Sustaining Healthy Aquatic Ecosystems in a Changing Climate: Understanding ecological relationships with flow

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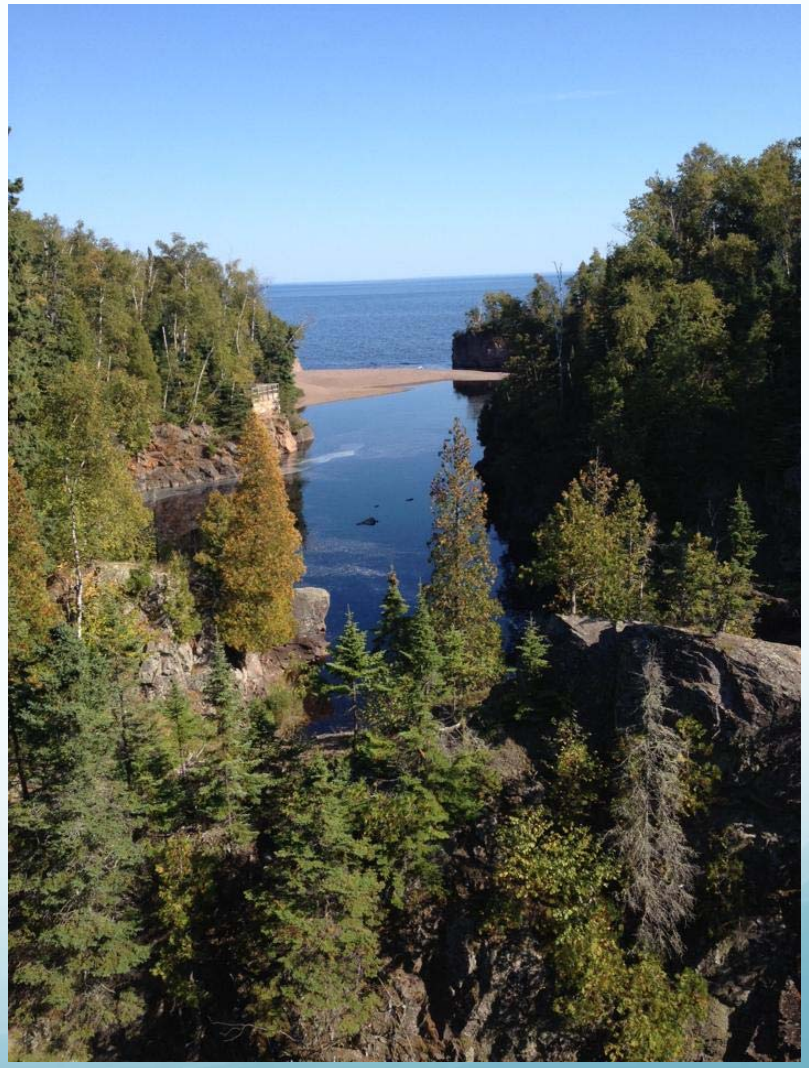
The Nature Conservancy

Sustaining Healthy Aquatic Ecosystems in a Changing Climate

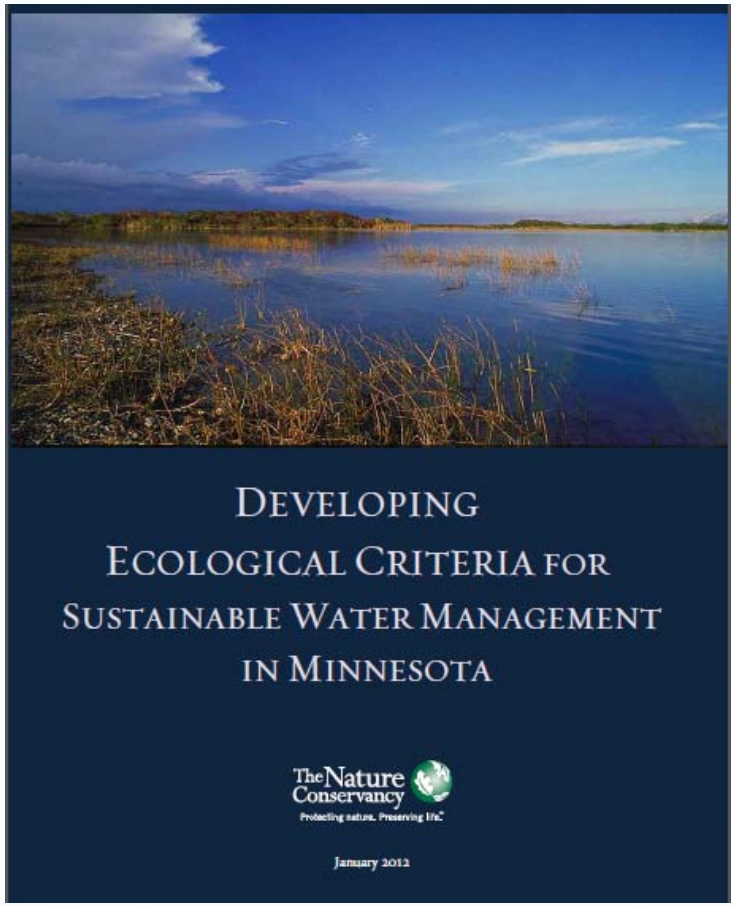
- Understand how ecological communities relate to flow regime
- Anticipate/predict ecological response to flow alteration
- Develop strategies and priorities based on stream resilience

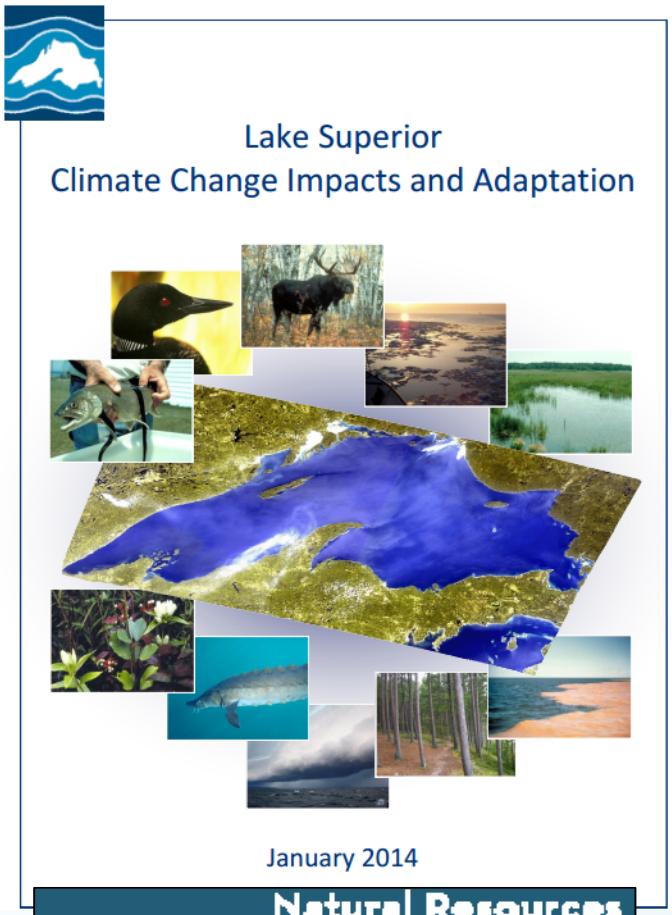


Overview:

- What do we already know?
- Modeling flow and predicting ecological implications
- What can we do ?

Background





Acknowledgments

MNDNR

NOAA

MINNESOTA'S LAKE SUPERIOR COASTAL PROGRAM

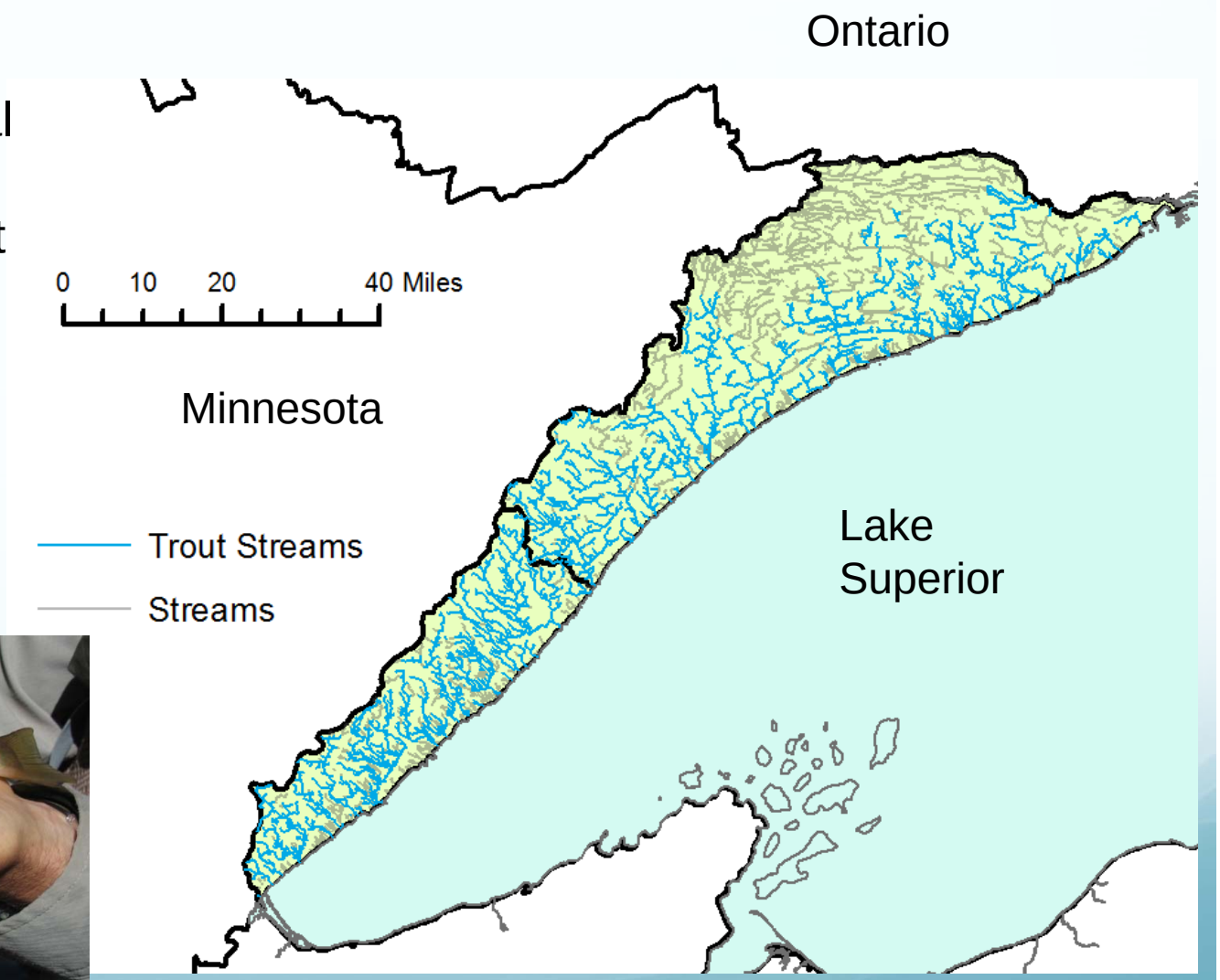
UMD Natural Resources Research Institute
University of Minnesota Duluth
Driven to Discover

Great Lakes RESTORATION

The Nature Conservancy

The Study Area:
Minnesota's North Shore of Lake Superior

- Highly valued regional coldwater fishery
- >150 designated trout streams
- Native Brook trout
- Steelhead, salmon, and brown trout also present & managed

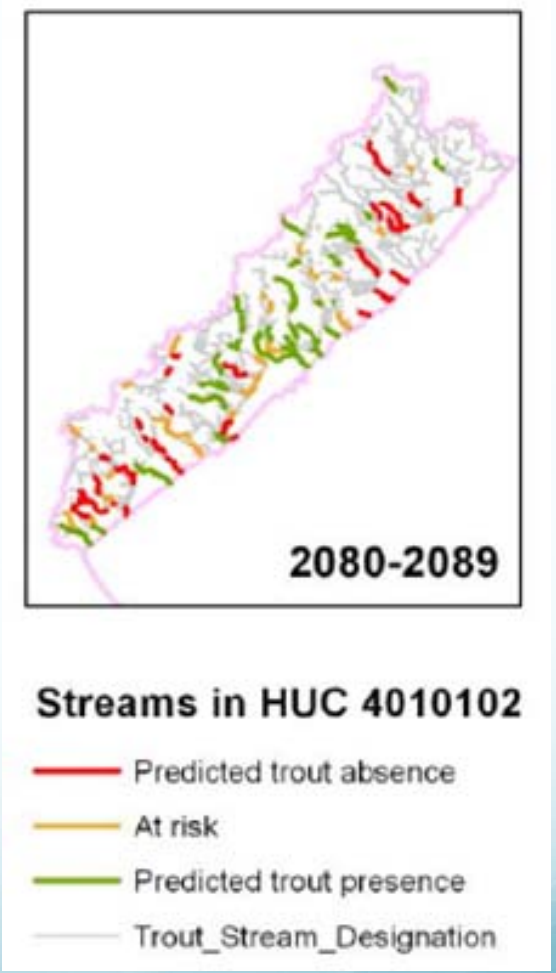


What We Know

- The combination of climate and land use changes can be expected to drive a series of cascading impacts to North Shore streams
- We have a lot of (recent) data and models out there to learn from and synthesize

Synthesizing & integrating previous work on stream hydrology and temperature

- Literature review – flow, ecology (fish), and climate
- North Shore Models: Stream temperature, flow, and fish
  - Johnson, Herb & Cai 2014
  - FishVis



Flow modeling and analysis: ecological response to flows

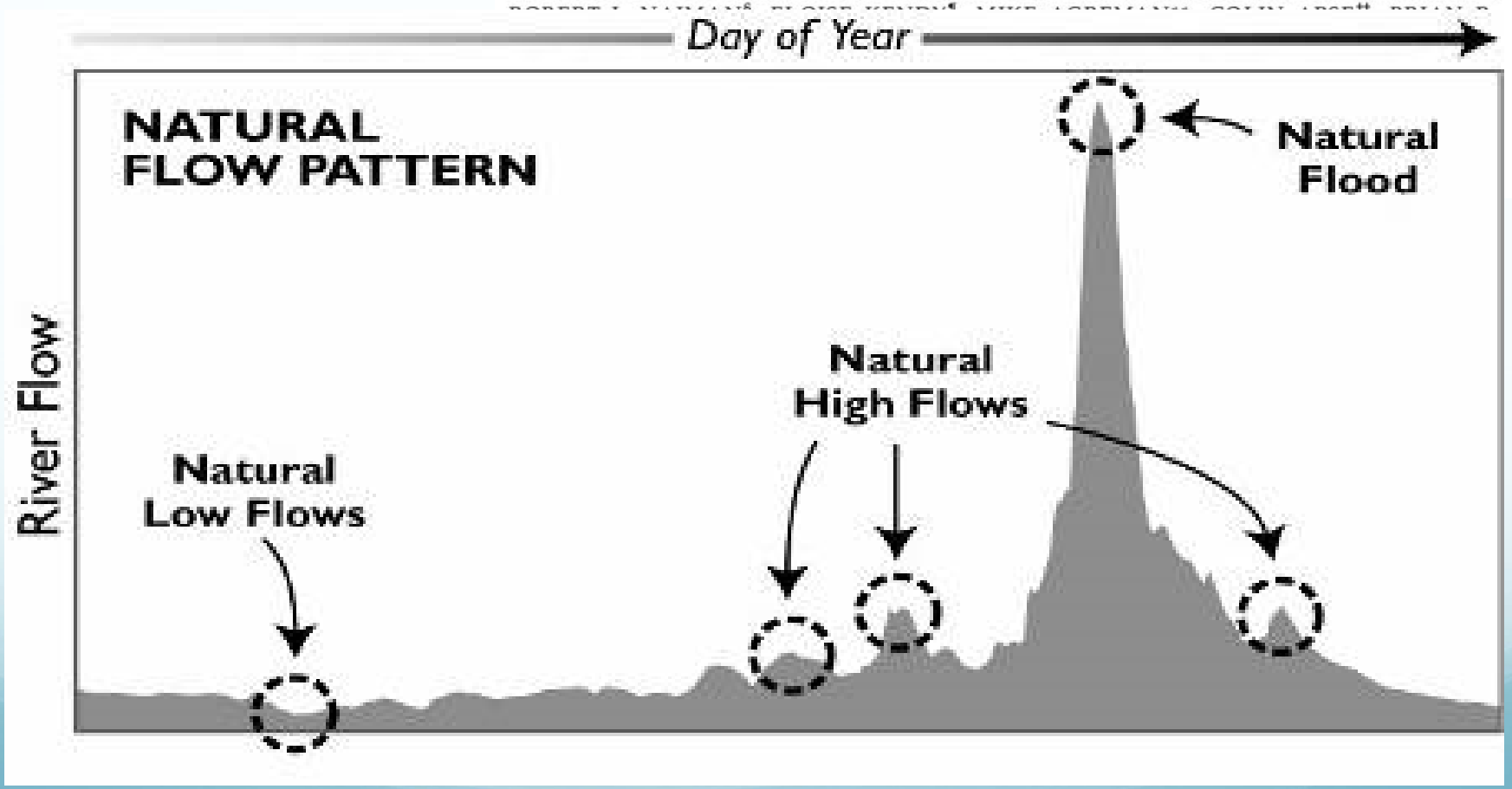
ELOHA

Freshwater Biology

Freshwater Biology (2010) **55**, 147–170 doi:10.1111/j.1365-2427.2009.02204.x

The ecological limits of hydrologic alteration (ELOHA): a new framework for developing regional environmental flow standards

N. LEROY POFF*, BRIAN D. RICHTER†, ANGELA H. ARTHINGTON‡, STUART E. BUNN‡,



Flow-Ecology Relationships

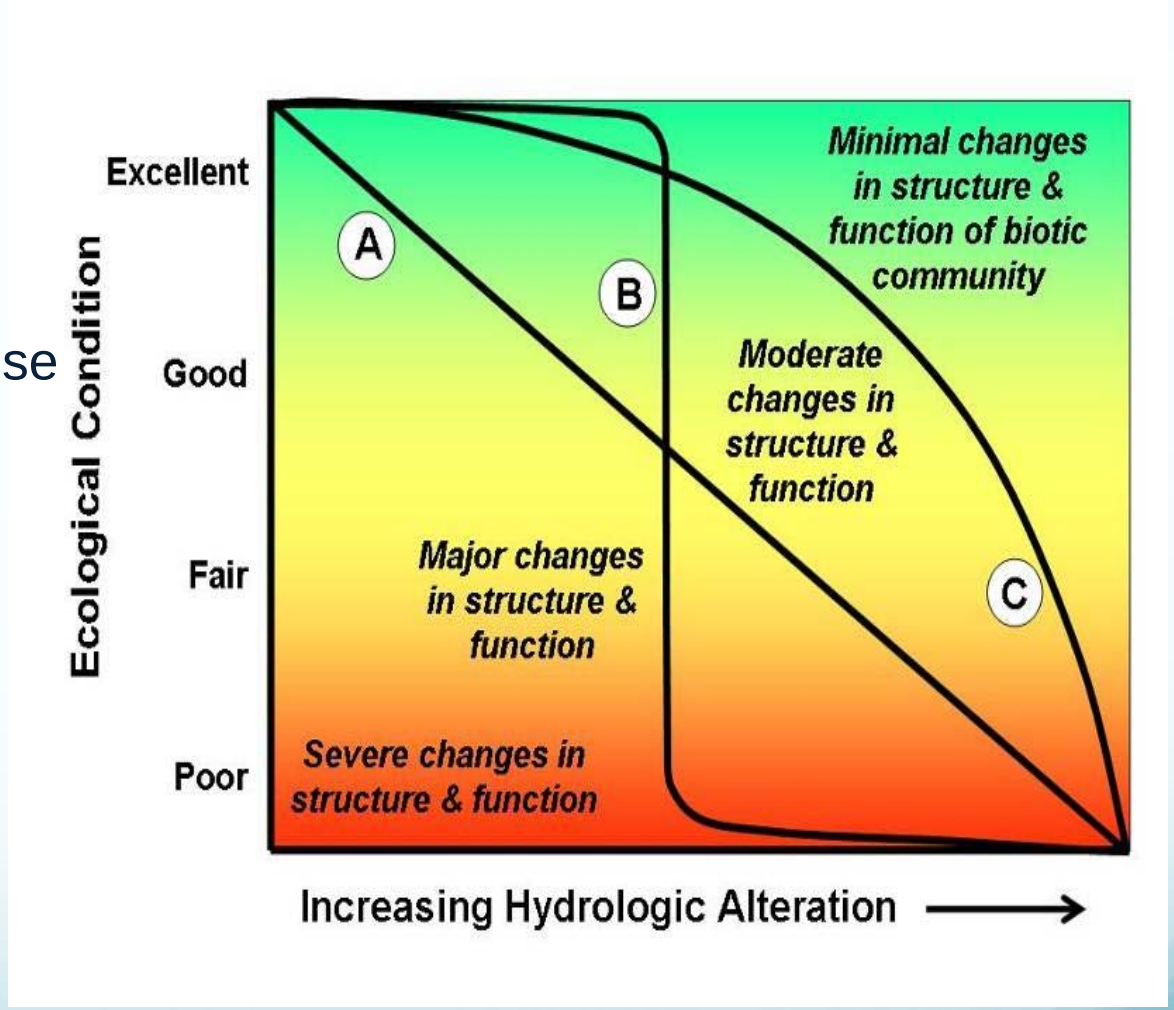
ELOHA:

1. The Flow – Ecology Response Curve

   How much ecological change occurs in response to each incremental alteration of the flow regime?

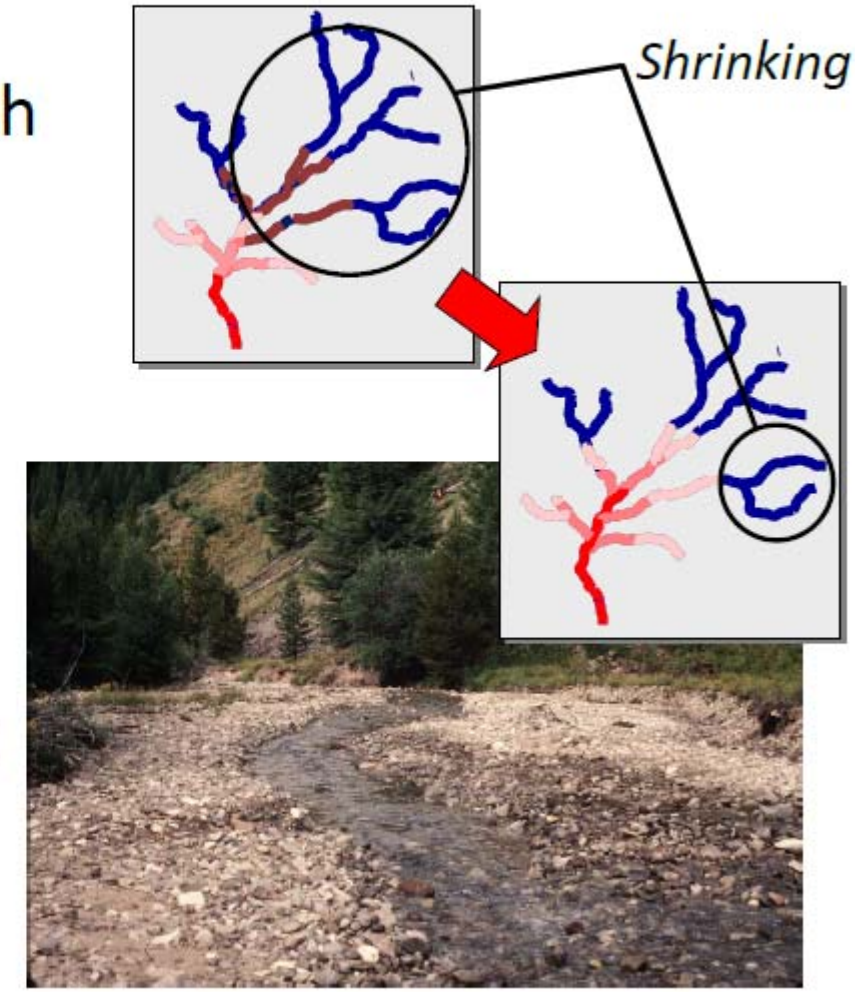
   Are there limits or thresholds?

2. Developing policy & practices for “mimicking” natural flow pattern



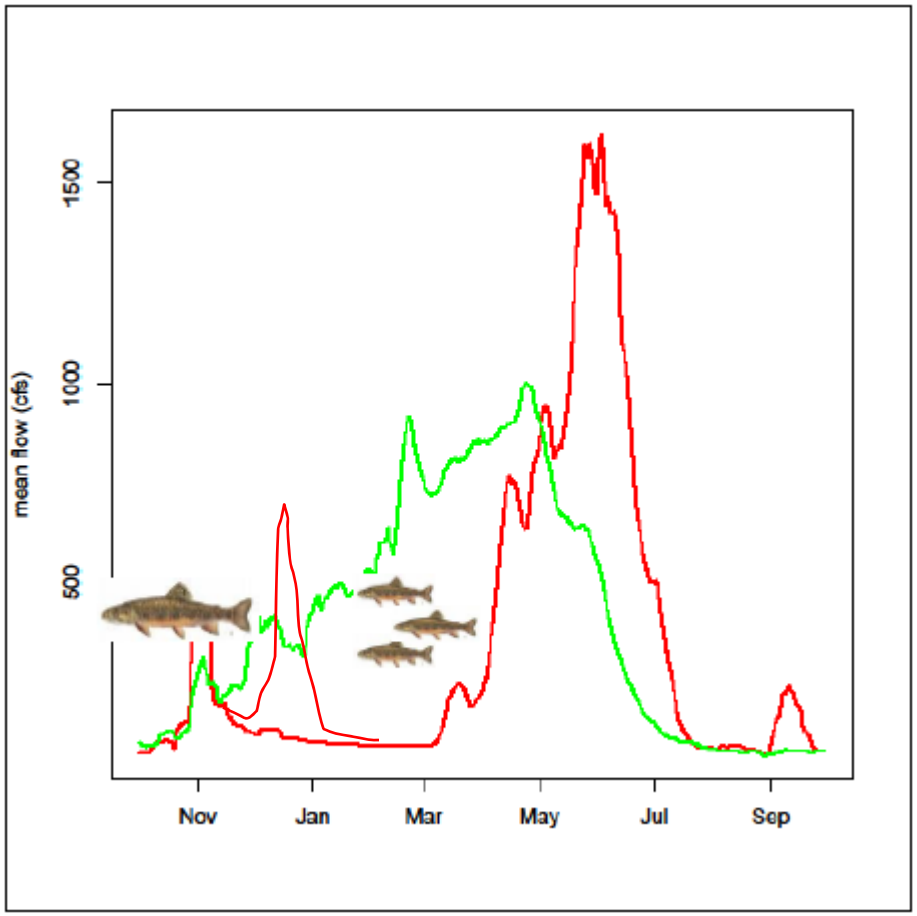
Flow and fish: low flows

- Less water = fewer fish
- Less water = warmer water
- Reduced access, restricted movement



Wenger 2015
http://www.fsl.orst.edu/fs-pnw/pep/aquaticsseminar/wenger/

Flow and fish: high flows



Wenger 2015
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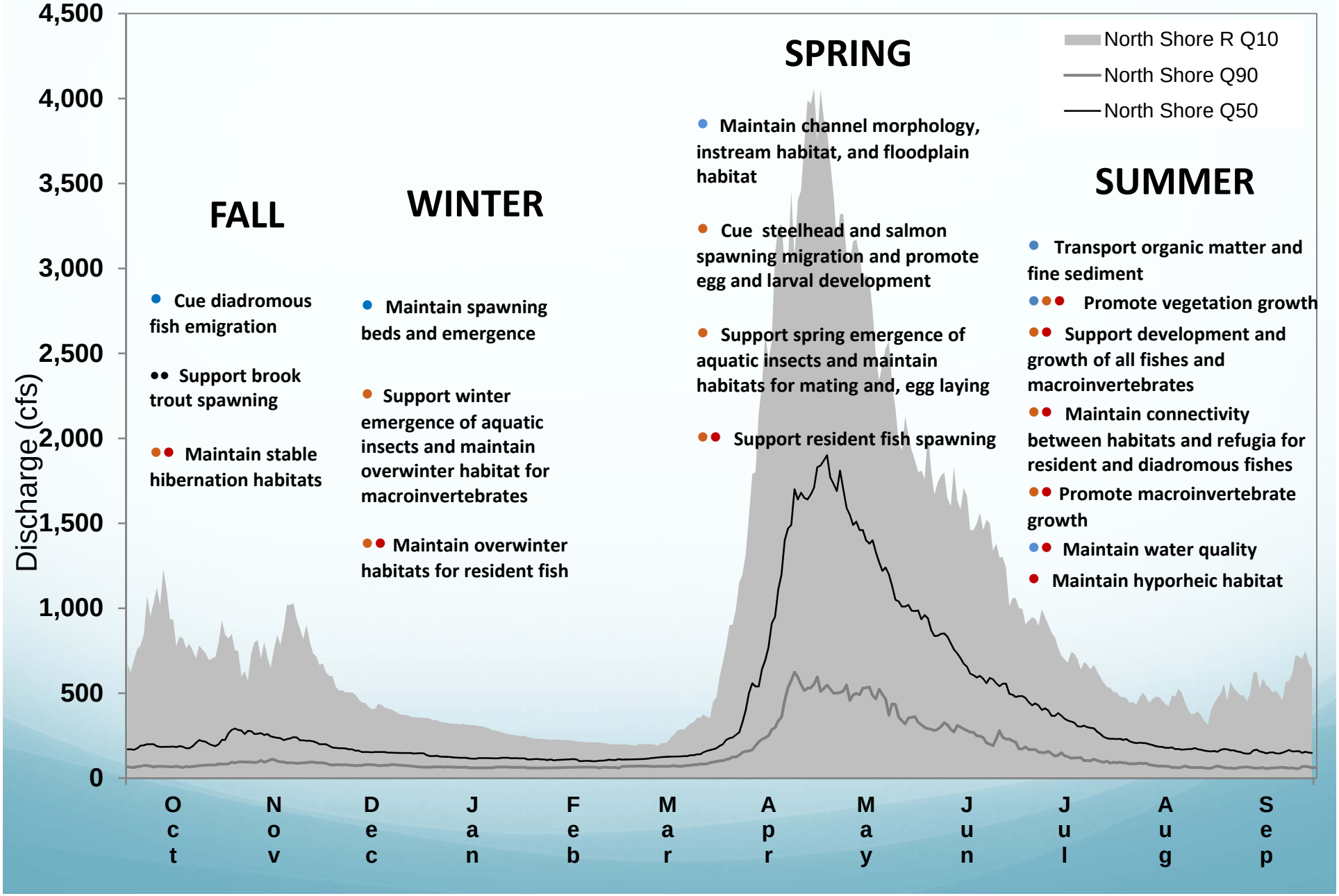
How much change can occur before we expect to see significant changes in biological communities?



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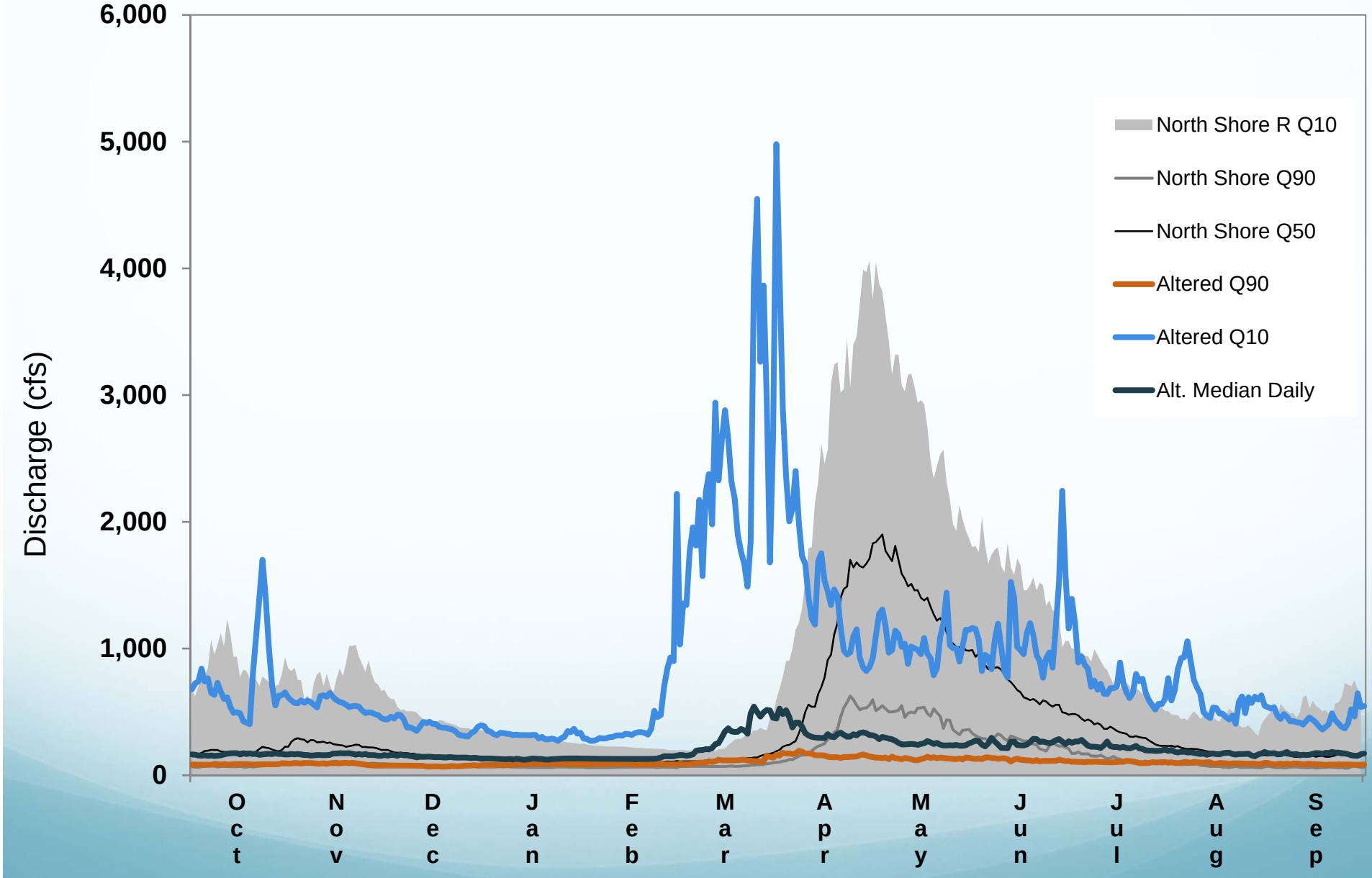
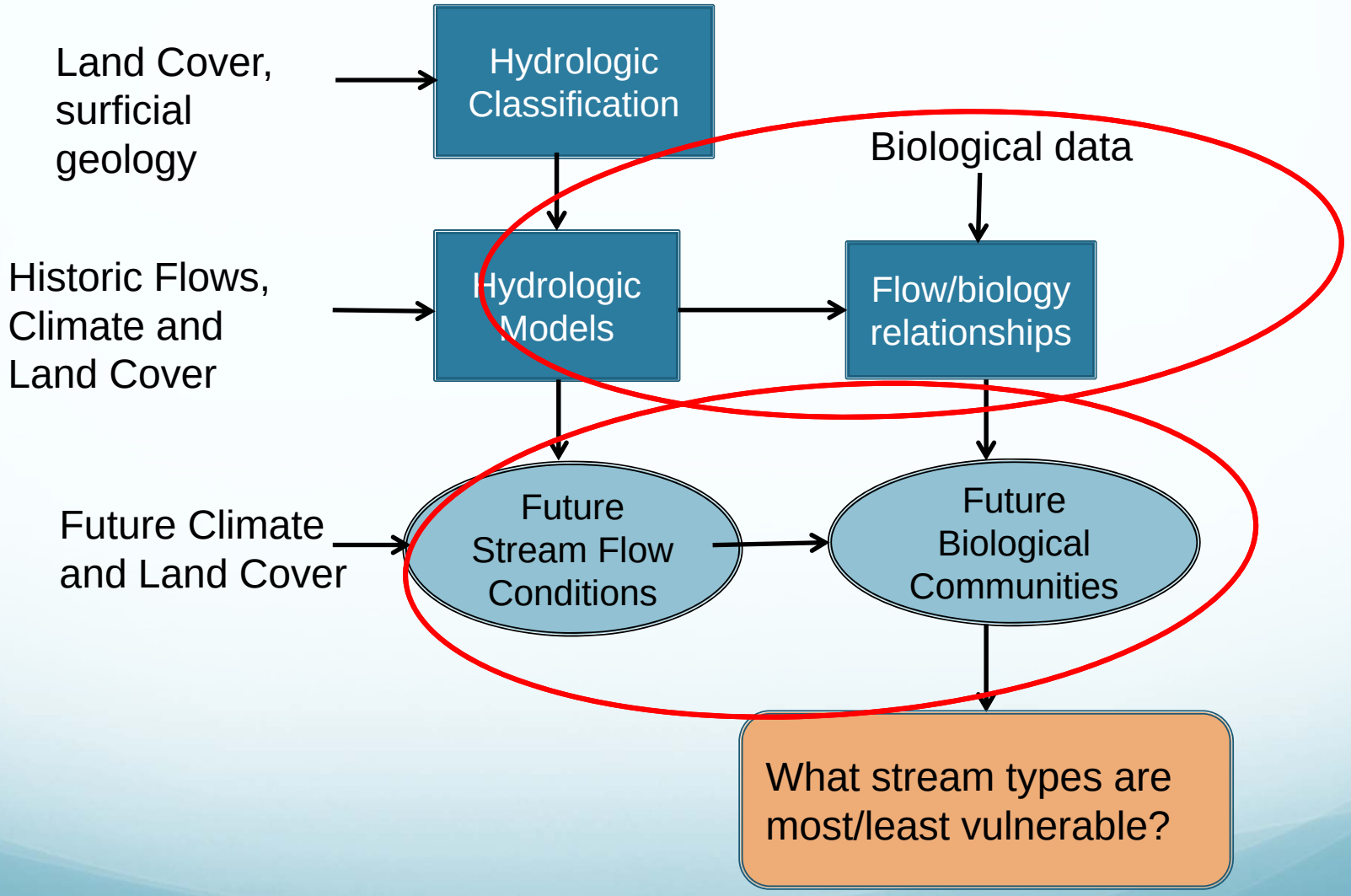


Methods Summary



Ecological Response

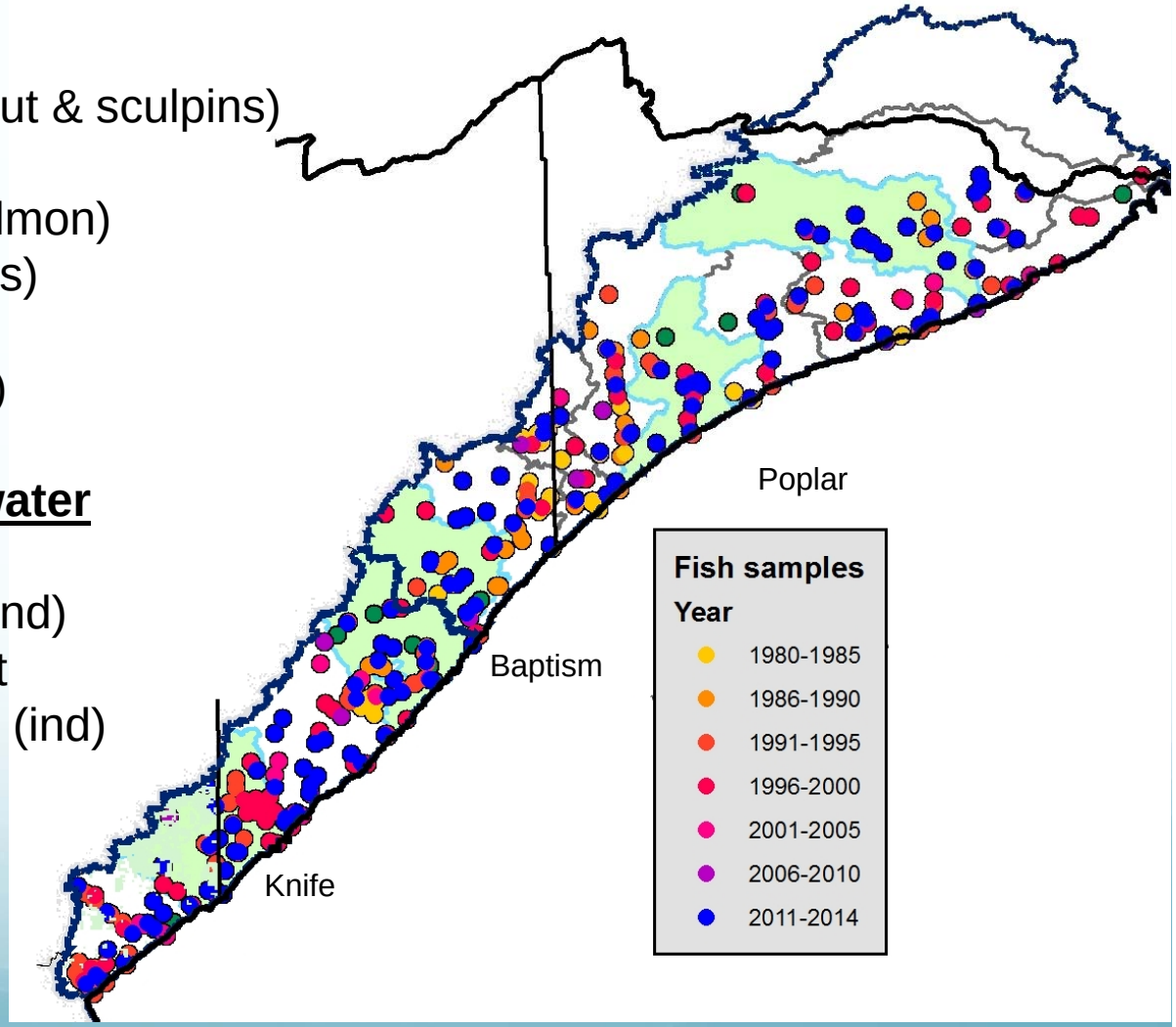
Fish species presence/absence & abundance

% Taxa by guild/life history:

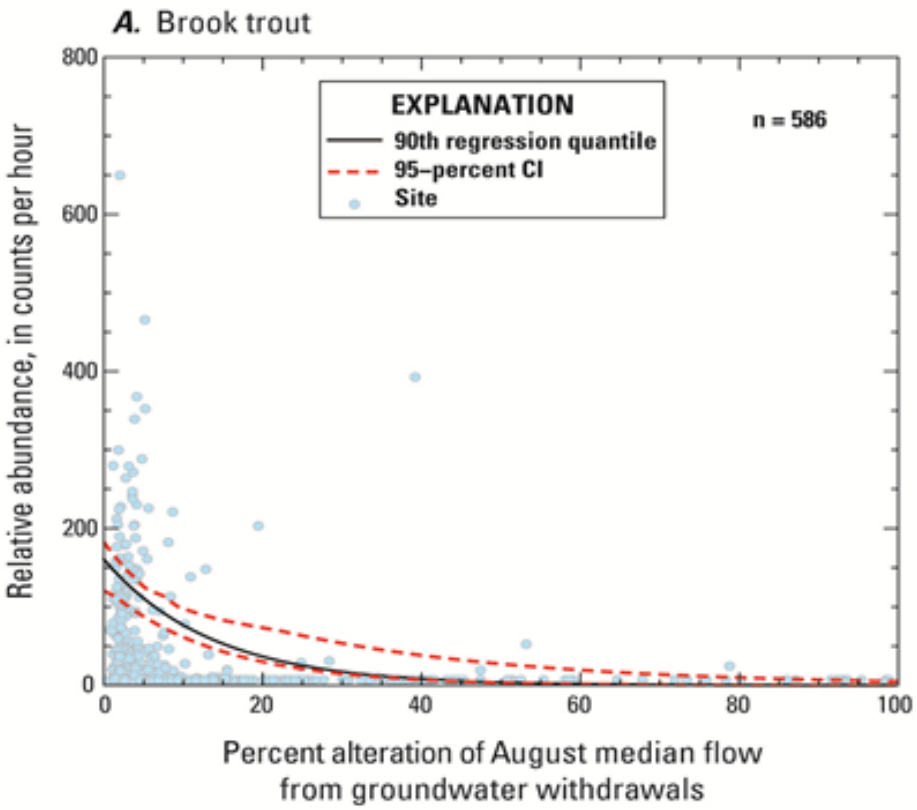
- Coldwater / headwater (trout & sculpins)
- Riffle obligates
- Anadromous sport fish (salmon)
- Nest builders (sunfish, bass)
- Nonlithophilic nester
- Marsh spawners (No. pike)

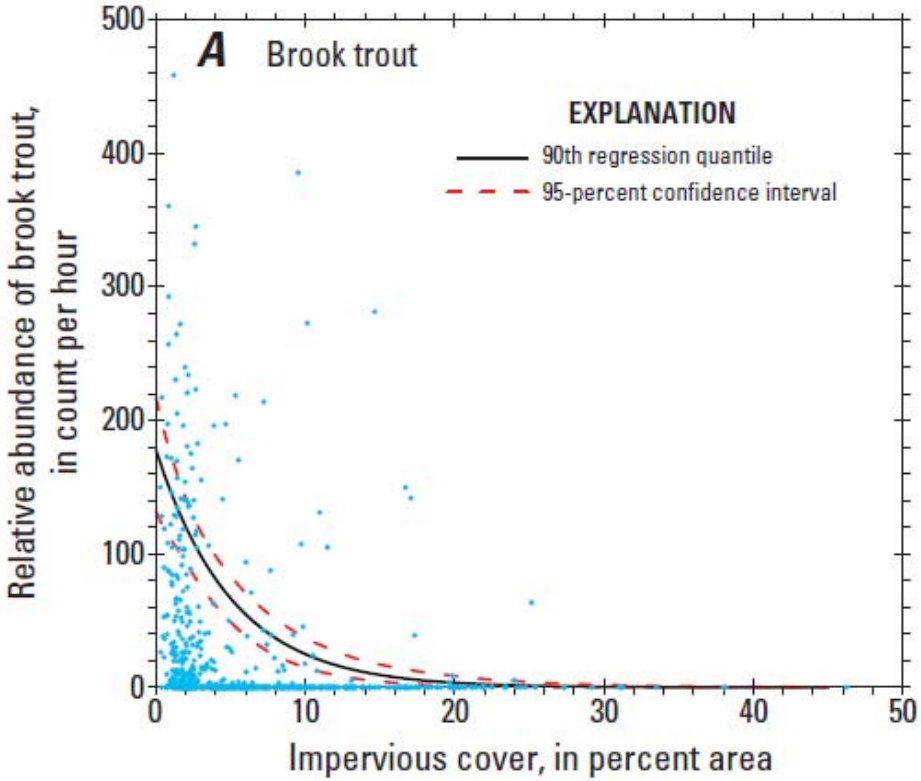
IBI Metrics – northern coldwater

- Coldwater (sp richness)
- Intolerant Coldwater_Pct (ind)
- Sensitive Coldwater_TxPct
- Non Lithophilic Nester_Pct (ind)
- Omnivore_TxPct
- Pioneer_TxPct
- Perciformes_Pct (ind)
- Silt tolerance (ind)



Both flow depletion (withdrawals) and surcharging (impervious surface) are associated with decreases in the abundance and diversity of river fish





Armstrong et al. 2010. (USGS) Accelerated Fish-Flow Study to Understand flow alteration impacts on River fish

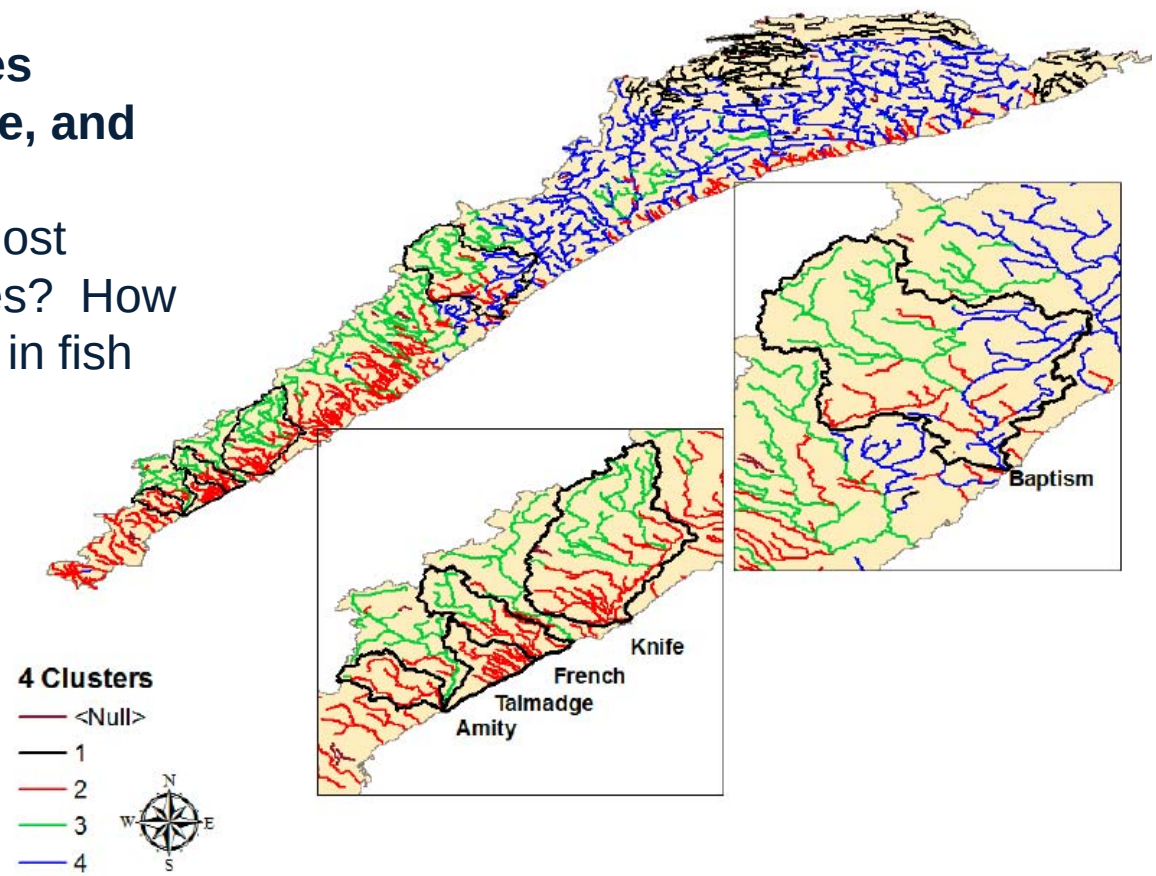
Flow ecology analysis

Evaluate species presence / absence and abundance in relation to:

- Stream classification based on catchment attributes
- Individual flow and catchment variables

Multivariate analyses of species presence / absence, abundance, and metrics :
Which ecological variables are most responsive to which flow variables? How much variance does flow explain in fish community?

Identify thresholds for fish response?



FishVis Mapper:

UPPER MIDWEST AND GREAT LAKES LANDSCAPE CONSERVATION COOPERATIVE
Effective conservation through **collaboration** *and* **sound science**

NATIONAL FISH HABITAT PARTNERSHIP

USGS *science for a changing world*

Possible changes in fish species occurrence in response to global climate change.

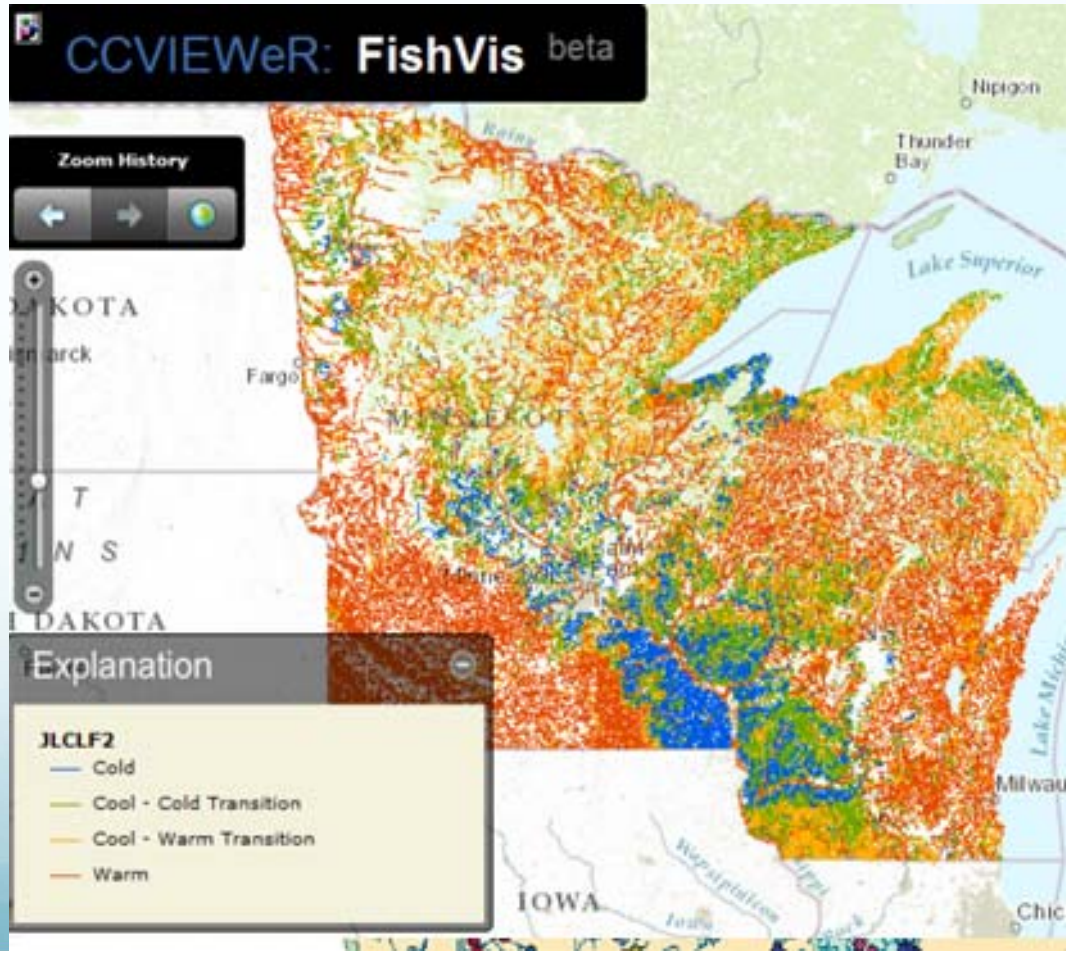
Fish species & thermal class

Climate:
A1B emissions➔ 13 GCMs

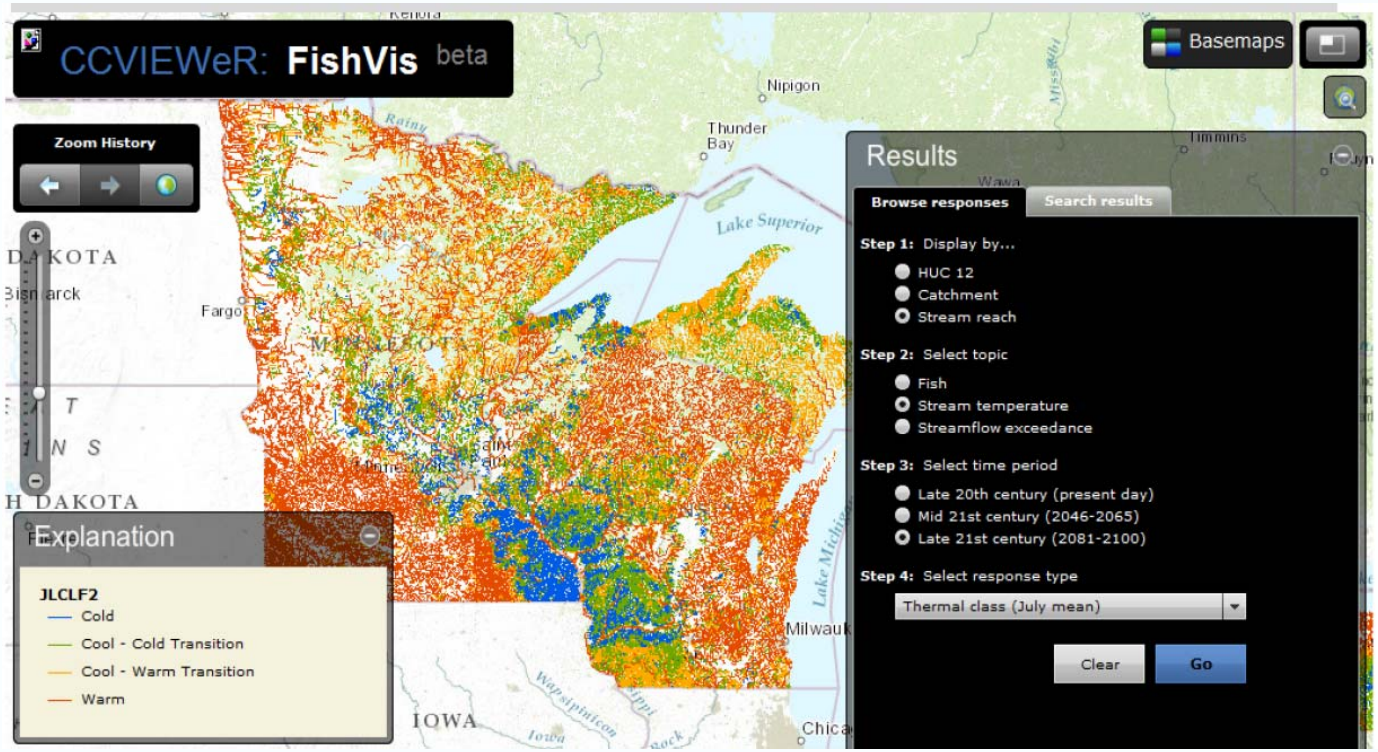
Groundwater recharge model:

Stream temperature model:

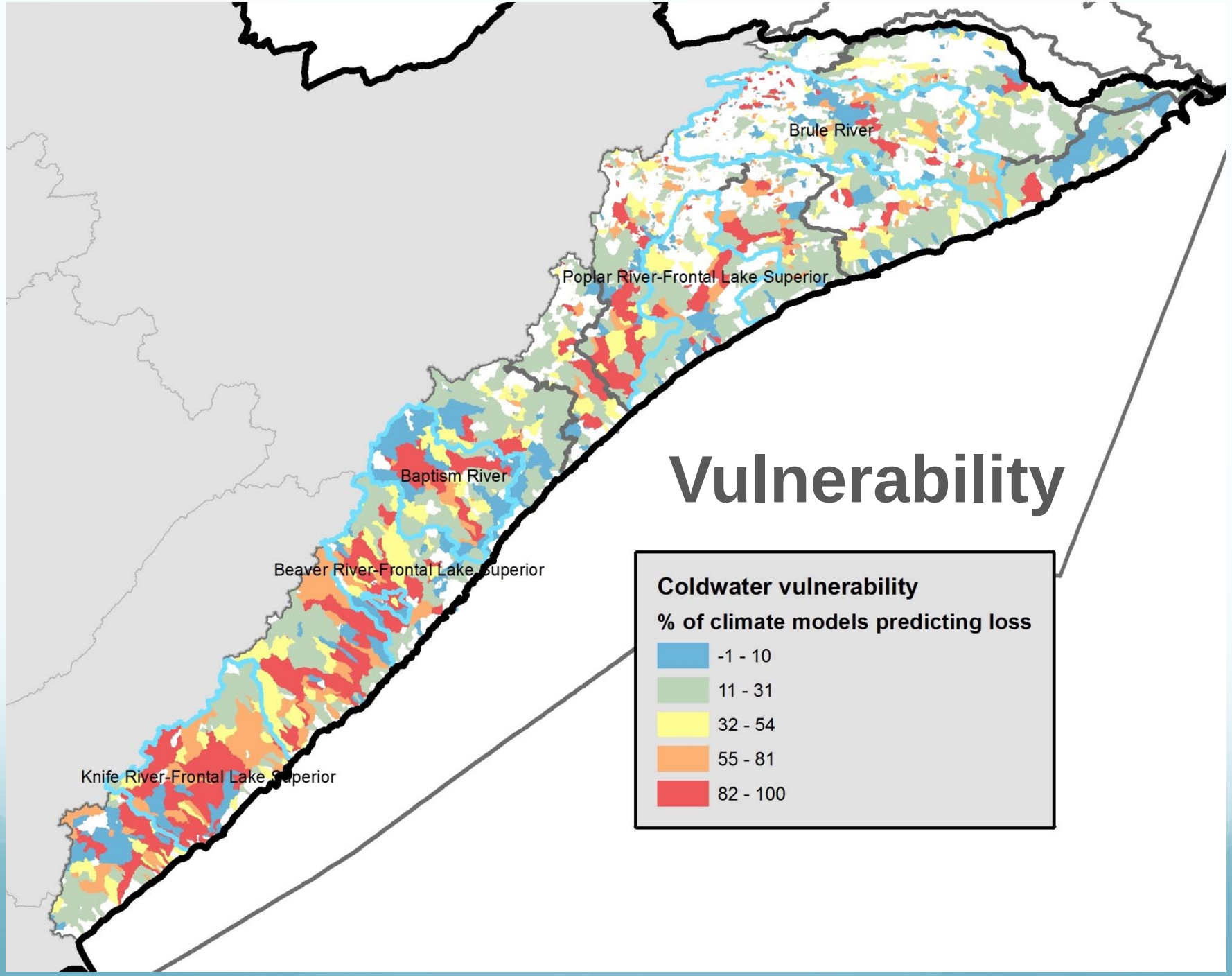
Stream flow model: Multiple linear regression models

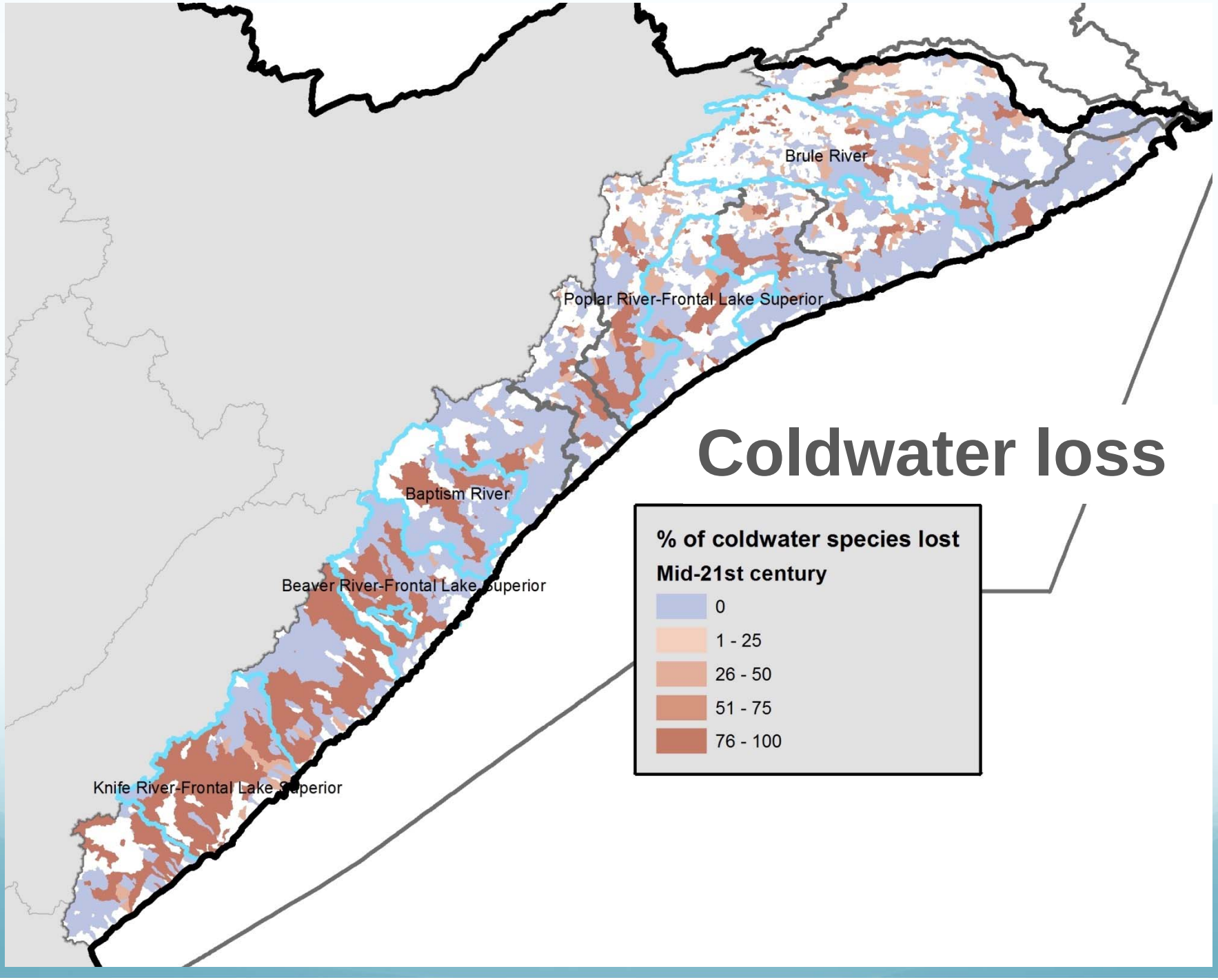


FishVis

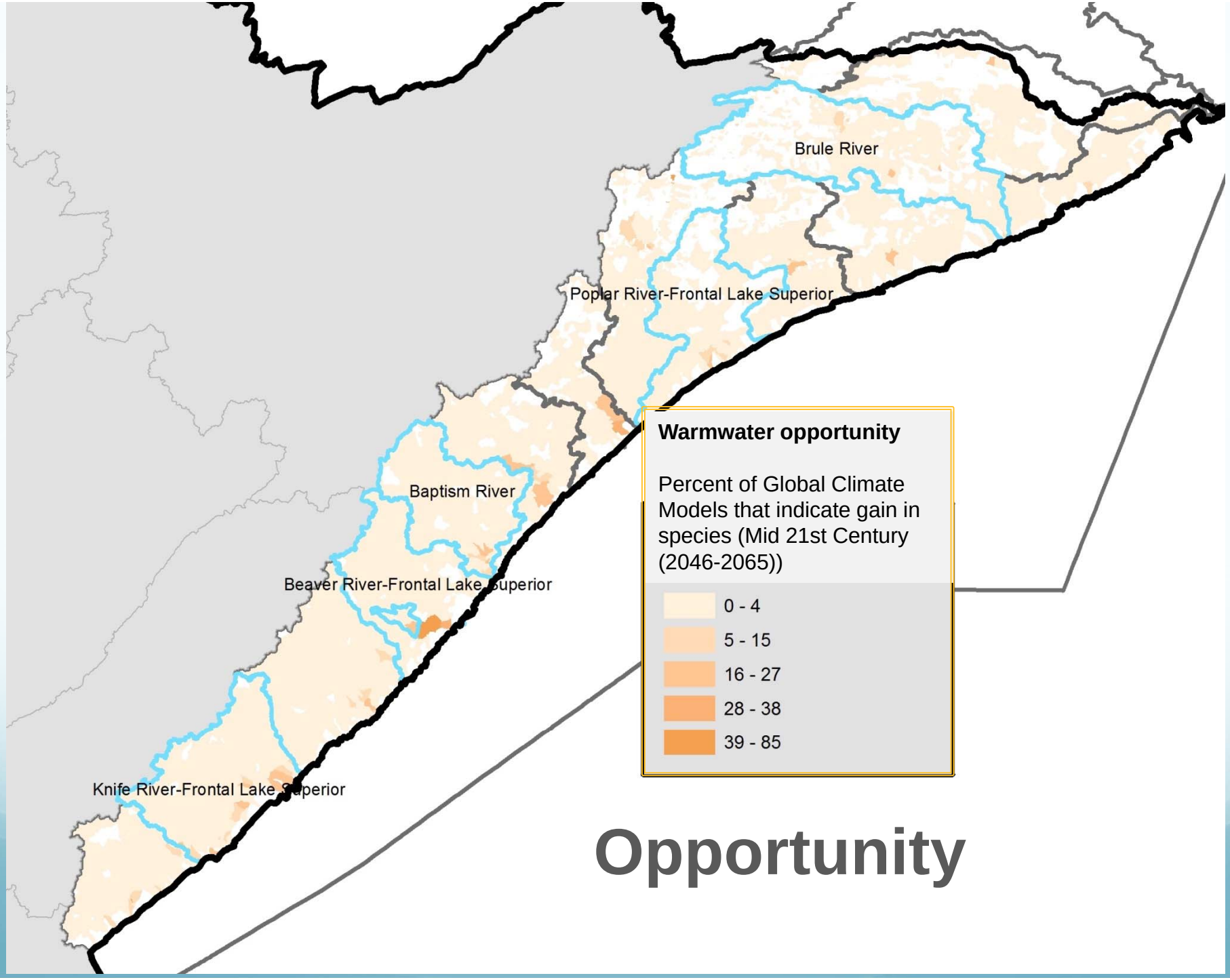


- Vulnerability – defined as % of climate models showing a loss of species
- Opportunity – defined as % of climate models showing a gain of species
- Sensitivity – defined as % of climate models showing gain OR loss (change)


Brule River
Poplar River-Frontal Lake Superior
Baptism River
Beaver River-Frontal Lake Superior
Knife River-Frontal Lake Superior
Vulnerability
Coldwater vulnerability
% of climate models predicting loss
-1 - 10
11 - 31
32 - 54
55 - 81
82 - 100



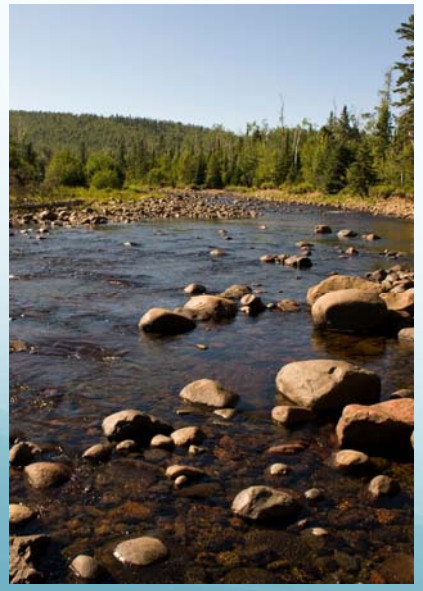
Coldwater loss



Opportunity

Next steps

- **Complete flow ecology analysis (March 1, 2016)**
- **Model flow changes under future land use & climate scenarios (March 1, 2016)**
- **Interpret implications for future stream vulnerability & resilience**
- **Engage stakeholders/managers to provide guidance and recommendations for policy & management (July 2016)**



Discussion and recommendations

Over the next century, we expect to see a shift from coldwater fish to cool- and warmwater fish

In some cases, changes in flow may actually help to mitigate the effects of increased temperature

For some stream reaches, maintaining coldwater regimes may be feasible with a combination of strategies for maintaining riparian shade and catchment forest conditions

It is critical to incorporate stream management goals into watershed, land use, and forest management plans