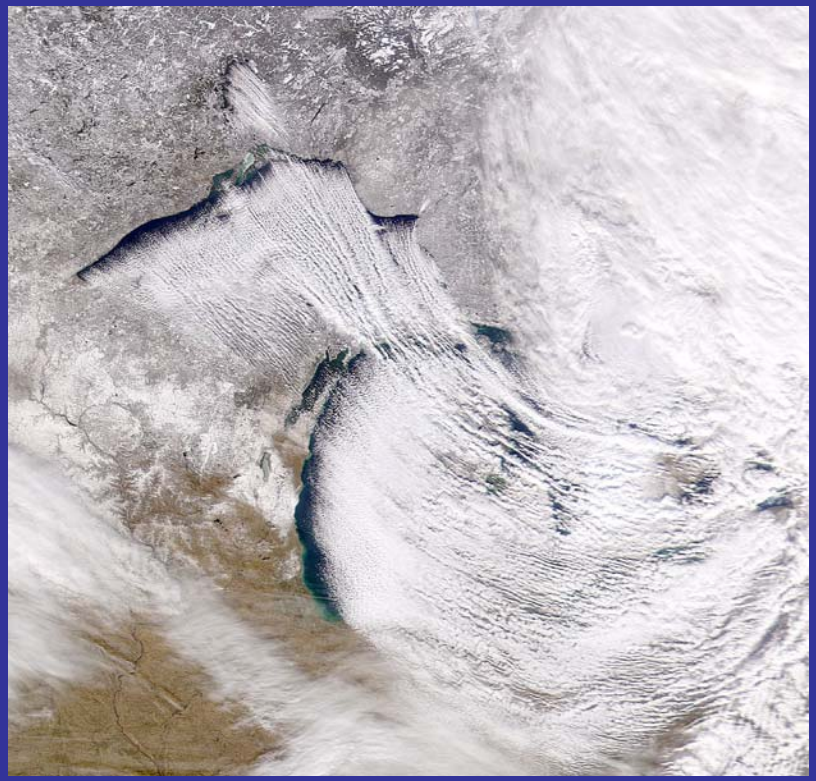
Climate Change, Trout Ecology and the Future of Inland Trout Management in Wisconsin



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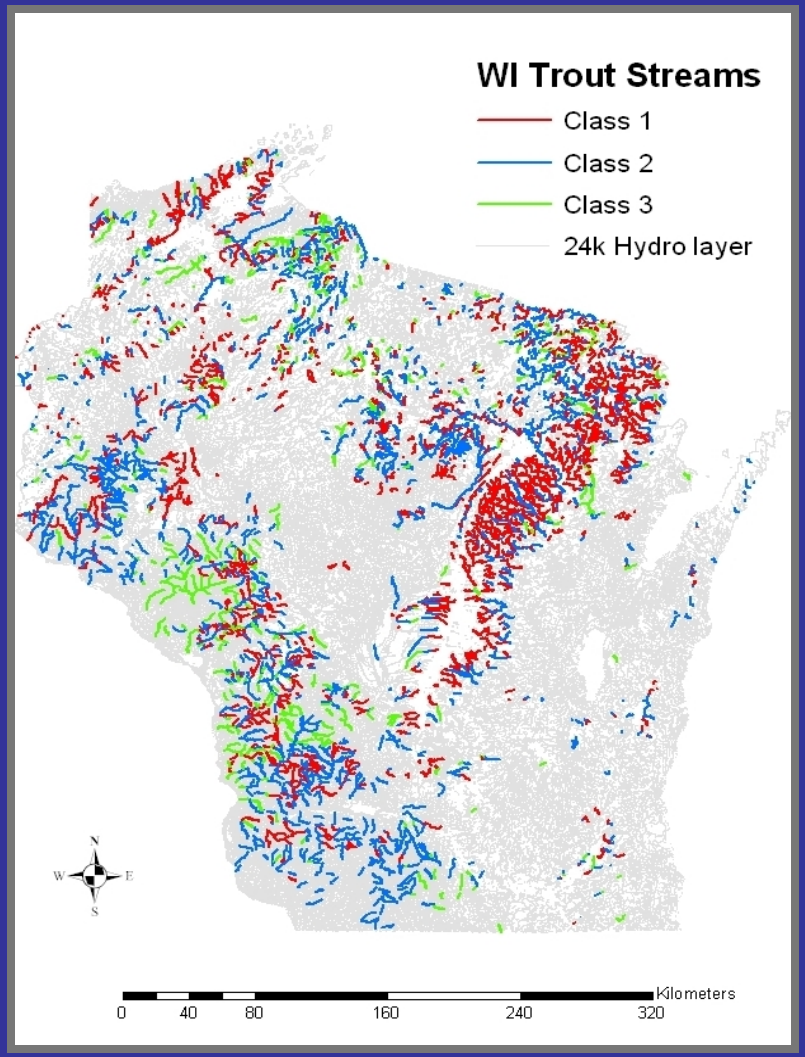
Wisconsin Trout Streams

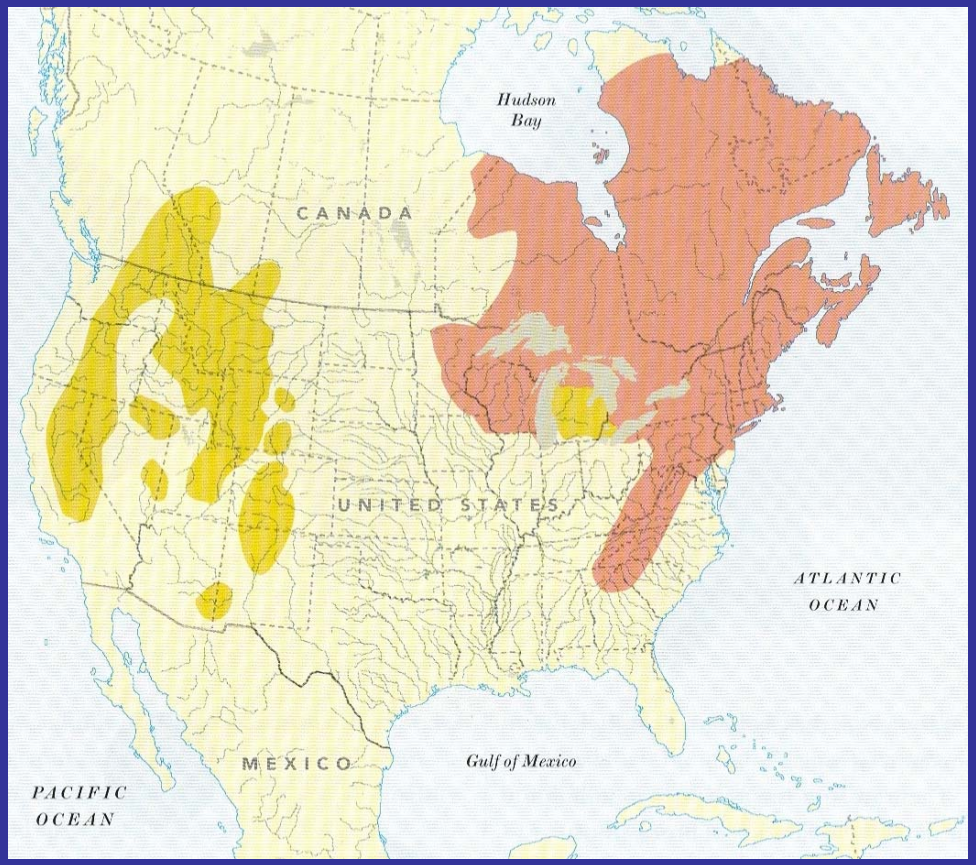


44,000 river miles

10,371 miles of trout streams

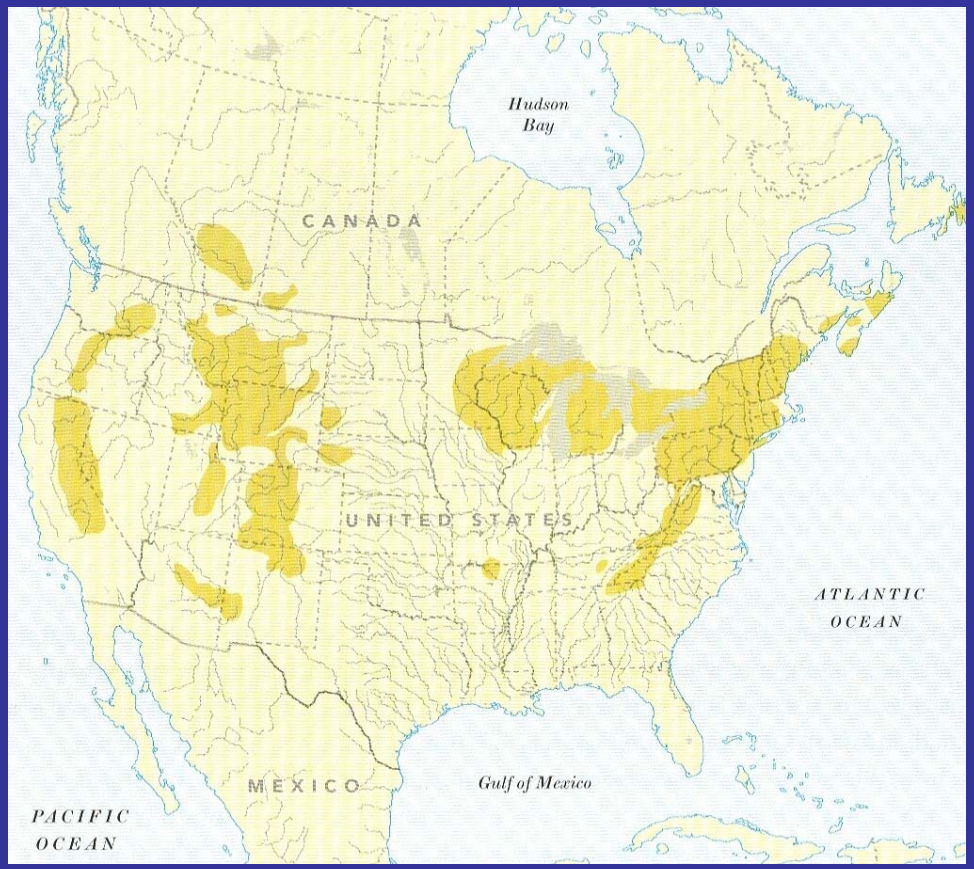
- 4,136 miles Class 1
- 4,644 miles Class 2
- 1,591 miles Class 3

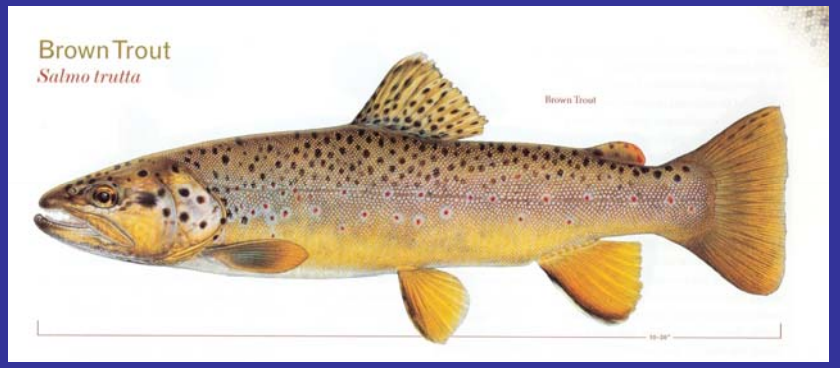
Brook Trout



Behnke, R.J., and J.R. Tomelleri. 2002. Trout and Salmon of North America
The Free Press, New York.

Brown Trout





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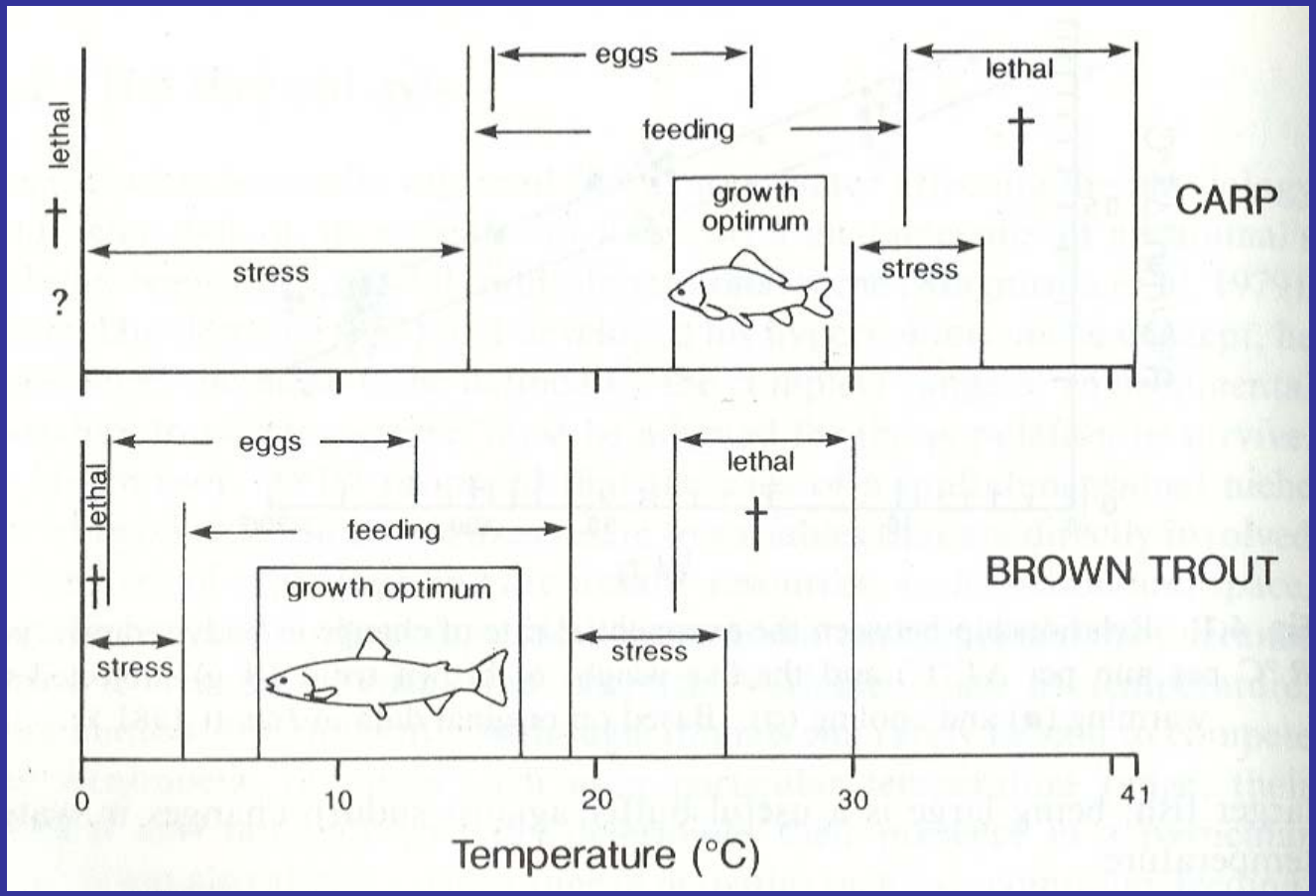
Climate Change and Trout

How do changes in climate effect changes in the stream environment?

How do changes in the stream environment effect changes in trout condition, abundance, and distribution?

Stream Temperature and Trout



Elliott, J. M. 1994. Quantitative Ecology and the Brown Trout. Oxford University Press, New York.

Stream Temperature and Trout

Maximum daily mean water temperature <22°C

Water temperature directly affects trout consumption and metabolism — components of growth

Temperature increases above optimum for growth:

- Reduced maximum consumption rates
- Increased metabolic rates
- Decreased growth

Sublethal stresses may affect probability of survival

Behavioral Adaptations to Temperature

High specific heat of water = slow temperature change

Trout can detect 1°C change in temperature

Trout can move to more favorable conditions if available

Trout can modify behavior to achieve target growth rate

Changes in behavior can effect changes in population

Population-Level Effects of Temperature

"Mechanisms for climate-induced mortality of fish populations in whole-lake experiments"
2007 PNAS
P.A. Biro, J. R. Post, and D. J. Booth

- Increased metabolism at higher temperatures resulted in increased consumption to compensate and maintain growth rates

- Greater feeding activity rates resulted in greater vulnerability to predators that reduced survival by 50%

Population-Level Effects of Temperature

McCaslin Brook, WI

N B Oconto River, WI

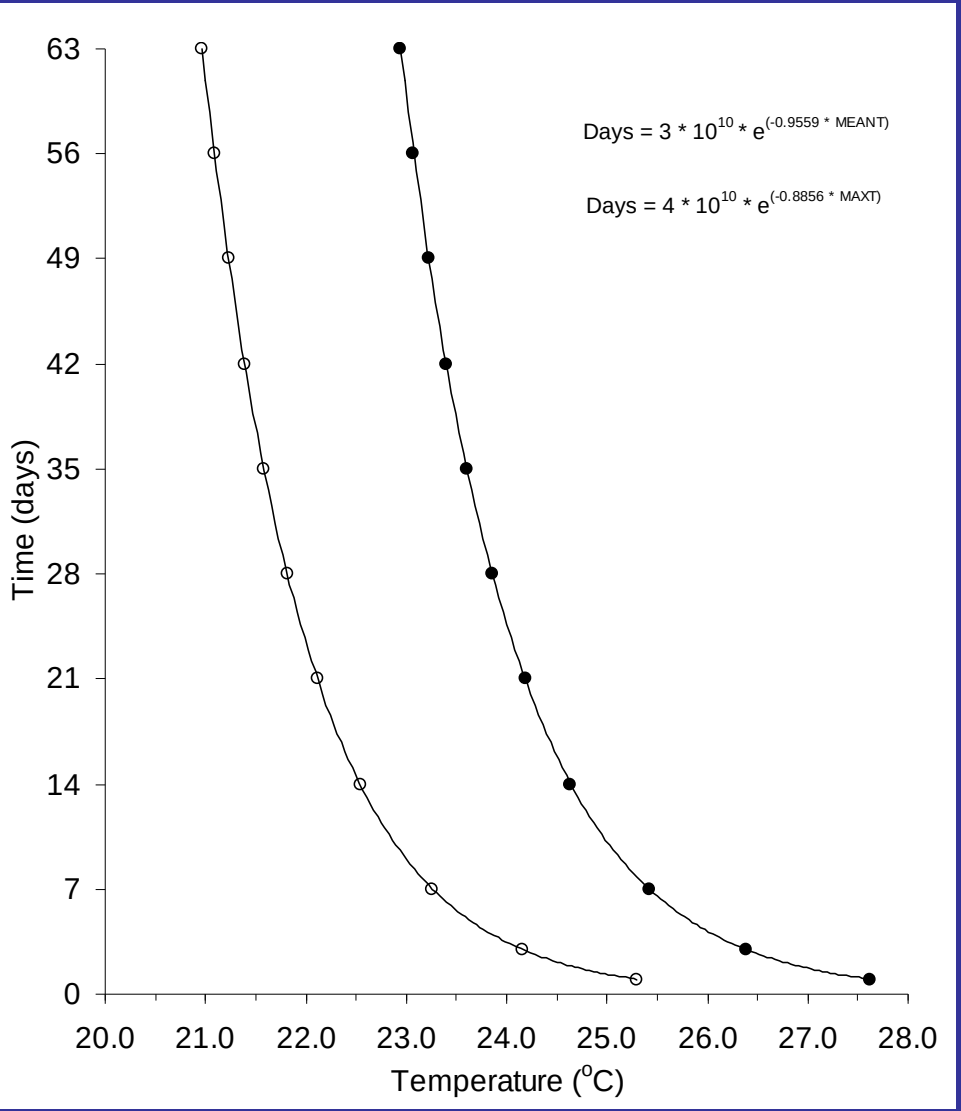
Wild brook trout (25%)
Stocked brown trout (75%)

In 1999, summer daily maximum temperature >26°C

Brown trout population declined but brook trout persisted

Brook trout may have exploited temperature refugia

Thermal Tolerance Limits for Trout



Chronic temperature effects play an important role in limiting trout distributions

No significant difference in relation between temperature and length of exposure time for brook and brown trout

Curves represent upper thermal limits at which trout can persist for various periods of time

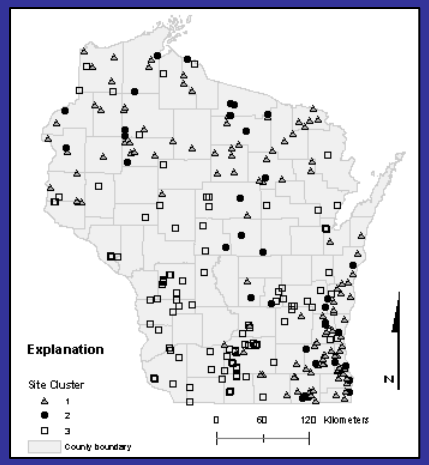
Modeling Water Temperature and Trout Distribution in Wisconsin Streams

Landscape Data

- Area
- Bedrock depth
- Bedrock type
- Groundwater input
- Land cover
- Soils
- Stream network
- Surficial deposit

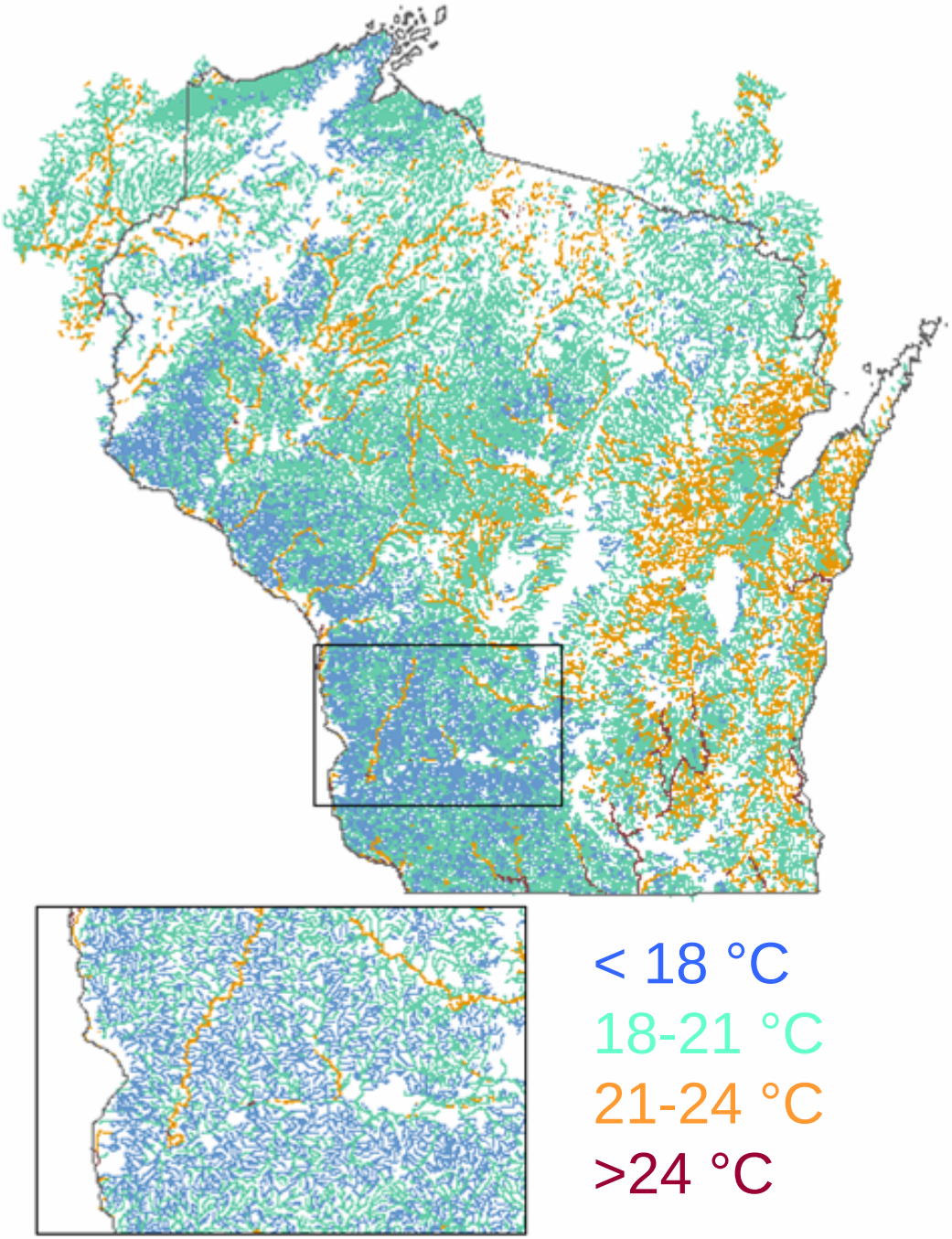
Climate Data

- Air temperature
- Air pressure
- Dew point temperature
- Precipitation
- Solar radiation



Stream Temperature

Fish community

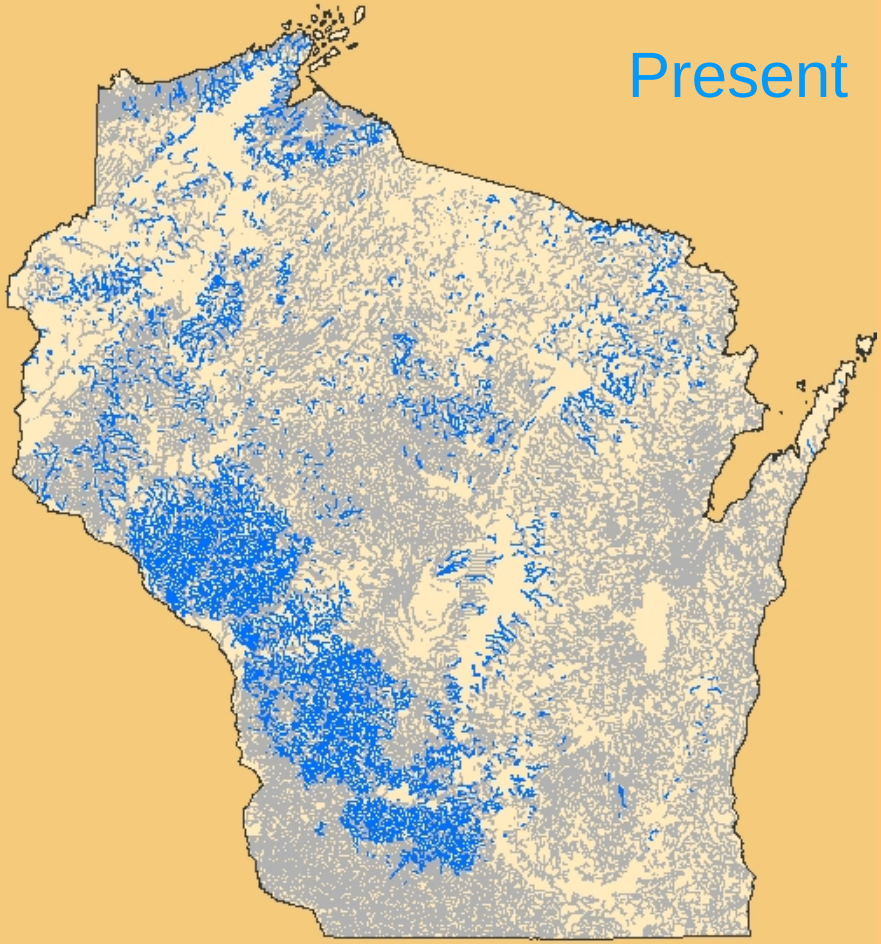


July

Mean Stream Temperature Categories

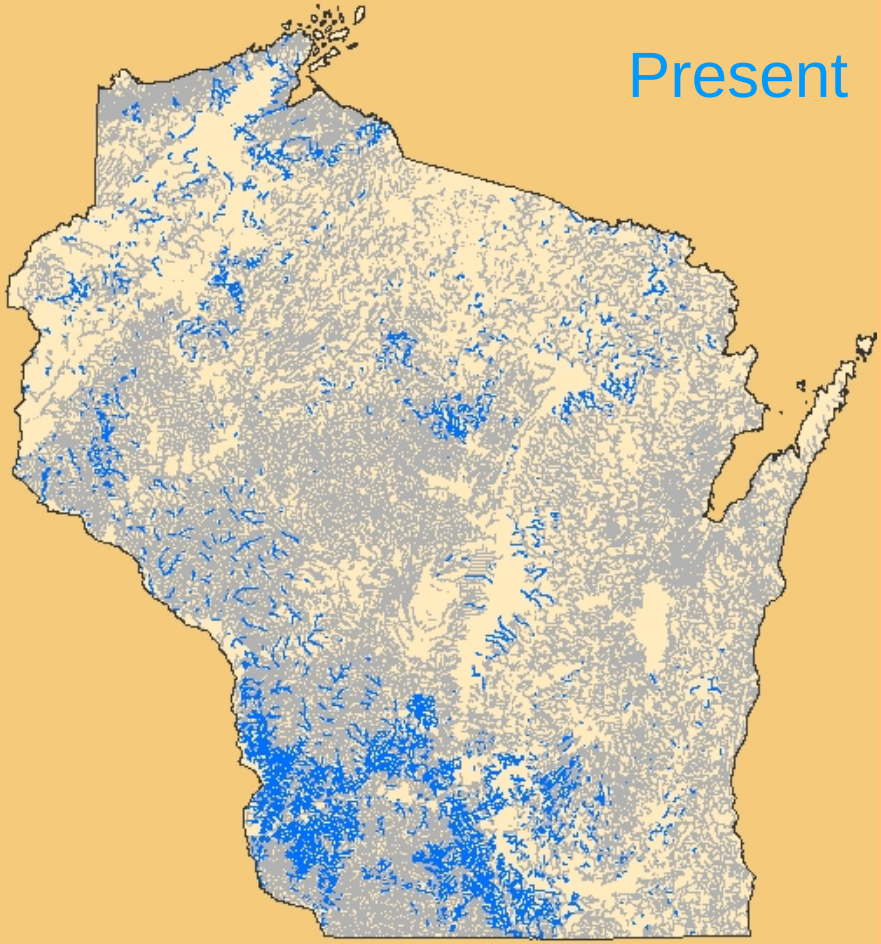
17,900 km

Present



12,500 km

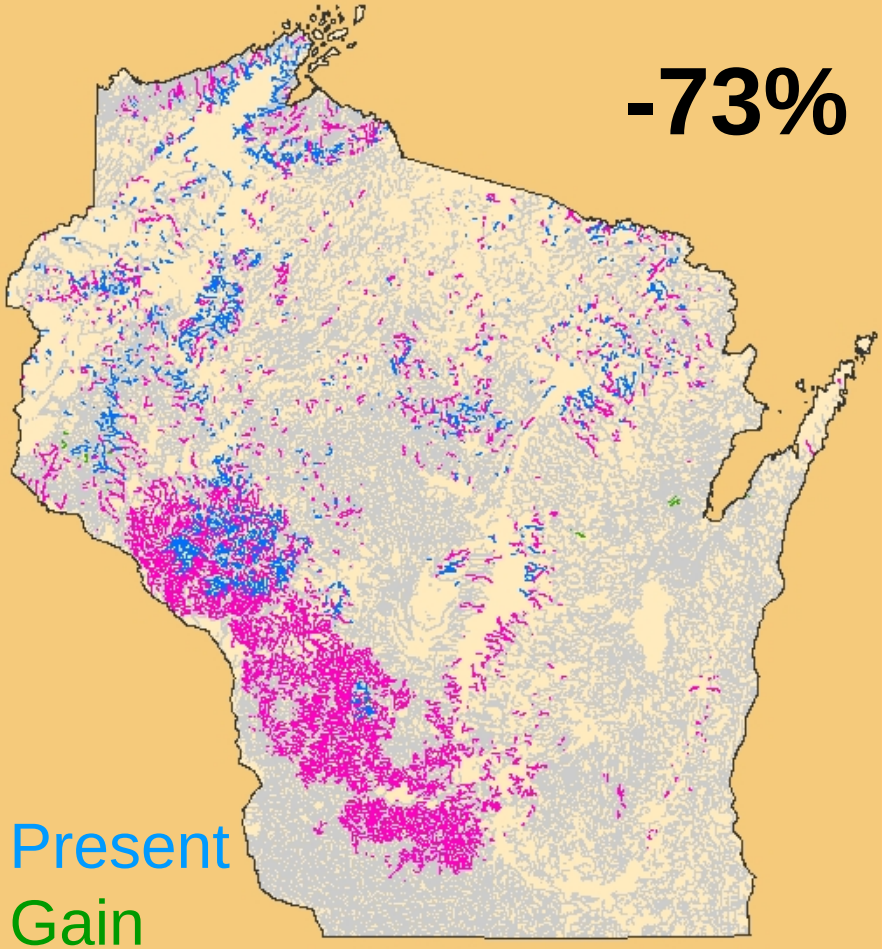
Present



+1°C

4,800 km

-73%

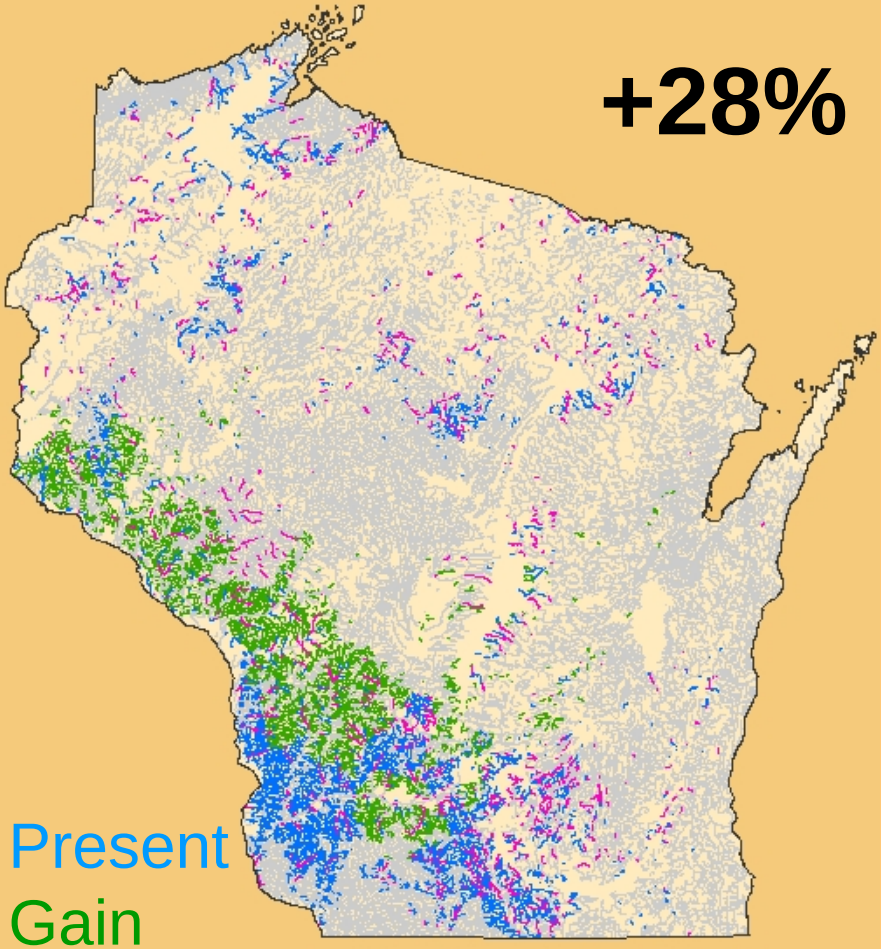


Present
Gain
Loss

+1°C

16,000 km

+28%

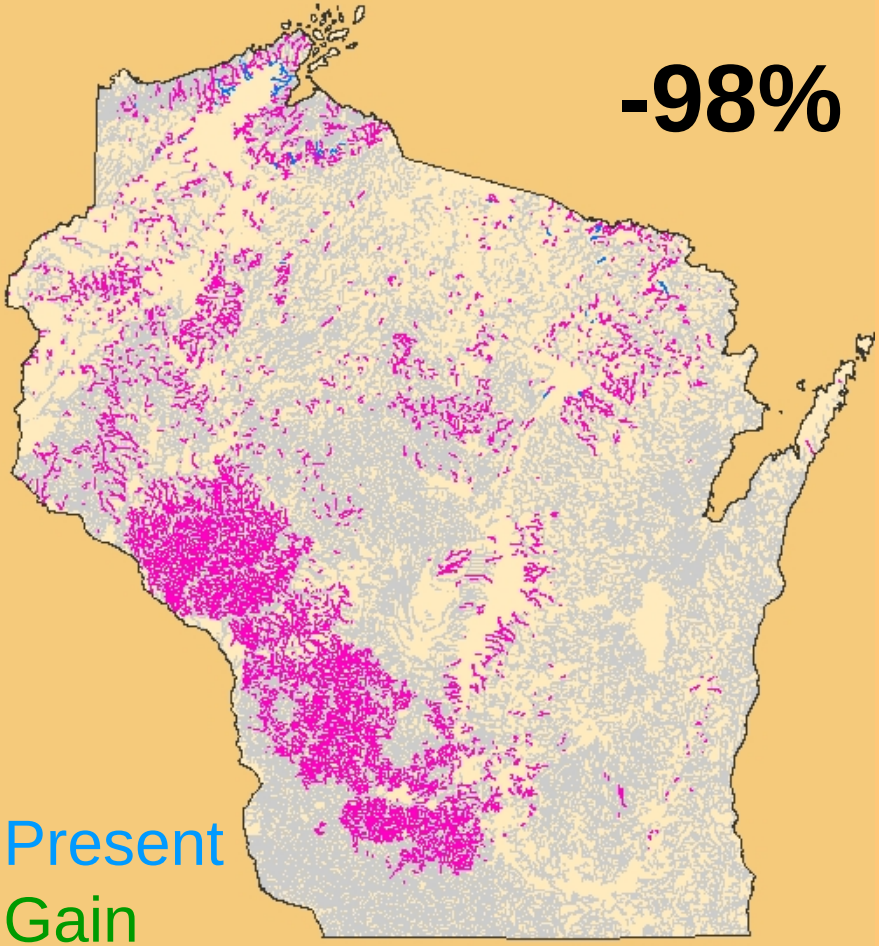


Present
Gain
Loss

+3°C

300 km

-98%

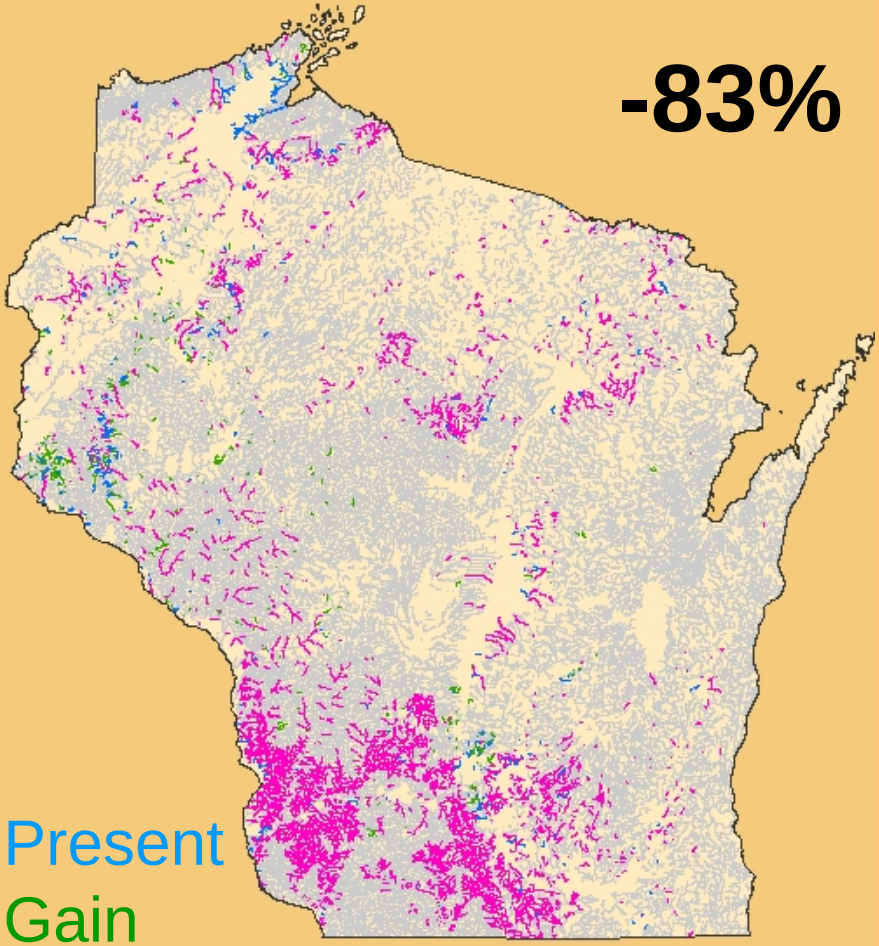


Present
Gain
Loss

+3°C

2,100 km

-83%

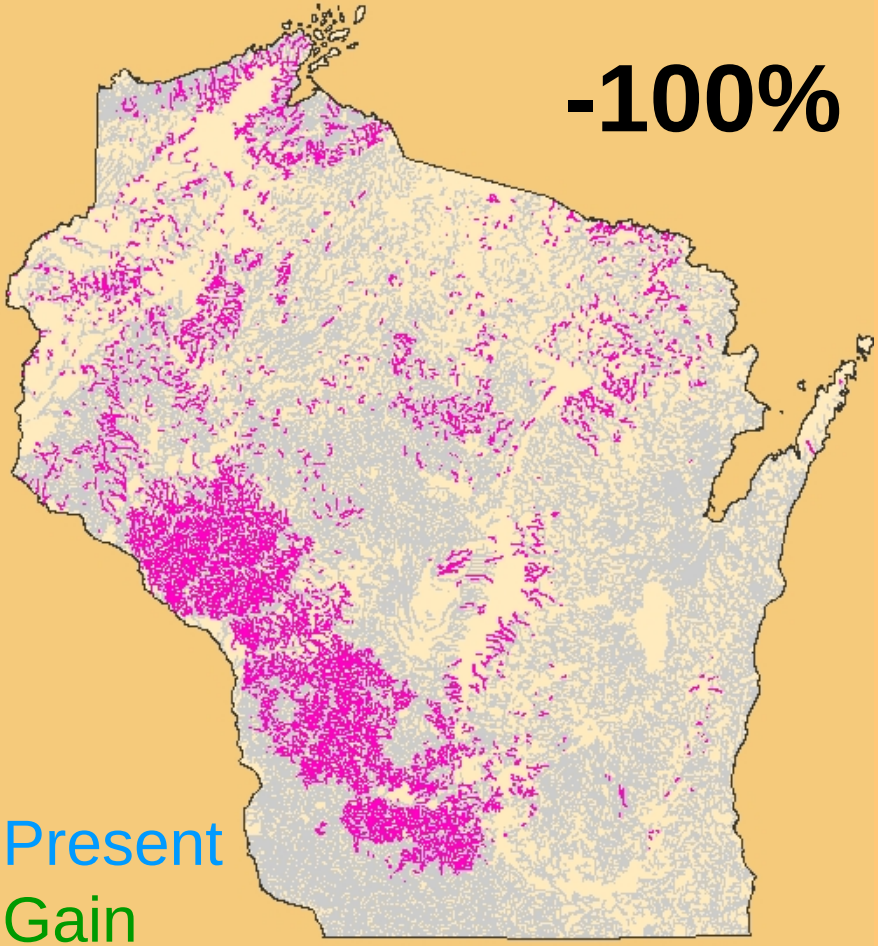


Present
Gain
Loss

+5°C

0 km

-100%



Present

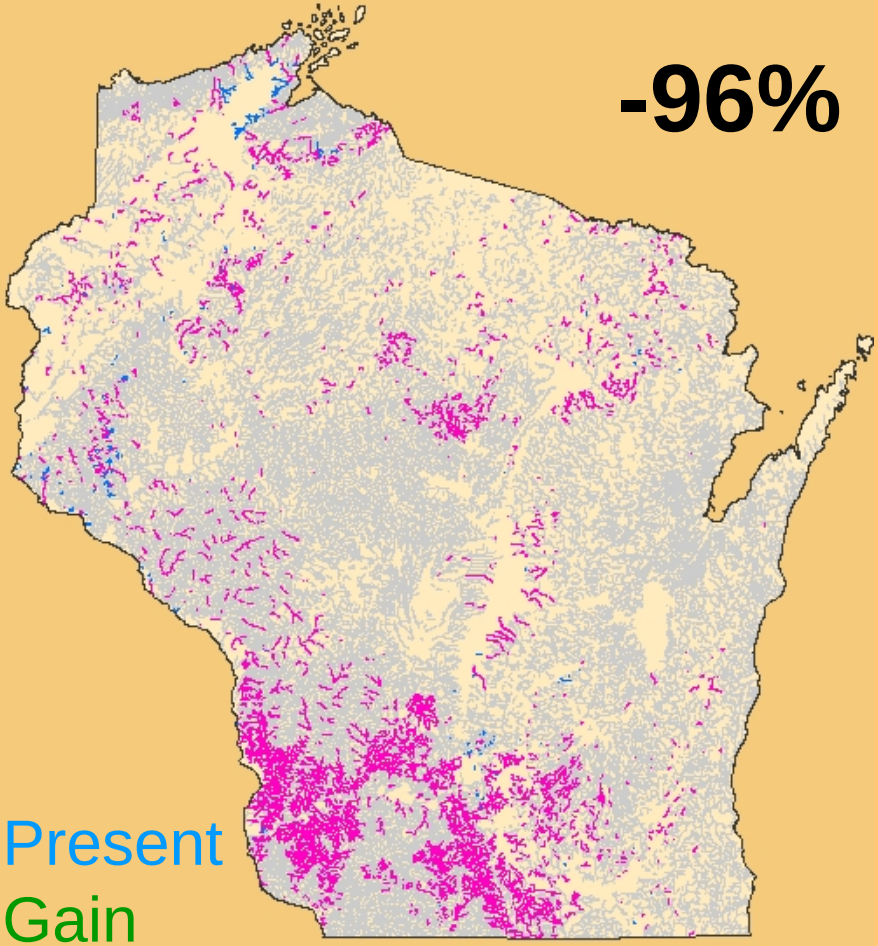
Gain

Loss

+5°C

500 km

-96%



Present

Gain

Loss

What Factors Determine Stream Temperature?

Model dynamic predictor variables include

daily air temperatures

Model categorical predictor variables include:

- Watershed area
- Agriculture land cover
- Urban land cover
- Wetland land cover
- Water land cover
- Groundwater input
- Downstream link
- Sinuosity
- Surficial deposit texture - fine

What Factors Determine Stream Temperature?

- Air temperature
- Amount of light reaching water
- Water depth
- Water turbidity
- Groundwater input
- Land surfaces in watershed

Climate Change: Precipitation and Trout

Stream flow during spring is a limiting factor for brook trout and brown trout recruitment

Summary: Climate Change and Trout

Stream temperature is the most important factor that determines where trout can live and cannot live

A warming climate will affect the distribution of trout

Extreme precipitation events associated with climate change may limit trout recruitment

Drought conditions associated with climate change will limit stream flows and fish habitat

Climate Change and the Future of Trout Management

Use stream temperature and fish distribution models to direct habitat restoration efforts to streams most likely to realize long-term benefits

Use riparian vegetation to provide shade for managing thermal habitats in streams

Climate Change and the Future of Trout Management

Protect groundwater and promote land conservation and conservation tillage methods for improving groundwater recharge

Time-of-day fishing restrictions to protect thermally-stressed fish