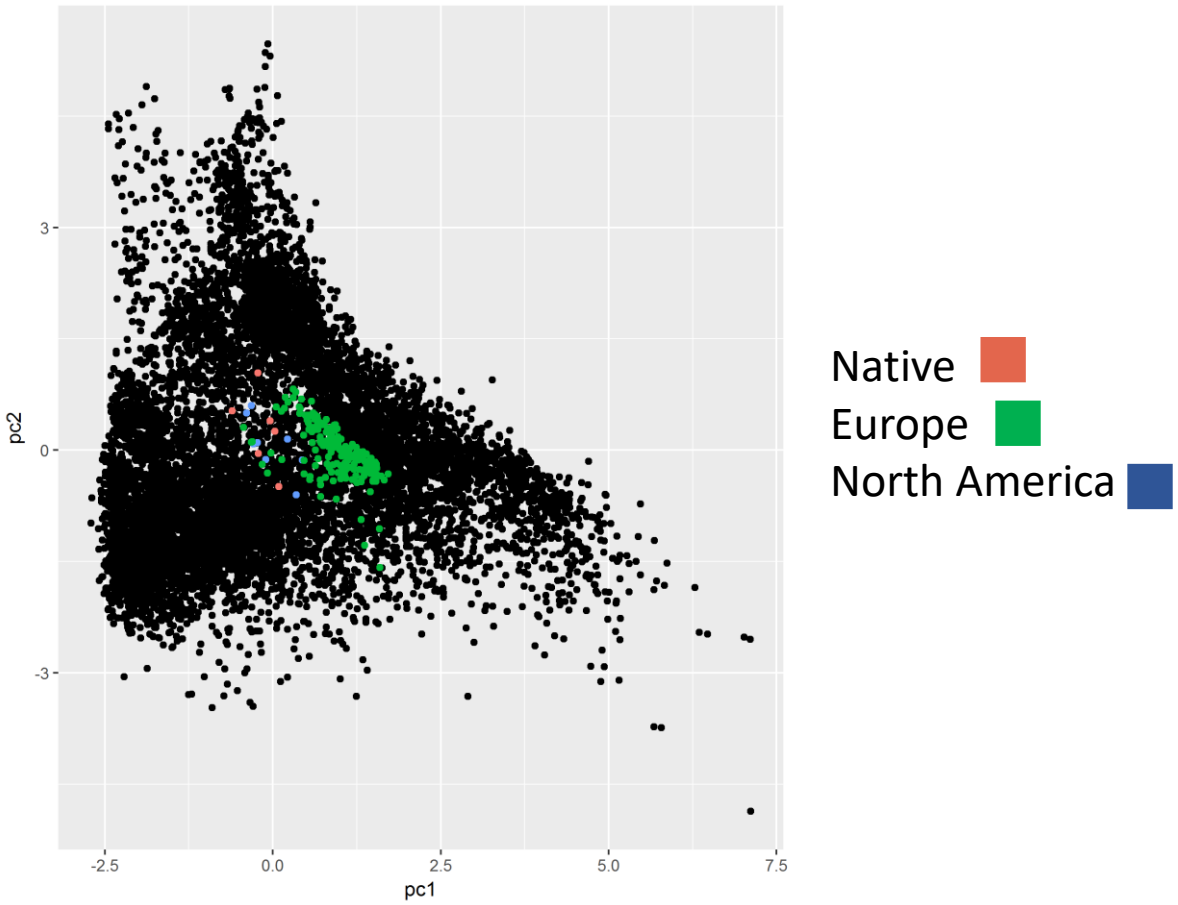
1980-1984



Escobar et al. In prep.

Suitability: Zebra mussels

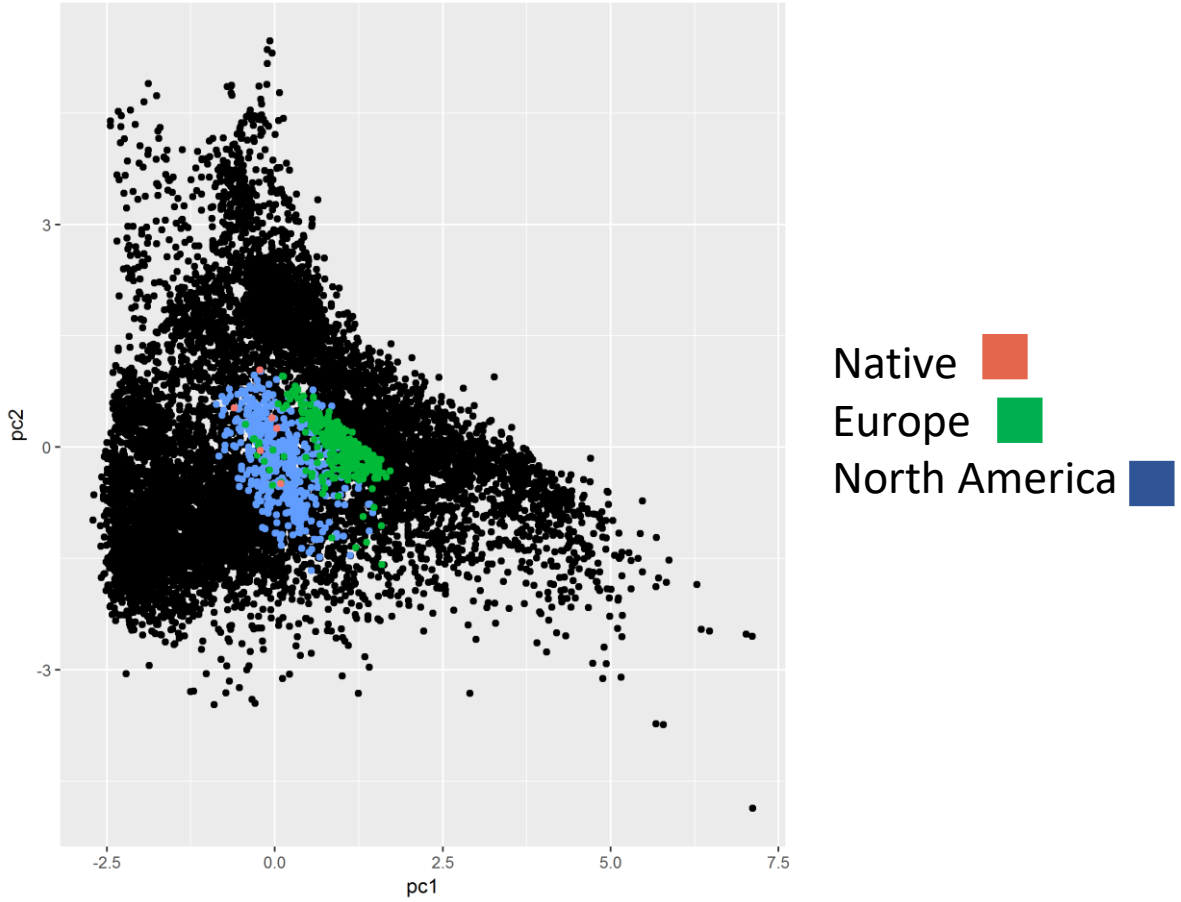
1985-1988



Escobar et al. In prep.

Suitability: Zebra mussels

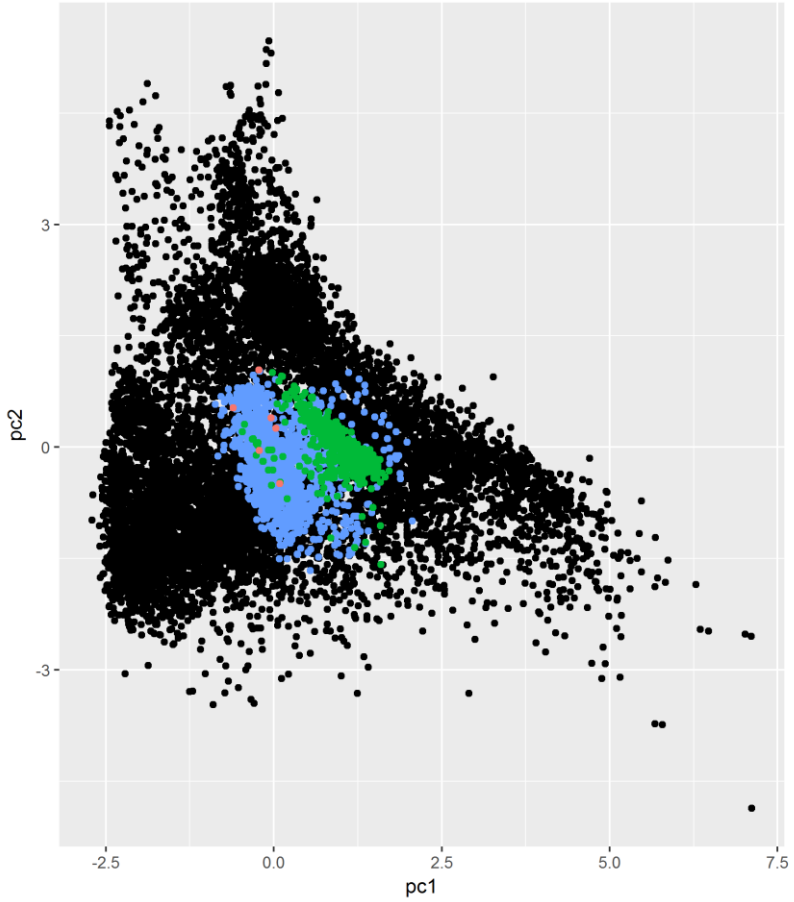
1989-1992



Escobar et al. In prep.

Suitability: Zebra mussels

1993-1996

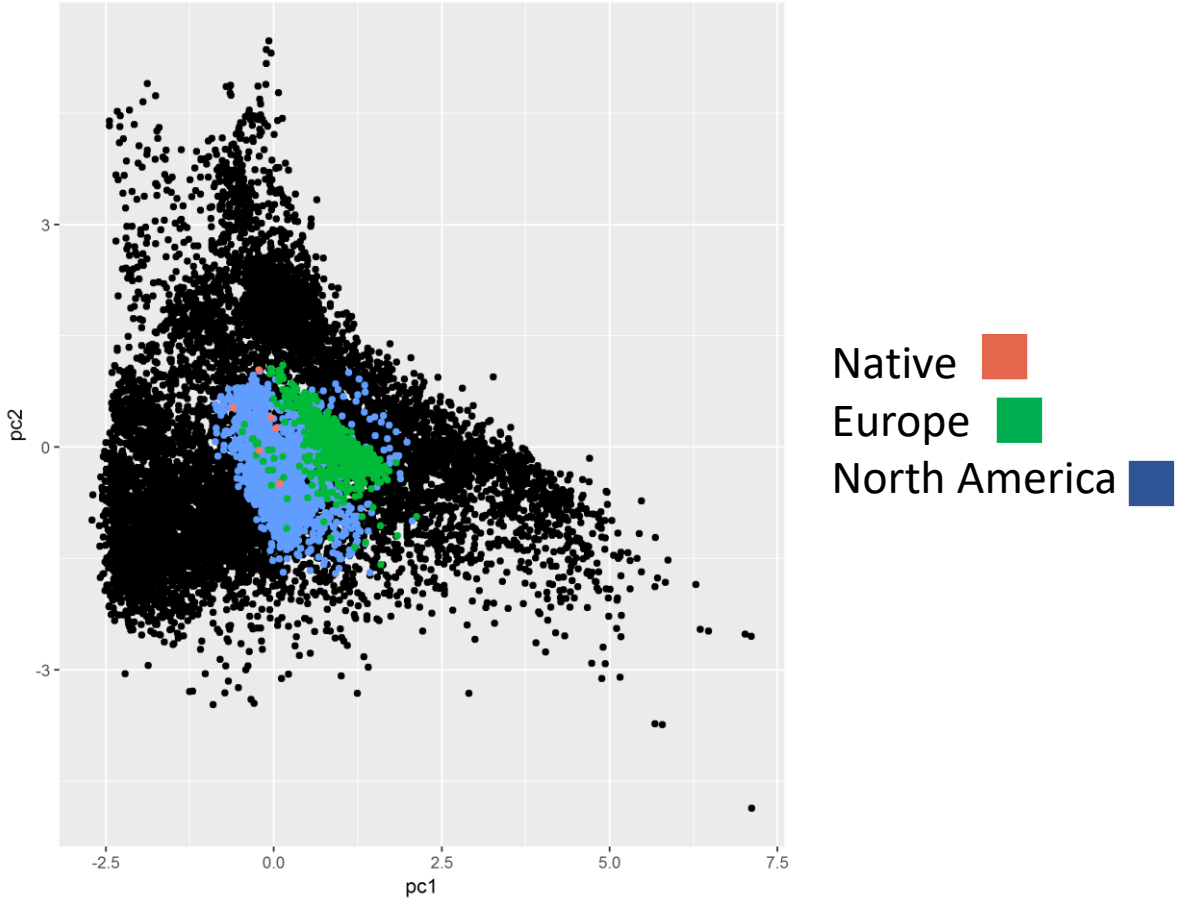


Native
Europe
North America

Escobar et al. In prep.

Suitability: Zebra mussels

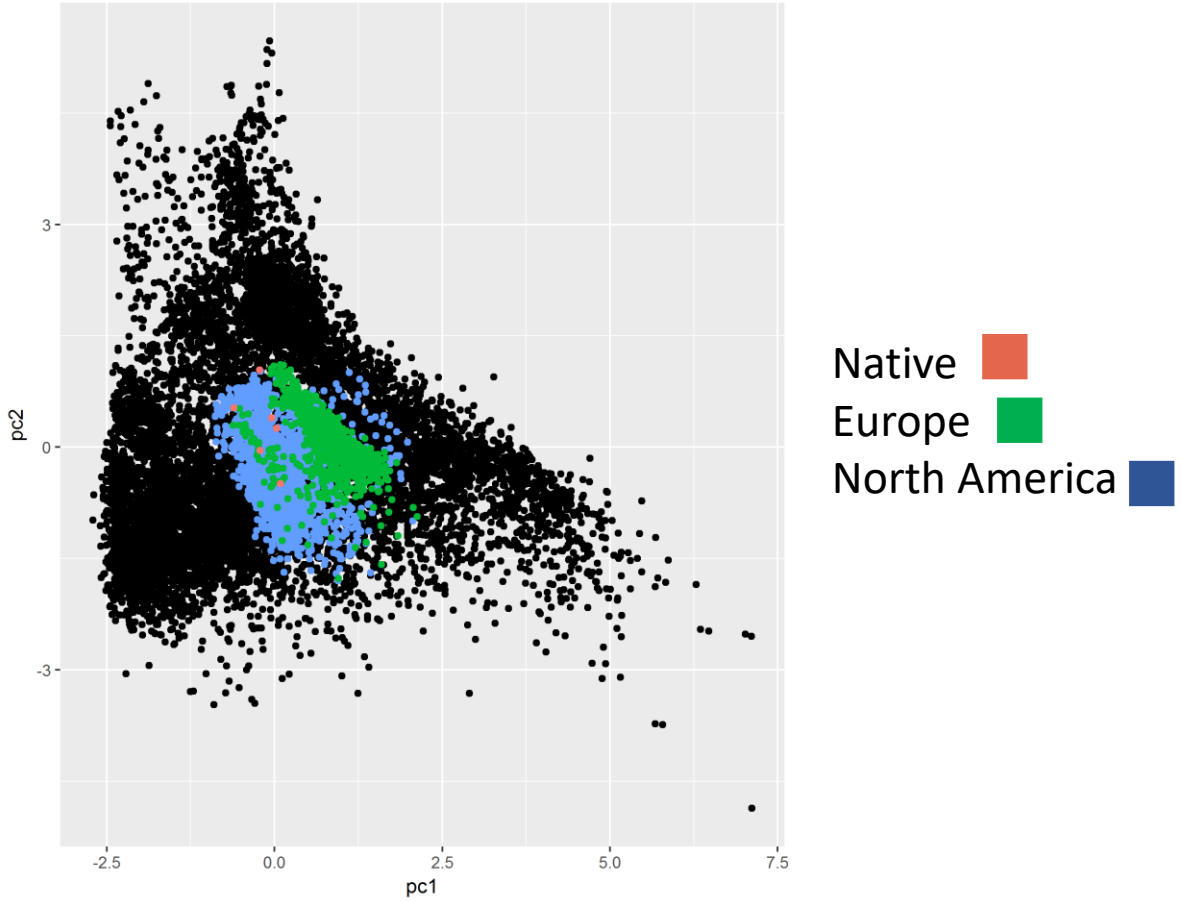
1997-2000



Escobar et al. In prep.

Suitability: Zebra mussels

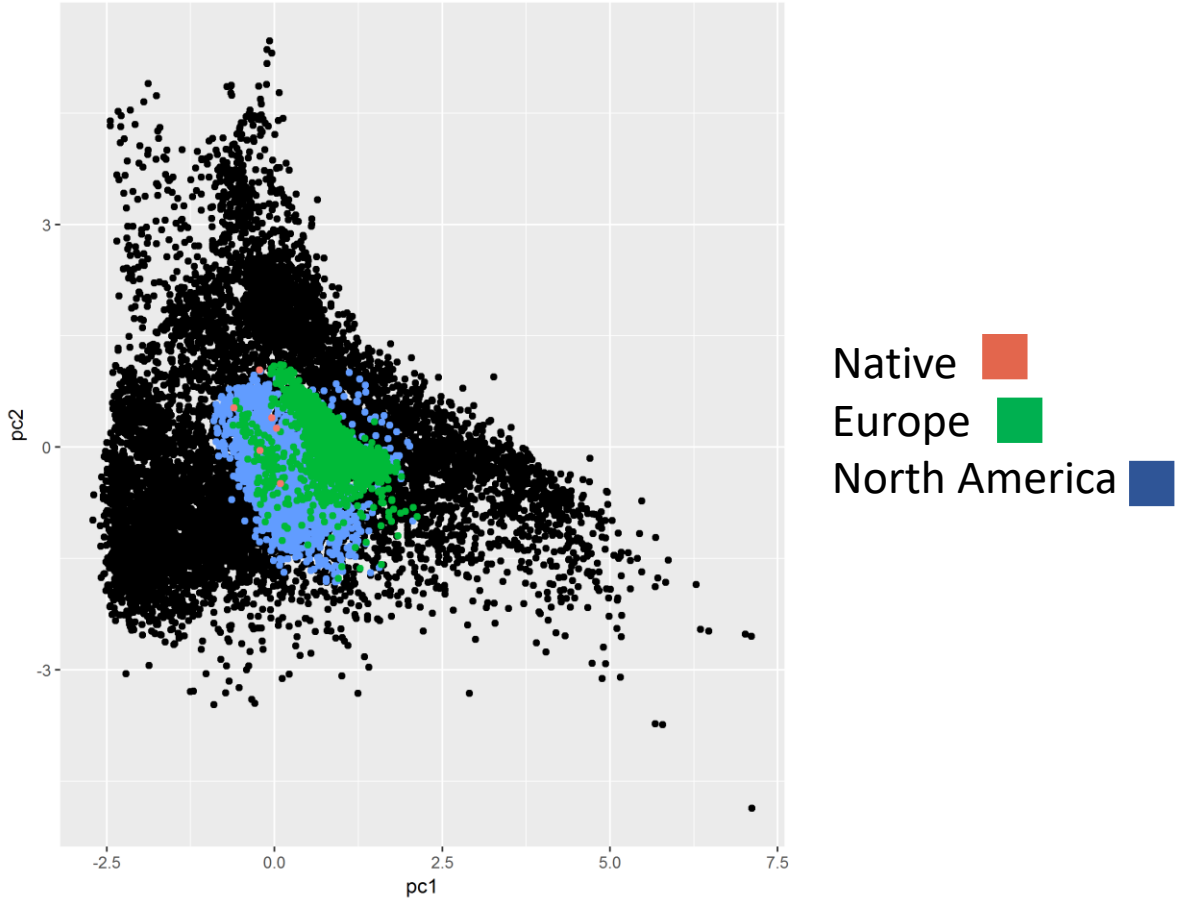
2001-2004



Escobar et al. In prep.

Suitability: Zebra mussels

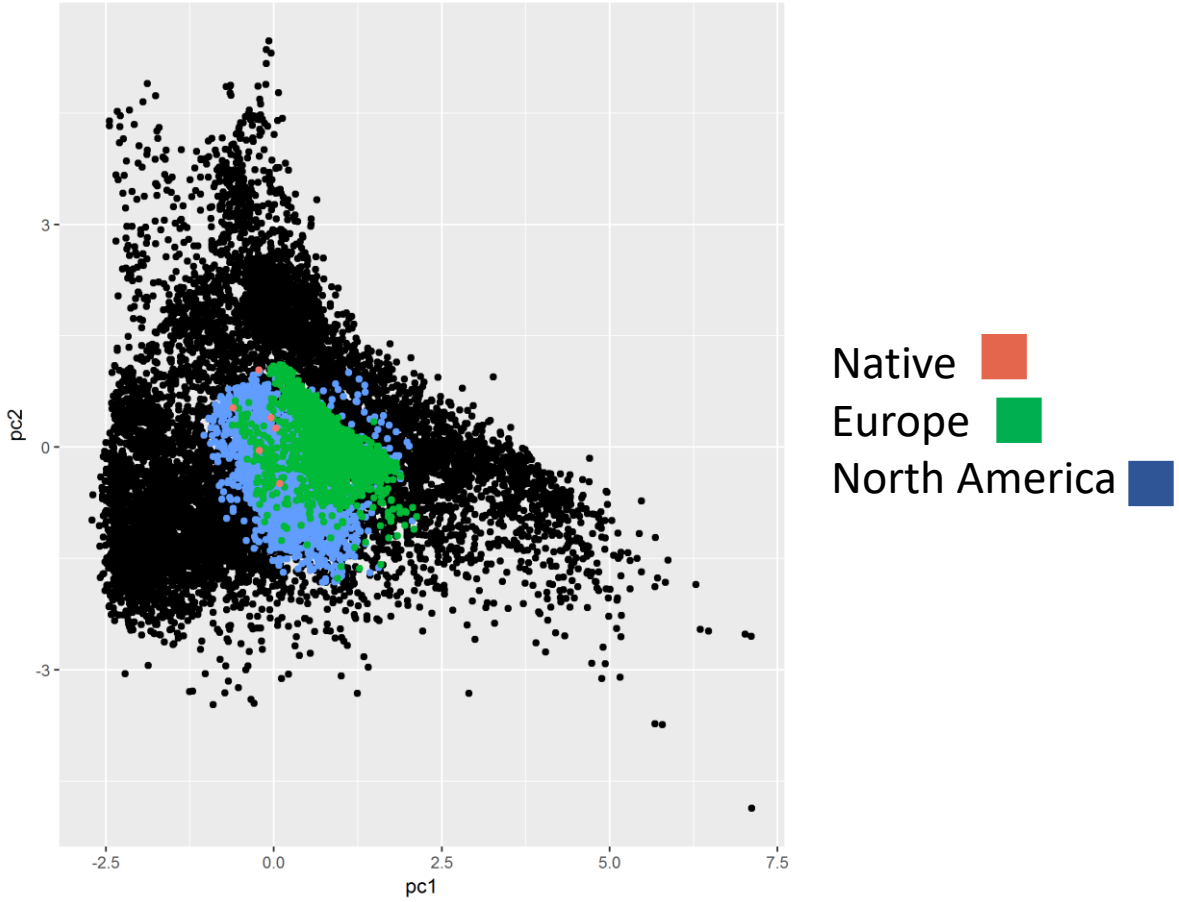
2005-2008



Escobar et al. In prep.

Suitability: Zebra mussels

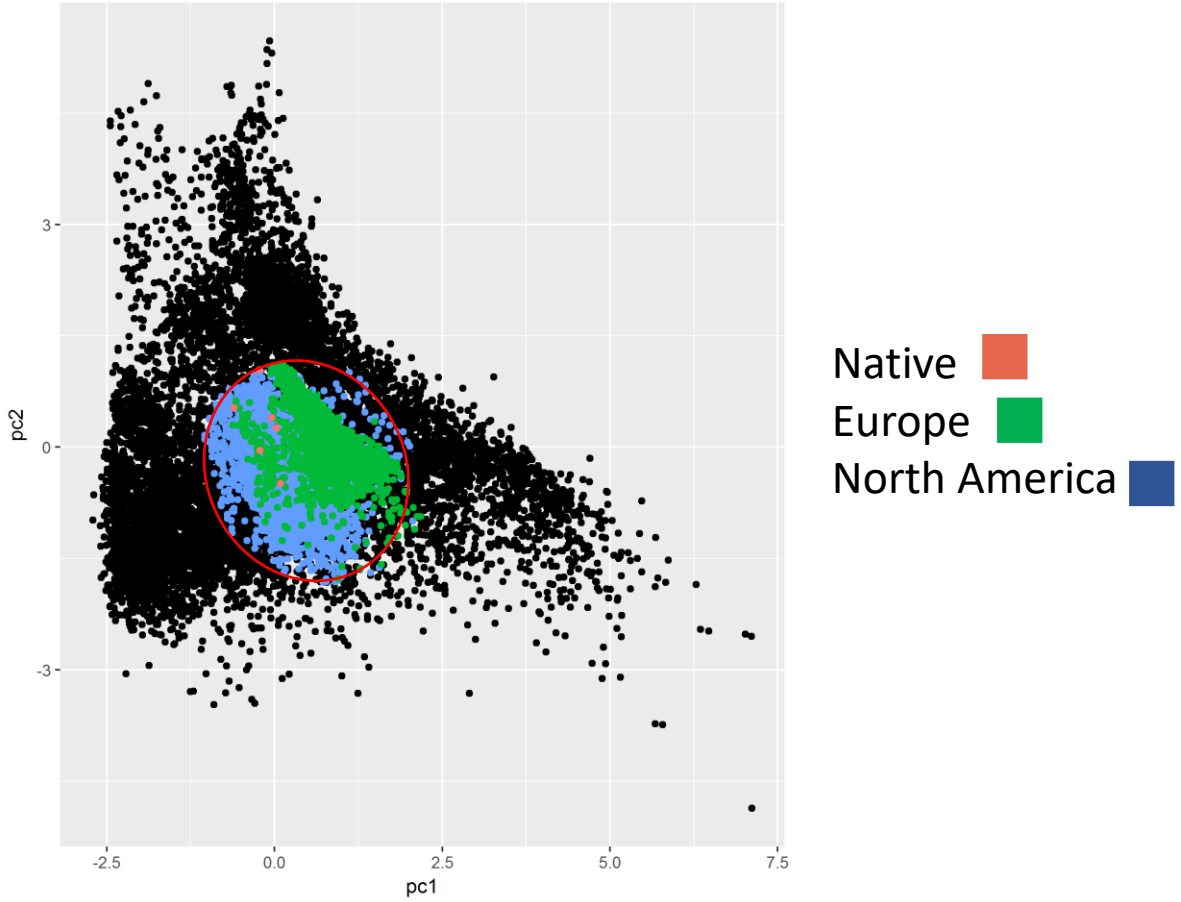
2009-2012



Escobar et al. In prep.

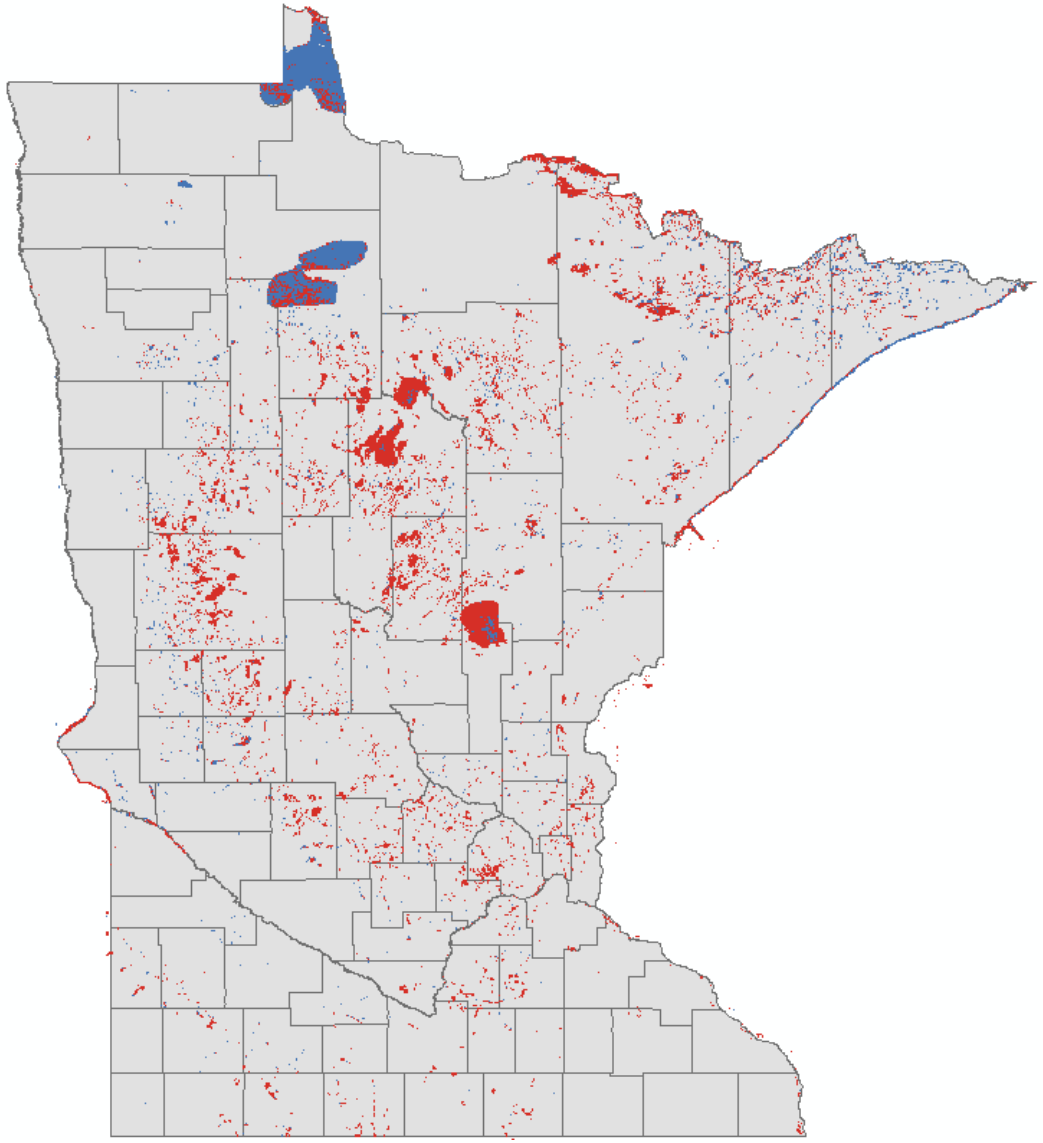
Suitability: Zebra mussels

2013-2016



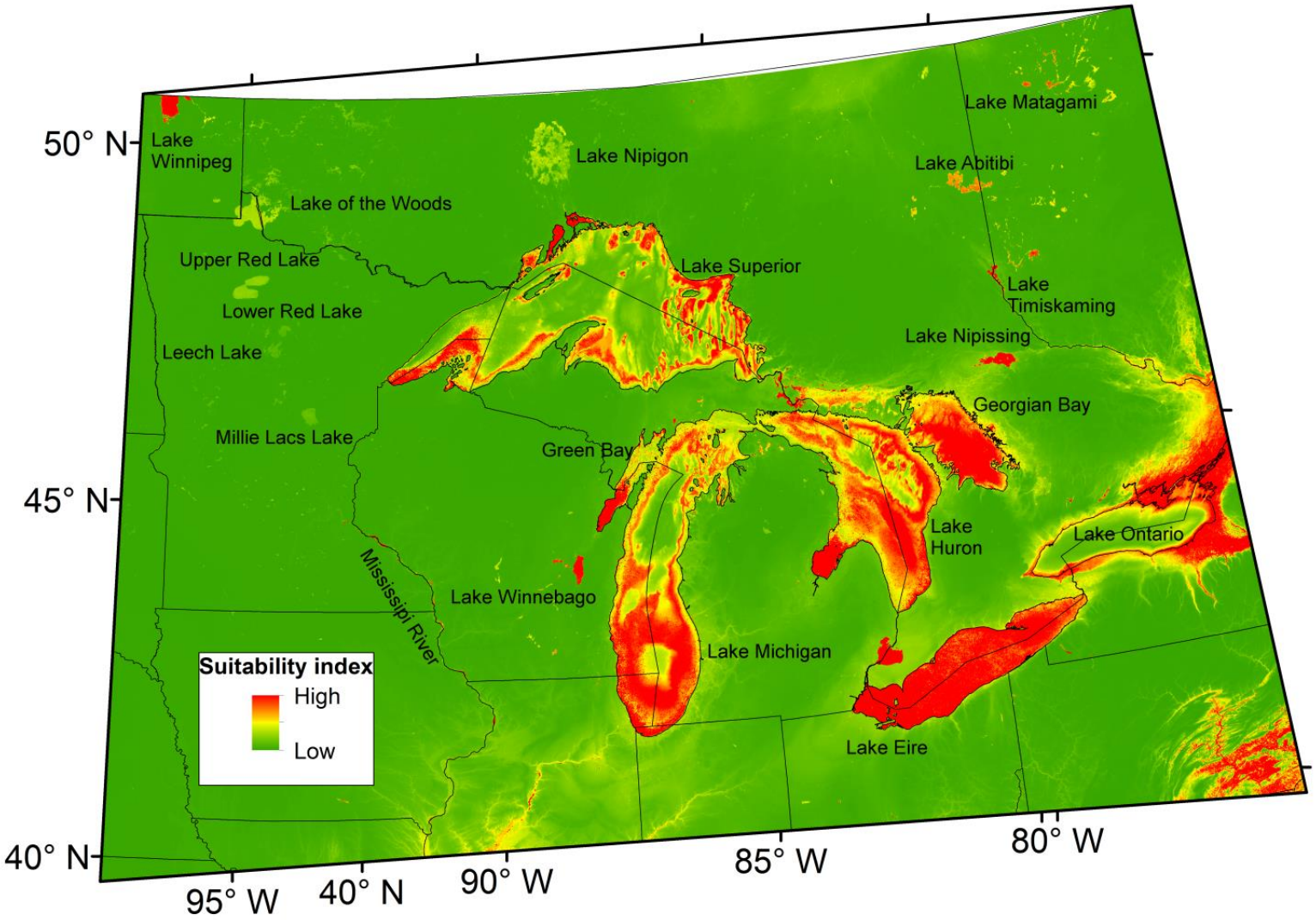
Escobar et al. In prep.

Suitability: Zebra mussels



Escobar et al. In prep.

Suitability: Viral hemorrhagic septicemia virus



Escobar et al. 2016. JFD.

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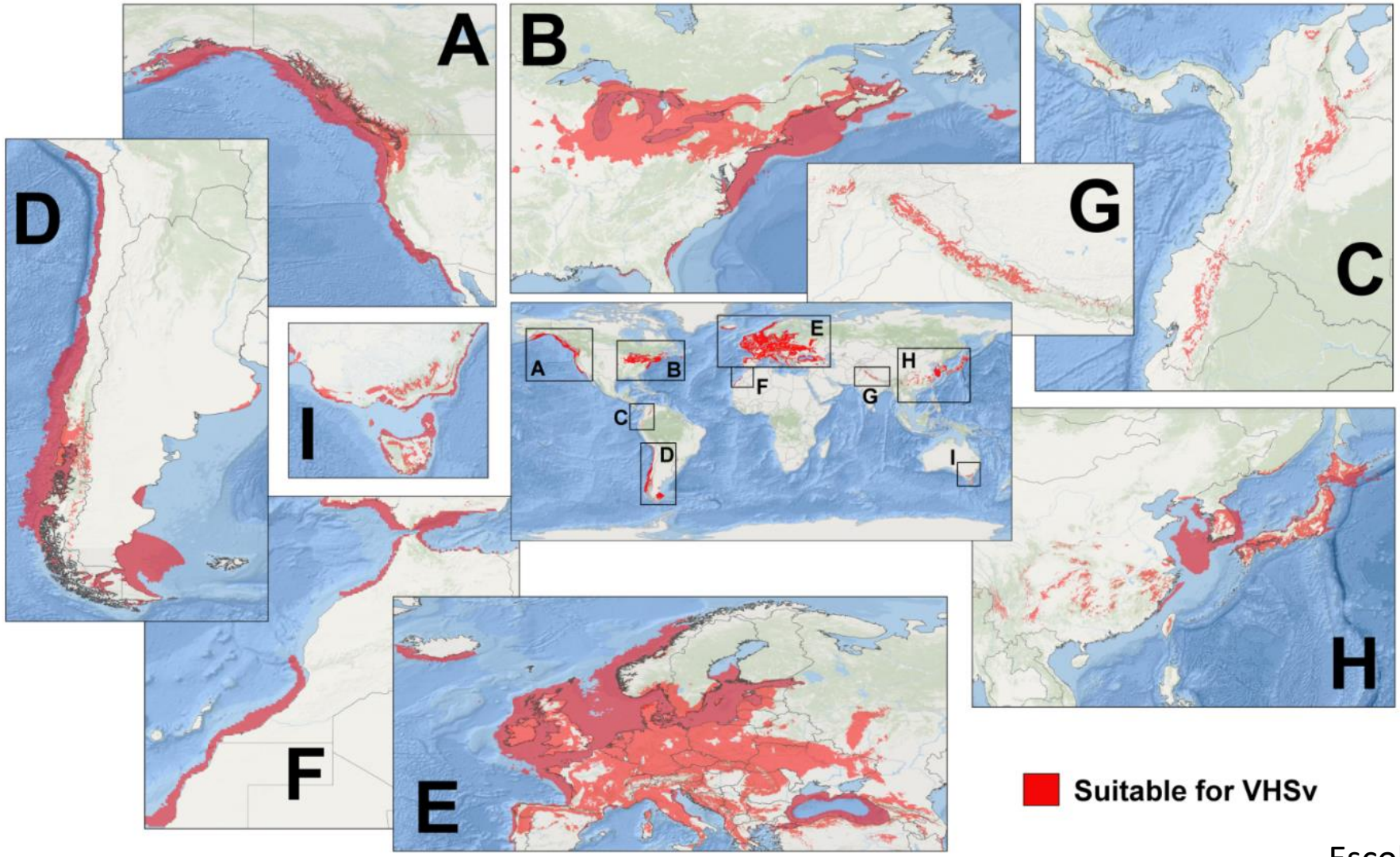
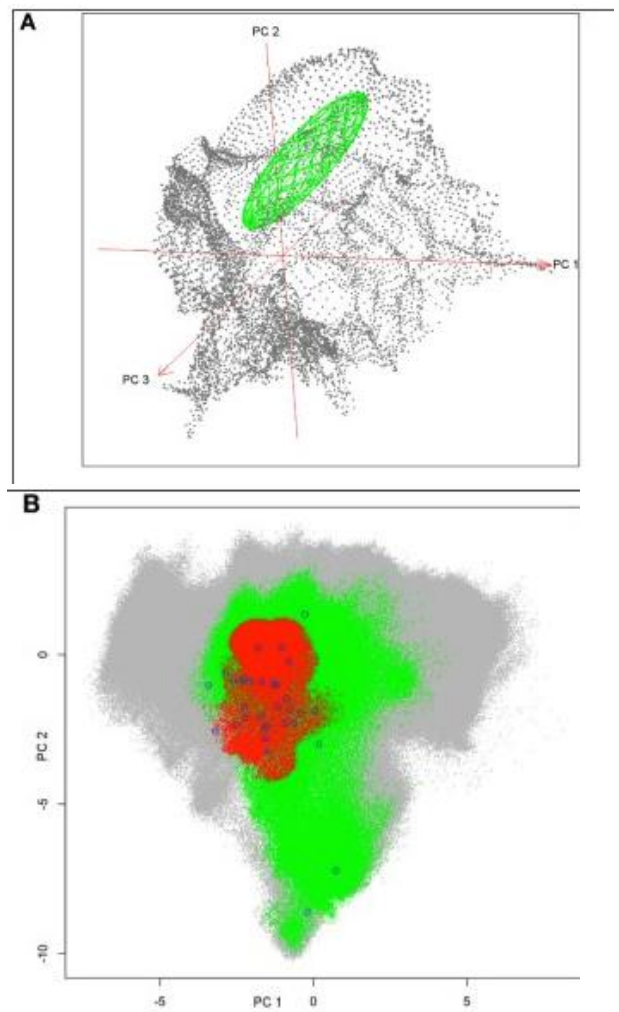
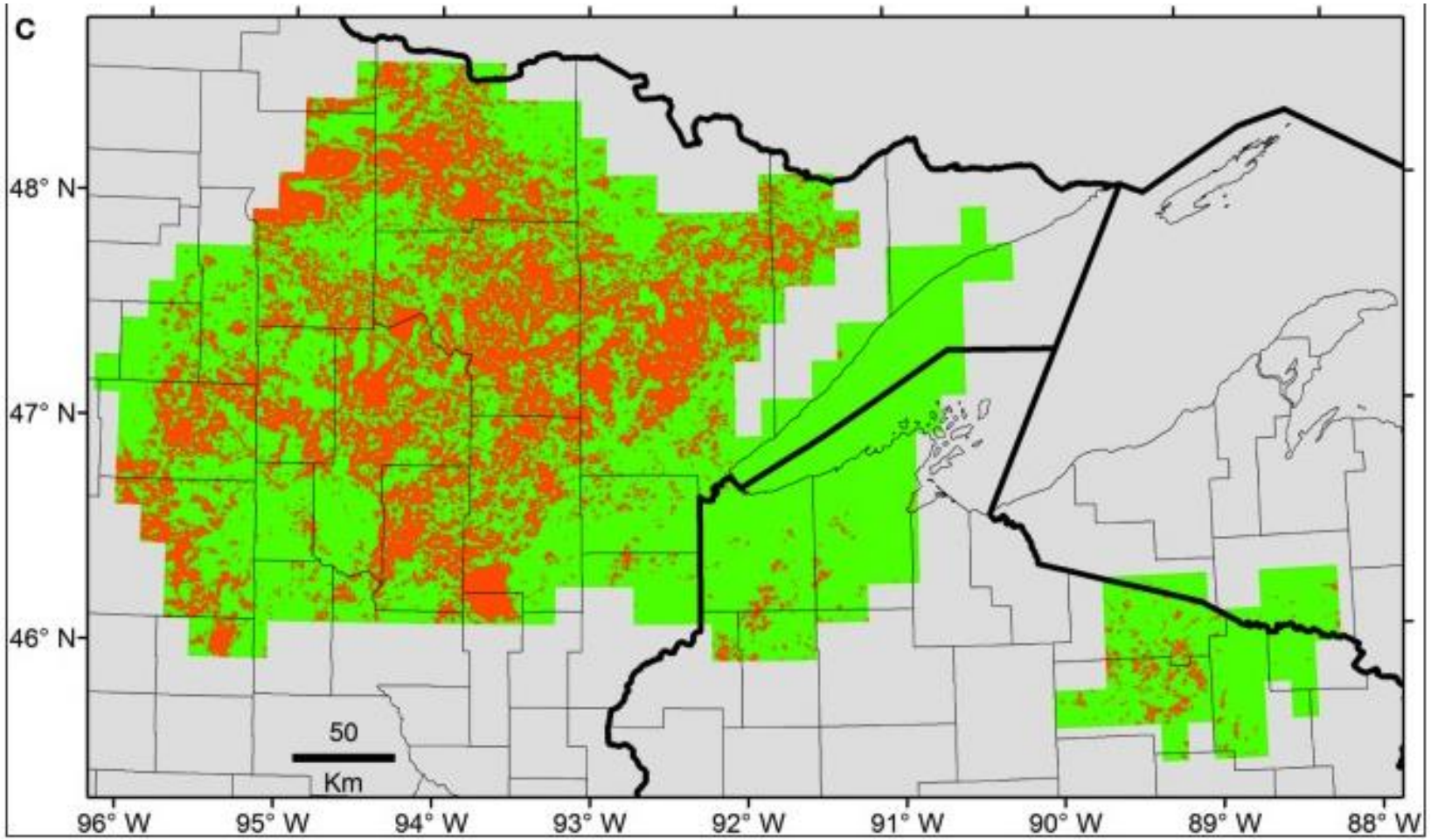


Escobar et al. In review.

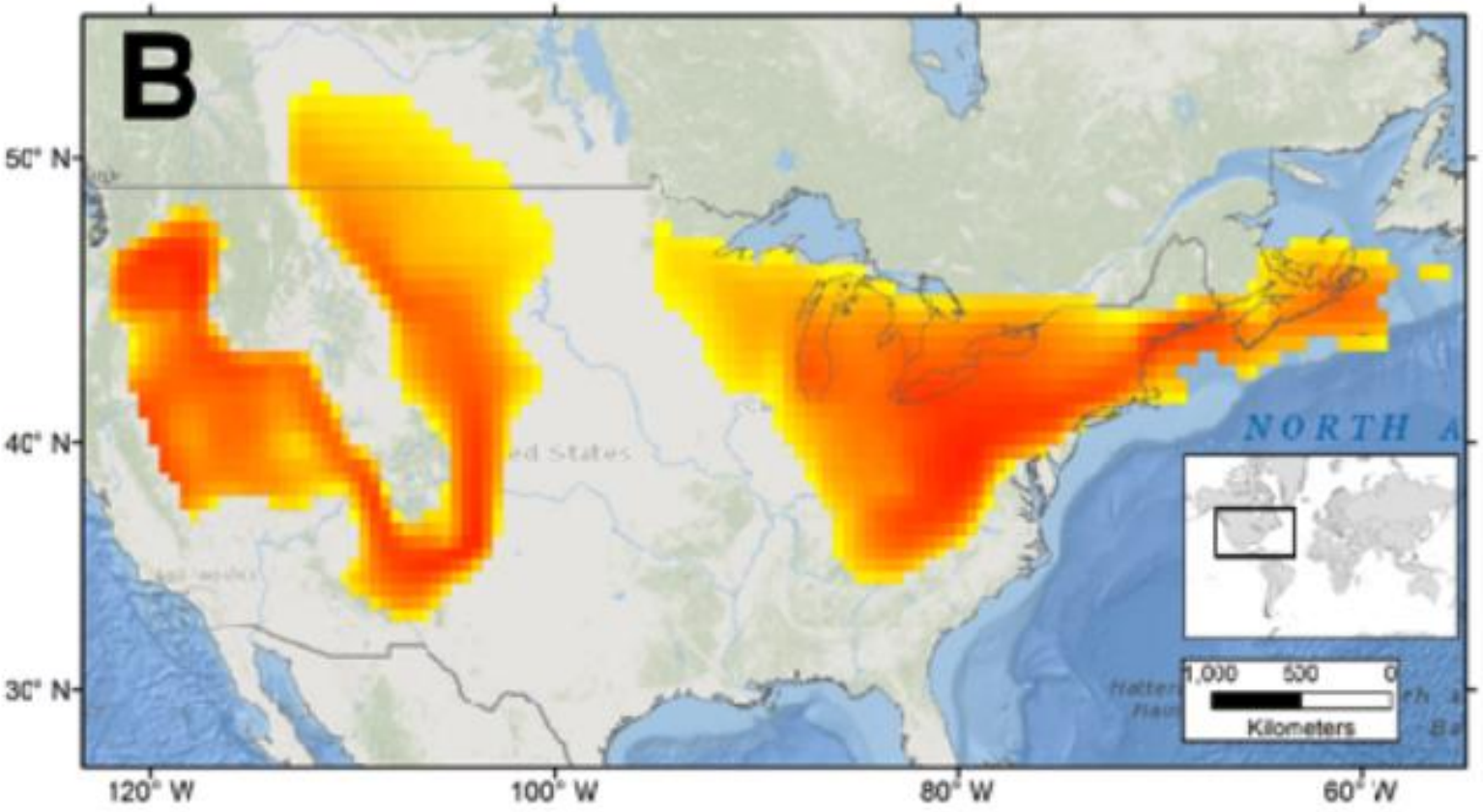
Suitability: *Heterosporis sutherlandae*



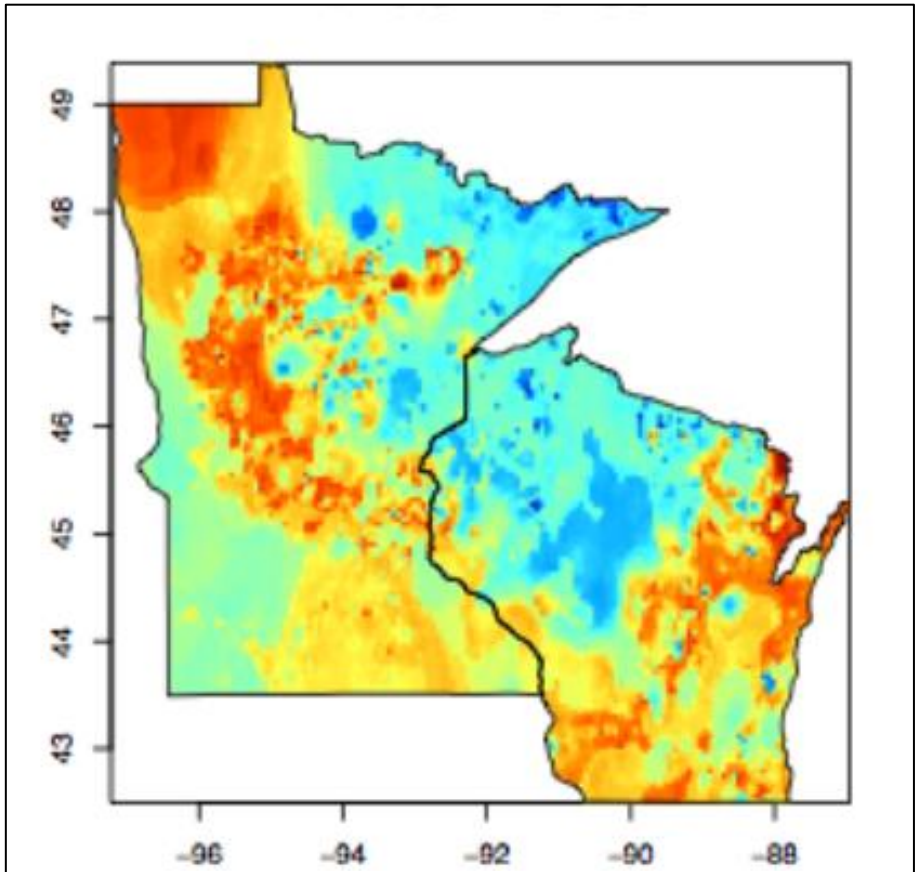


Escobar et al. 2017. FVS.

Suitability: Starry Stonewort

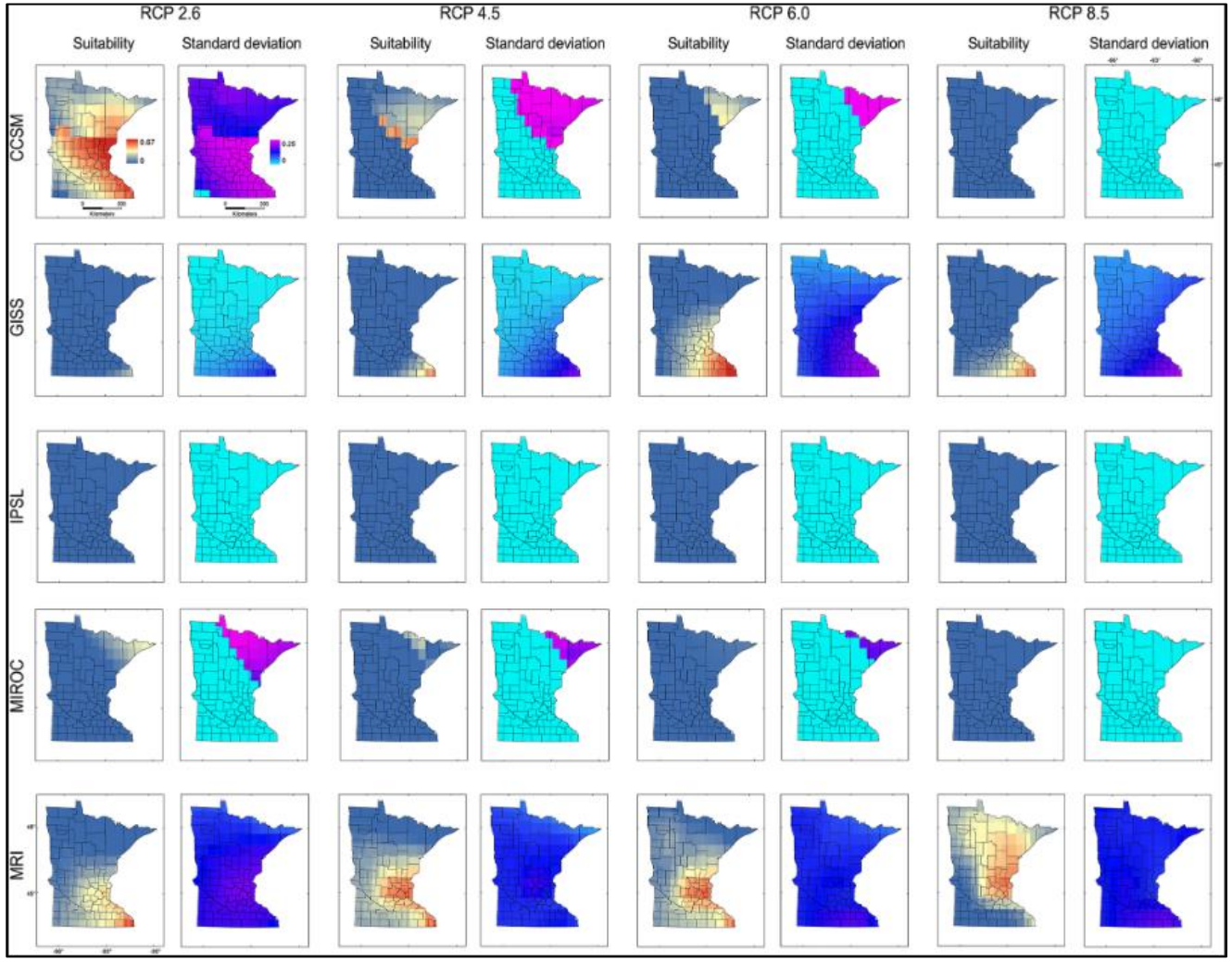


Escobar et al. 2016. Sci Reports.



Muthukrishnan and Larkin. In prep.

Suitability: Starry Stonewort



Romero-Alvarez et al. 2017. PLoS.

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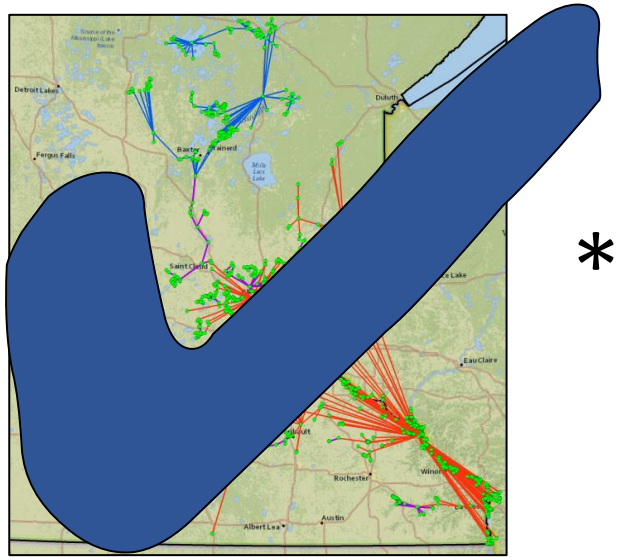

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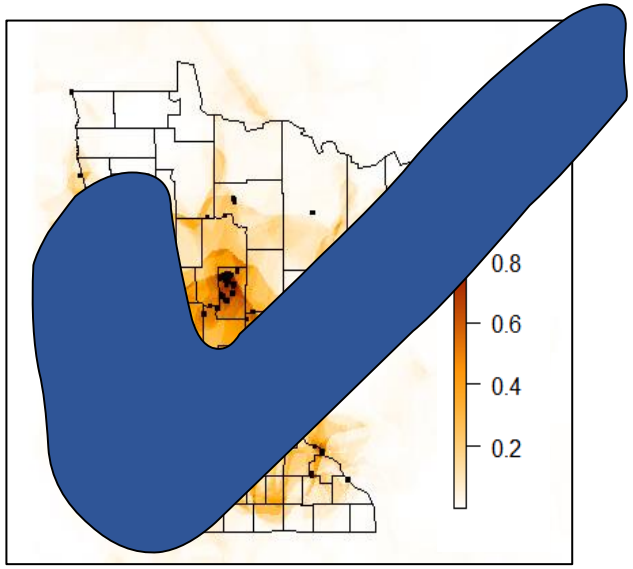


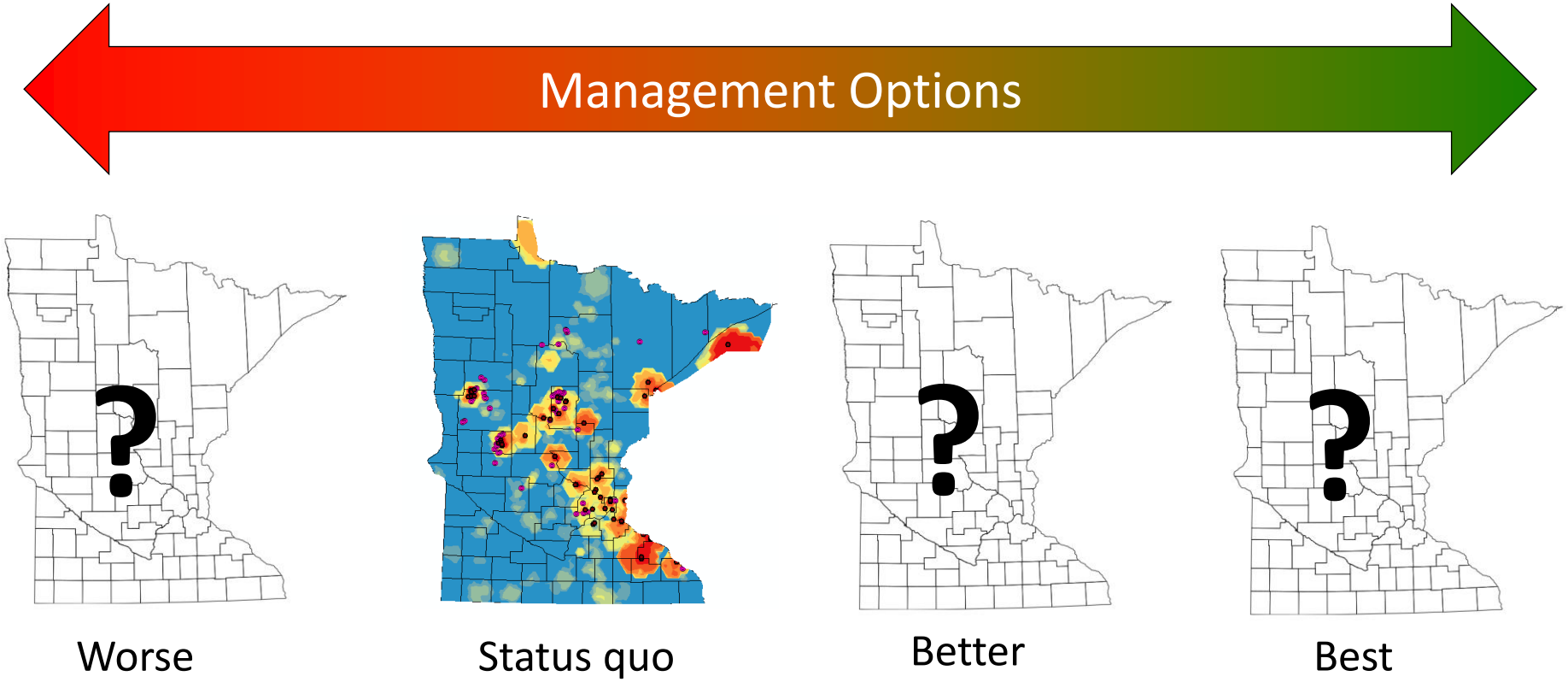
Using spatial models to inform management

Zebra mussel suitability

Lake Connectivity

		Low									High
		1	2	3	4	5	6	7	8	9	10
10	High	12	12	28	39	36	55	47	62	117	327
9				1	17	5	4	2	8	9	13
8		12	37	42	78	31	48	56	75	138	164
7		21	8	48	19	49	23	59	40	39	54
6		95	144	170	168	145	103	125	135	133	151
5		179	348	345	422	333	183	240	227	192	122
4		325	638	426	494	396	251	170	293	180	158
3		163	246	181	206	128	84	49	68	45	116
2		186	220	110	134	86	46	63	64	52	50
1	Low	3303	1424	490	318	327	287	184	232	179	244

Next step: Modeling management intervention



Questions?

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