Prioritizing road crossing improvement to restore stream connectivity for stream-resident fish

Project Contacts

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Fish need to move to survive.

- Migration
- Refuge or recovery from disturbance
- Genetic exchange

Road crossings impede fish movement.

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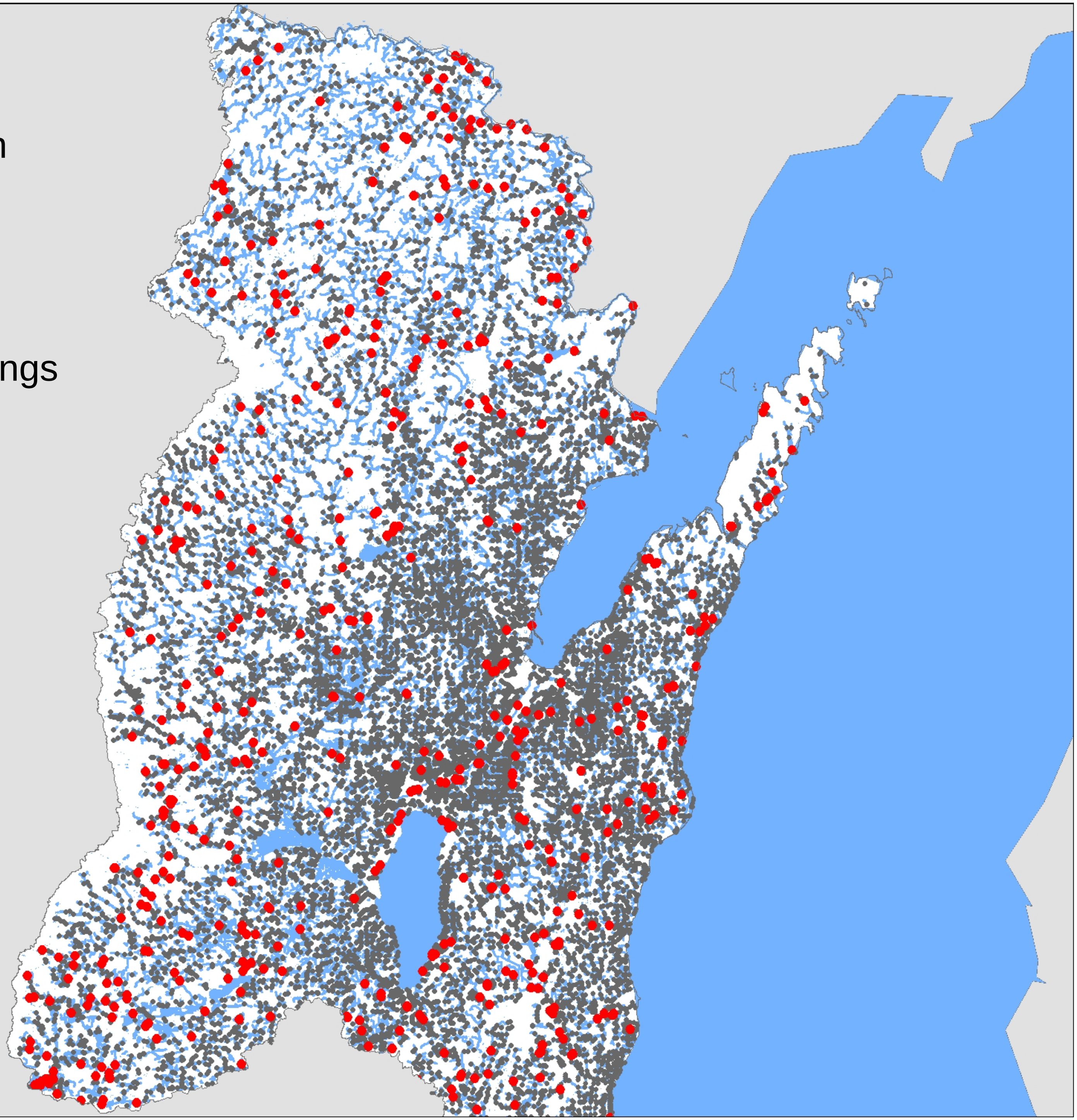
Lake Michigan Basin in Wisconsin

- 606 dams
- 18,675 road crossings



Questions

How do road crossings affect stream connectivity?

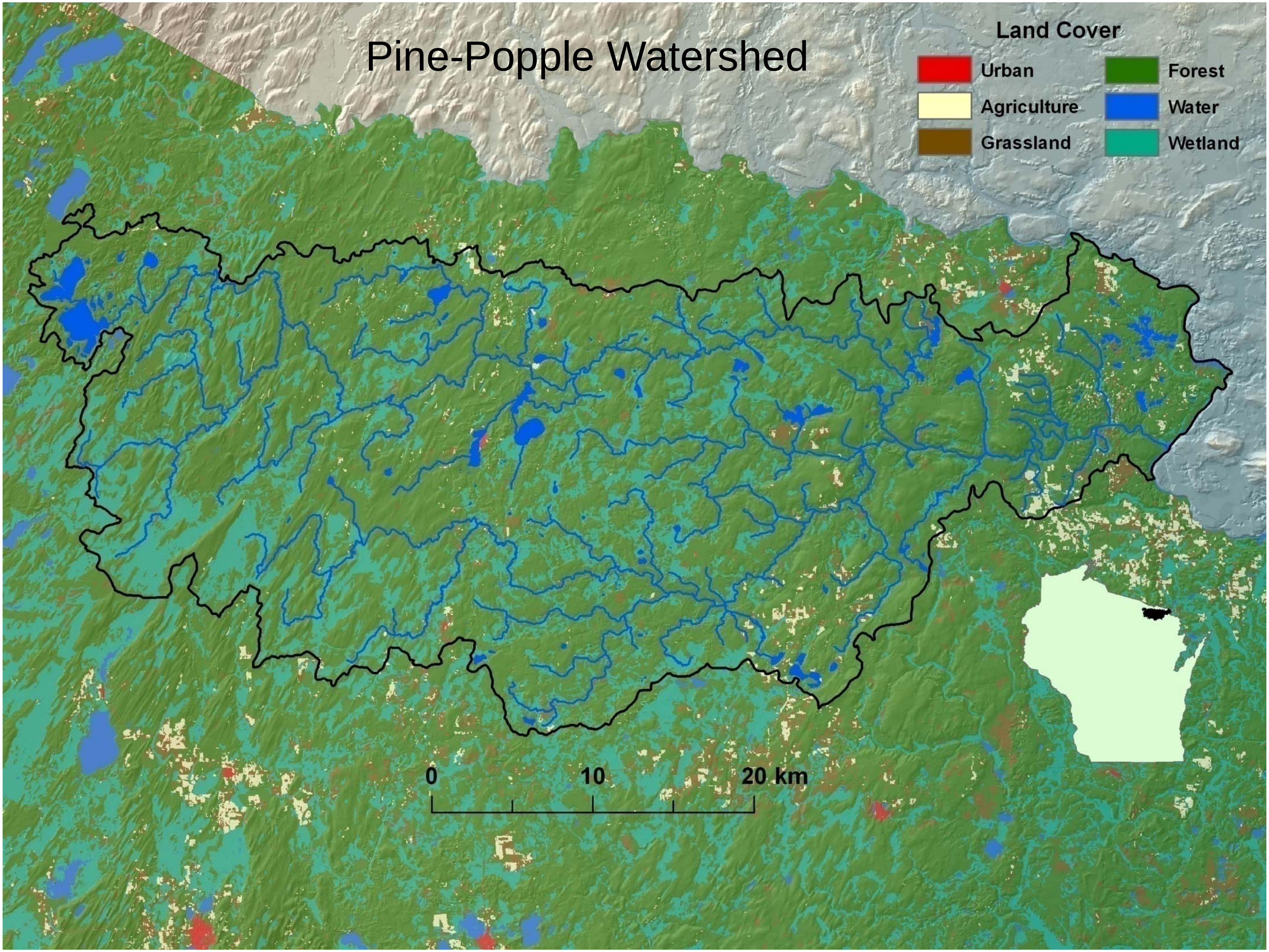
- Are they often barriers?
- How can we quantify connectivity?

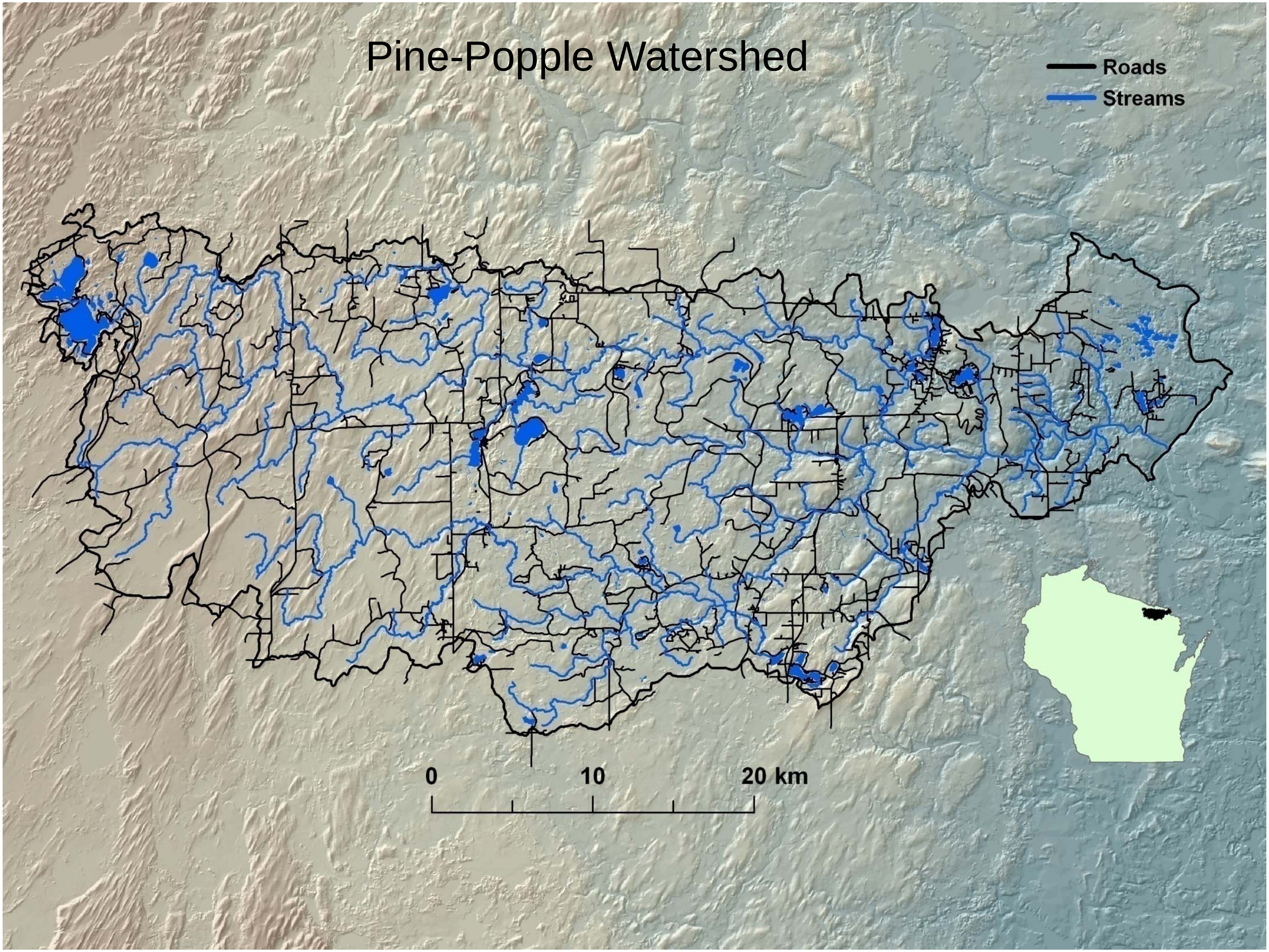
Does connectivity affect stream fish communities?

Objective

Develop a transferable decision support tool to prioritize barrier removal.

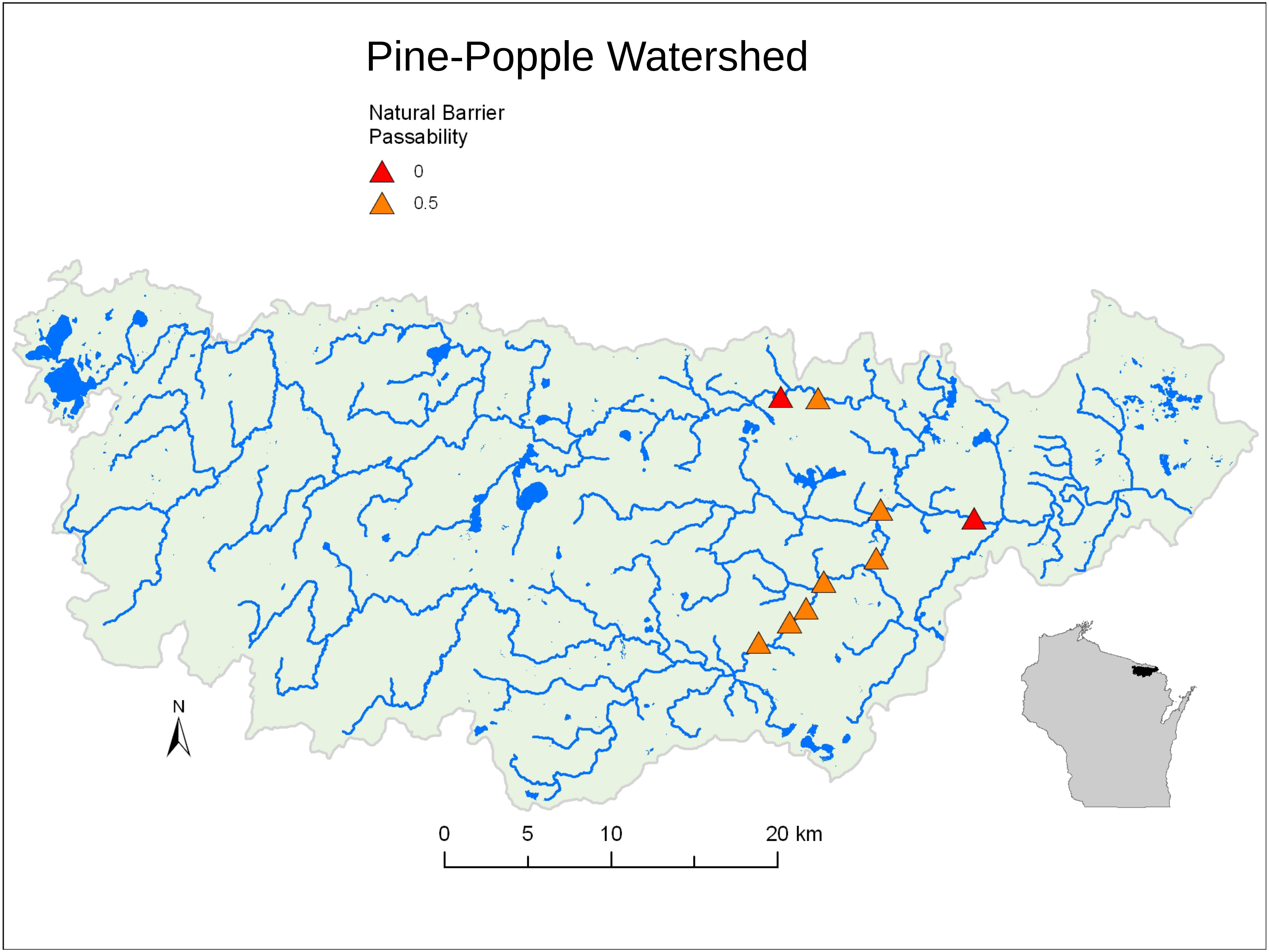
- Cost/benefit
- Project sequence

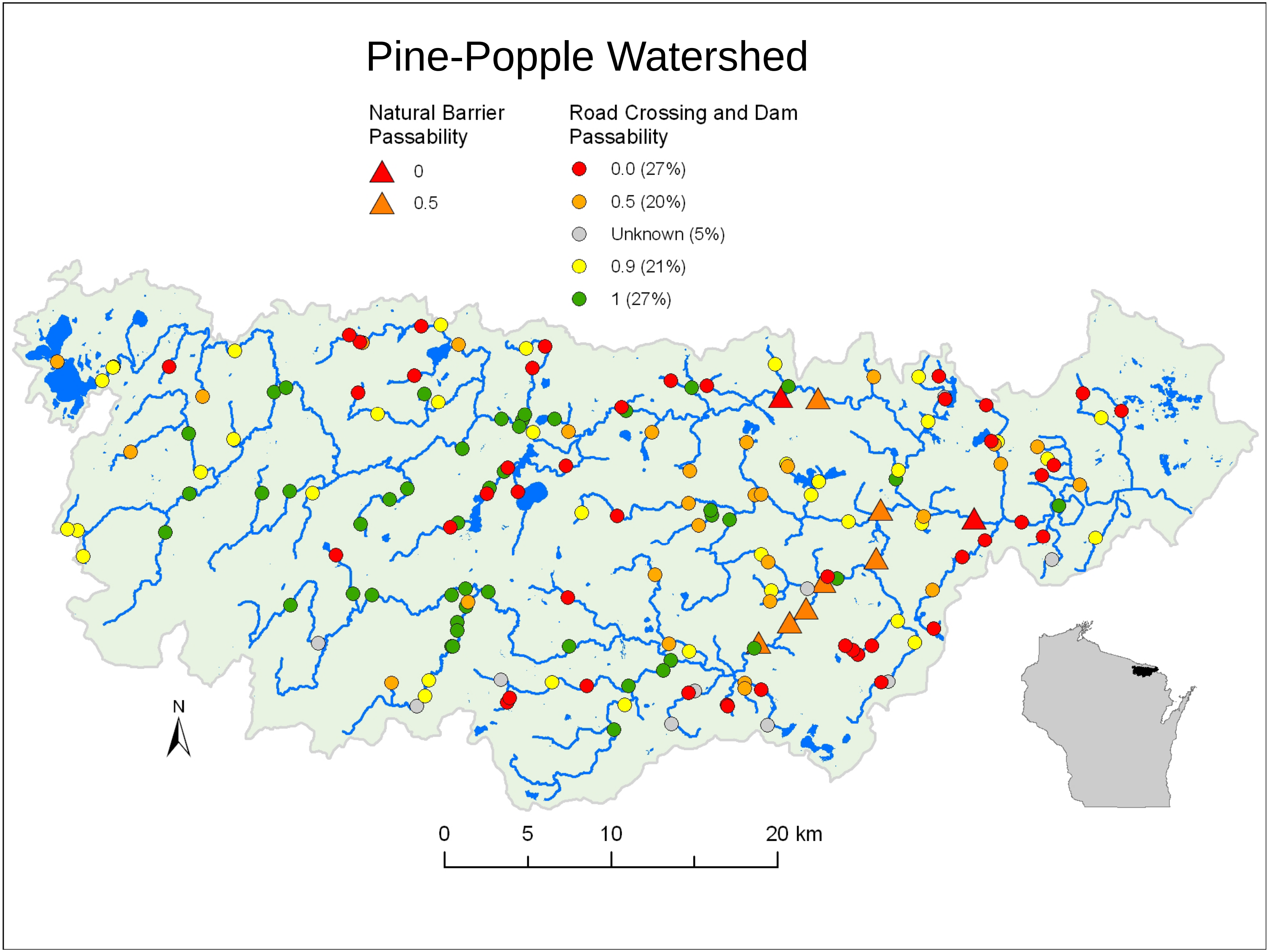

Pine-Popple Watershed
Land Cover
Urban
Agriculture
Grassland
Forest
Water
Wetland
0
10
20 km



Pine-Popple Watershed
Roads
Streams
0
10
20 km

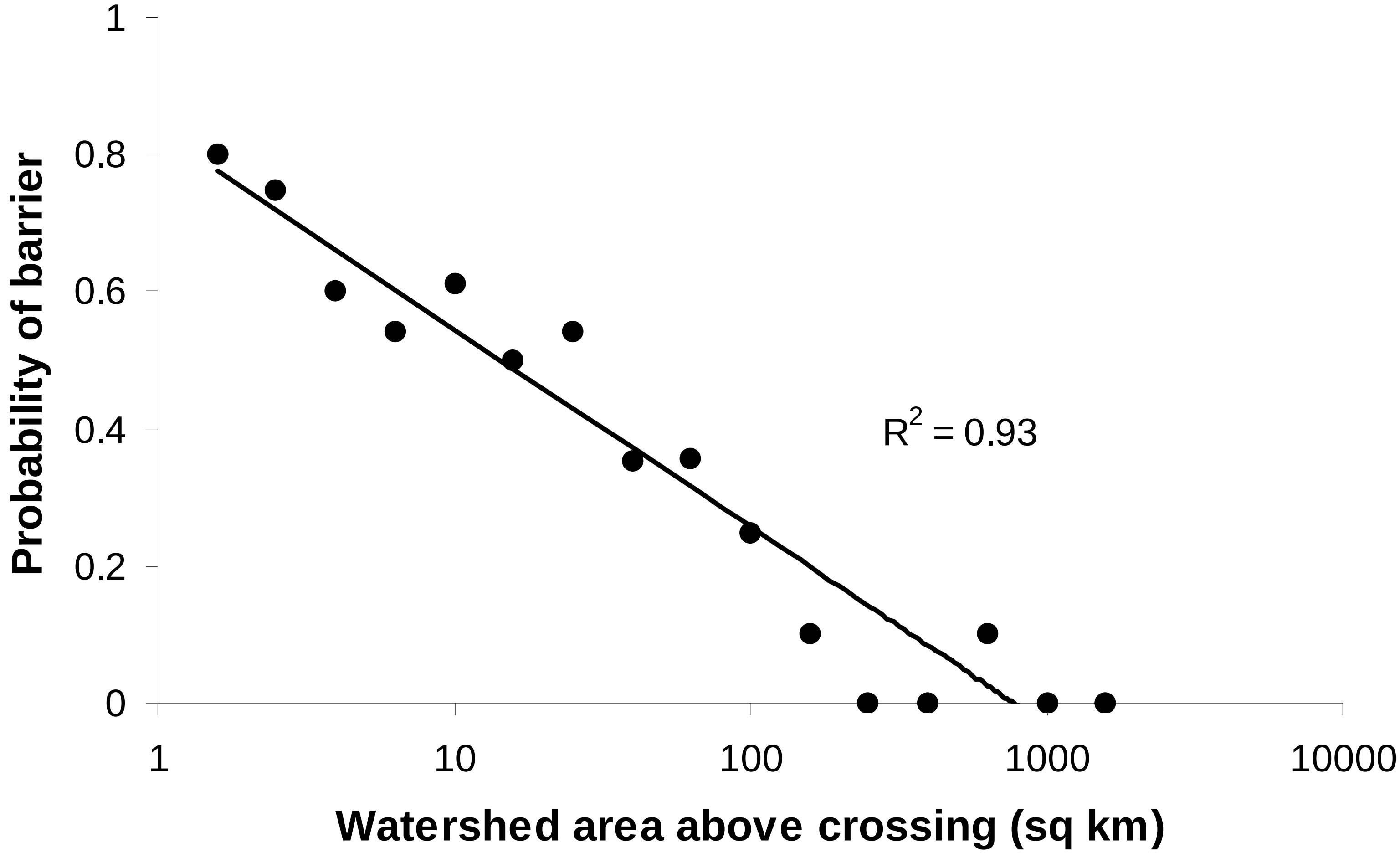
Estimating Passability


Pine-Popple Watershed
Natural Barrier
Passability
0
0.5
N
0
5
10
20 km

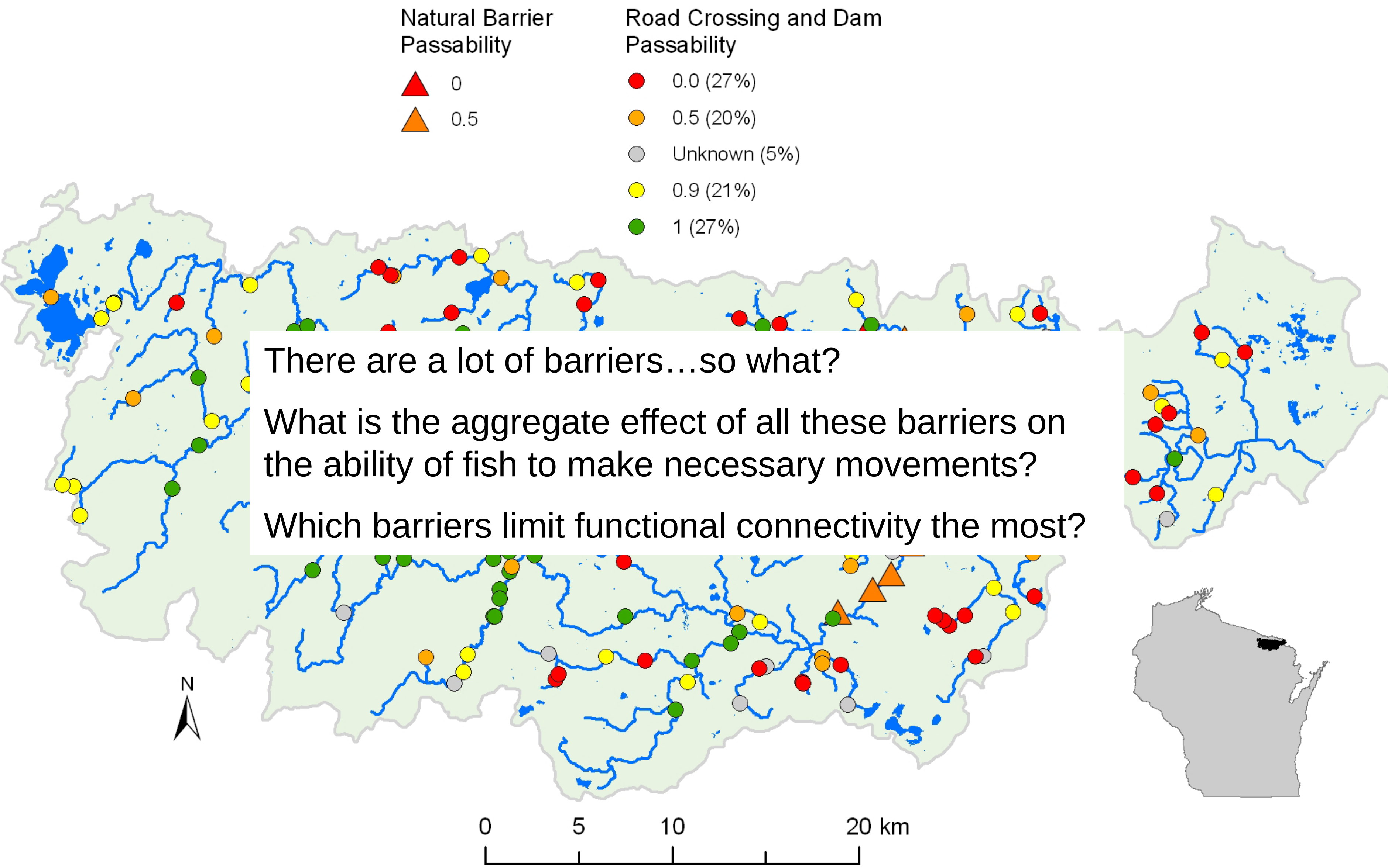


Pine-Popple Watershed
Natural Barrier Passability
0
0.5
Road Crossing and Dam Passability
0.0 (27%)
0.5 (20%)
Unknown (5%)
0.9 (21%)
1 (27%)
N
0
5
10
20 km

What kind of crossings are barriers?



Pine-Popple Watershed



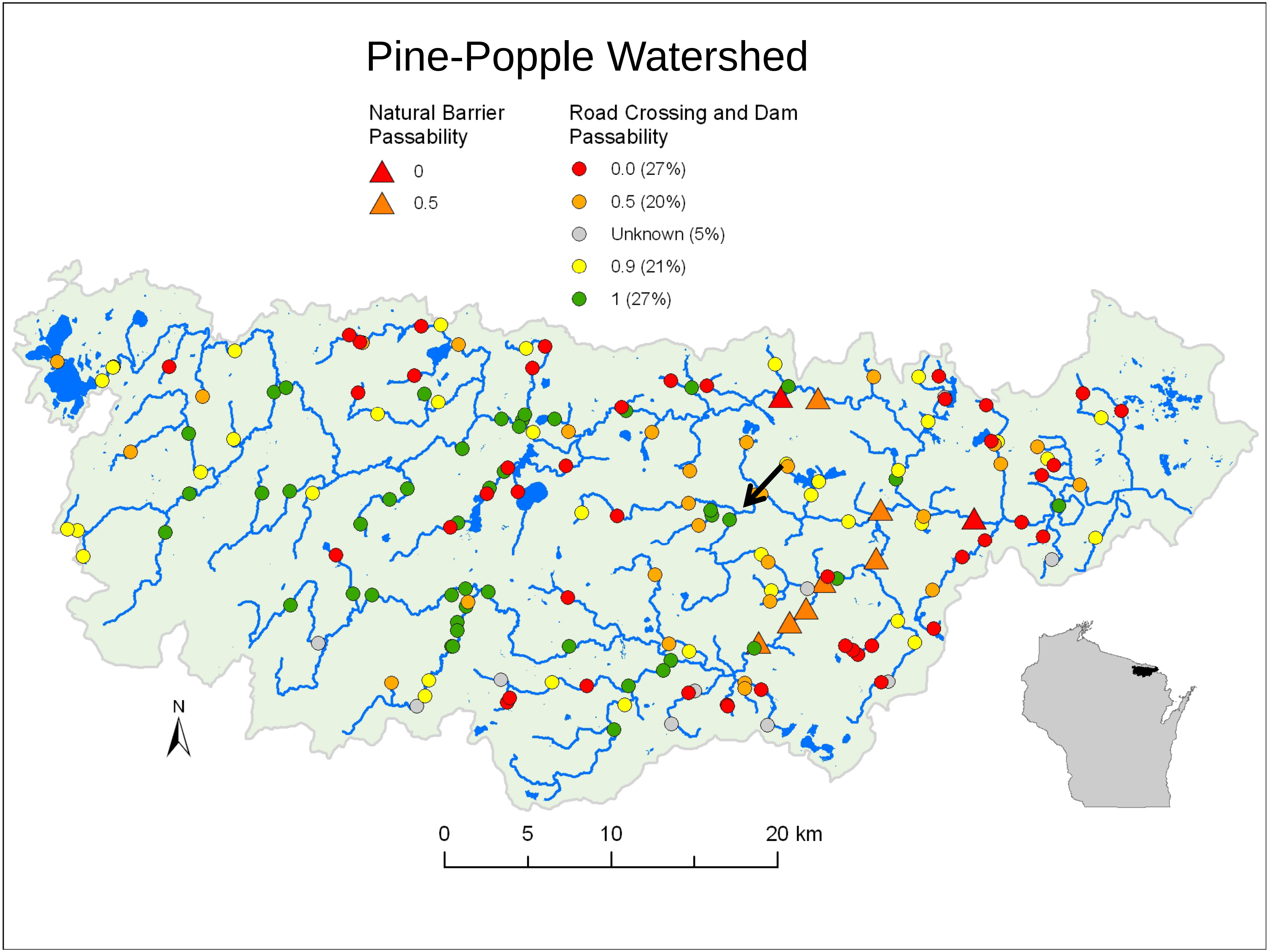
There are a lot of barriers…so what?

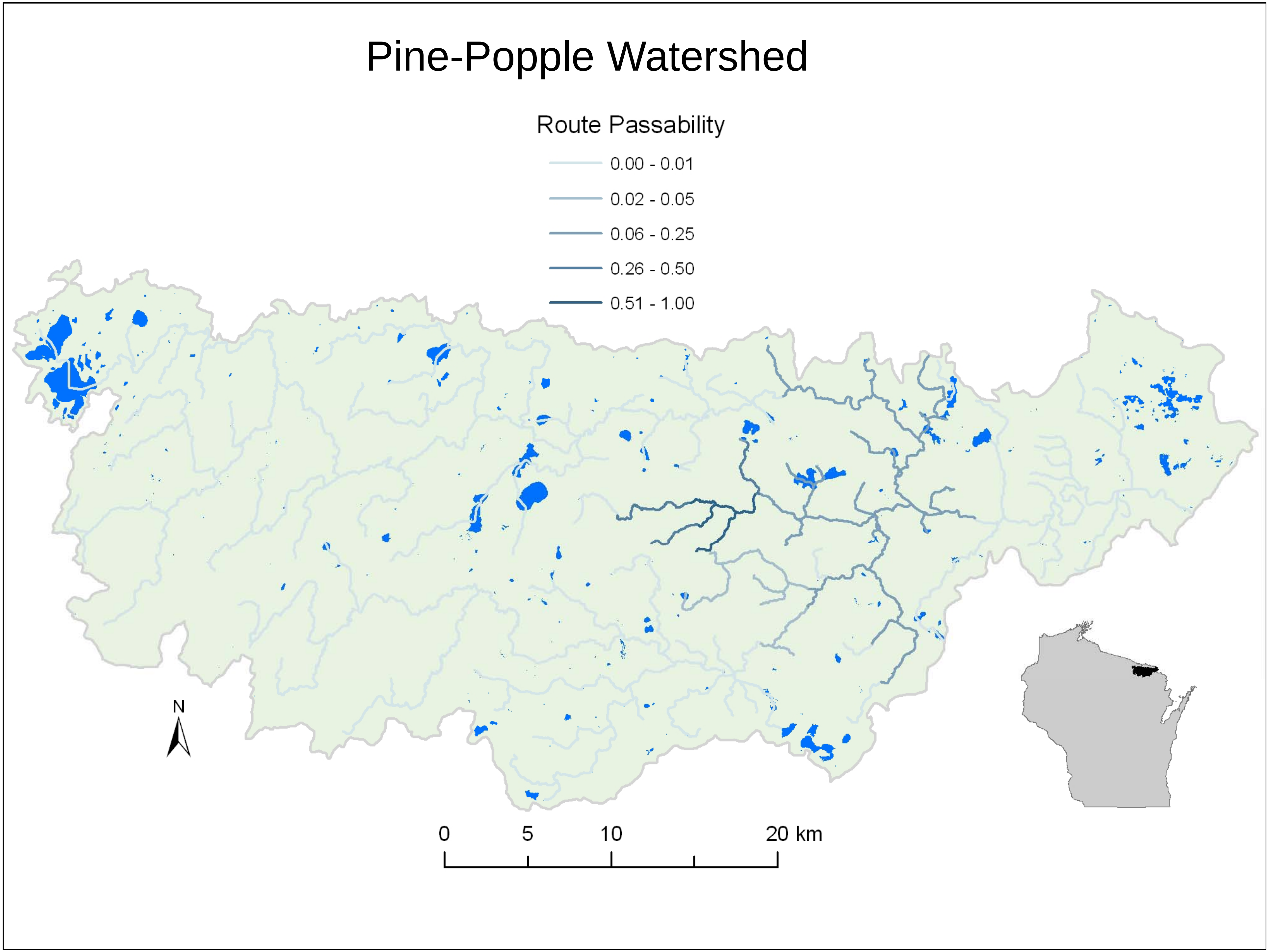
What is the aggregate effect of all these barriers on the ability of fish to make necessary movements?

Which barriers limit functional connectivity the most?

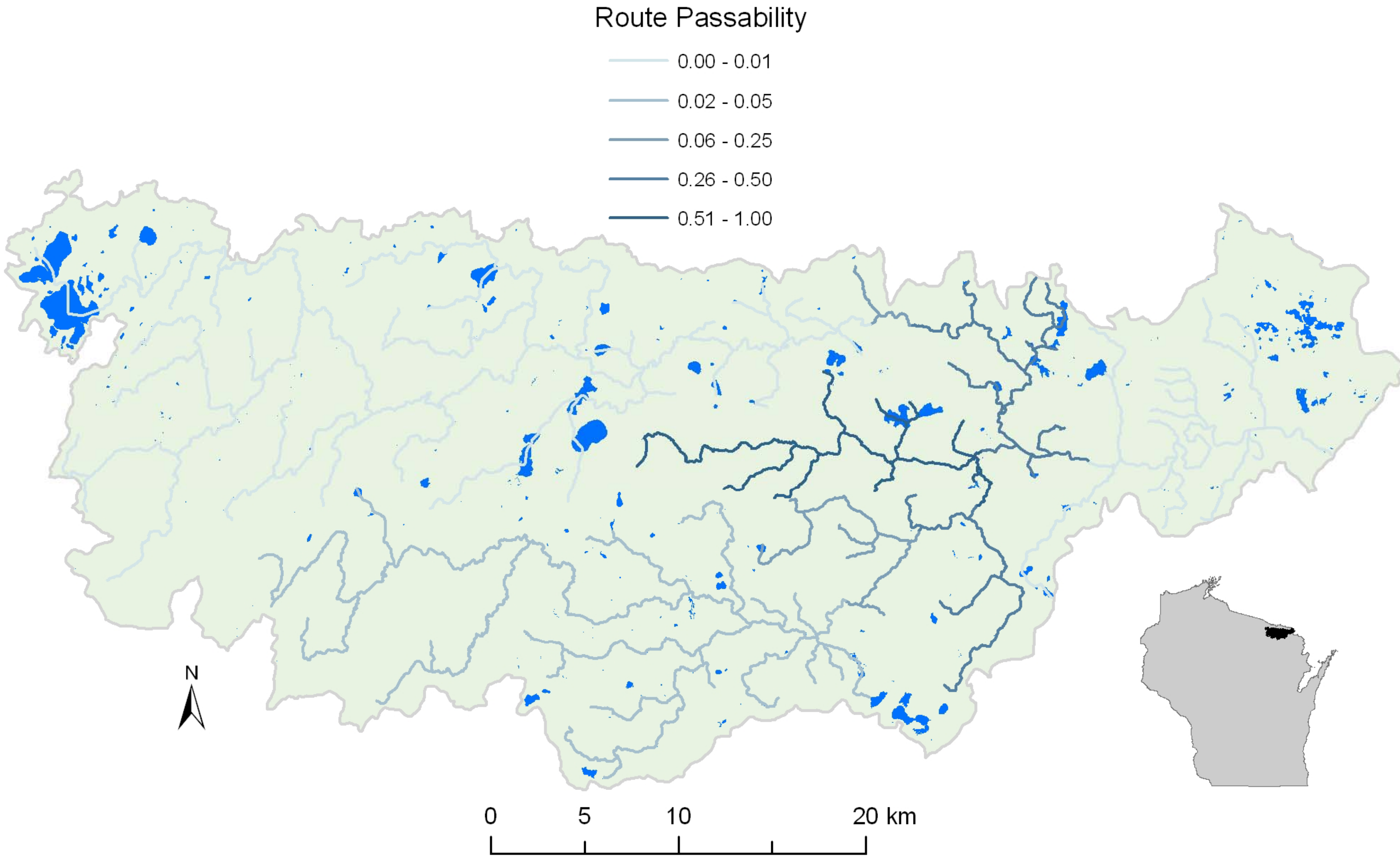
Designing a connectivity metric

- Start with recently developed "Dendritic Connectivity Index" (Cote et al. 2009 Landscape Ecology)
  - Segment scale: percentage of stream network that is connected
  - Watershed scale: length-weighted average of segment scale connectivity
- Add parameters to make DCI more biologically realistic
  - What is the baseline (expected) connectivity when there are natural barriers?
  - Connectivity between nearby segments is more important than connectivity between distant segments.
  - Most fish require access to a variety of habitat types, rather than just a large amount of habitat.
  - Connections to high quality habitat are more valuable than connections to poor quality habitat.

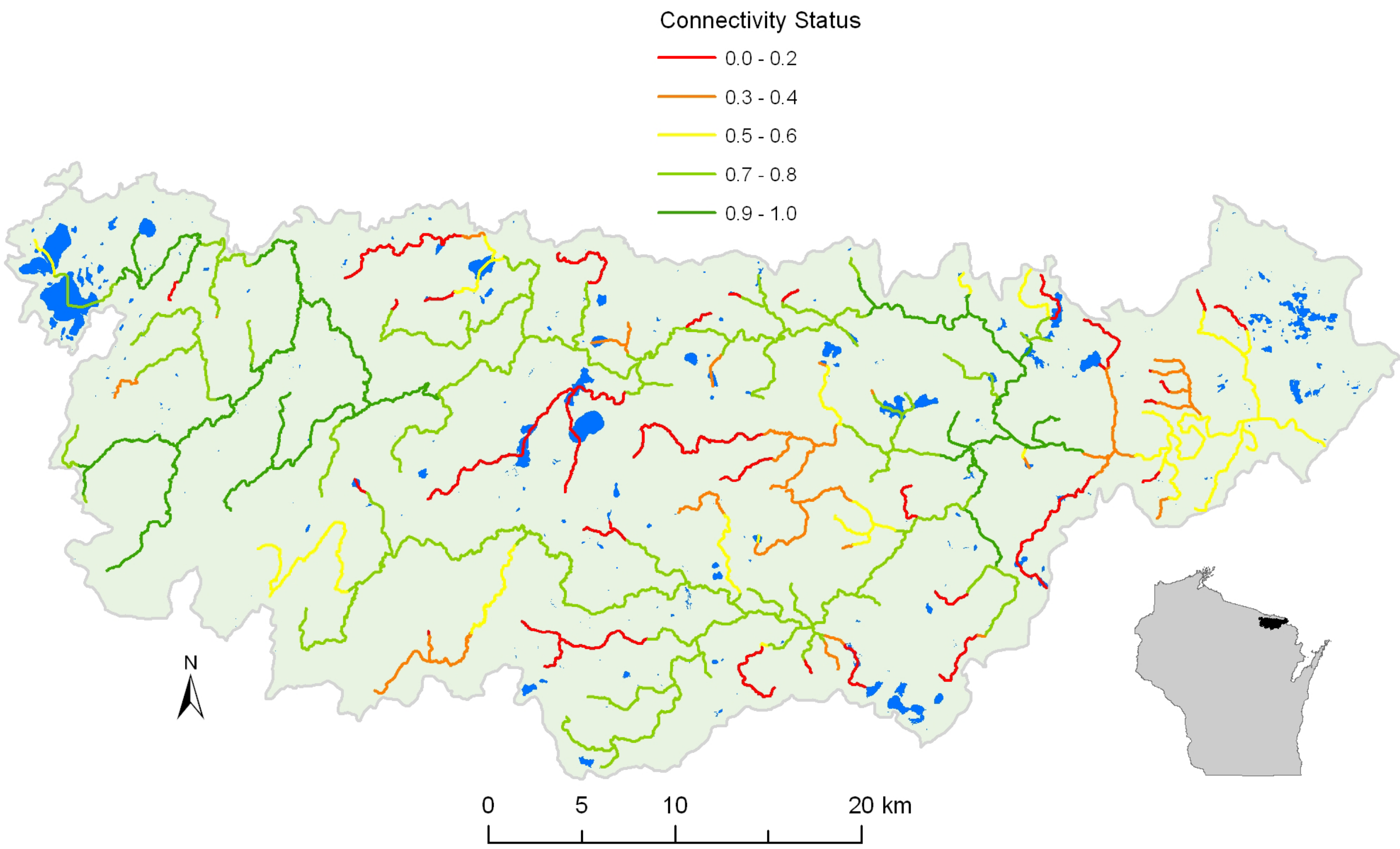

Pine-Popple Watershed
Natural Barrier Passability
0
0.5
Road Crossing and Dam Passability
0.0 (27%)
0.5 (20%)
Unknown (5%)
0.9 (21%)
1 (27%)
N
0
5
10
20 km


Pine-Popple Watershed
Route Passability
0.00 - 0.01
0.02 - 0.05
0.06 - 0.25
0.26 - 0.50
0.51 - 1.00
N
0
5
10
20 km

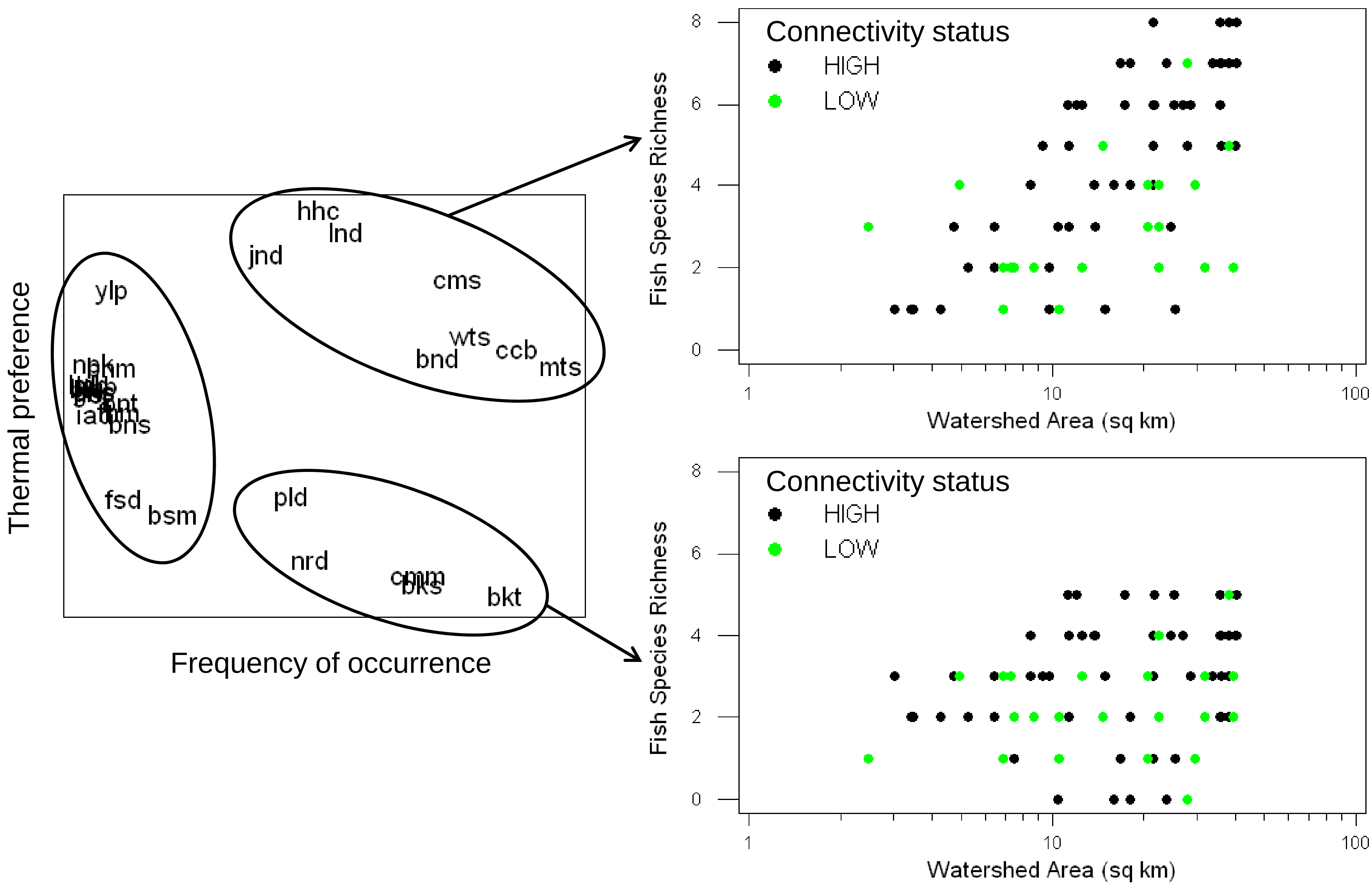
Pine-Popple Watershed



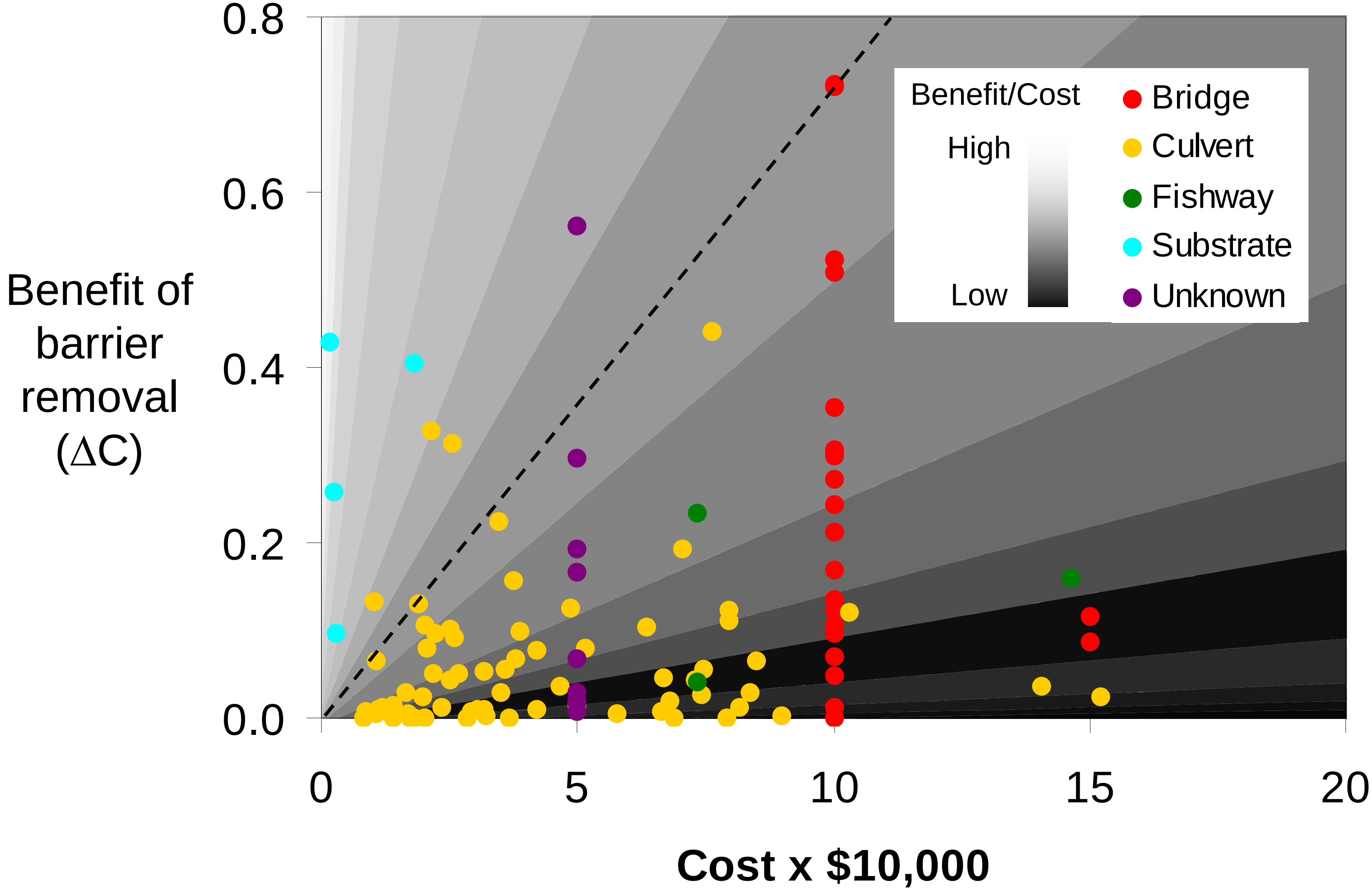
Pine-Popple Watershed



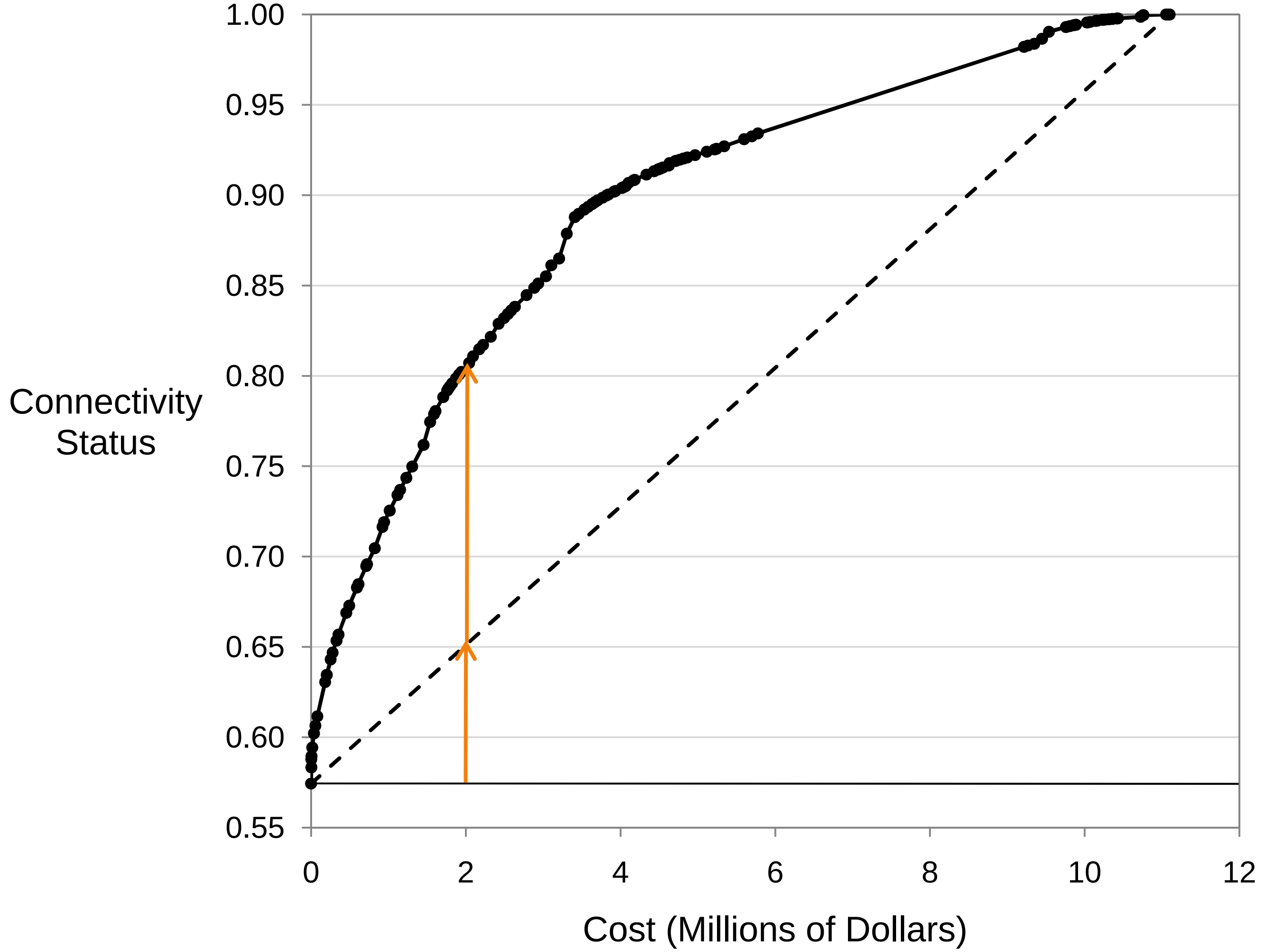
Does connectivity affect fish communities?



Prioritizing Remediation



Prioritizing Remediation

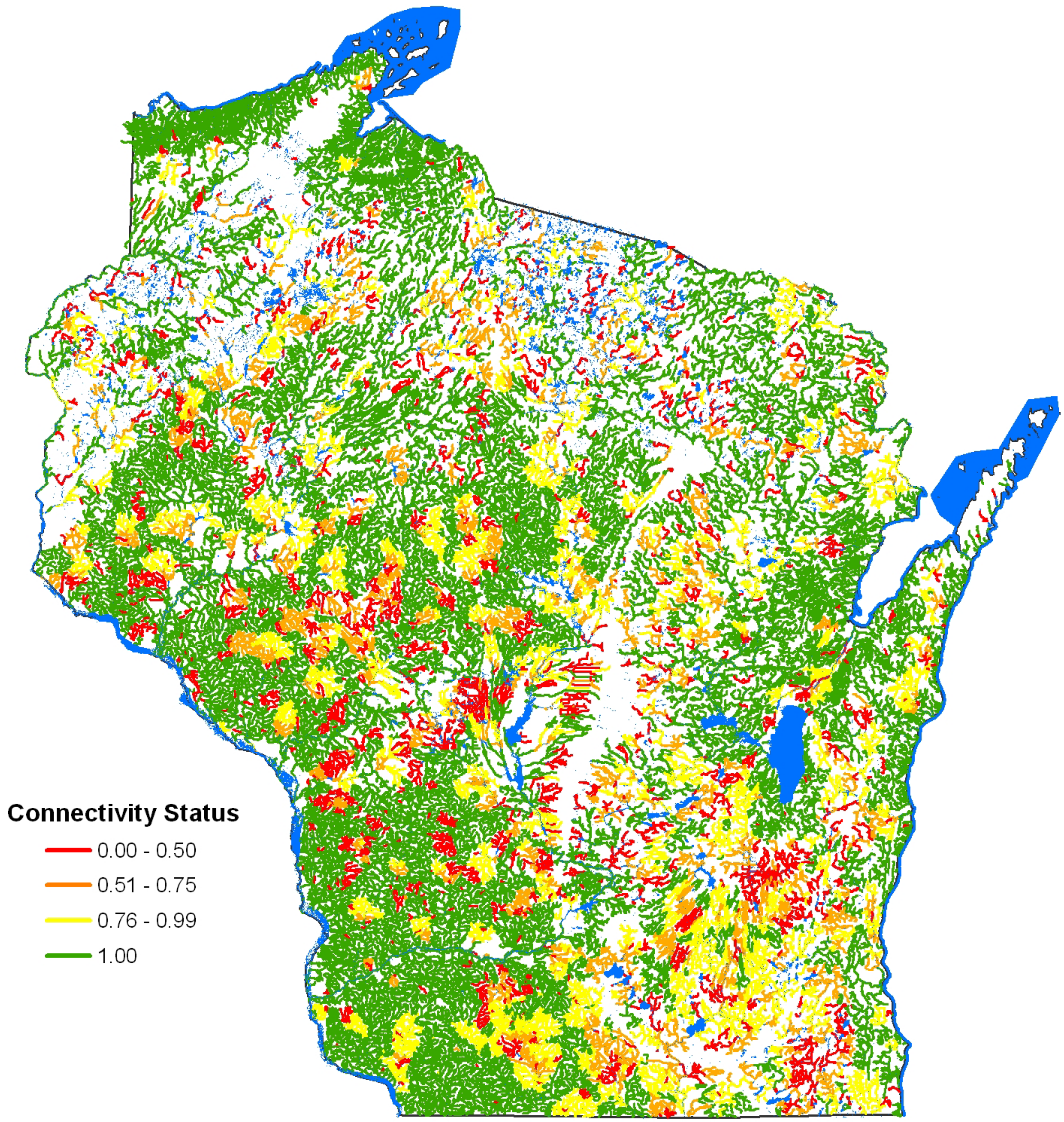


Summary

- Road crossings significantly limit stream connectivity in the Pine-Popple watershed.
- Connectivity status (C) measures the cumulative effect of multiple barriers at the stream segment and watershed scale.
- Warmwater species richness was influenced by connectivity status.
- Barriers were ranked for remediation by connectivity effect per cost.

Next Steps

- Develop empirical estimates of model parameters
- Application to individual species
  - Habitat needs and passability better defined
  - Could be integrated with habitat restoration plans for target species
- Examine ecosystem-scale consequences of connectivity impairment
- Balance connectivity restoration goals with need to prevent spread of invasive species
- Application at larger scales
  - Prioritize connectivity restoration among watersheds
  - Support successful on-the-ground efforts


Connectivity Status
0.00 - 0.50
0.51 - 0.75
0.76 - 0.99
1.00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Jeff Maxted
For more information…
http://conserveonline.org/workspaces/streamconnect

Connectivity Status Equations

$$A_{jt}^{b} = \sum_{i=1}^{n} \left(L_{it} \cdot P_{itj}^{n} \cdot D_{itj} \cdot Q_{it} \right)$$

$$A_{jt} = \sum_{i=1}^{n} \left(L_{it} \cdot P_{itj}^{n} \cdot P_{itj}^{a} \cdot D_{itj} \cdot Q_{it} \right)$$

$$C_{j} = \frac{\sum_{t=1}^{m} \left(\frac{A_{jt}}{A_{jt}^{b}} \right)}{m}$$

$$\overline{C} = \frac{\sum_{j=1}^{n} C_{j} \cdot L_{j}}{\sum_{j=1}^{n} L_{j}}$$