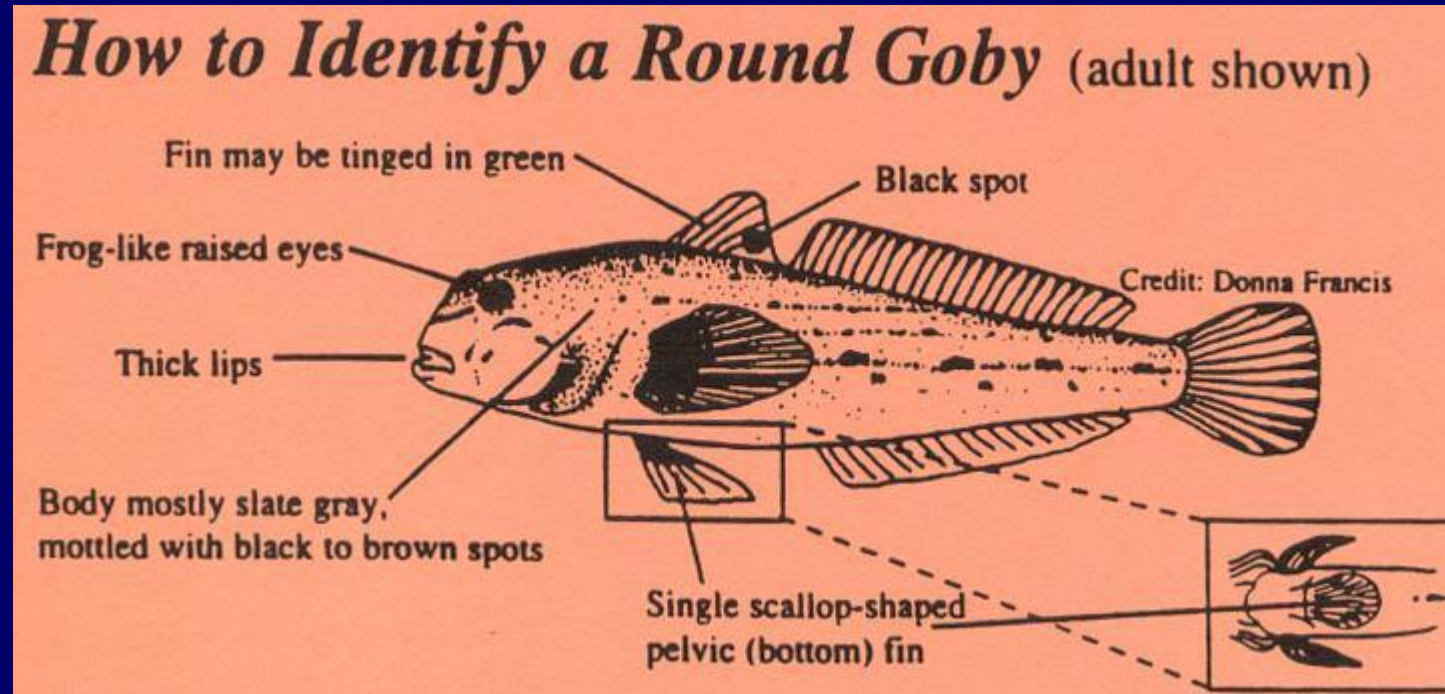


Human-mediated and natural dispersal of an invasive fish in the eastern Great Lakes



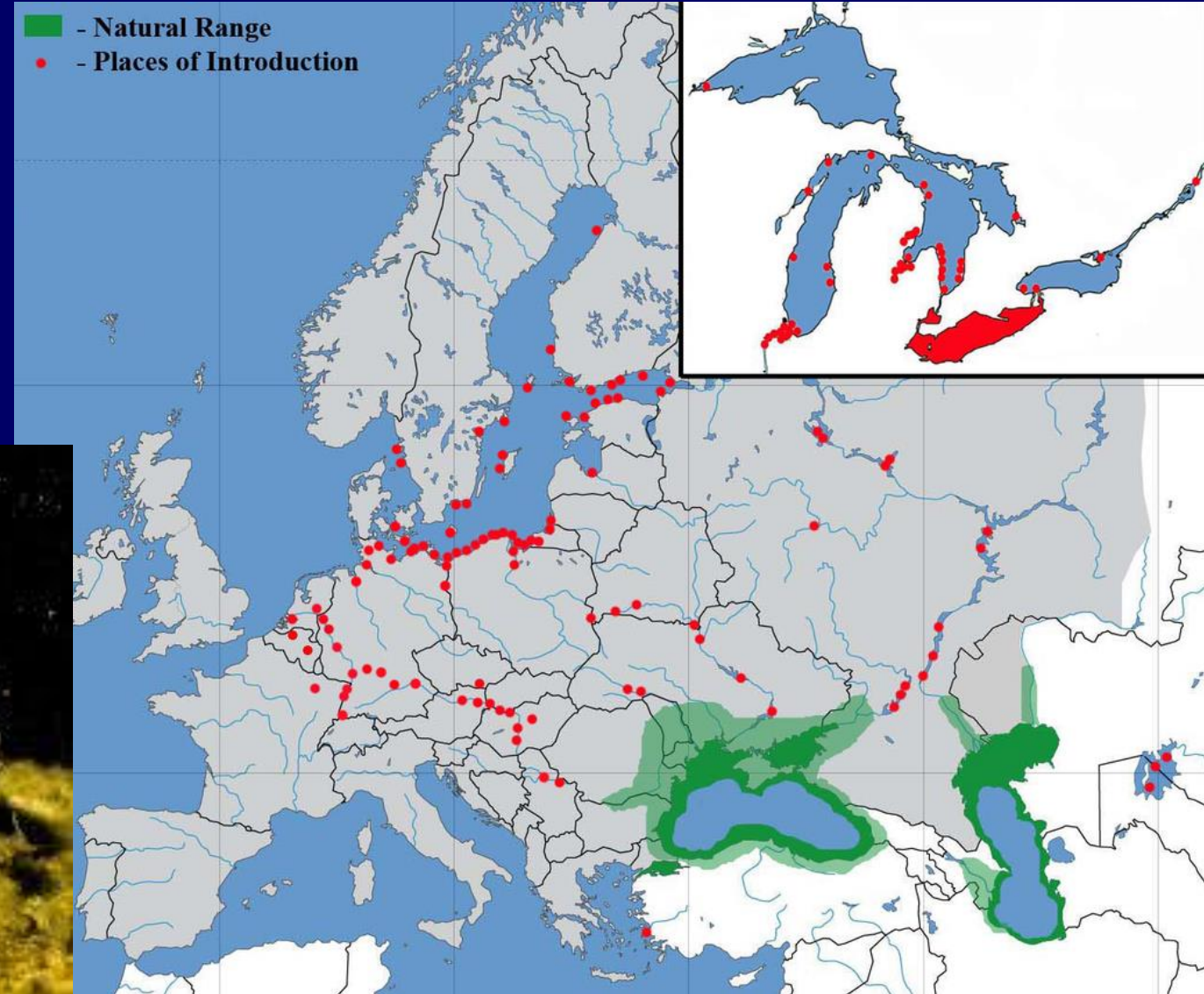
Mattias L. Johansson[‡], Bradley A. Dufour, Kyle W. Wellband,
Lynda D. Corkum, Hugh J. MacIsaac, Daniel D. Heath

Great Lakes Institute for Environmental Research, University of Windsor

October 25, 2017

Round Goby

Neogobius melanostomus



Round Goby life history

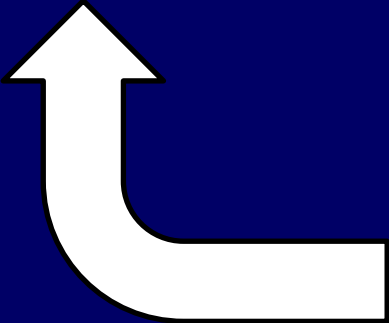


♀ 1-2 years*



♂ 3-4 years*

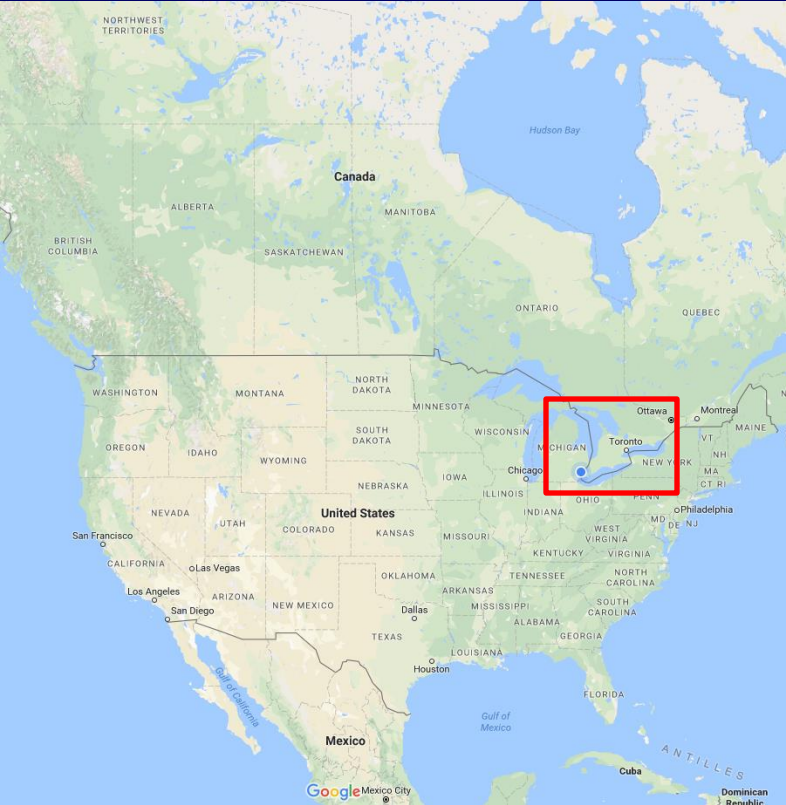


- 
- Male guarding
 - Up to 95% hatch



- 
- 250 to 5000 eggs
 - Up to 6 clutches/year/♀

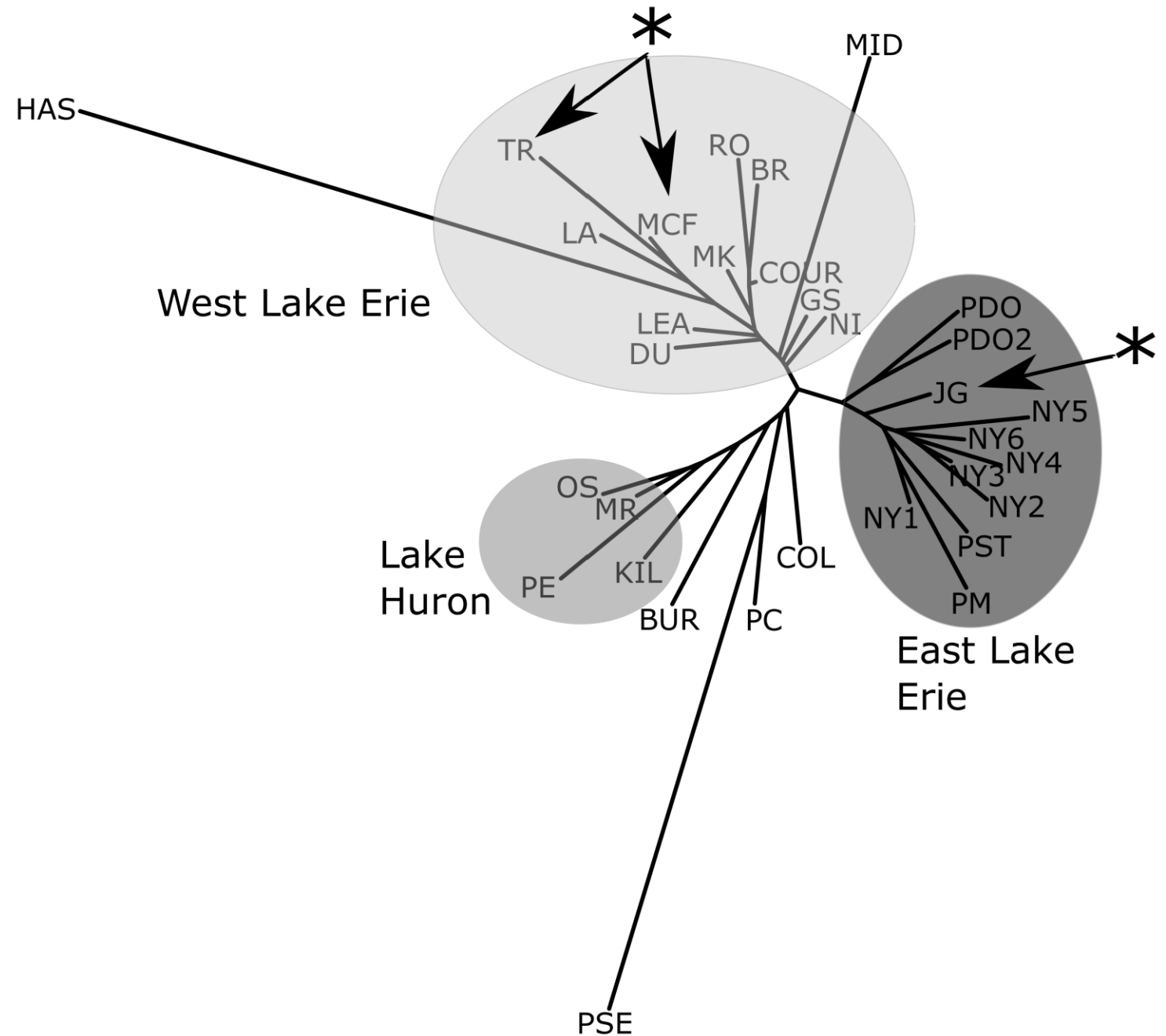
Project design



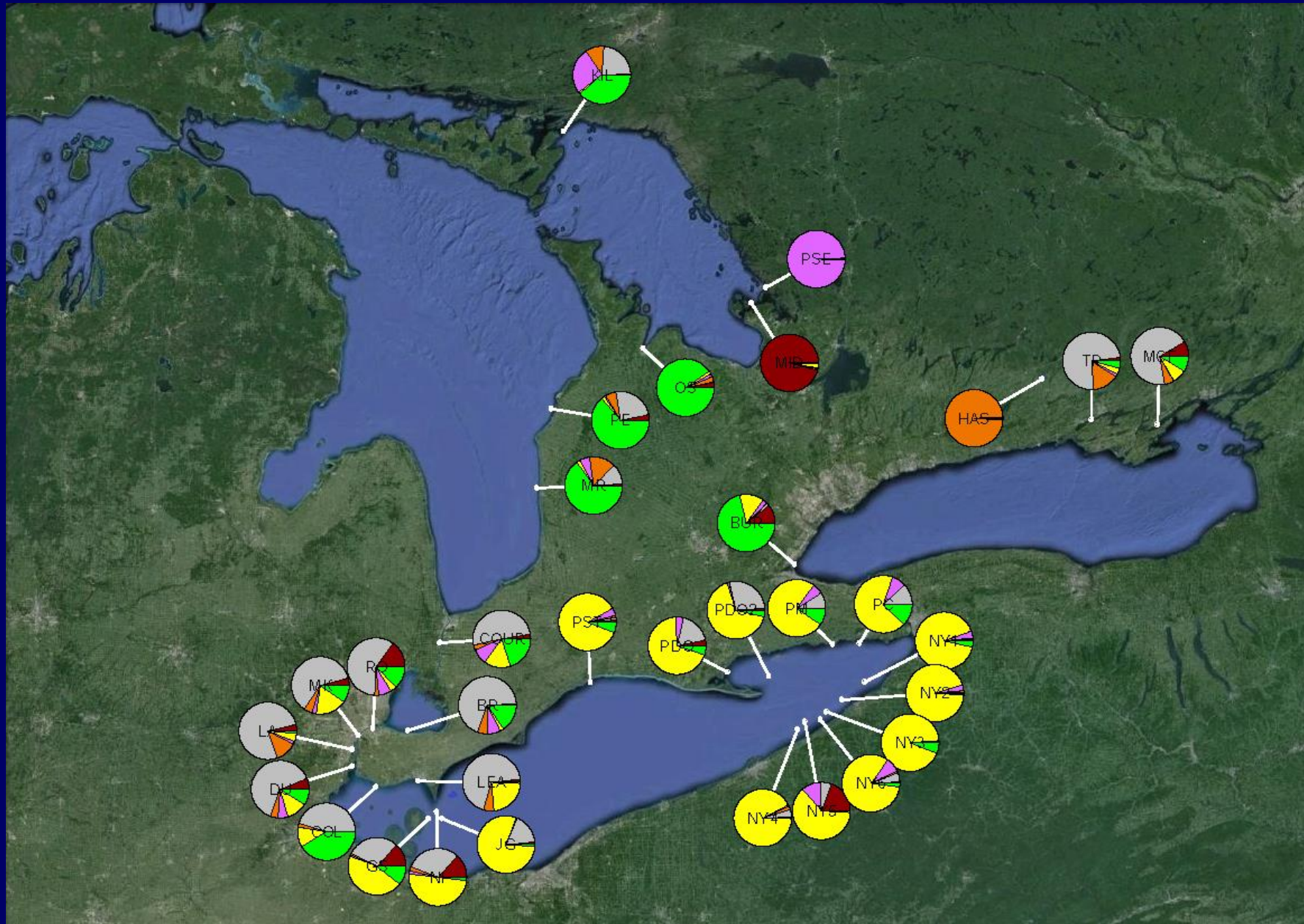
- 32 Sites
- 1958 Samples
- 9 microsatellite markers

Neighbor-joining tree

- 3 Clusters, correspond to Lakes
- 3 Divergent populations
- A few populations that are geographic outliers



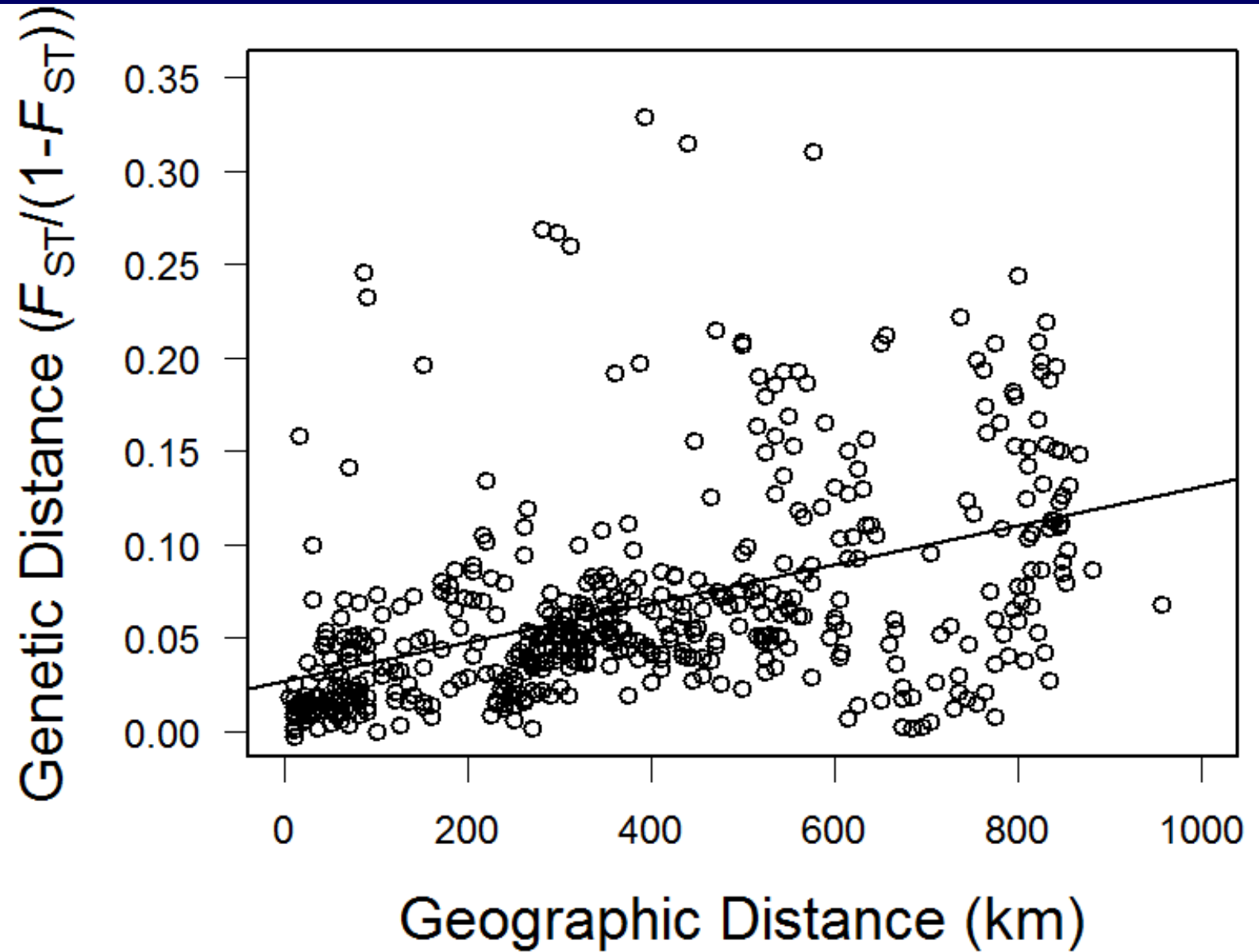
STRUCTURE results



Isolation-by-distance

$P < 0.001$

Adj. $R^2 = 0.21$



Our real interest: Drivers of current structure

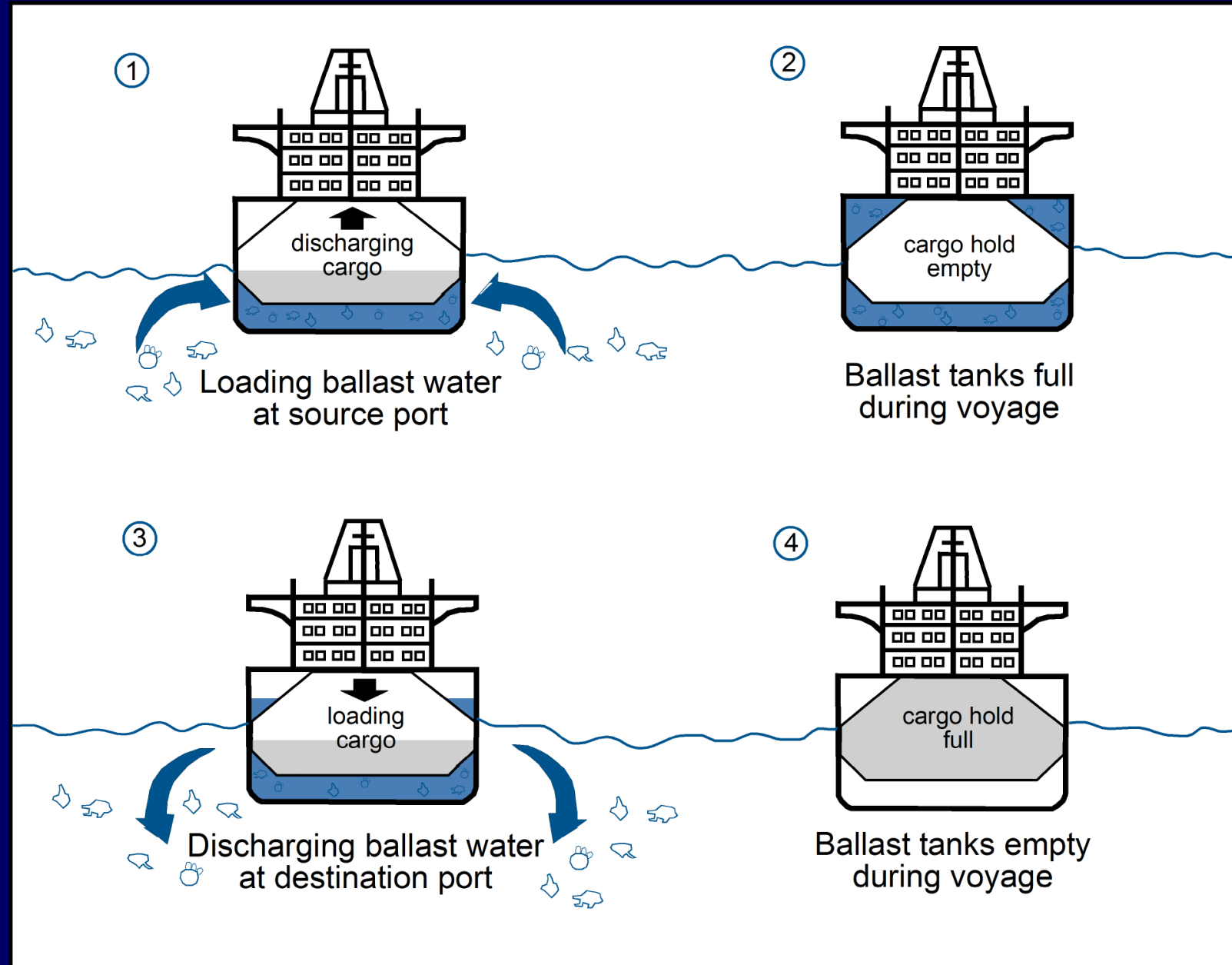
A variety of mechanisms may have played a role in the spread of Round Gobies in the Great Lakes

- Ballast water transport
- Bait bucket transport
- Natural dispersal

Each mechanism should leave a characteristic signal in the population genetic structure

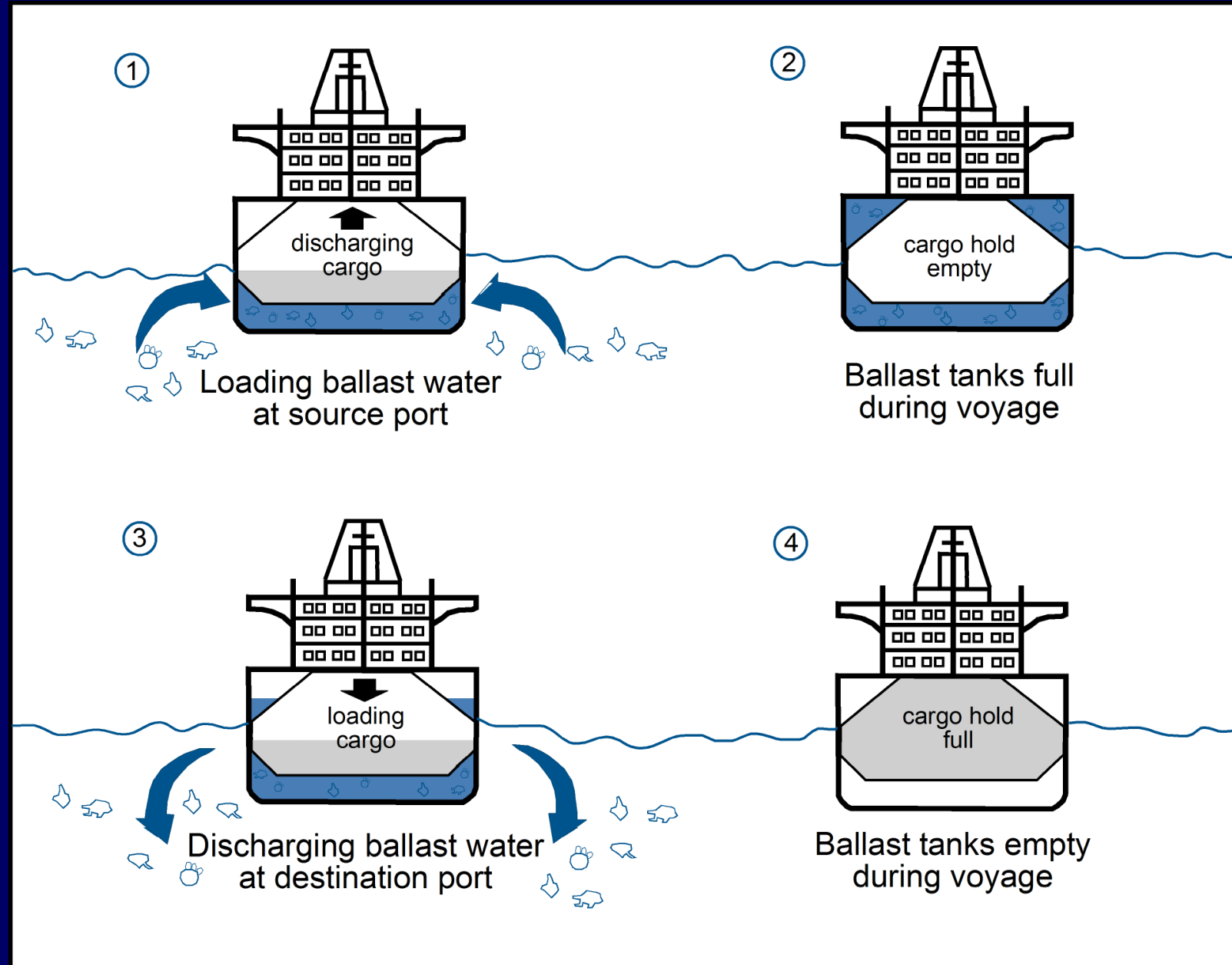
Our goal is to find these signals

Ballast water transport

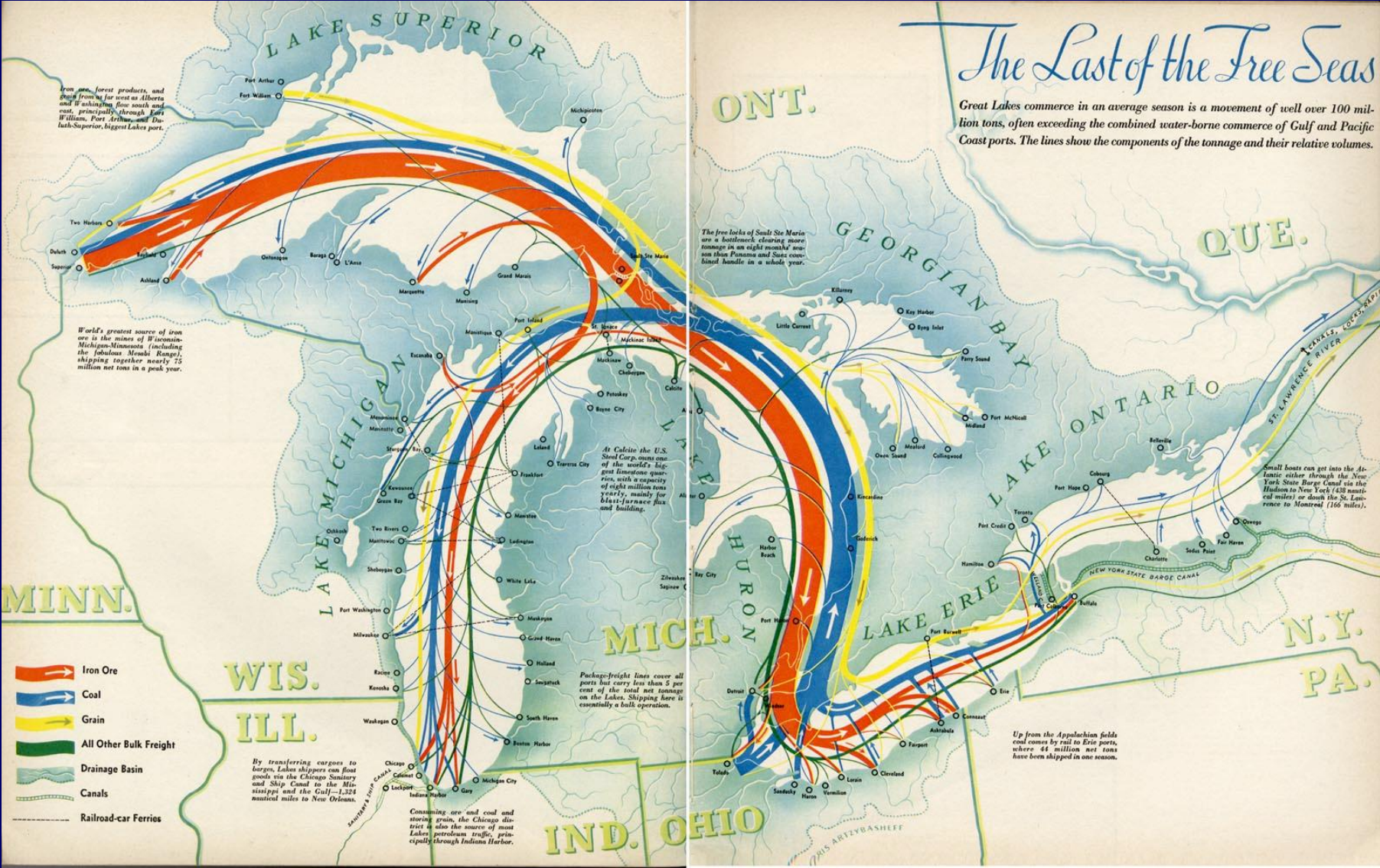


Ballast water transport

Ships may also adjust ballast levels when entering/exiting narrow or shallow water

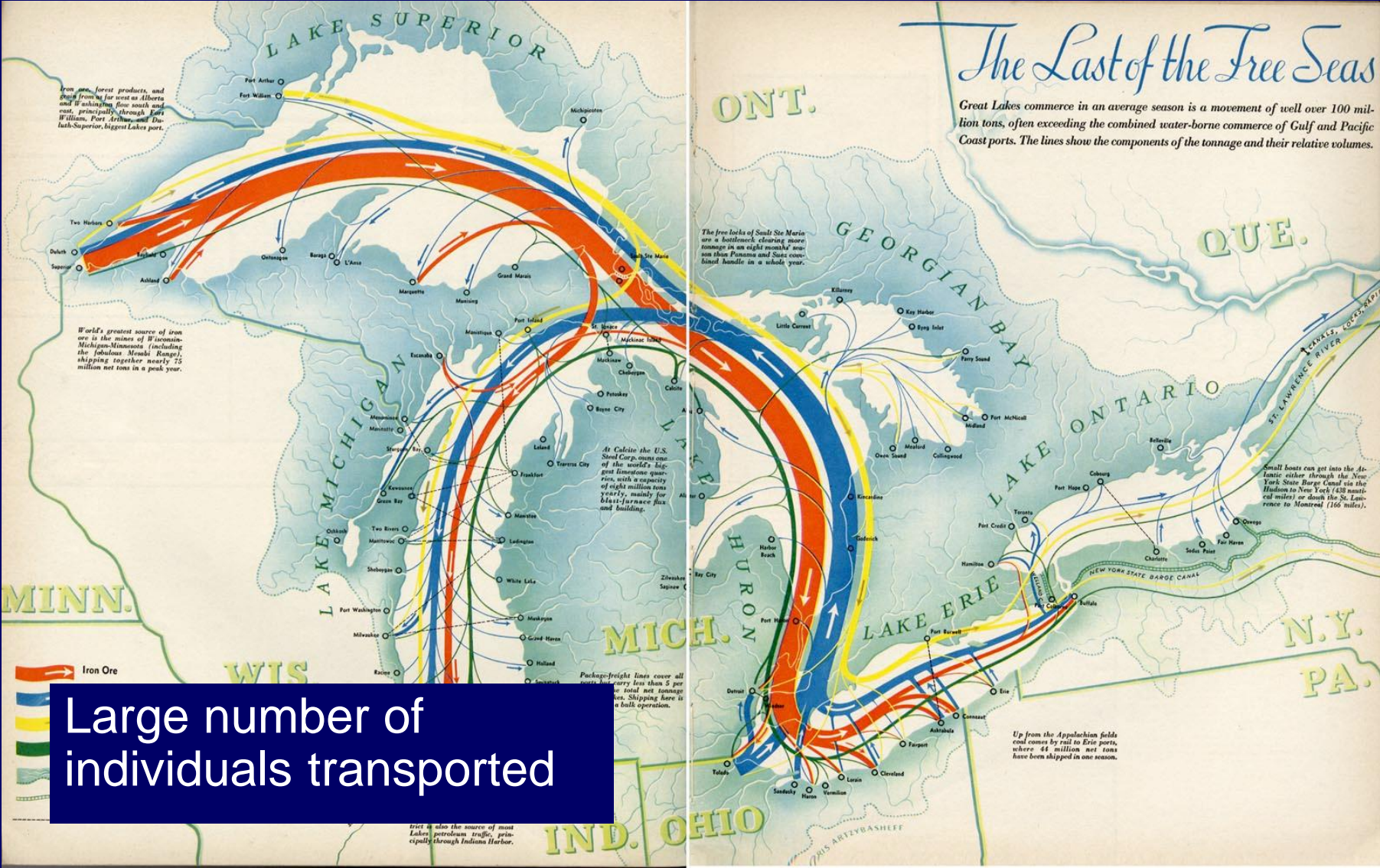


Ballast water transport



Great Lakes Shipping Routes, 1940

Ballast water transport



Great Lakes Shipping Routes, 1940

Bait bucket transport or intentional release

The Dry Hands Minnow Bucket is the worlds first and only **DISPENSING** Minnow Bucket



It gently **DELIVERS ONE** minnow at a time into the palm of your hand with only tiny droplets of water traveling with the minnow.

FREE
Aerator Included!
a \$15.95 value


MADE IN THE U.S.A

www.dryhandsminnowbucket.com



Bait bucket transport or intentional release

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MADE IN THE U.S.A

www.dryhandsminnowbucket.com

Usually, a small number of individuals transported

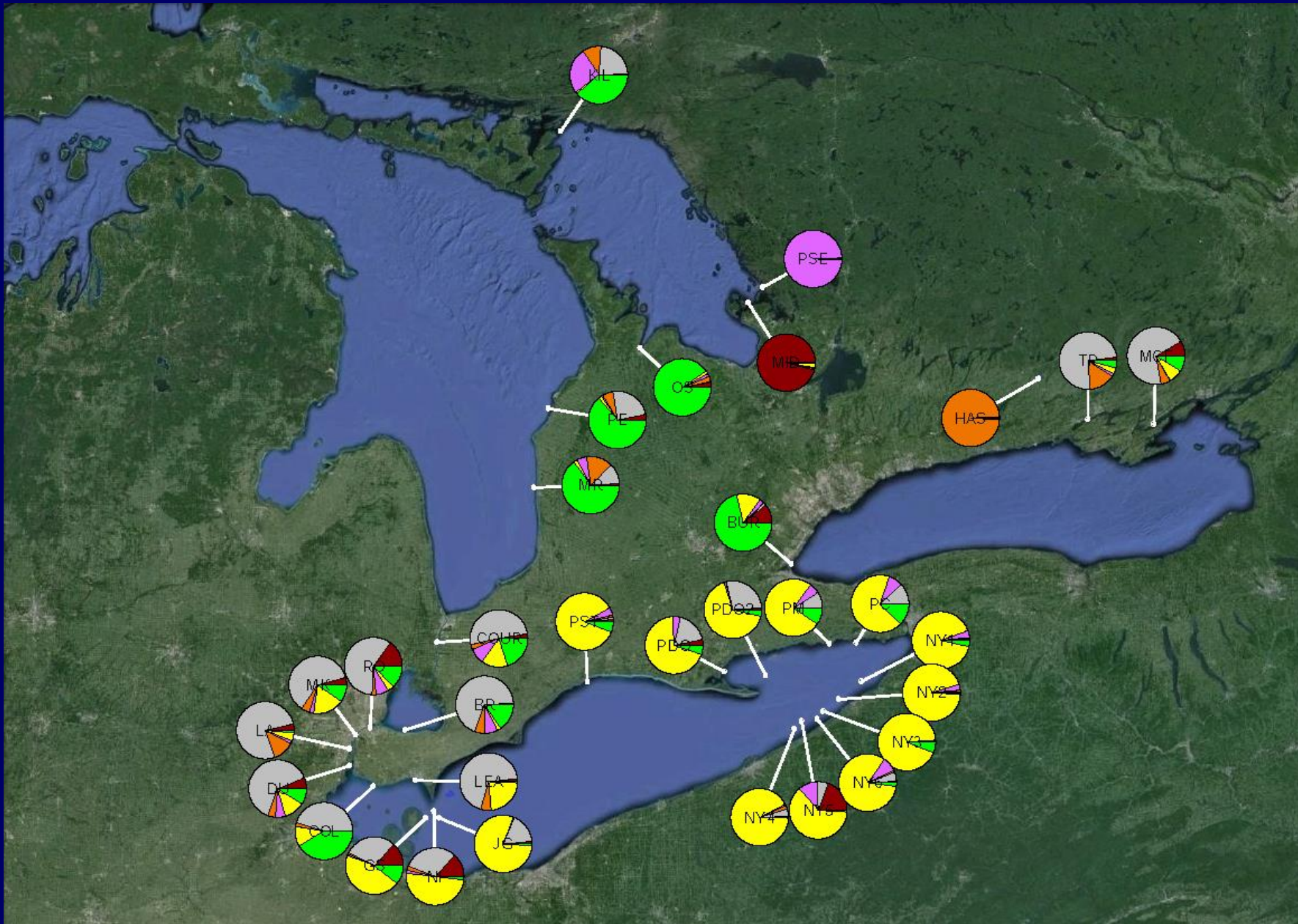


Natural dispersal

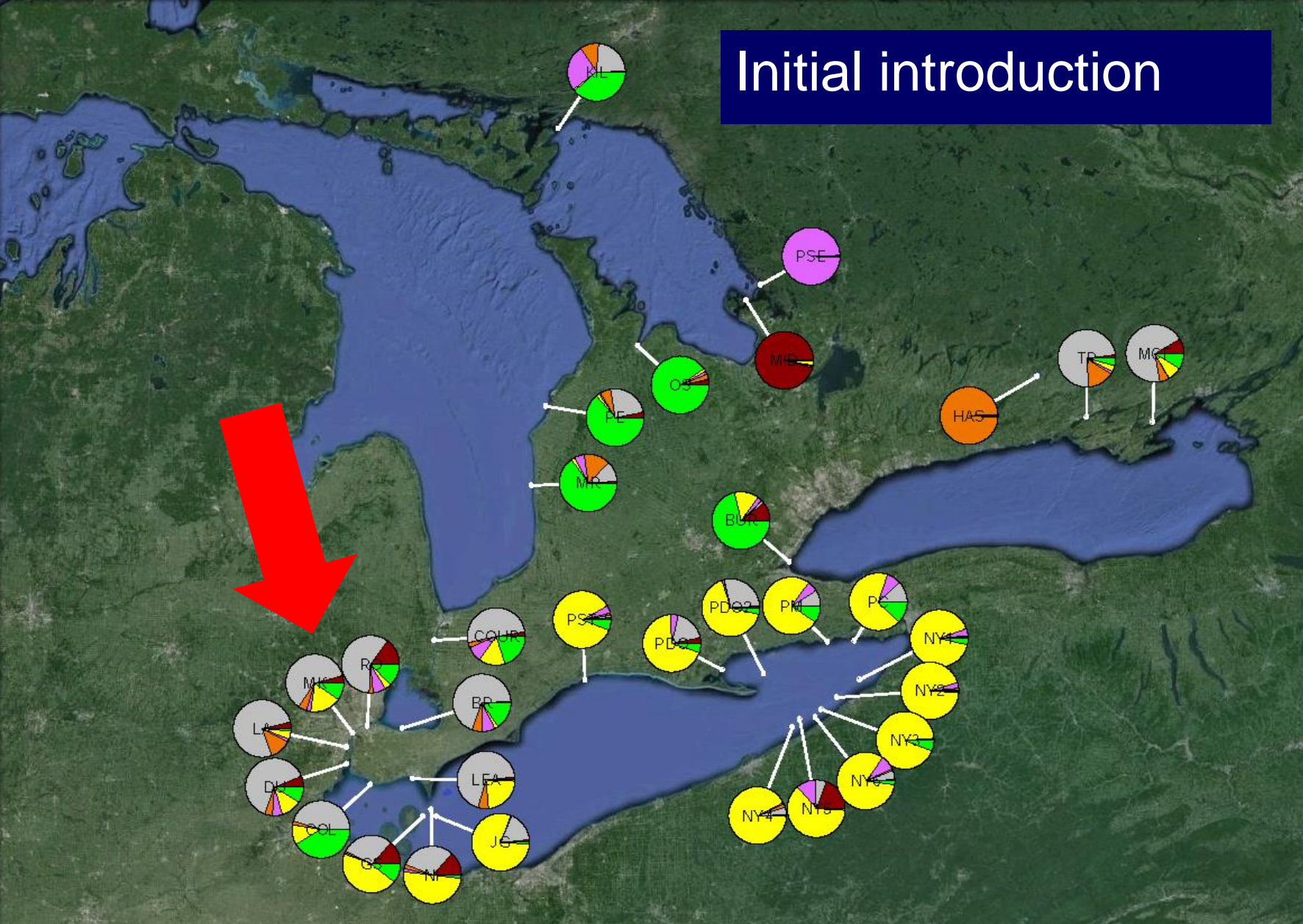


Number of individuals migrating/dispersing may vary widely

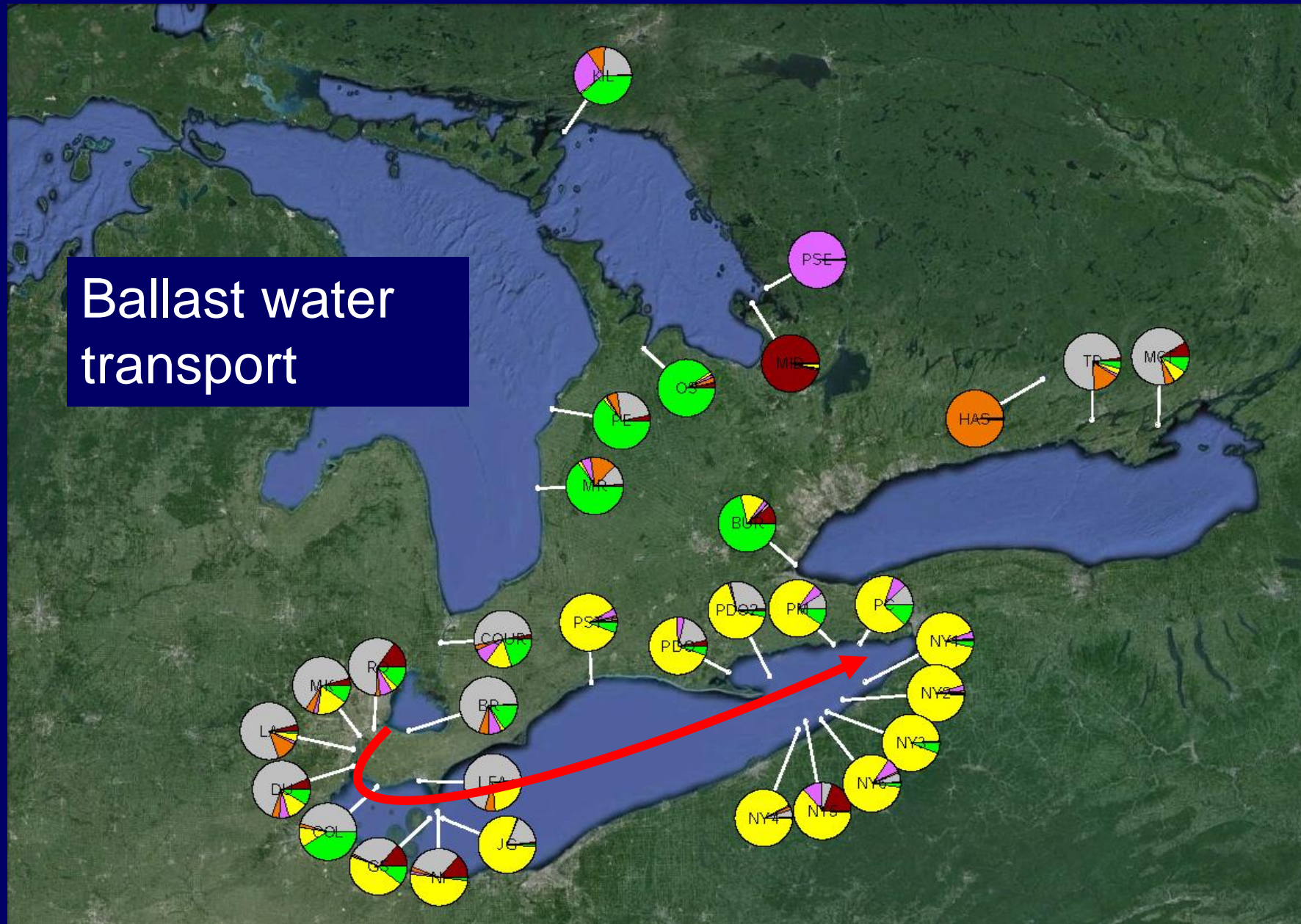
Drivers of large-scale structure



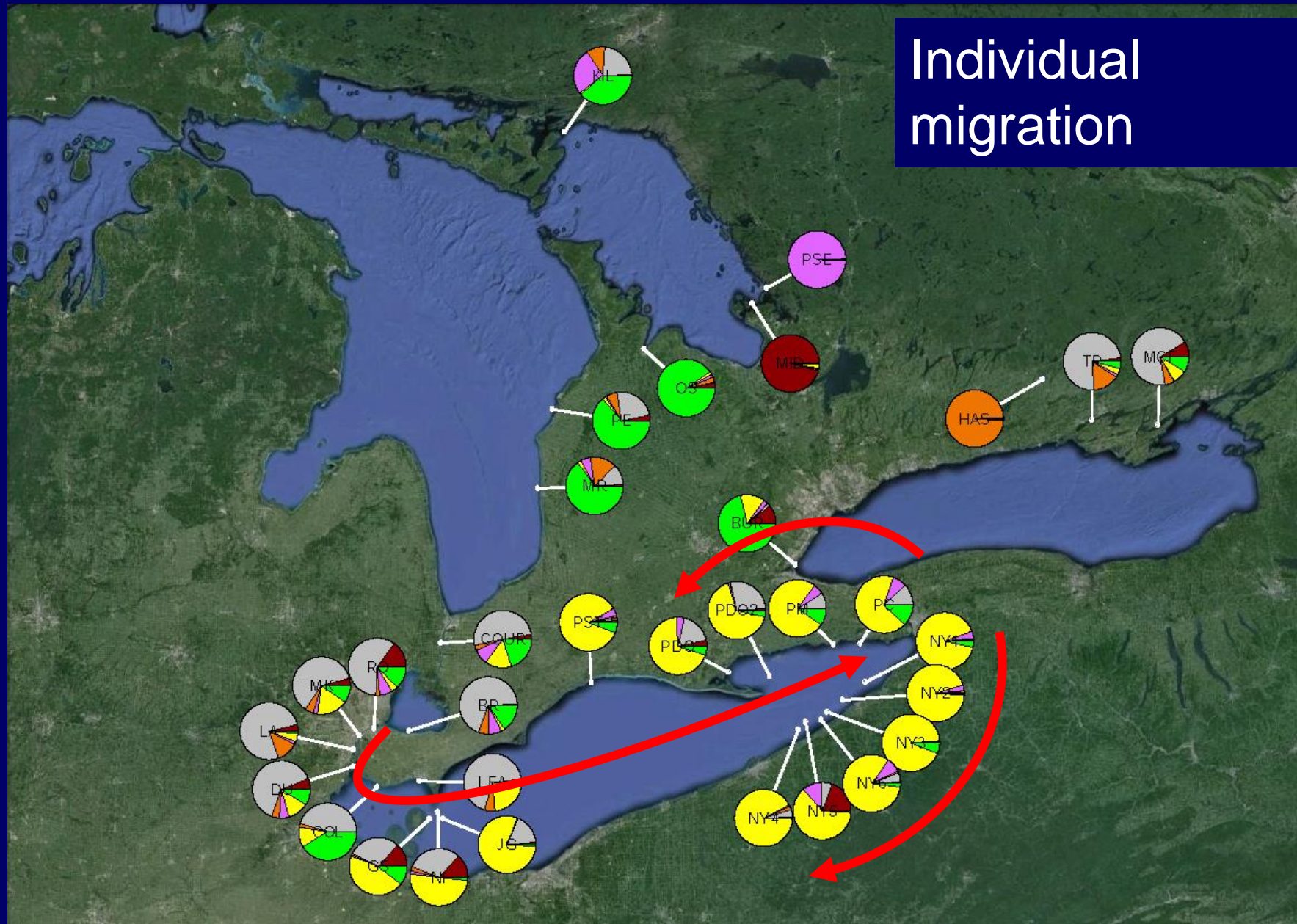
Drivers of large-scale structure



Drivers of large-scale structure



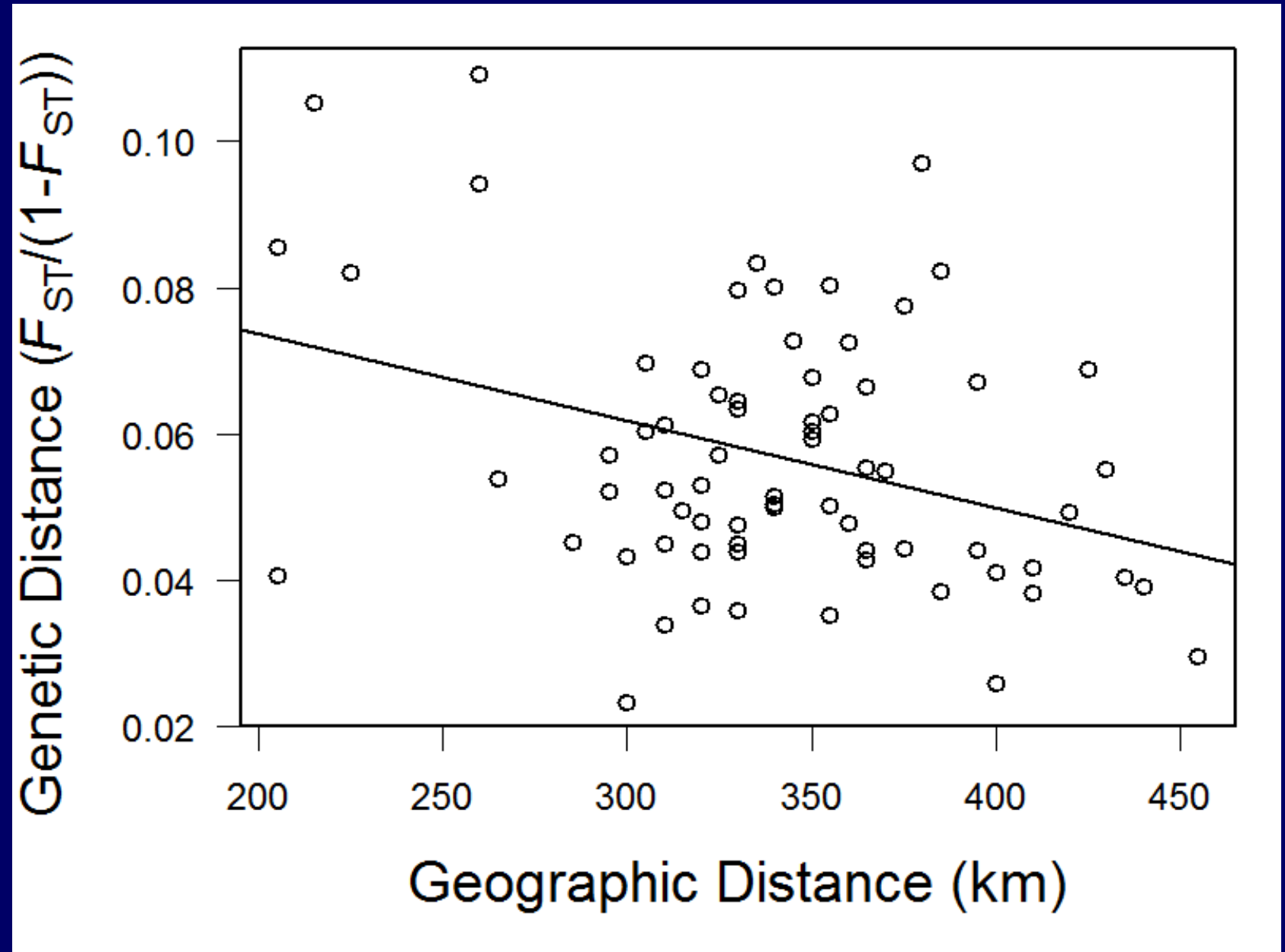
Drivers of large-scale structure



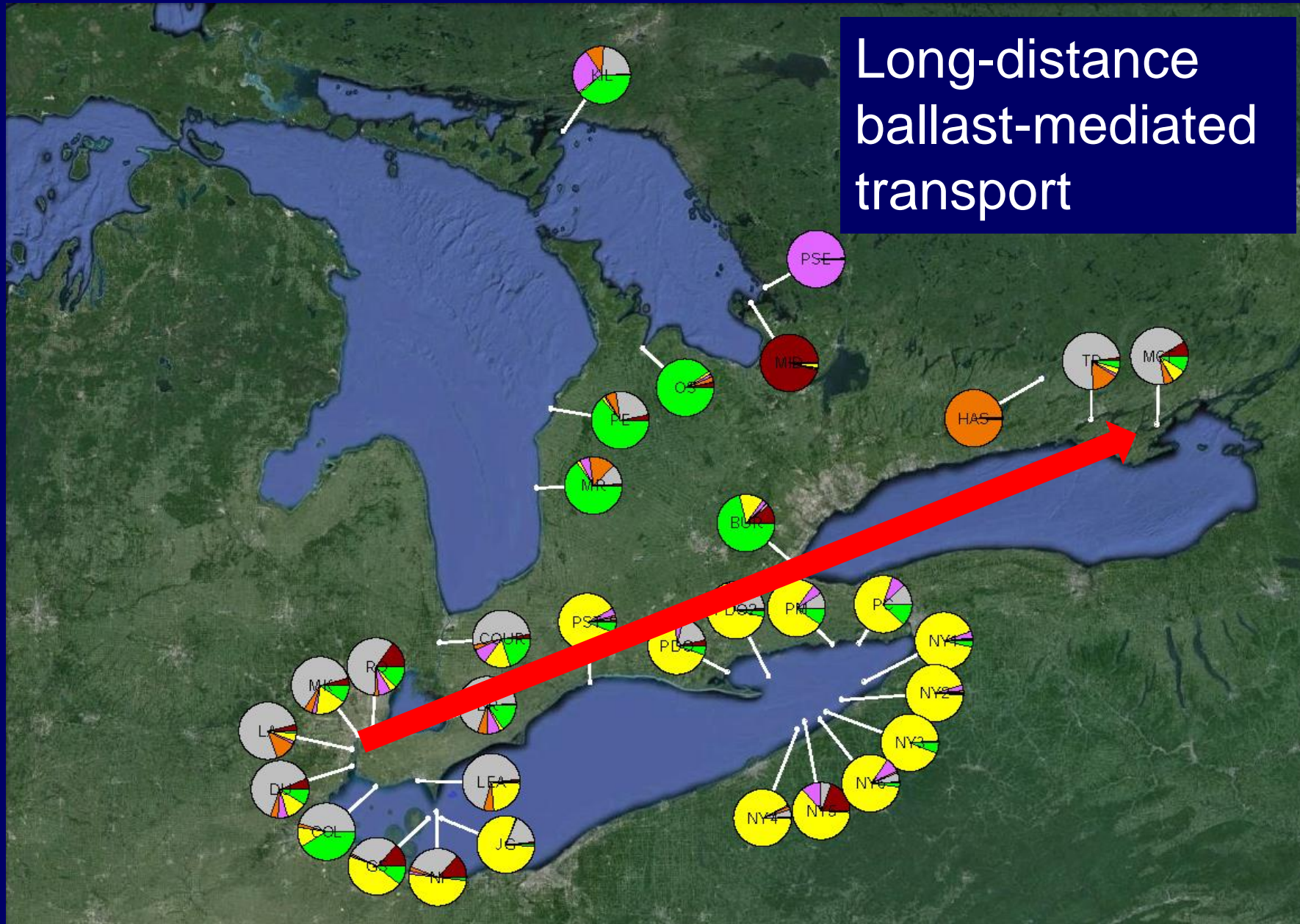
Isolation by proximity

$P = 0.004$

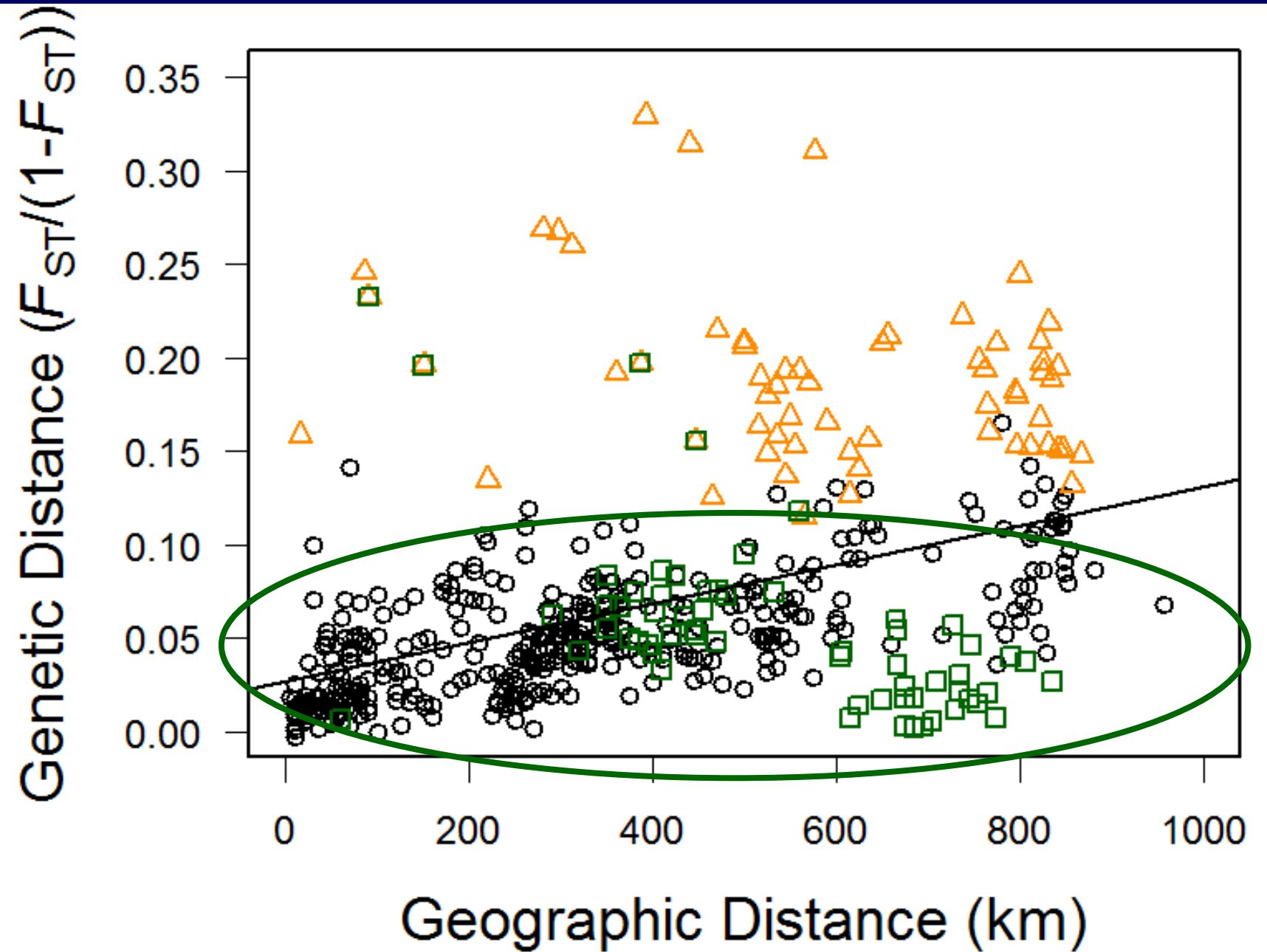
Adj. $R^2 = 0.10$



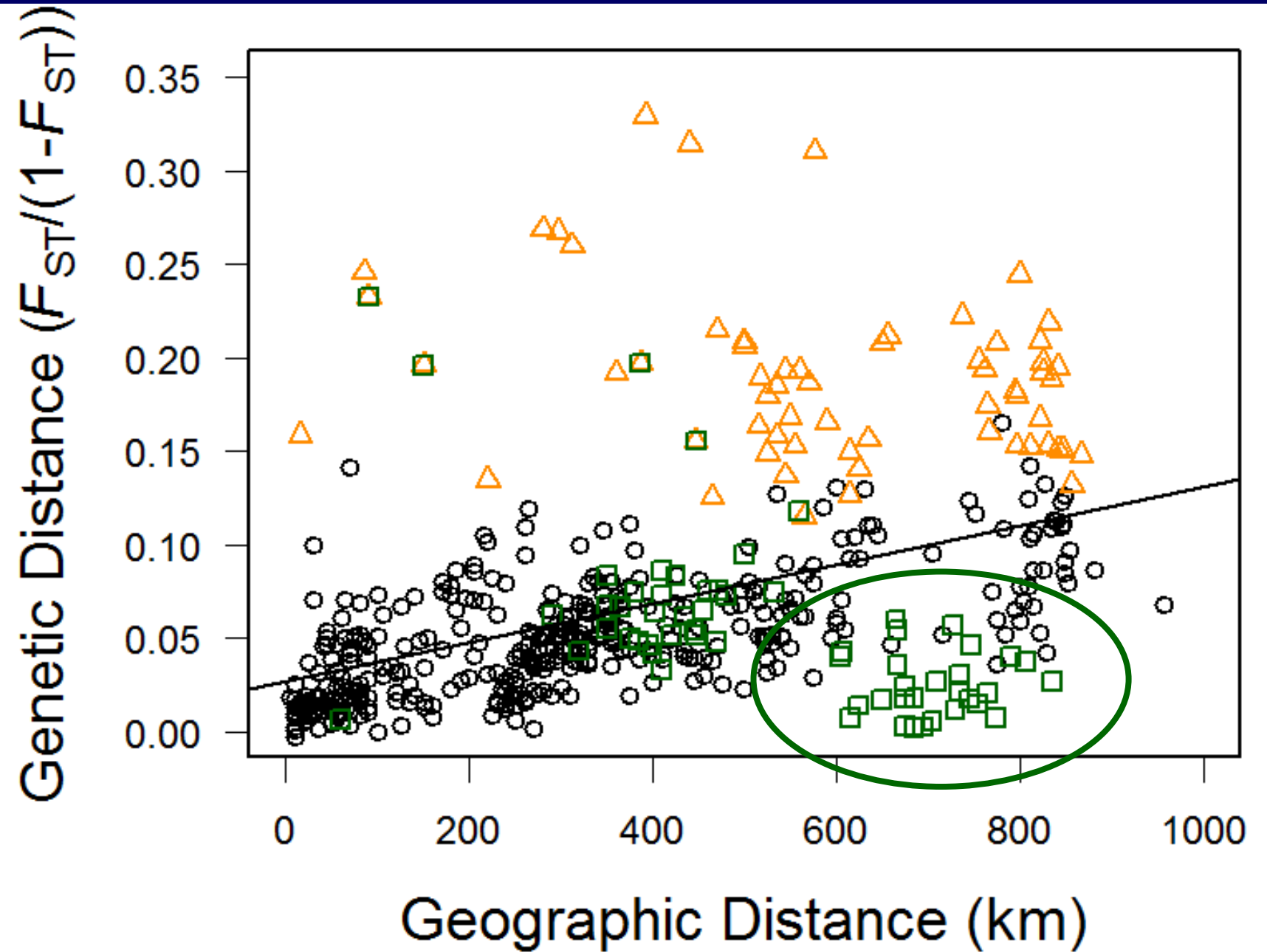
Drivers of large-scale structure



Low genetic
distance



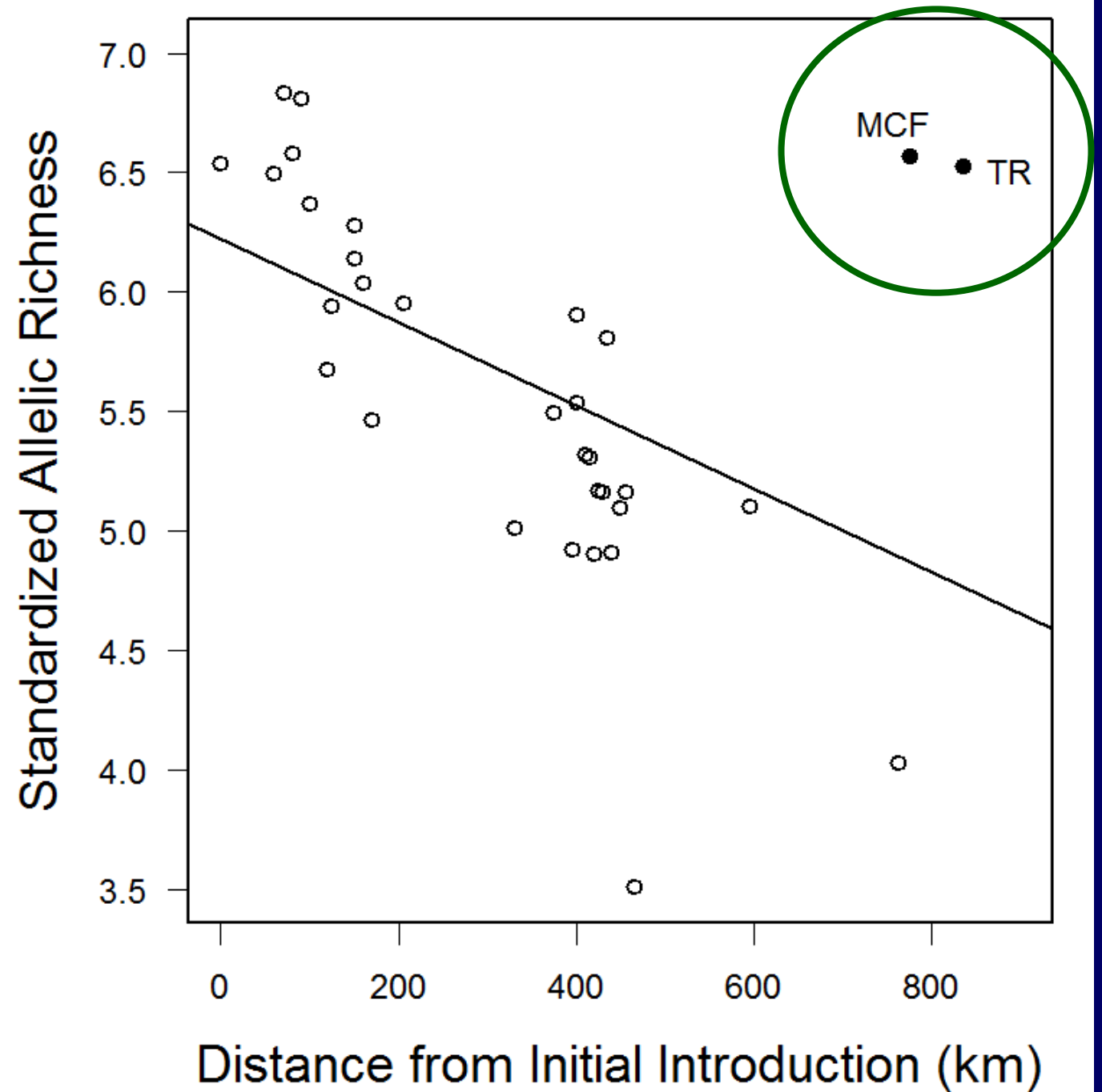
Low genetic distance



High allelic richness

$P = 0.005$

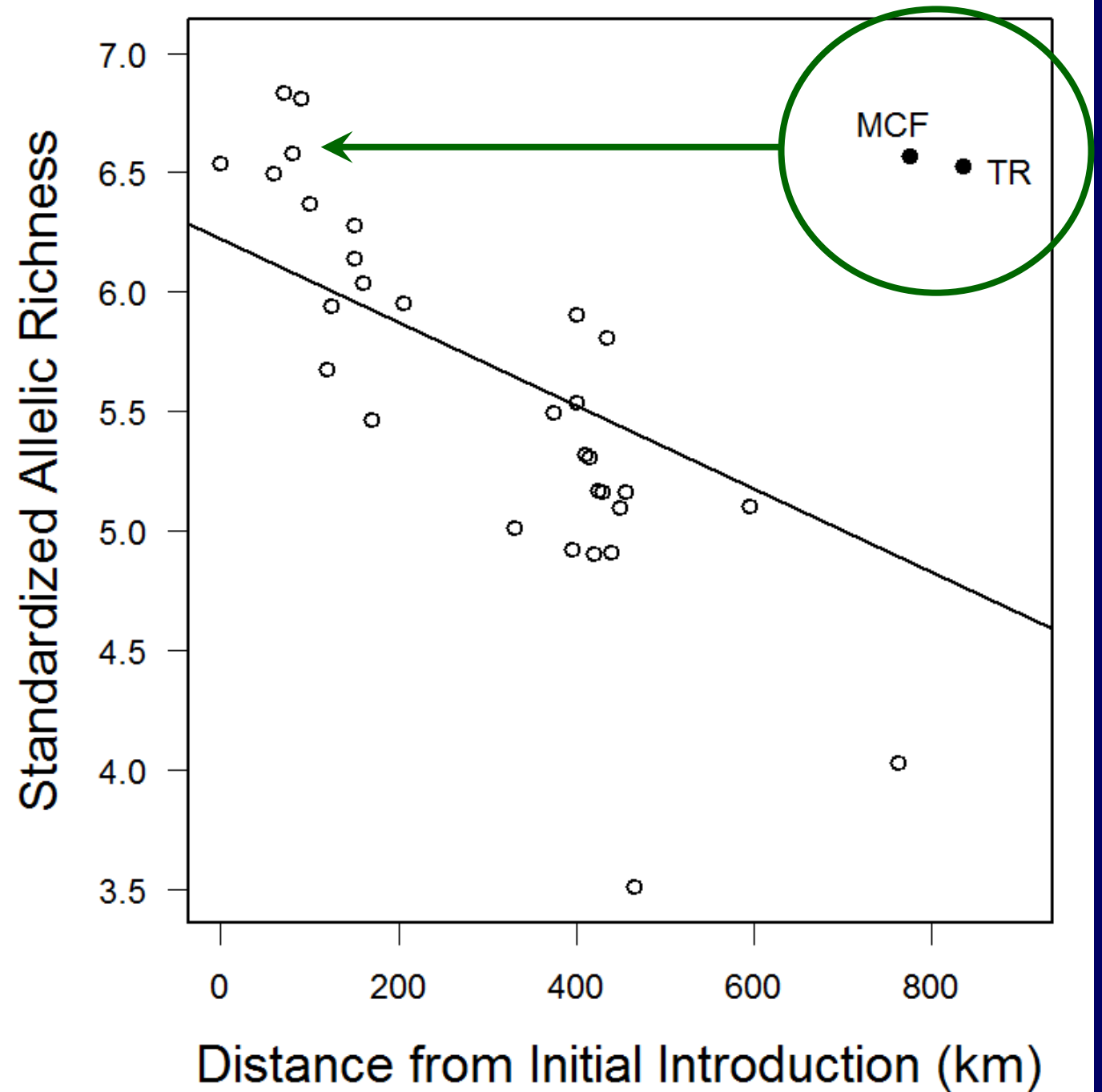
Adj. $R^2 = 0.21$



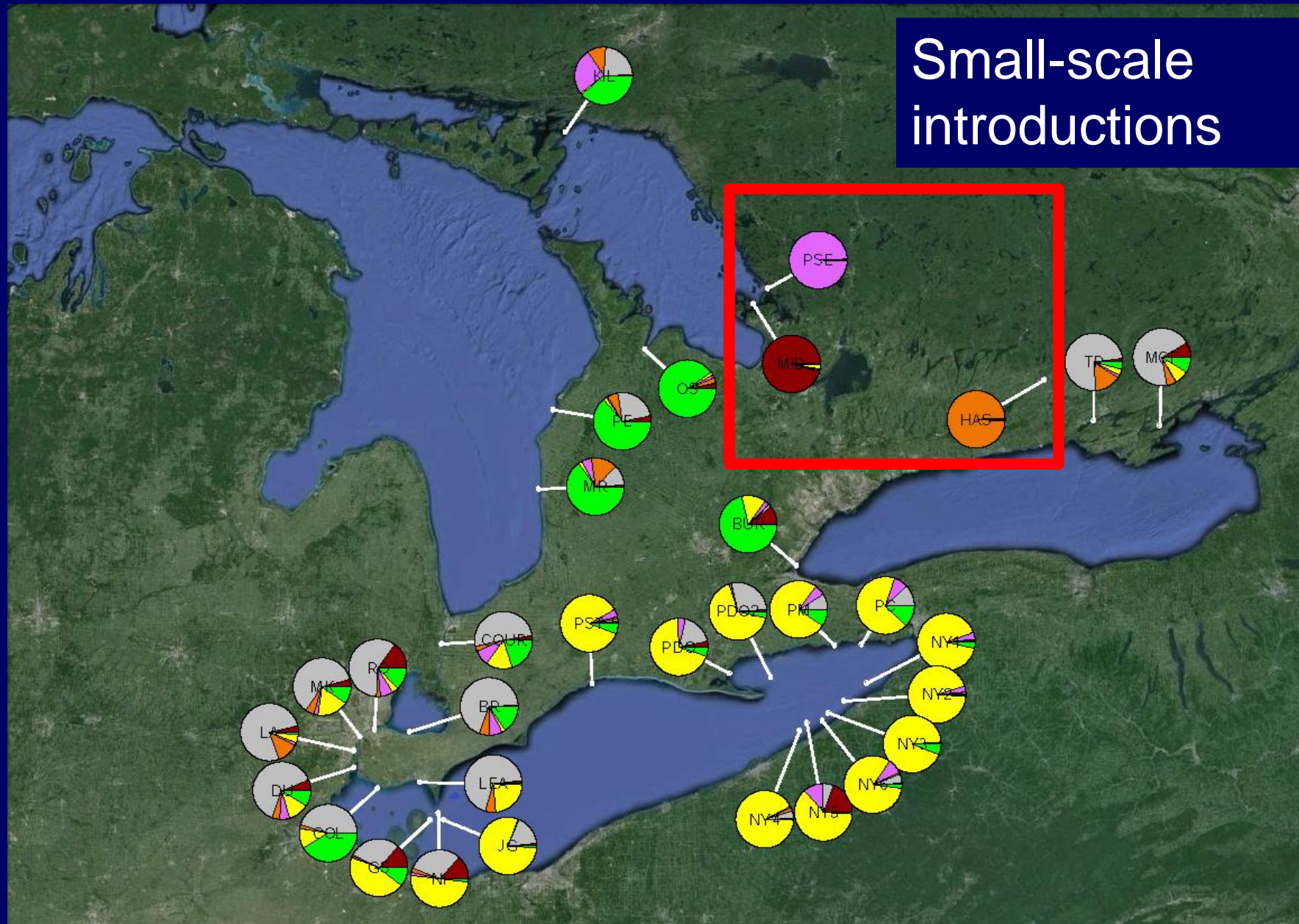
High allelic richness

$P = 0.005$

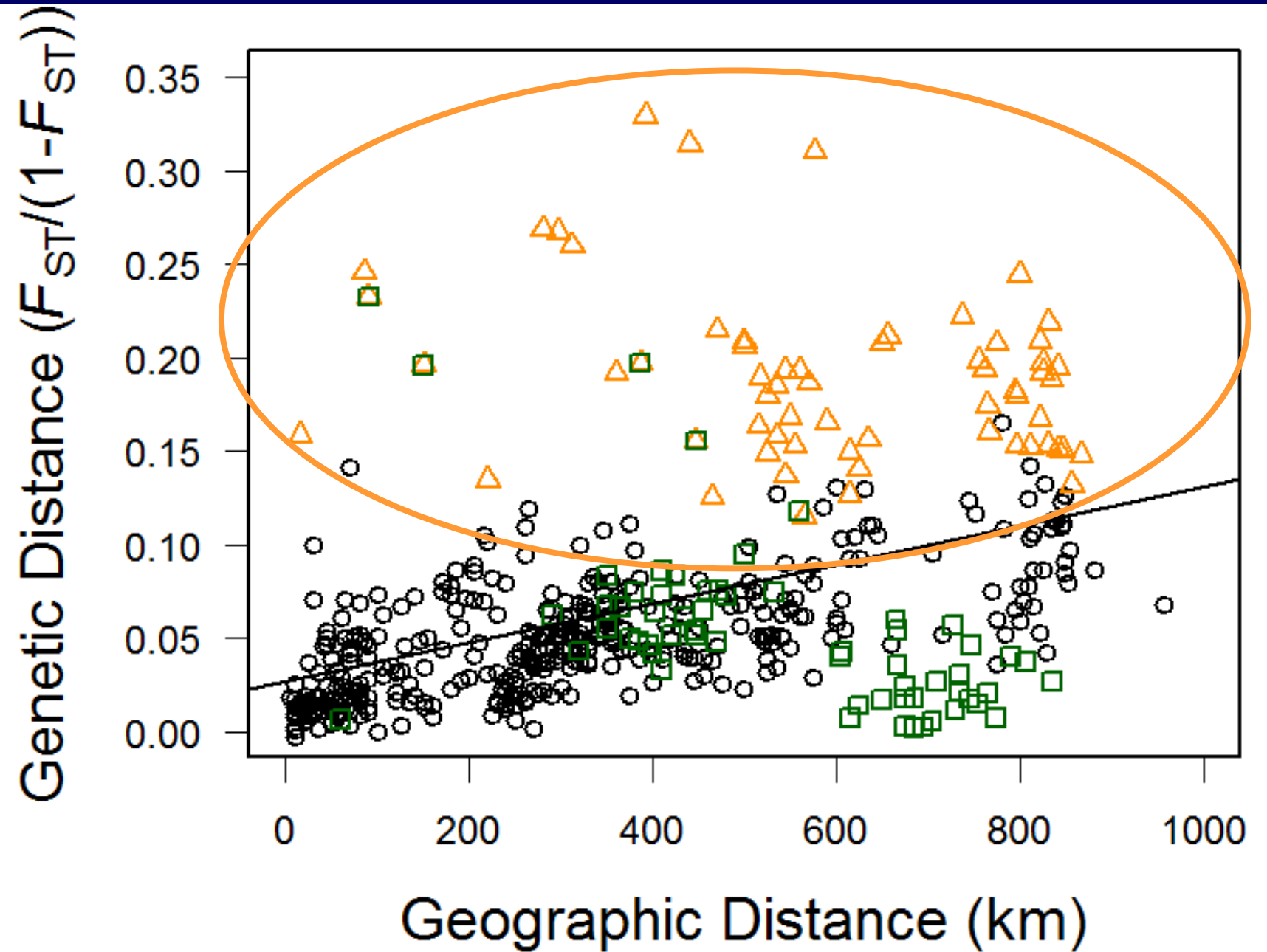
Adj. $R^2 = 0.21$



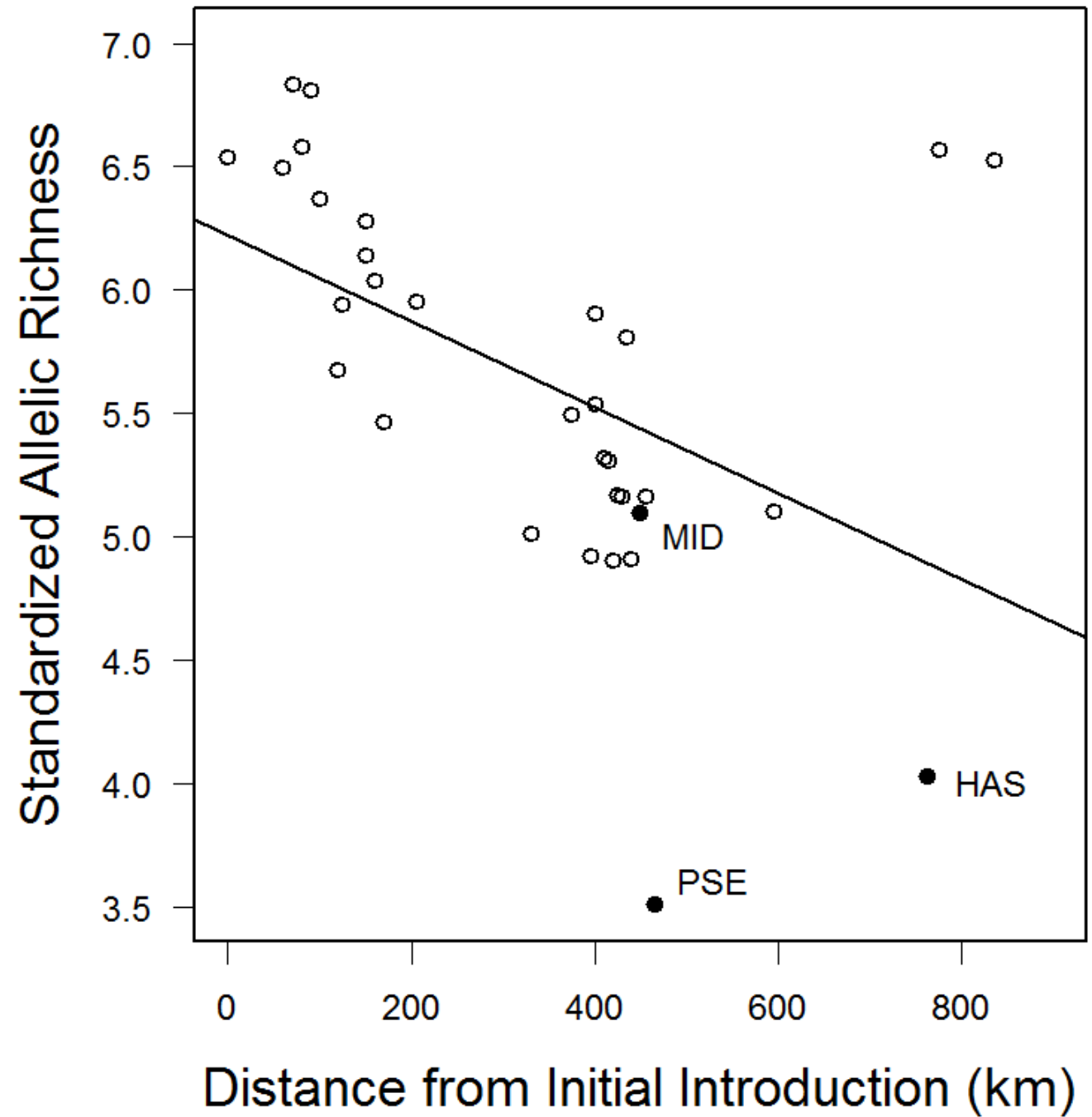
Drivers of large-scale structure



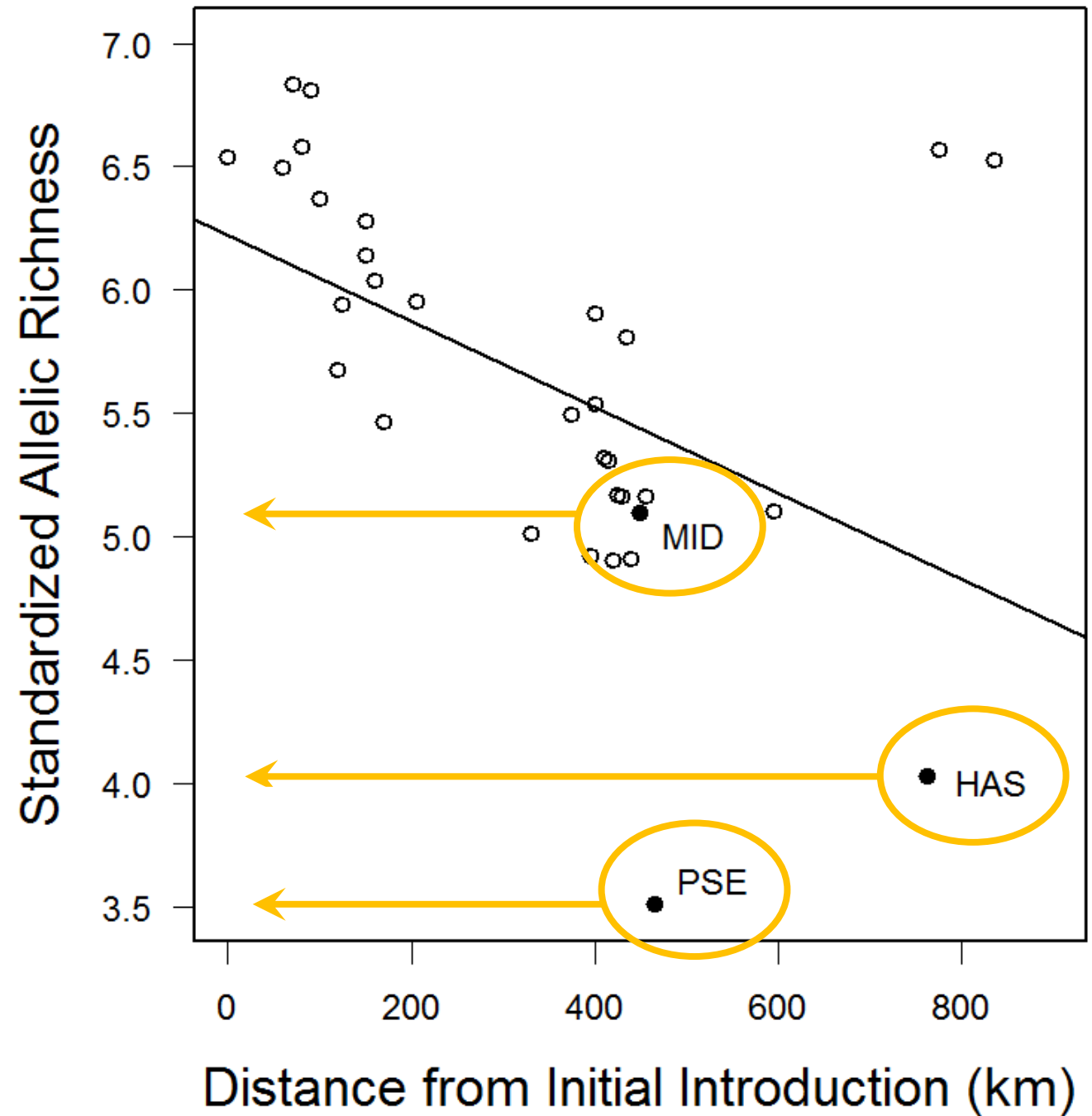
High genetic
distance



Low allelic richness

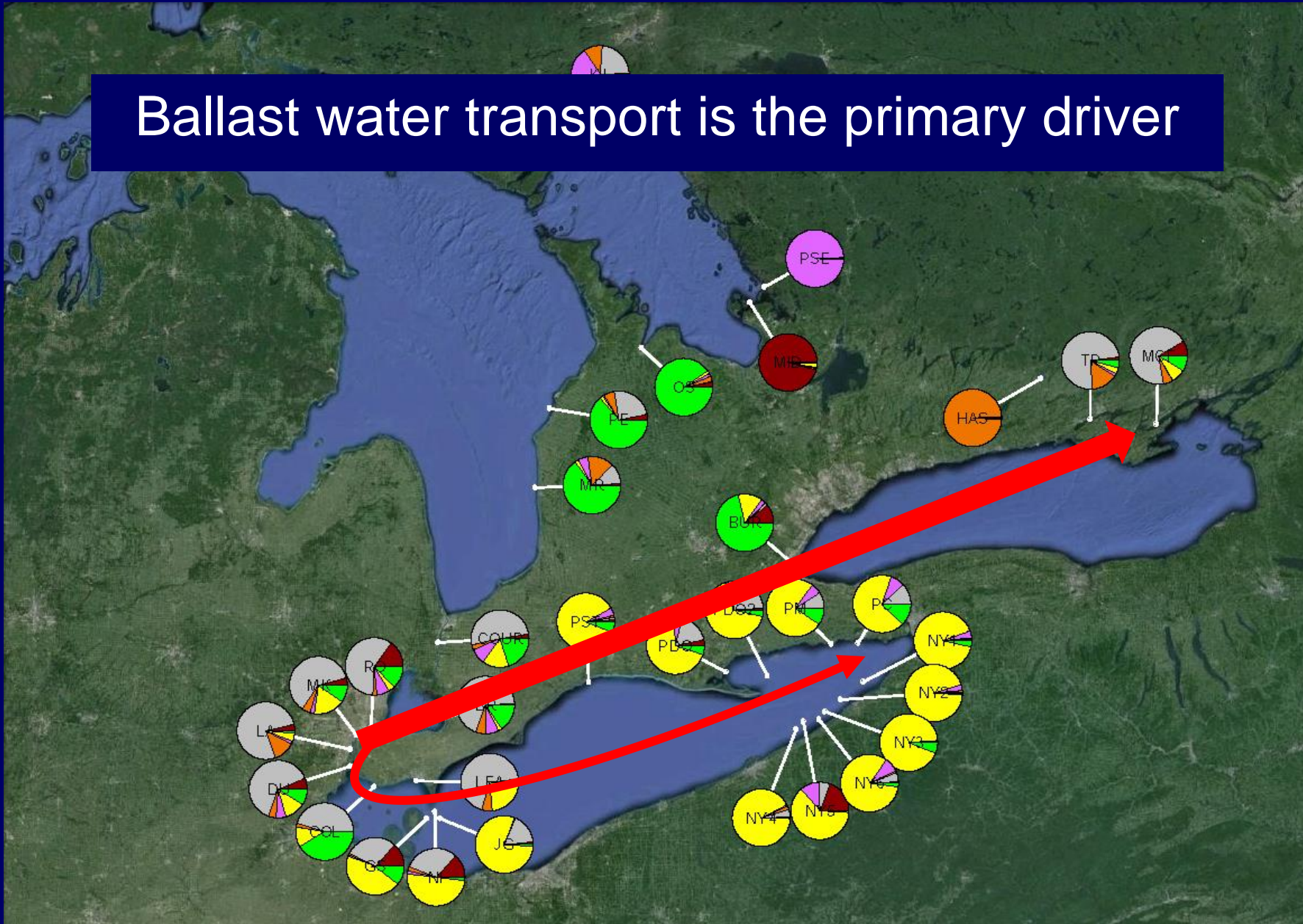


Low allelic richness



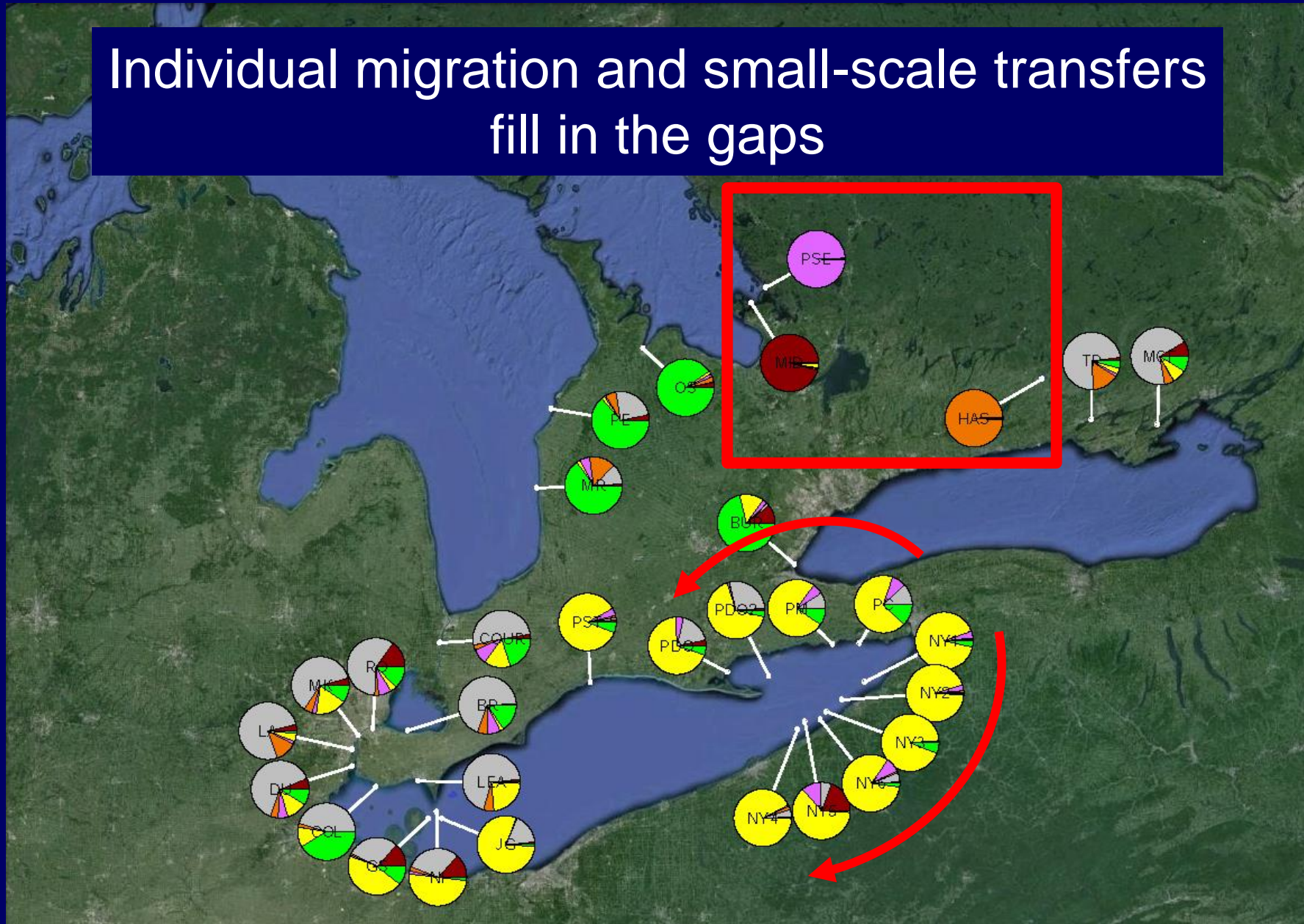
Conclusions

Ballast water transport is the primary driver



Conclusions

Individual migration and small-scale transfers fill in the gaps



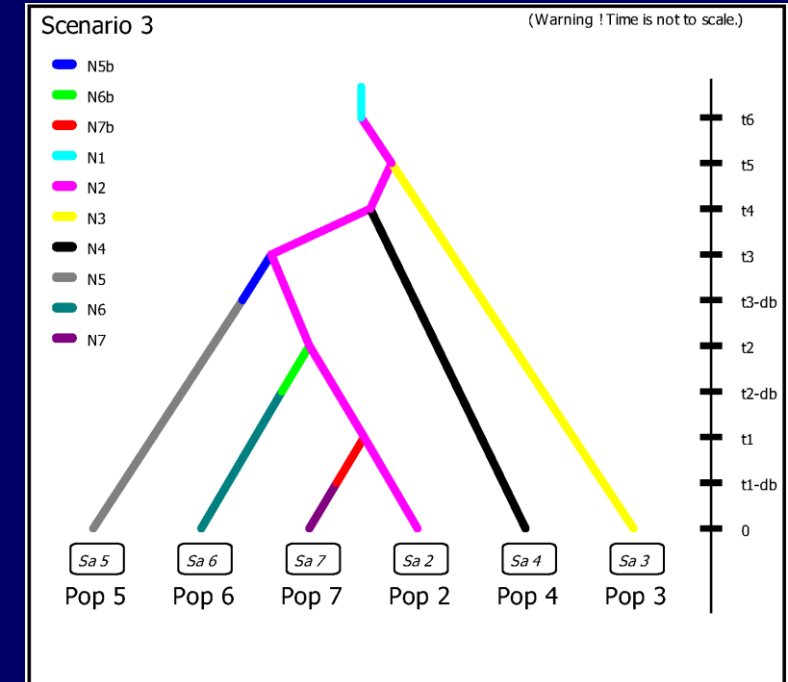
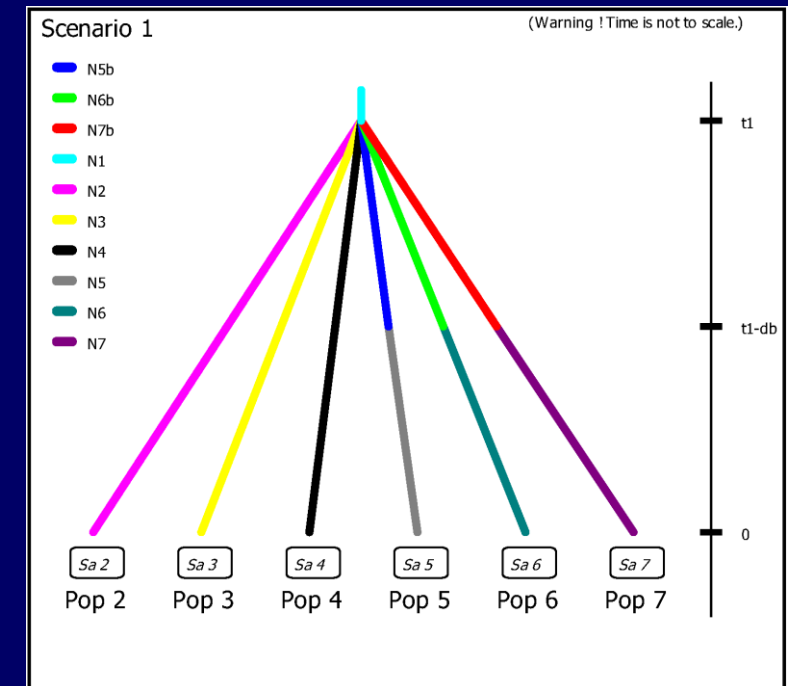
Additional hypothesis testing

What we have is circumstantial evidence

Now, we're using

1. IMa2 – MCMC simulations
2. DIYABC – Approximate Bayesian Computations

To test different potential invasion scenarios more formally



Conclusions

Current management may prevent introductions via ballast water

However, if an introduction occurs, rapid ballast-mediated spread is still possible

Thank you!

- Advisors (Past & Present)
 - Hugh MacIsaac, Dan Heath, Filipe Alberto, Michael Banks, Ralph Larson
- Collaborators and Coauthors
 - Lynda Corkum, Brad Dufour, Kyle Wellband
- Two Anonymous Heredity Reviewers
- Lab Mates
 - Marco Hernandez, Sharon Lavigne, Dylan Xia, Samir Qureshi, Emma Deroy, Josh Finn, Tedi Hoxha



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