Climate Change Impacts on Minnesota Waters and Ecosystem Services

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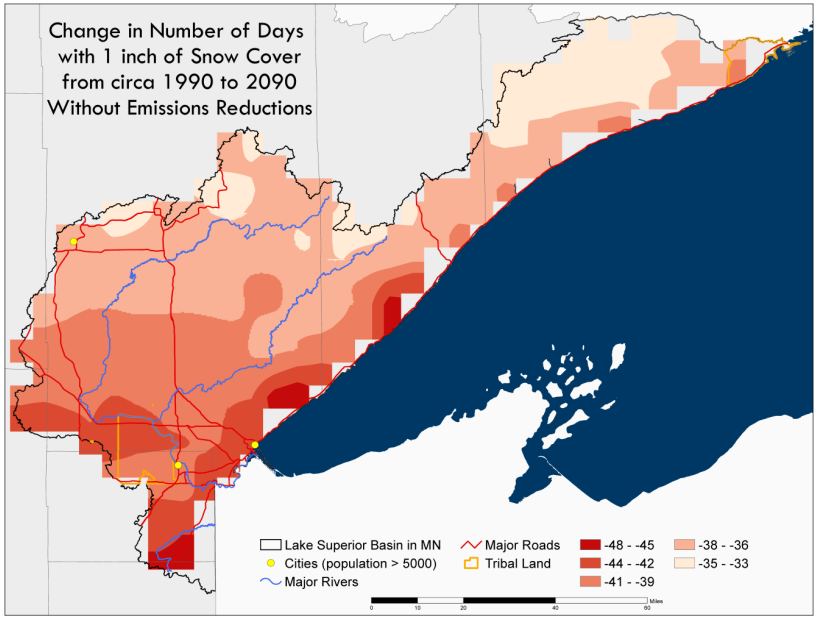
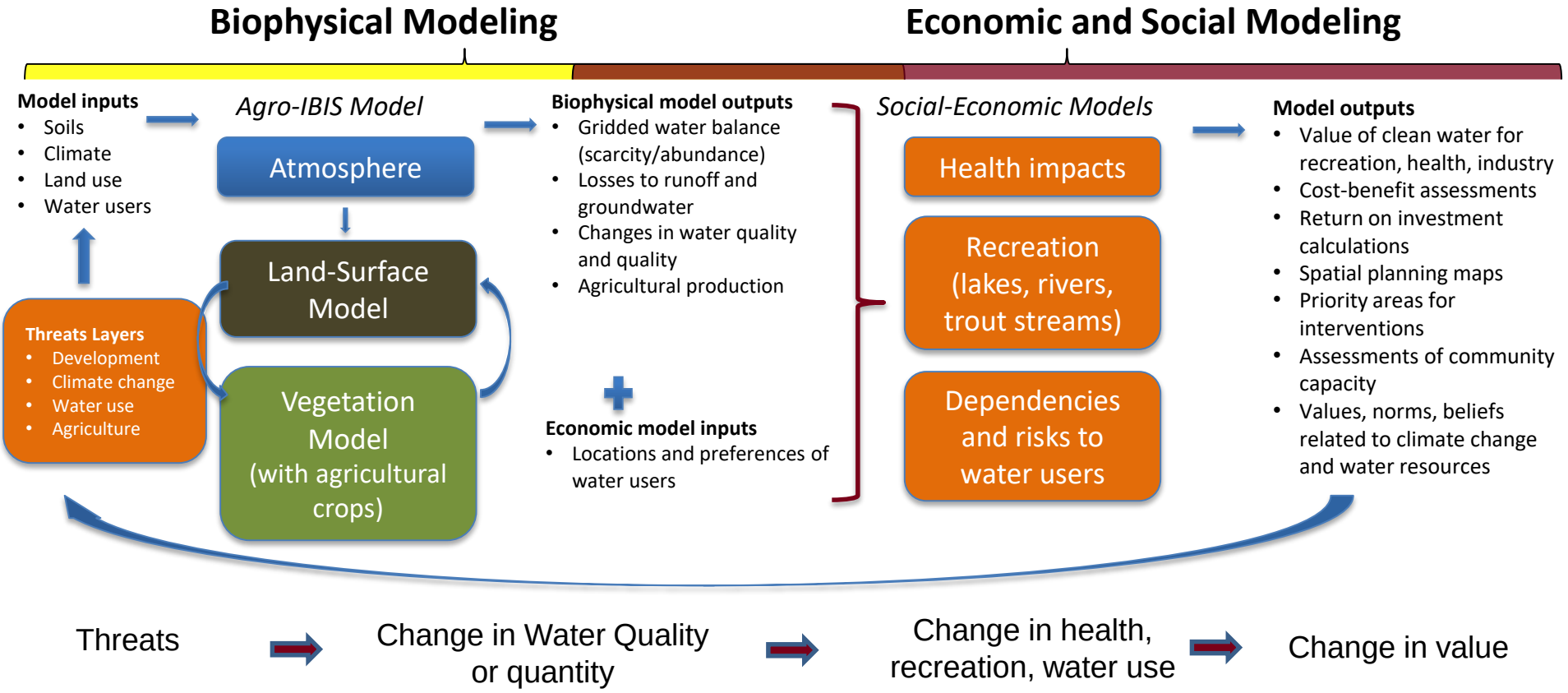
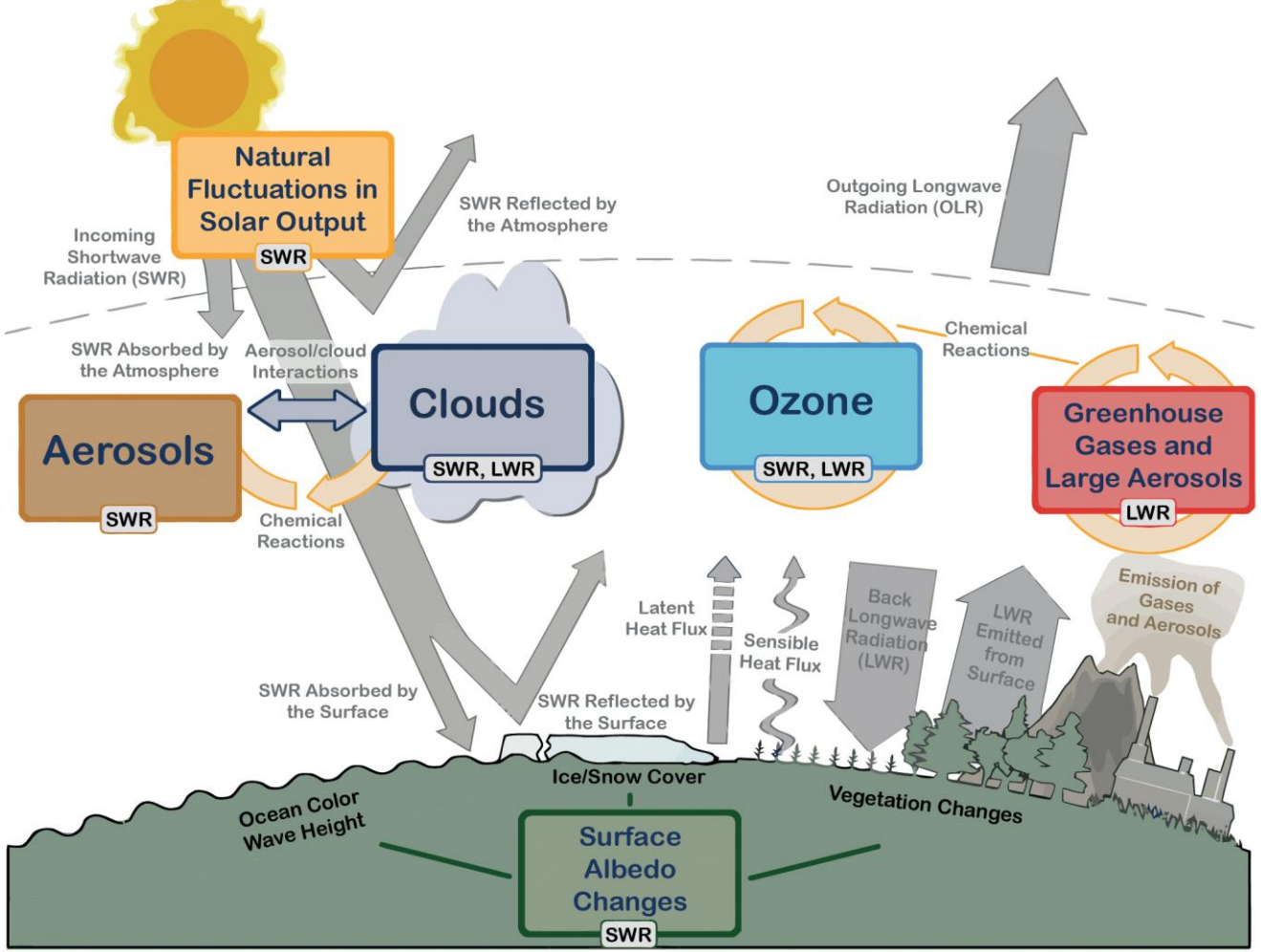



Biophysical Modeling
Economic and Social Modeling
Model inputs
Soils
Climate
Land use
Water users
Agro-IBIS Model
Atmosphere
Land-Surface Model
Vegetation Model (with agricultural crops)
Threats Layers
Development
Climate change
Water use
Agriculture
Biophysical model outputs
Gridded water balance (scarcity/abundance)
Losses to runoff and groundwater
Changes in water quality and quality
Agricultural production
Economic model inputs
Locations and preferences of water users
Social-Economic Models
Health impacts
Recreation (lakes, rivers, trout streams)
Dependencies and risks to water users
Model outputs
Value of clean water for recreation, health, industry
Cost-benefit assessments
Return on investment calculations
Spatial planning maps
Priority areas for interventions
Assessments of community capacity
Values, norms, beliefs related to climate change and water resources
Threats
Change in Water Quality or quantity
Change in health, recreation, water use
Change in value

Roadmap

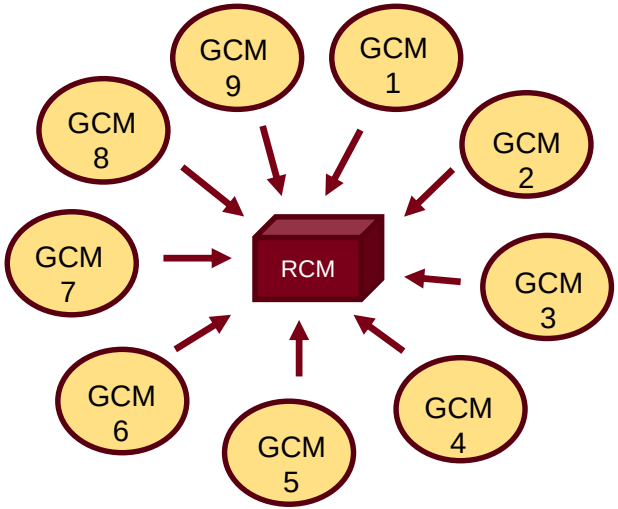
- Climate modeling and downscaling 101
- Climate projections for Minnesota
- Water-related ecosystem services

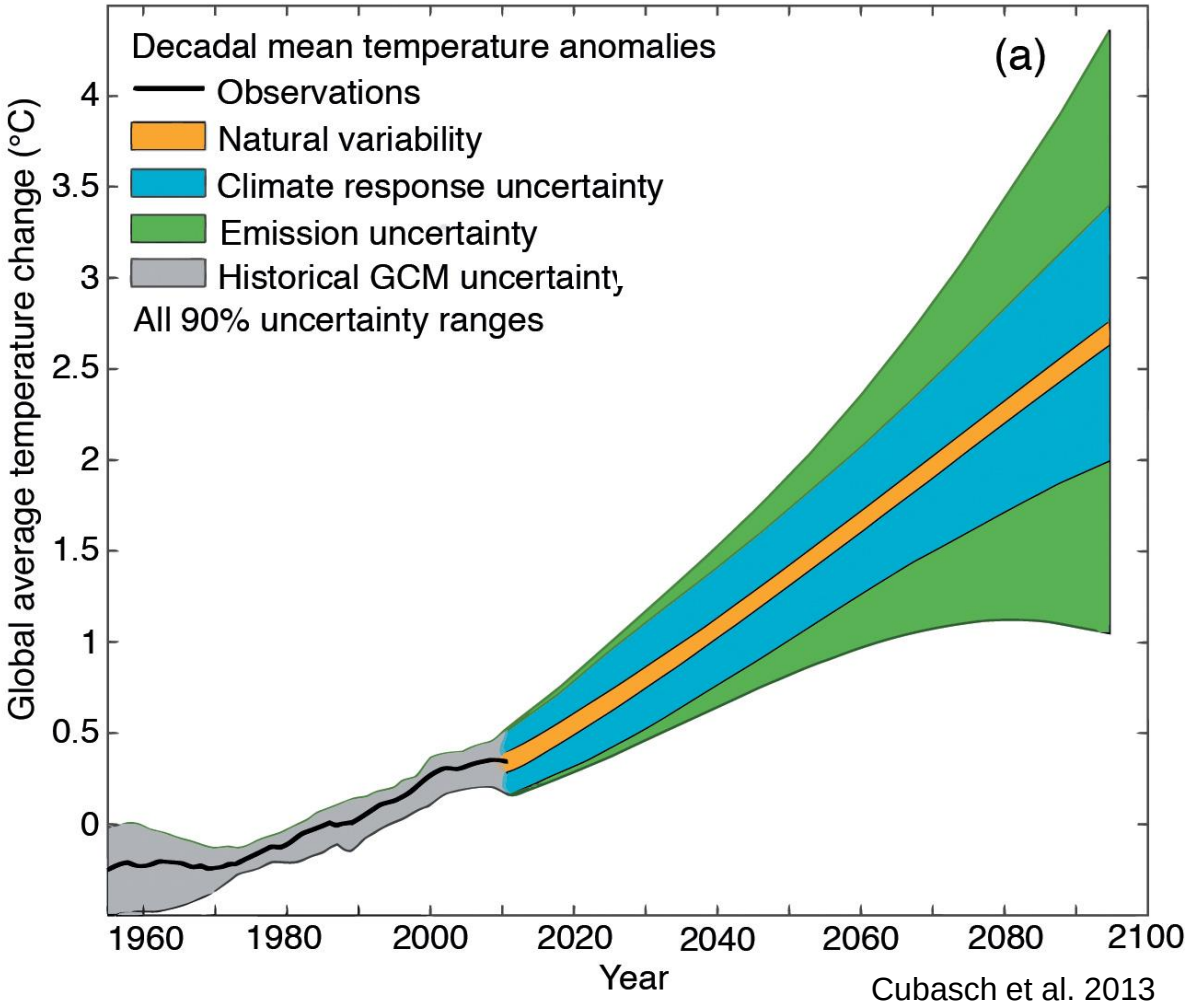
What is a climate model?



Cubasch et al. 2013

Models come with uncertainties

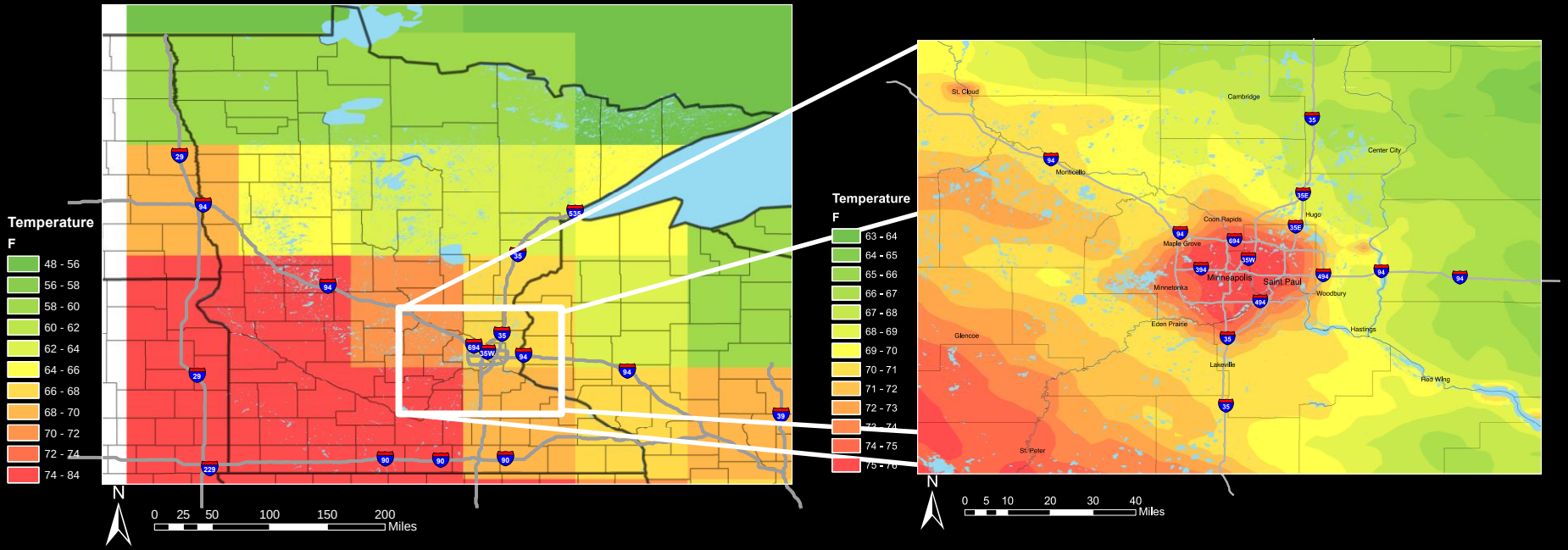




Cubasch et al. 2013

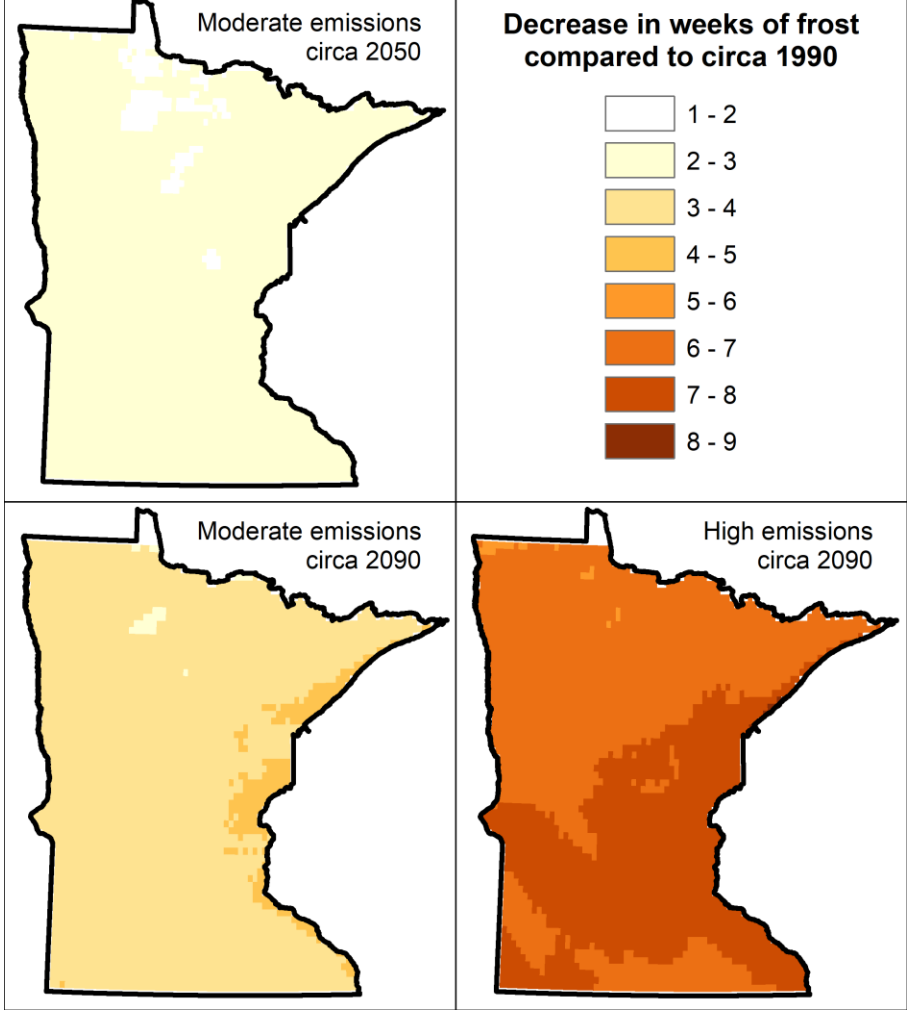
Advantages of downscaled, regional models

July 1, 1995

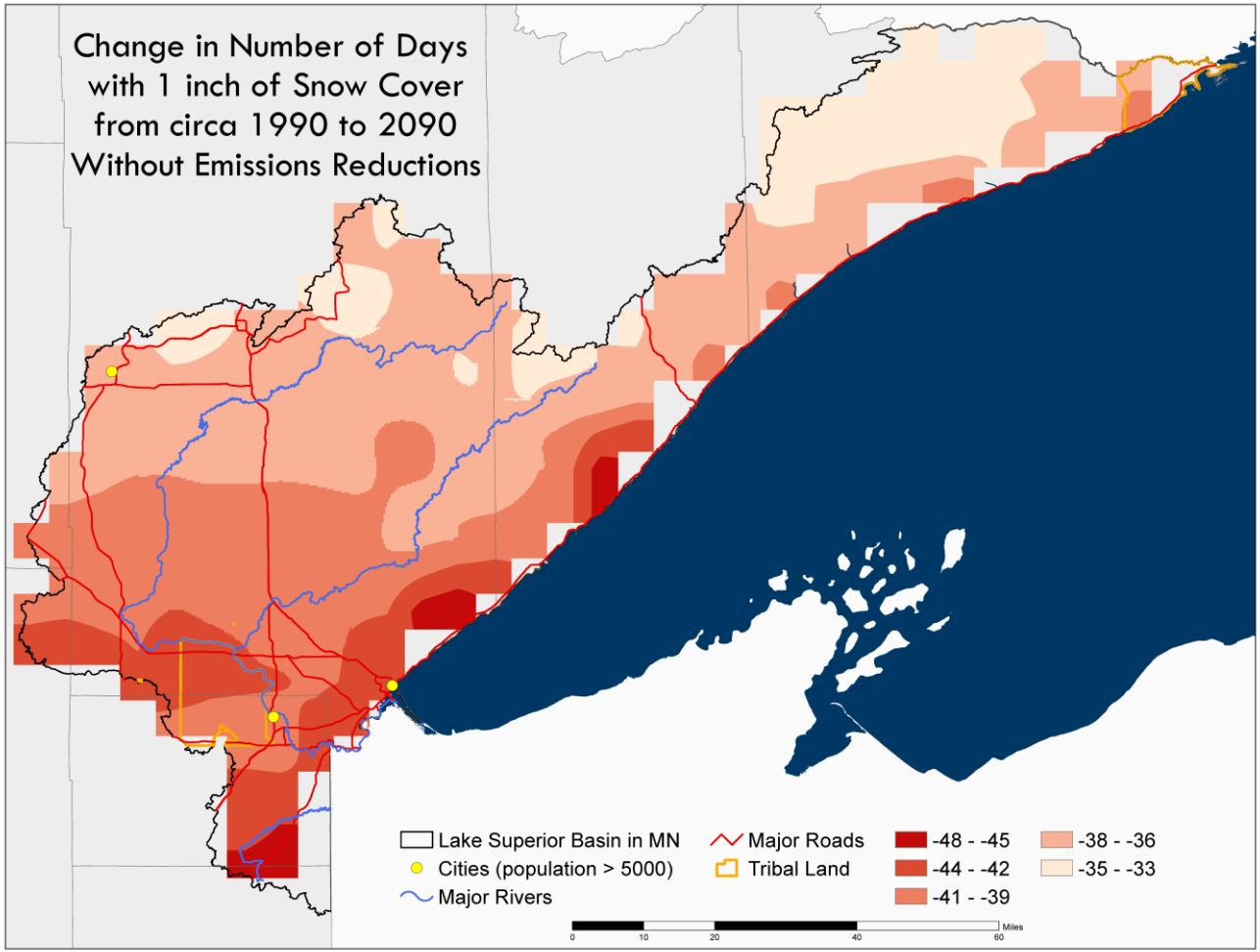


P. Snyder

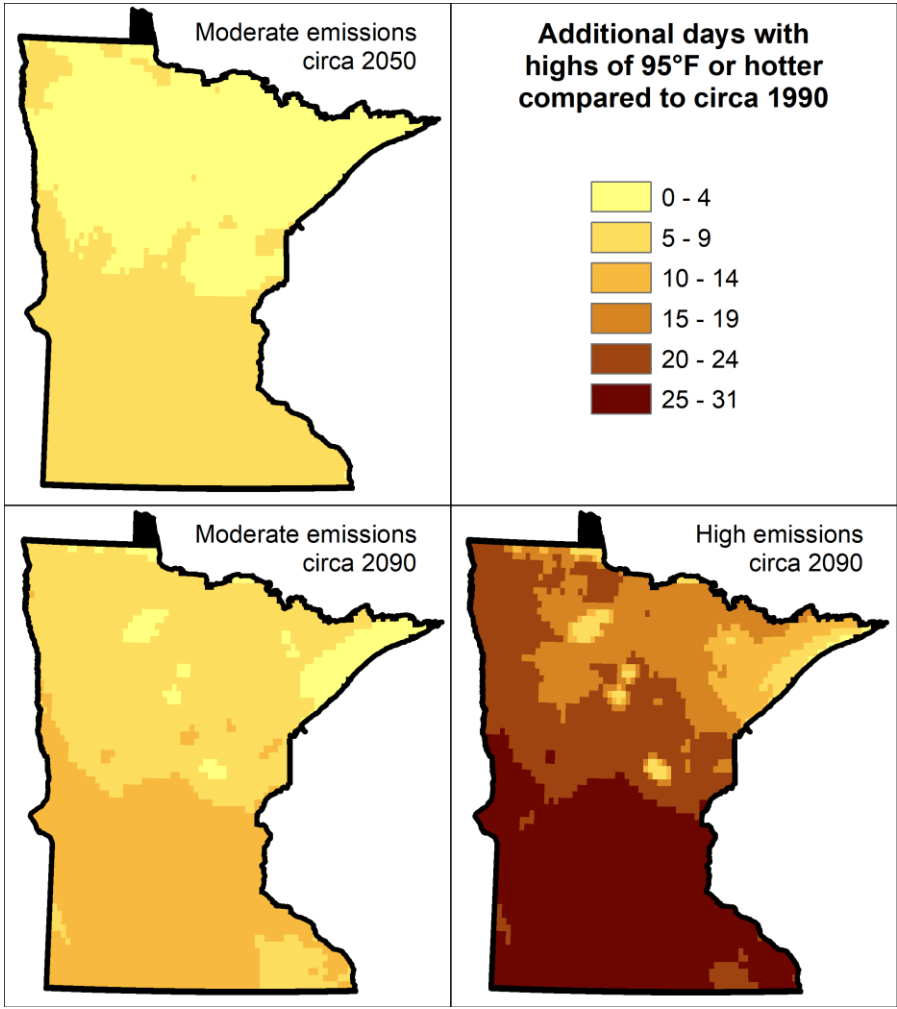
Finding: Warmer winter temperatures and fewer weeks of frost



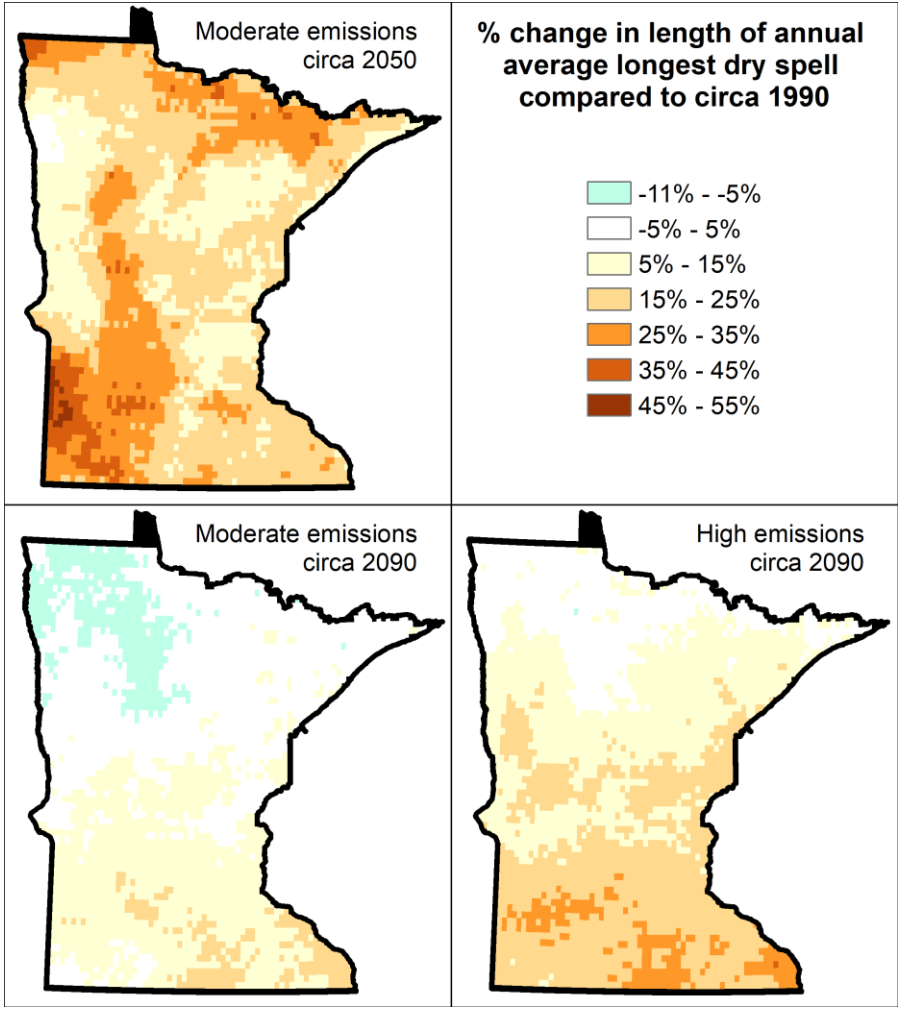
Finding: Reduction in the duration of snow cover



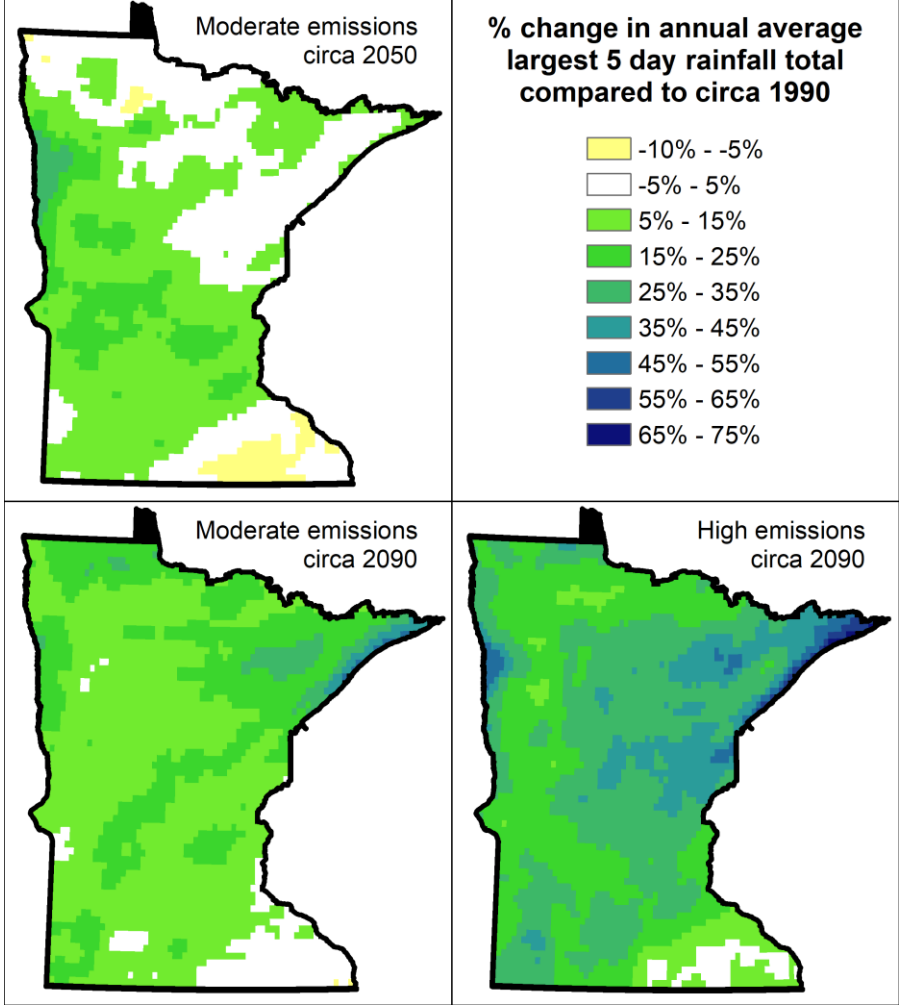
Finding: More frequent hot days



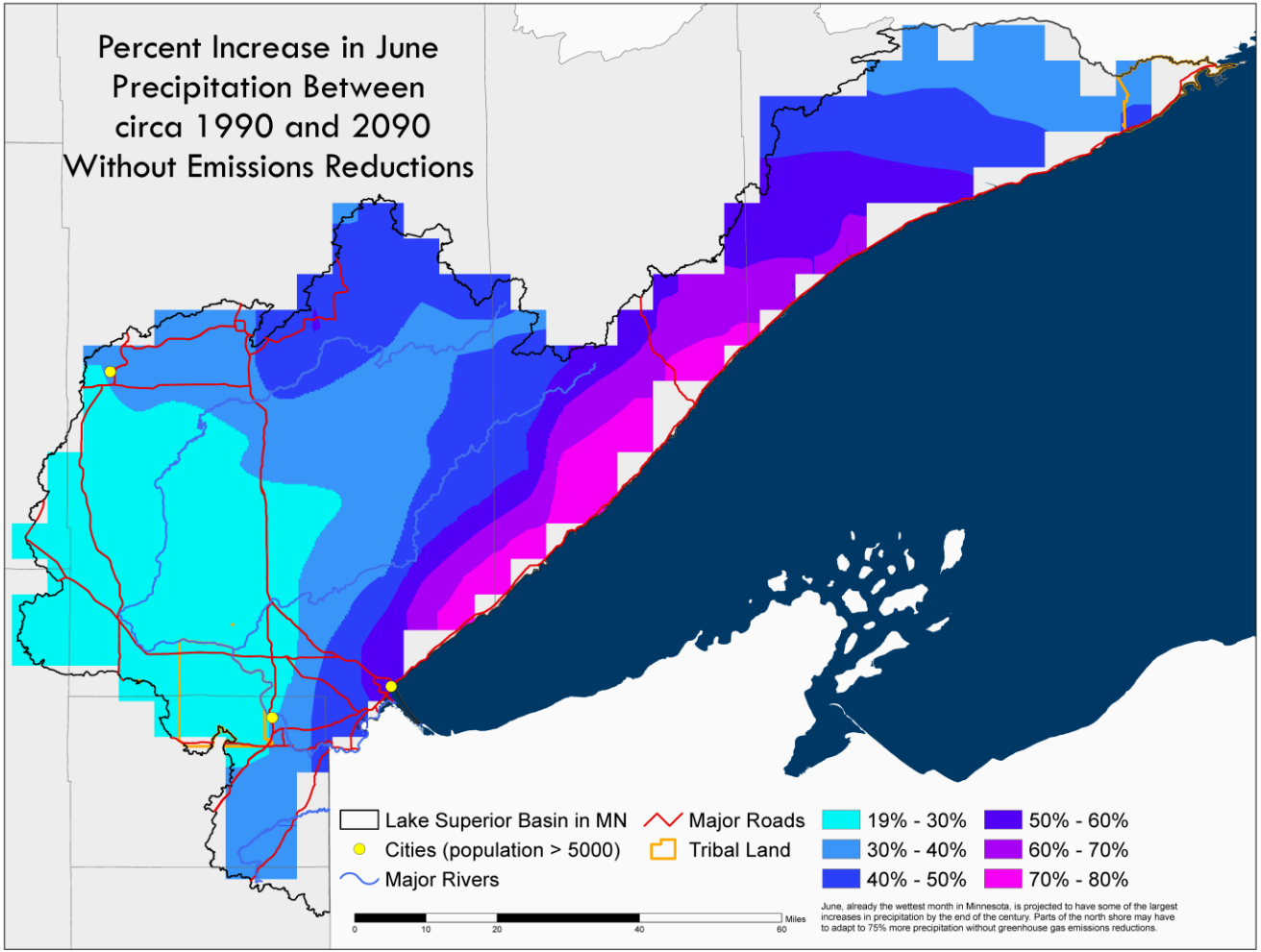
Finding: Longer gaps between rain events



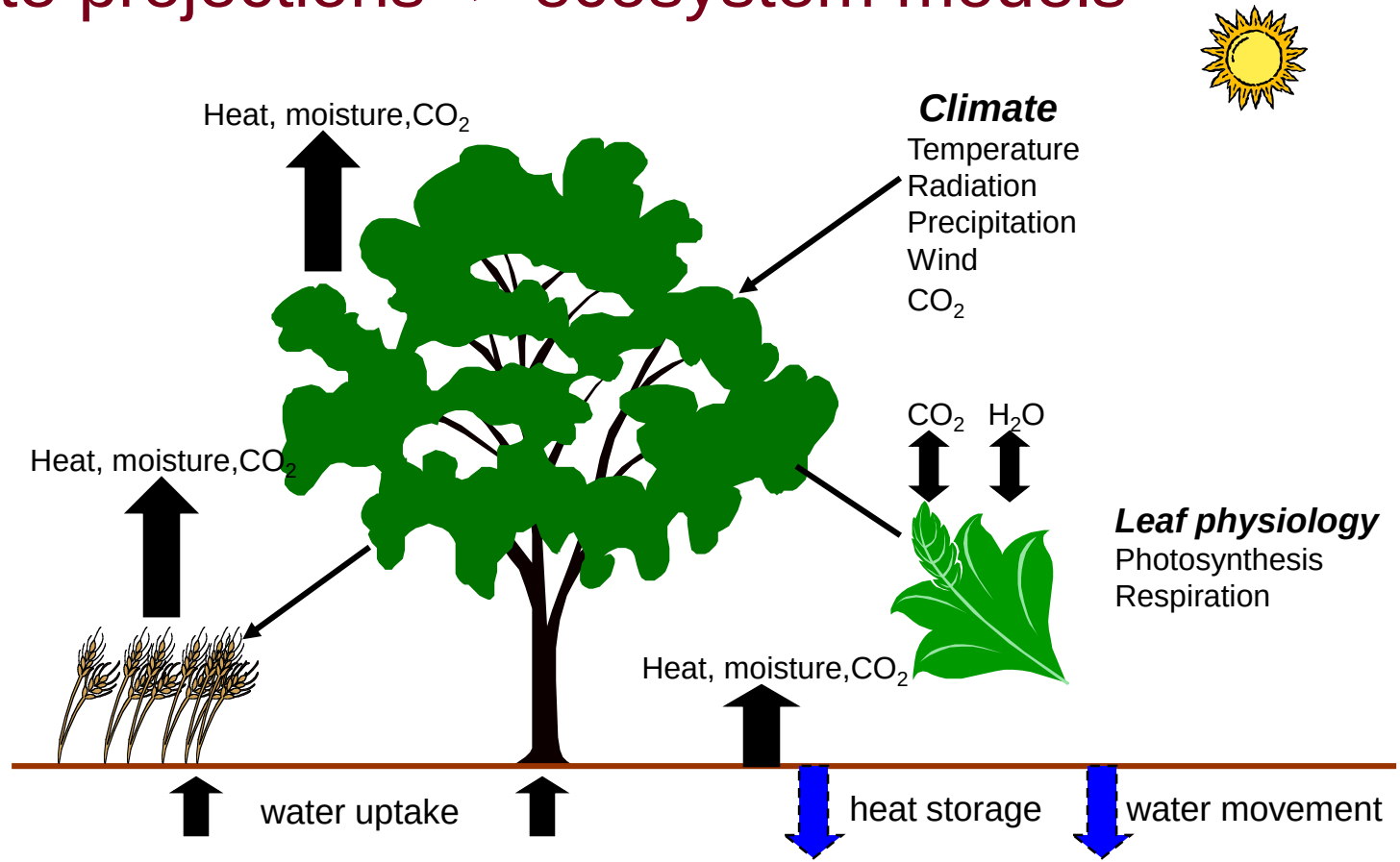
Finding: Rainy periods will be wetter



Finding: Potential for up to 80% more rain in June

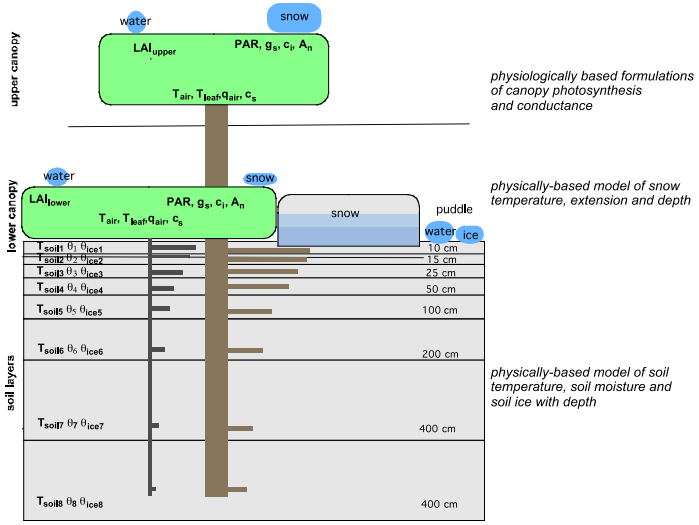


Climate projections -> ecosystem models



***Soil Physical Processes**: temperature, moisture, ice (function of depth)*

Model grid cell



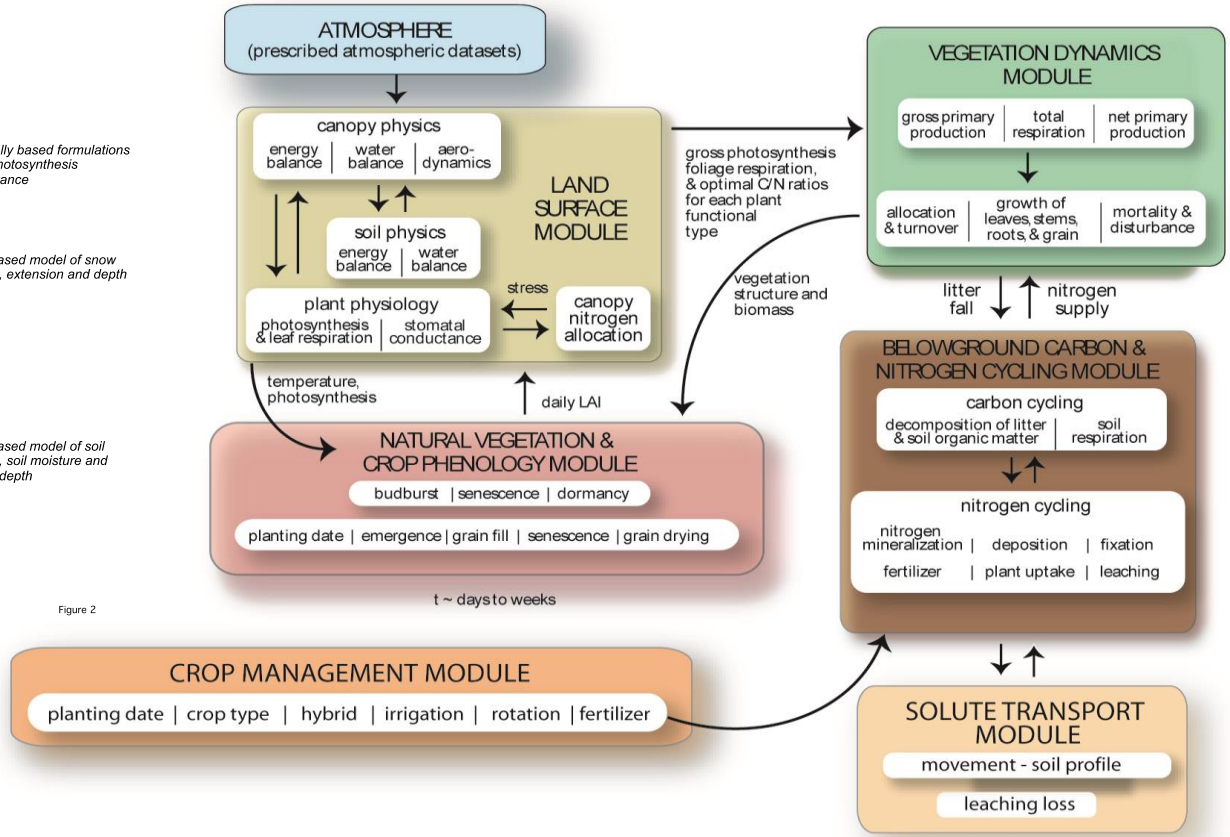
physiologically based formulations of canopy photosynthesis and conductance

physically-based model of snow temperature, extension and depth

physically-based model of soil temperature, soil moisture and soil ice with depth

Figure 2

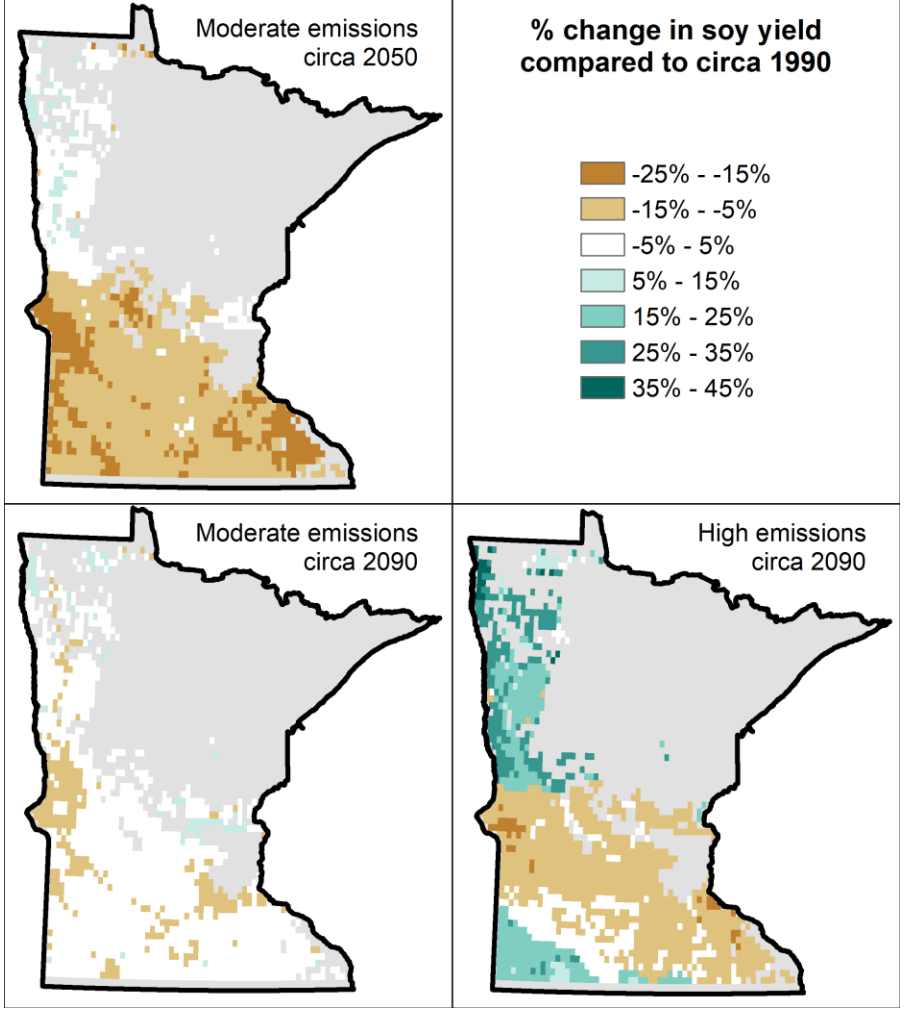
Agro-IBIS Structure



Kucharik 2003

Finding: Changes in crop yields

- Wetter springs can delay planting
- Variable yield impacts
- Yield variability will increase with extreme events and encourage adoption of irrigation



PART II: Ecosystem Services

Biophysical Modeling

Economic and Social Modeling

Model inputs
- Soils
- Climate
- Land use
- Water users

Agro-IBIS Model

Atmosphere

Land-Surface Model

Vegetation Model (with agricultural crops)

Threats Layers
- Development
- Climate change
- Water use
- Agriculture

Threats

Change in W
or qu

Climate x Water interactions

Ecosystem Service	Climate driver	Indicators	Uncertainties/Drivers
Stormwater and wastewater infrastructure	Frequency and intensity of precipitation events	Sewage and wastewater overflows, infrastructure damage	Infrastructure design and maintenance, land use
Trail and recreational infrastructure	Shifts in shoulder season climate, frequency and intensity of precipitation events	Trail damage	Infrastructure design and maintenance, land use, user preferences and behavior
Water-based recreation in inland lakes – swimming, boating, fishing*	Warming water temperatures, increased frequency/intensity of precip events	Changes in lake clarity, composition of fish species, algal blooms, pests and parasites, changing forest composition.	Interactions with land use and increased nutrient loading, invasive species
Municipal and household water supply	Changes in precipitation regimes	Groundwater availability, surface water quality at intake	Land use, invasives, population growth, technology

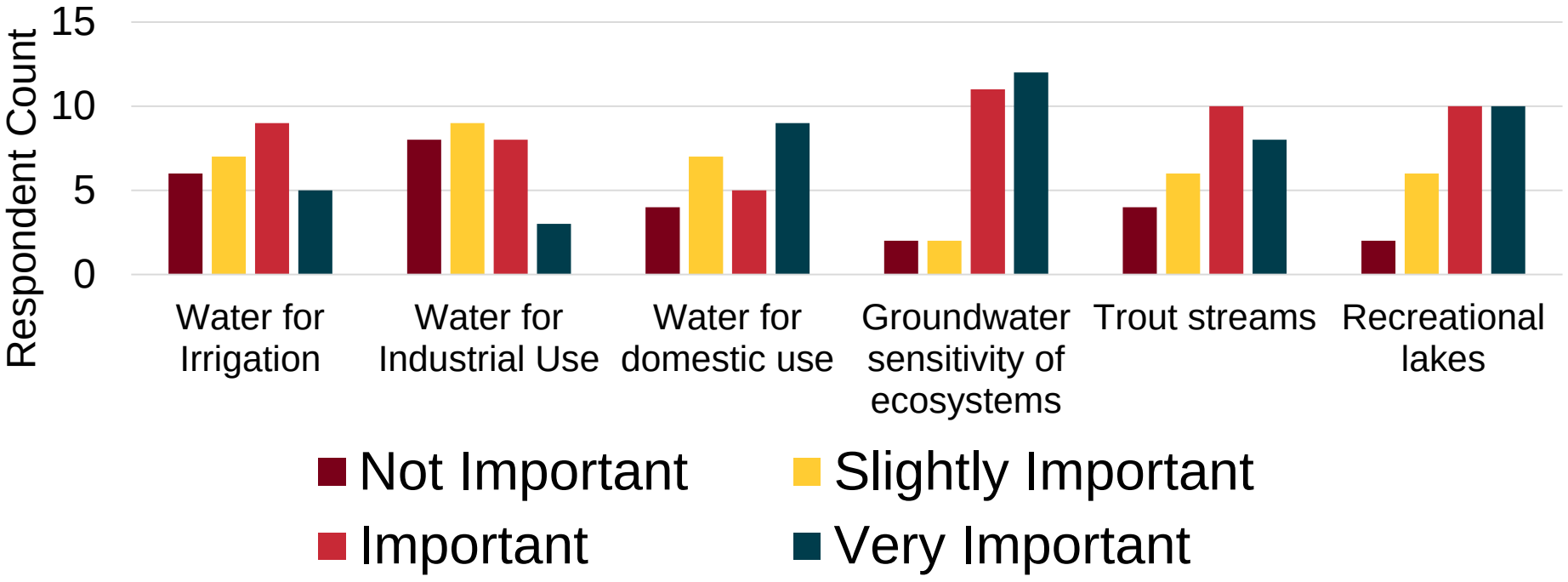
Climate x Water interactions

Ecosystem Service	Climate driver	Indicators	Uncertainties/Drivers
Trout angling	Temperature and precip	Late season baseflow, stream temperature	Land use – water temps, sediment, invasives, fishing pressure
Waterfowl and wildlife viewing	Temp & precip	Changes in presence, abundance of desired species	Land use, ecological factors
Snow and ice-based winter recreation	Warmer winter temps, frequency and intensity of winter storm events	Changes in duration and amount of snow cover, ice in/out dates, ice thickness	Social preferences, trail infrastructure, access

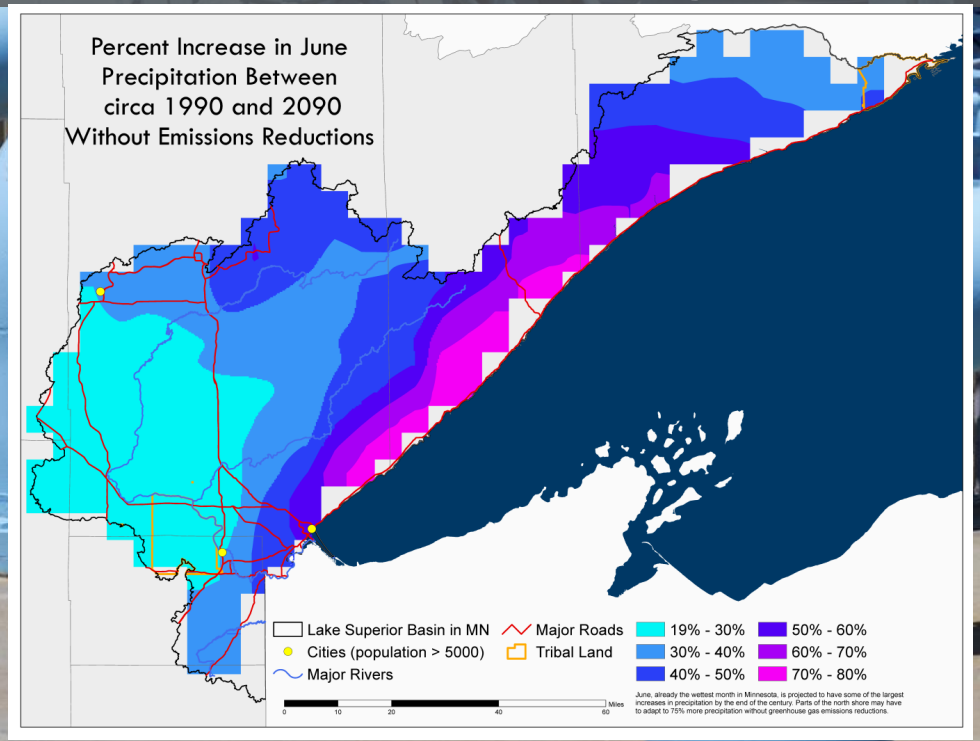
Describe how projections of future trends in temperature, precipitation, and water availability currently affects decisions you contribute to as a resource manager or planner.

- “prioritize infrastructure projects that increase community resilience”
- “understanding how restoration activities can be prioritized to improve populations of various grassland wildlife and game species.”
- “Projections of precipitation trends is assisting with emergency flood planning at our wastewater plant”
- “planning watershed restoration and protection strategies, identifying effective BMP's for restoration or protection”
- “developing a methodology for incorporating climate change considerations into asset management of bridges and culverts”
- “Better understanding the potential health impacts from more extreme weather events.”
- “Tree species selection and recommendation for community forests”

In your professional work, how important are the following impacts of climate change and water availability?



MN needs $11B in WATER INFRASTRUCTURE INVESTMENTS over the next 20 years

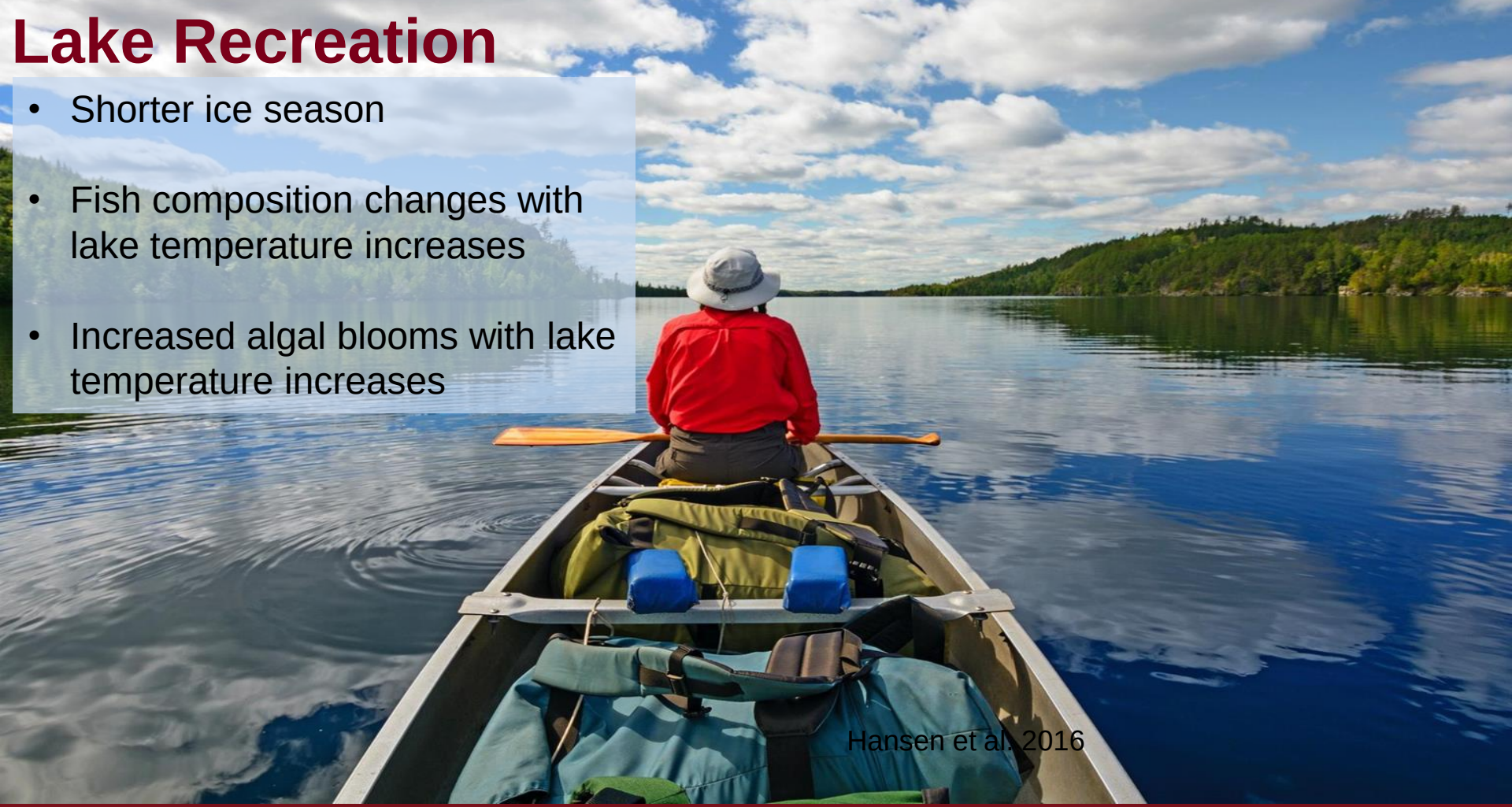


Lake recreation

Hansen et al. 2016

Lake Recreation

- Shorter ice season
- Fish composition changes with lake temperature increases
- Increased algal blooms with lake temperature increases

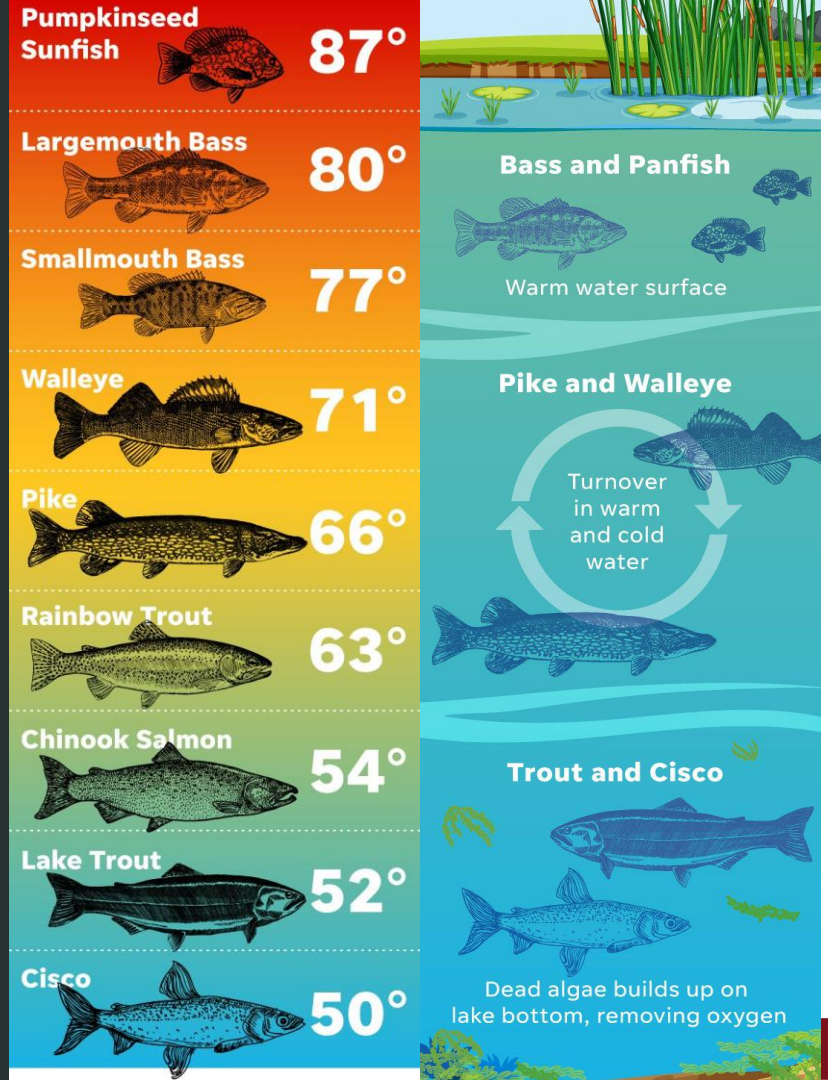


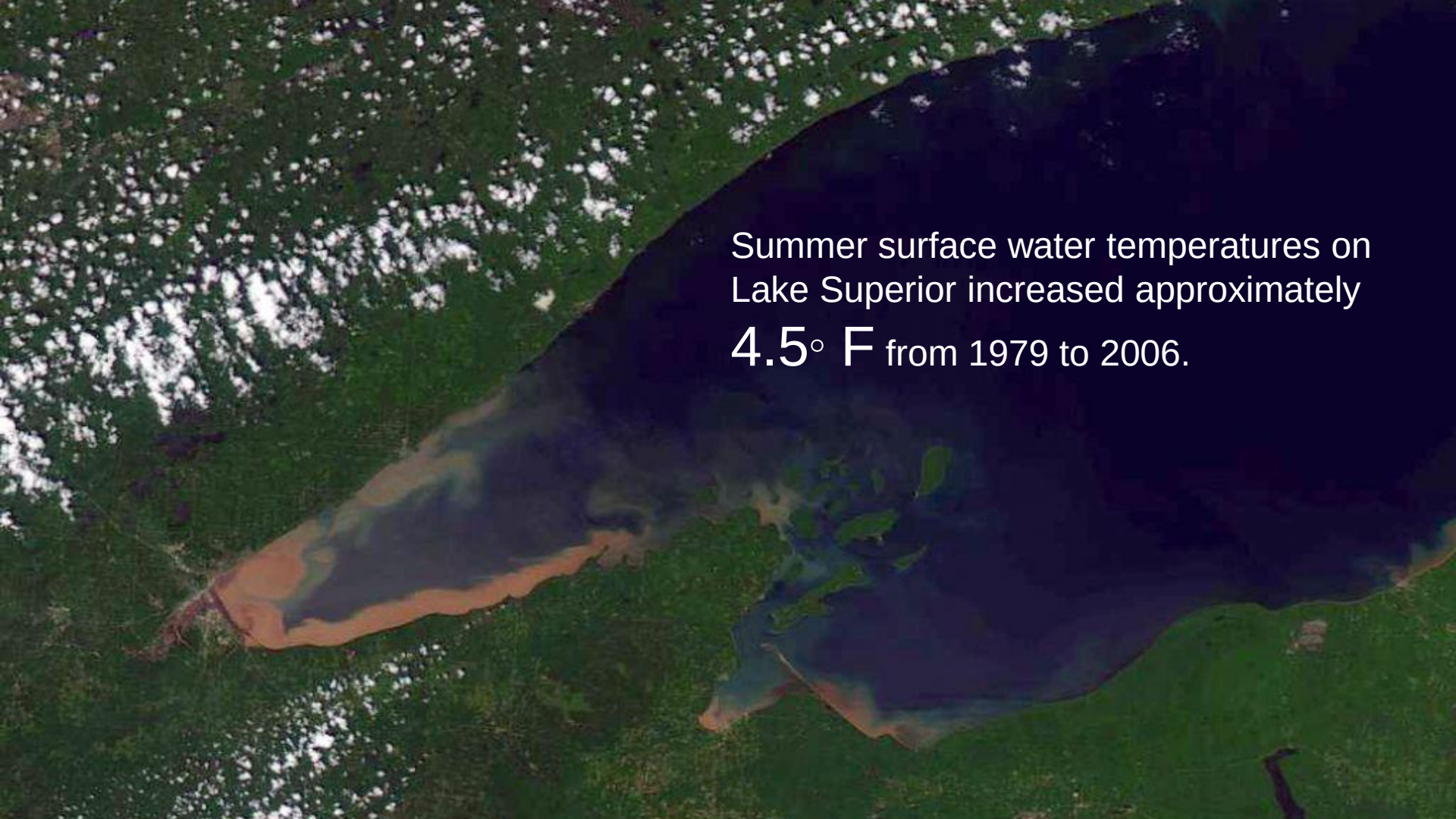
Hansen et al. 2016

“

If you like bass, things are looking good. But if you like walleye or cisco, things aren't looking as good.

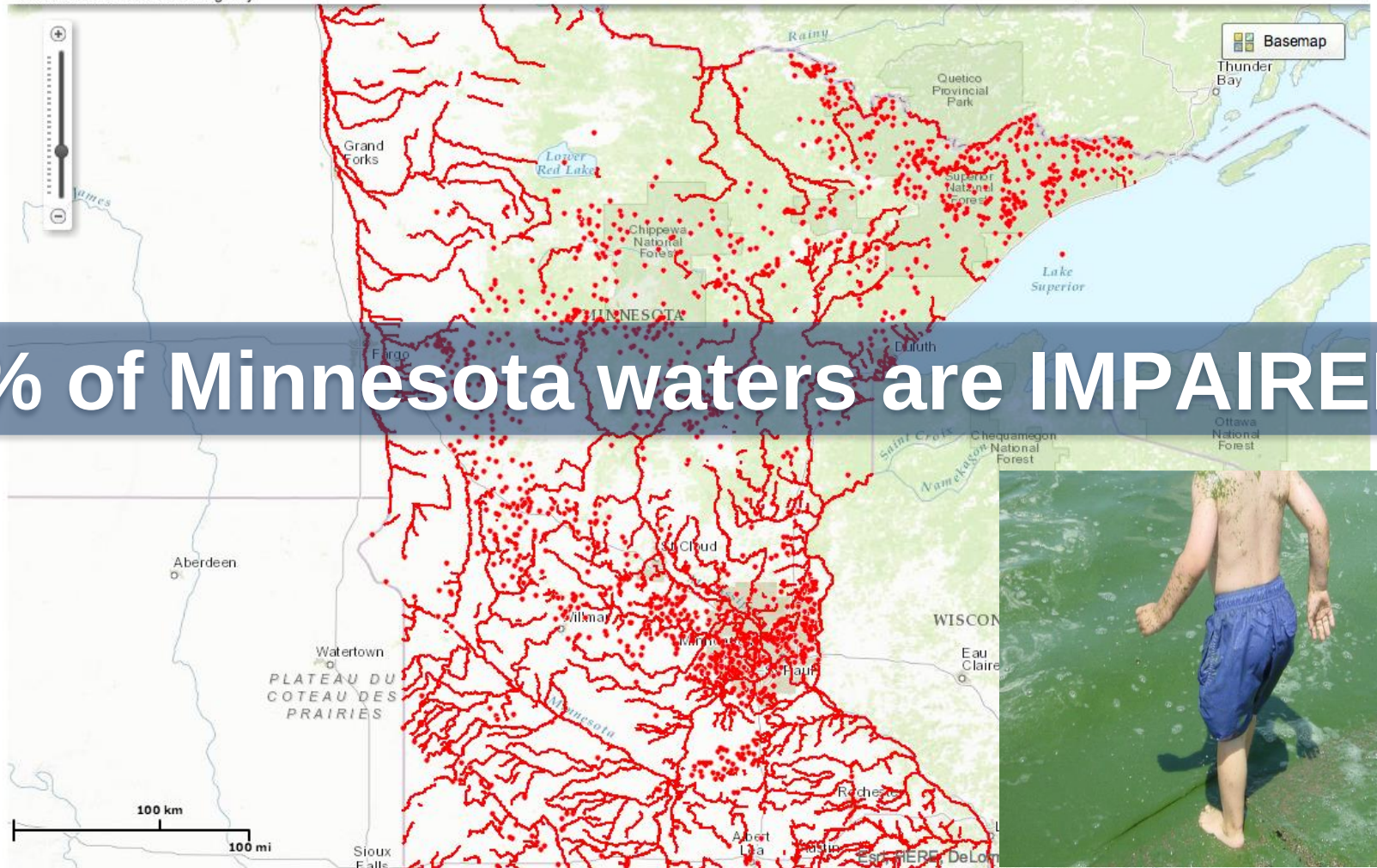
Gretchen Hansen, an assistant professor at the University of Minnesota's Department of Fisheries, Wildlife and Conservation Biology

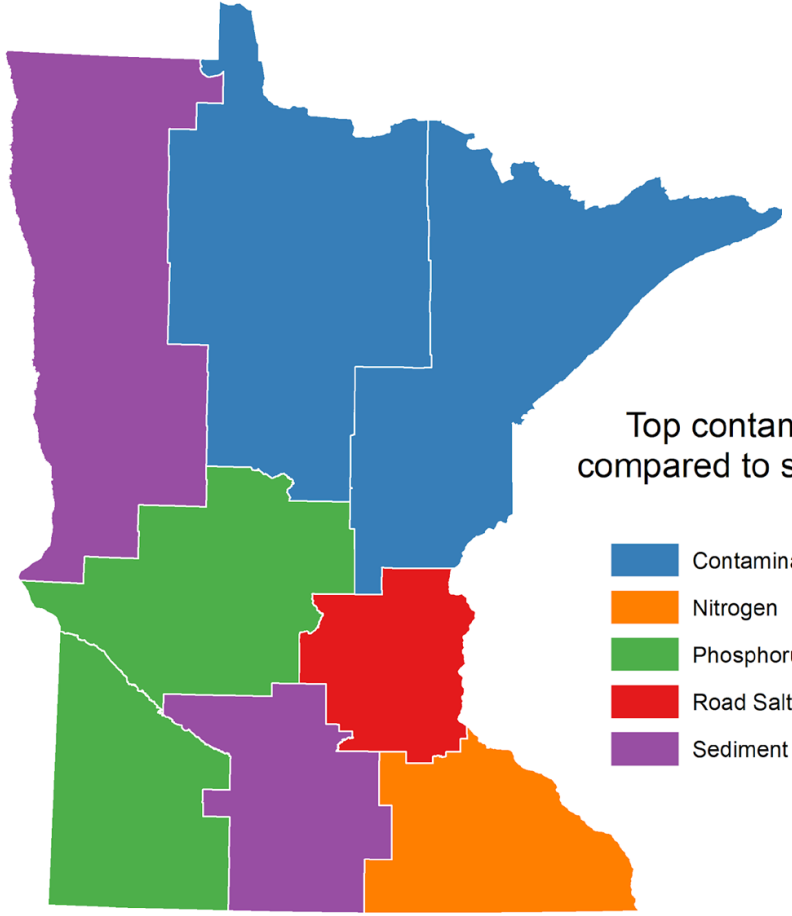



Summer surface water temperatures on Lake Superior increased approximately
4.5° F from 1979 to 2006.

What about water quality?

Hansen et al. 2016


Surface water data access
Minnesota Pollution Control Agency
Enter Minnesota city or address
Basemap
Rainy
Quetico Provincial Park
Thunder Bay
Grand Forks
Lower Red Lake
Superior National Forest
Chippewa National Forest
Lake Superior
MINNESOTA
Fargo
Duluth
Chequamegon National Forest
Ottawa National Forest
Aberdeen
St Cloud
Wilmar
Watertown
PLATEAU DU COTEAU DES PRAIRIES
Eau Claire
WISCON
Minnesota
Rochester
Albert Lea
Austin
Sioux Falls
100 km
100 mi
40% of Minnesota waters are IMPAIRED



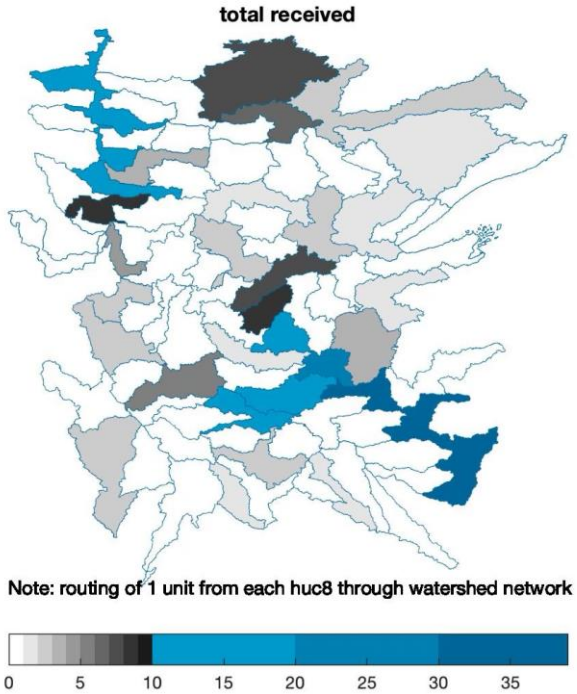
25BY25

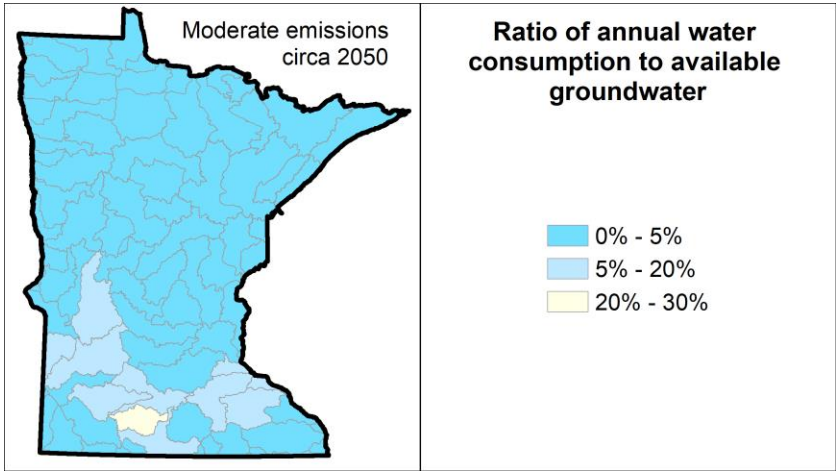
Top contaminant concern
compared to statewide average

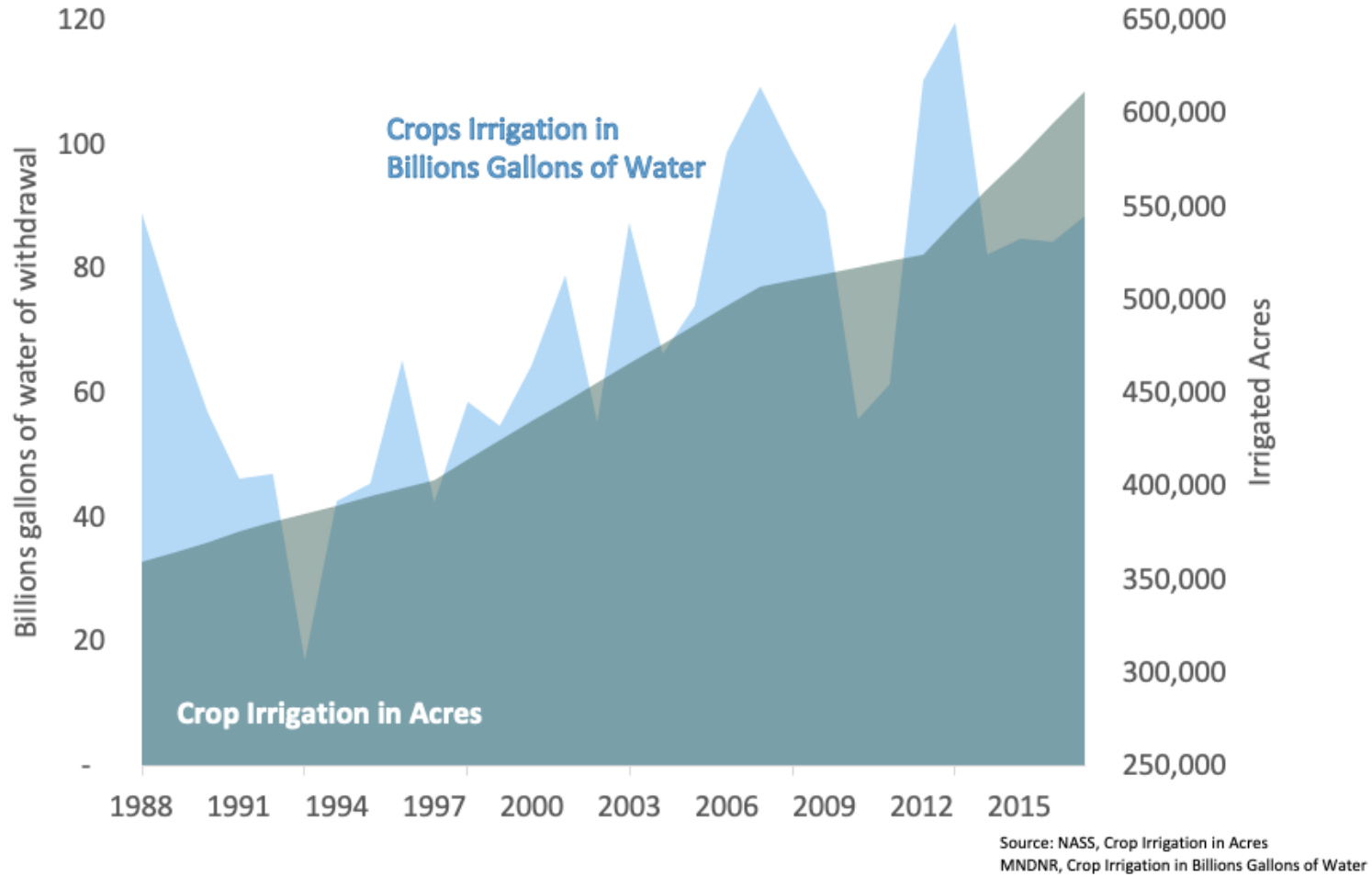
- Contaminants of Emerging Concern
- Nitrogen
- Phosphorus
- Road Salt
- Sediment

BRIAN PETERSON, STAR TRIBUNE

Water scarcity under climate change



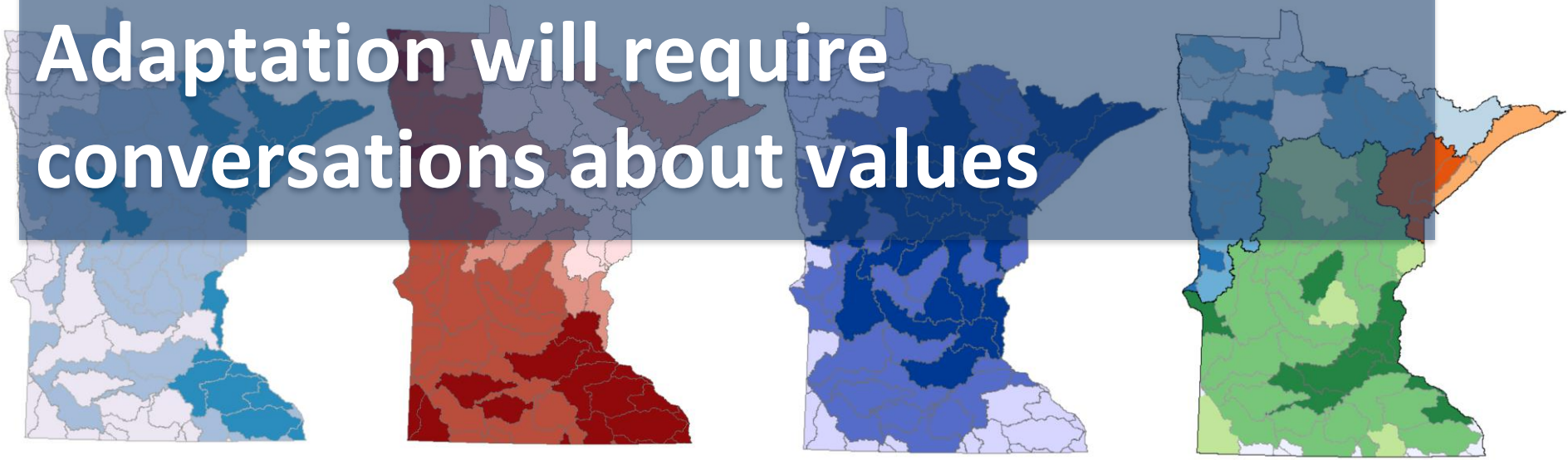




Source: NASS, Crop Irrigation in Acres
MNDNR, Crop Irrigation in Billions Gallons of Water


TEXAS
UTAH
CA
NEW MEXICO
BACK OFF SUCKERS
WATER DIVERSION . . . THE LAST STRAW
VIACOM

Adaptation will require conversations about values



Trout miles and visitation

- Low priority
- Medium priority
- High priority

People reliant on groundwater and contamination susceptibility

- Lowest priority
- Low priority
- Medium priority
- High priority

Lake P sensitivity and visitation

- Low priority
- Medium priority
- High priority

Nutrient Export

Winnipeg basin

- No data
- Low priority
- Medium priority
- High priority

Great Lakes

- Low priority
- High priority

Mississippi basin

- No data
- Low priority
- Medium priority
- High priority

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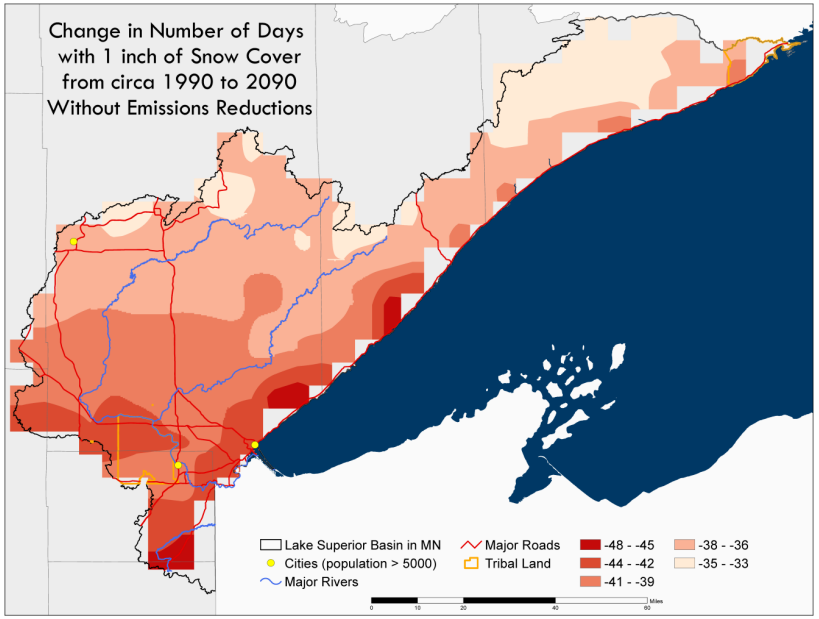
Ryan Noe, **Terin Mayer**, **Maggie Rogers**

Humphrey School of Public Affairs



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