Adaptation strategies for Wisconsin lakes facing climate change

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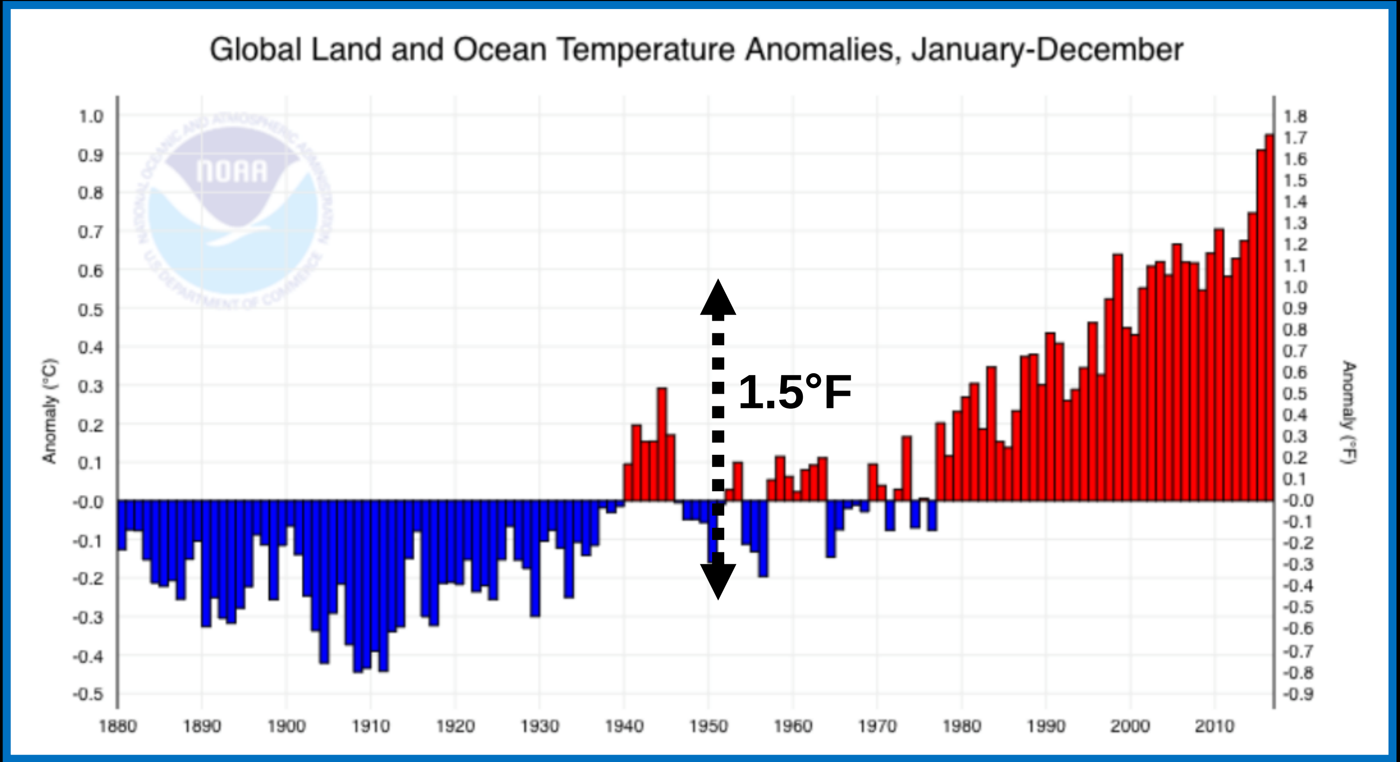
WISCONSIN DEPT. OF NATURAL RESOURCES
Office of Great Waters
Great Lakes & Mississippi River

Climate Change

Global temperature is increasing (so is regional temperature)

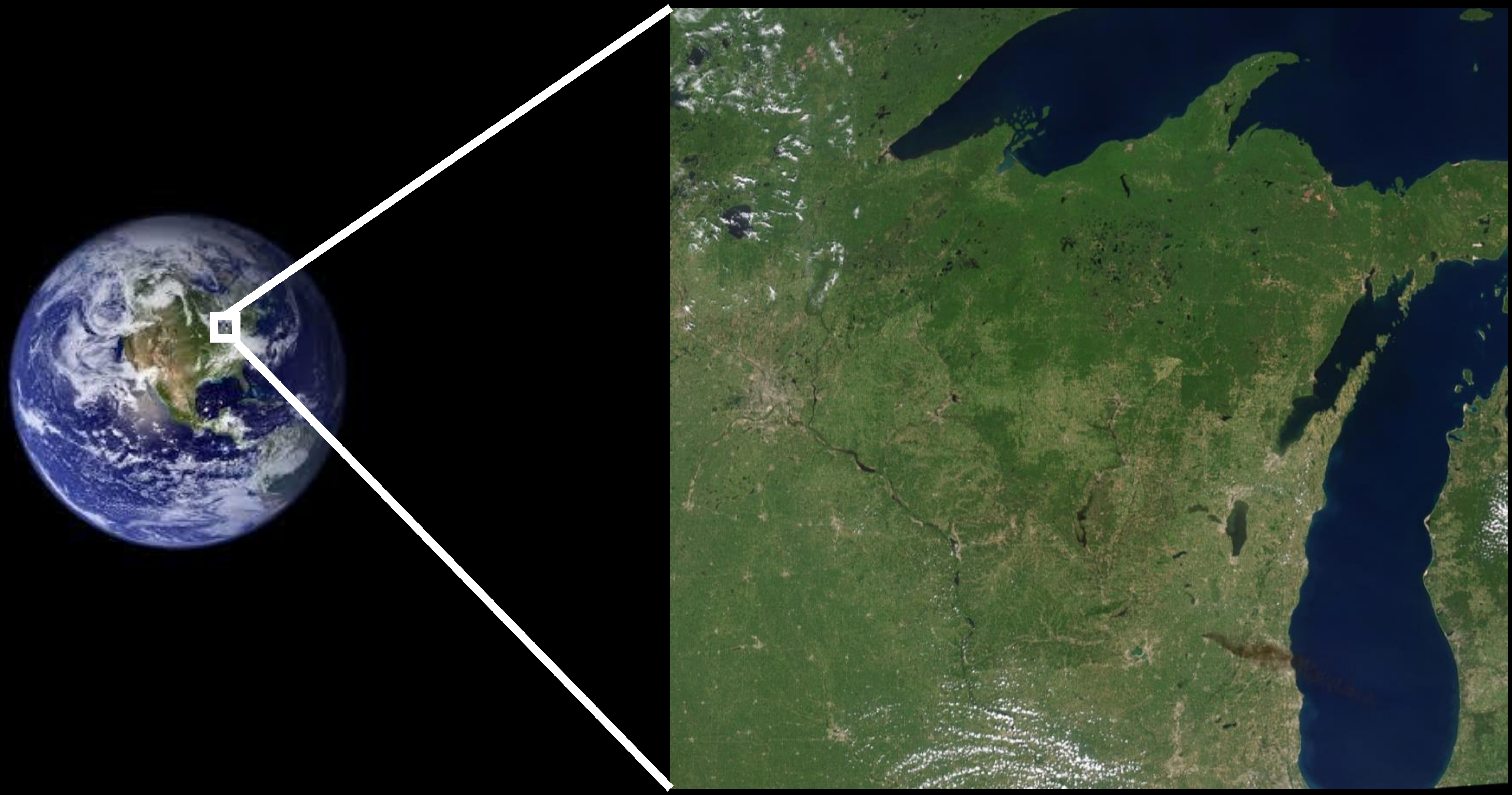


Global temperature has warmed by about 1.5°F since 1900.

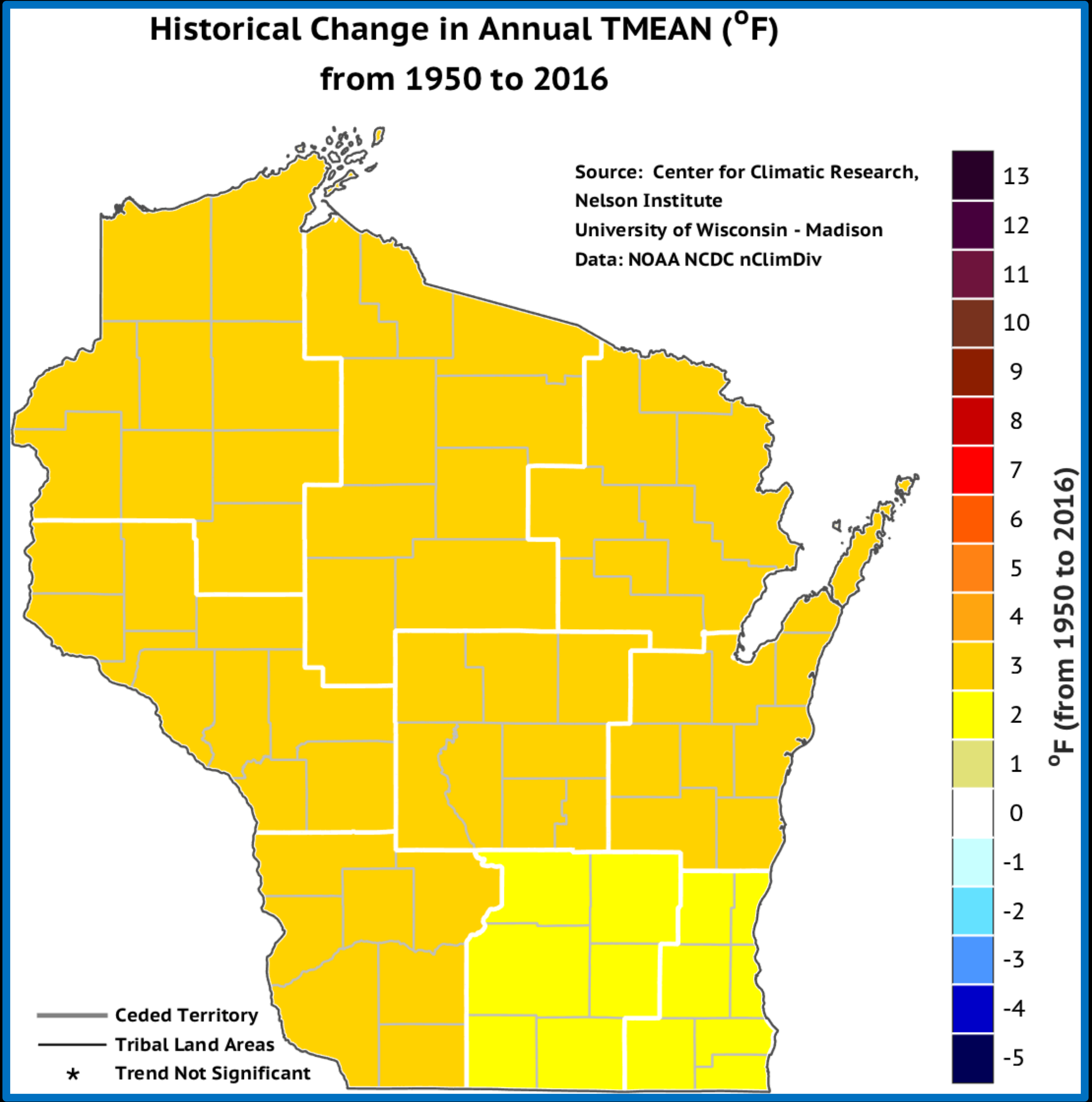
NOAA: https://www.ncdc.noaa.gov/cag/time-series/global/globe/land_ocean/ytd/12/1880-2016

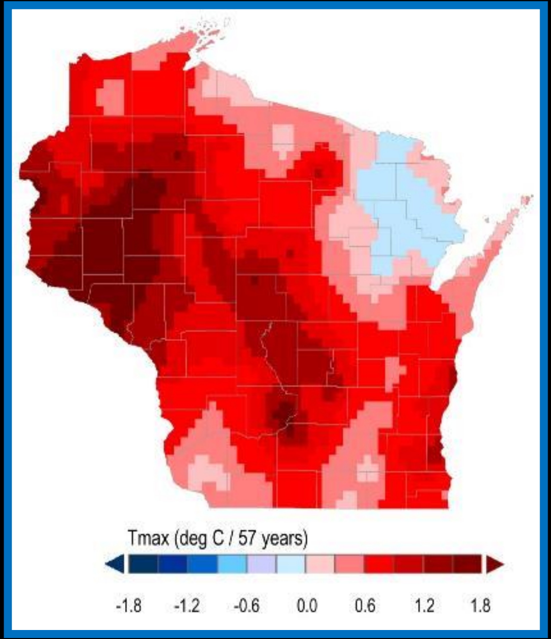
Dan Vimont; WICCI

Climate Change

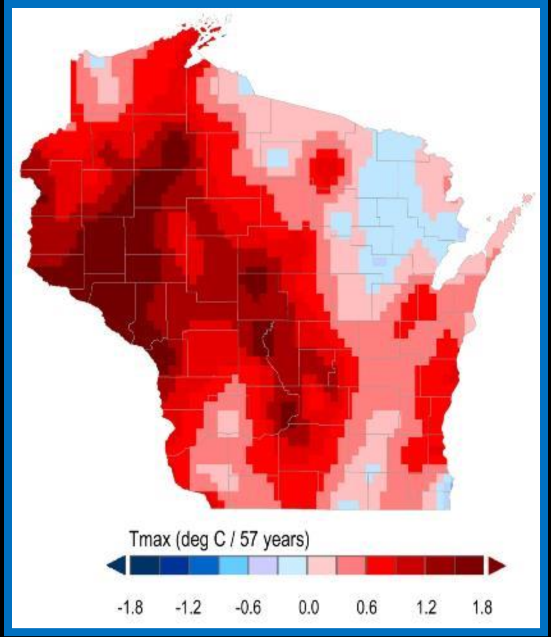


Climate Change





Winter



Spring

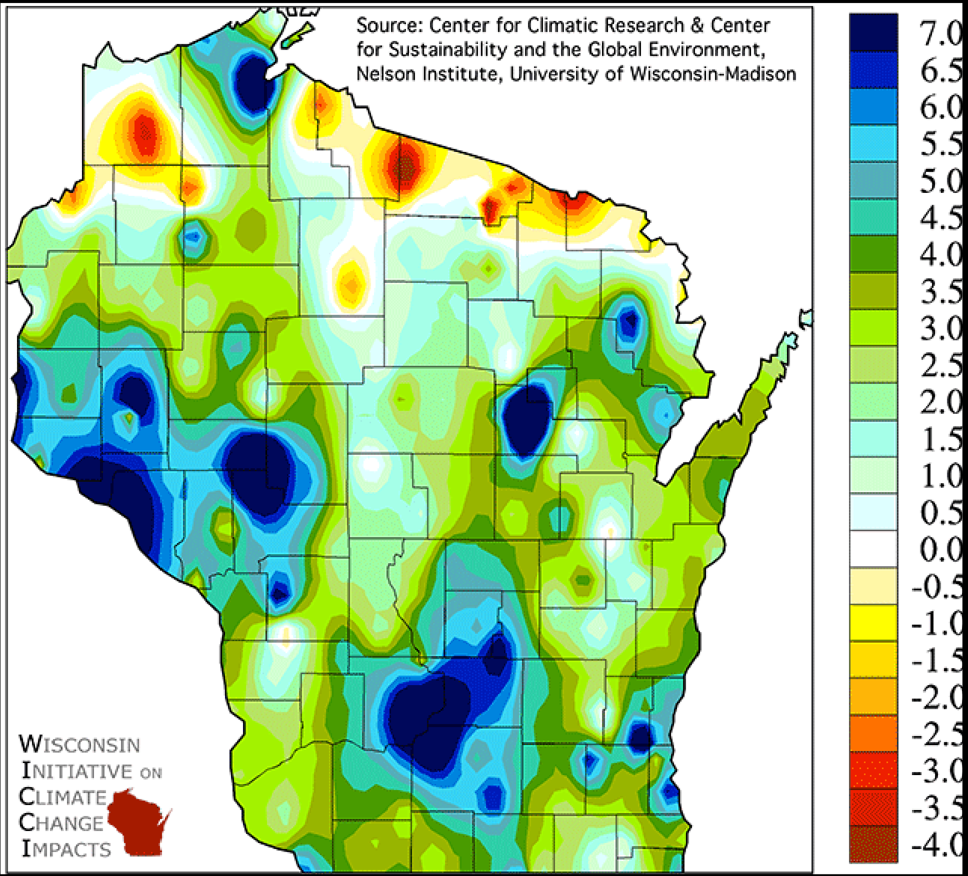
Wisconsin has warmed by about 2°– 3°F since the mid 20th Century

most in winter and spring

Figures from Dan Vimont; WICCI

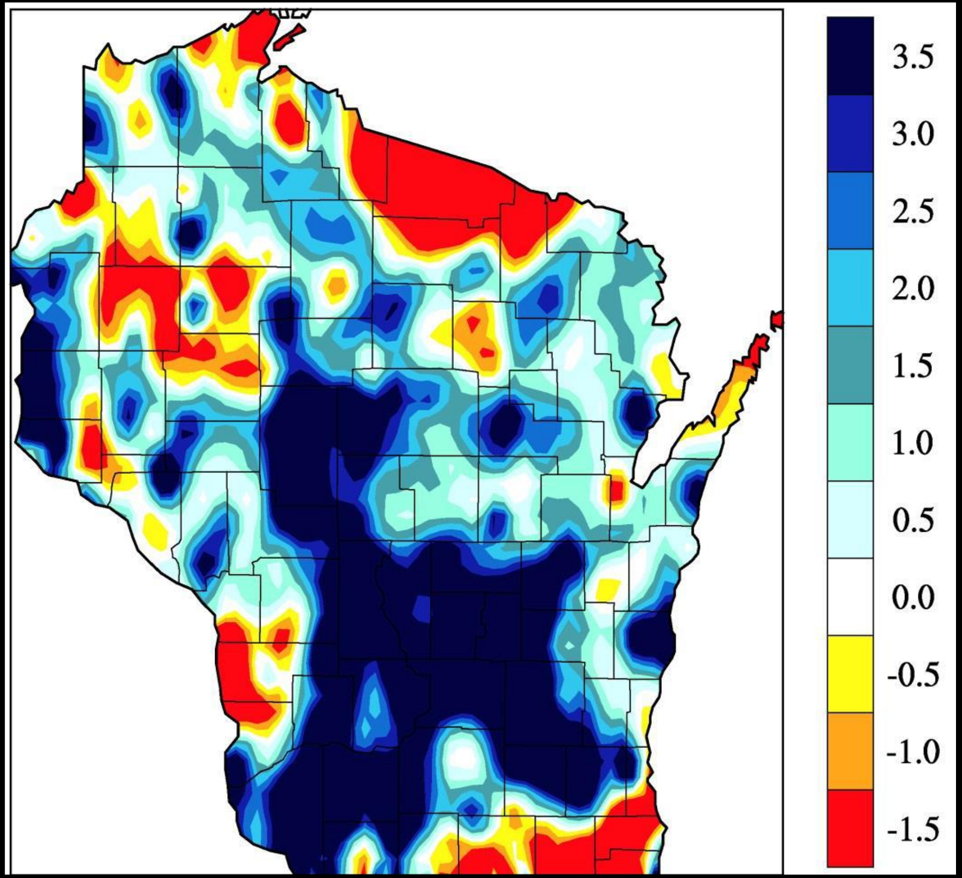
Climate Change

Change in annual average precipitation
(inches)1950 to 2006



↑7” to ↓4” (drought)

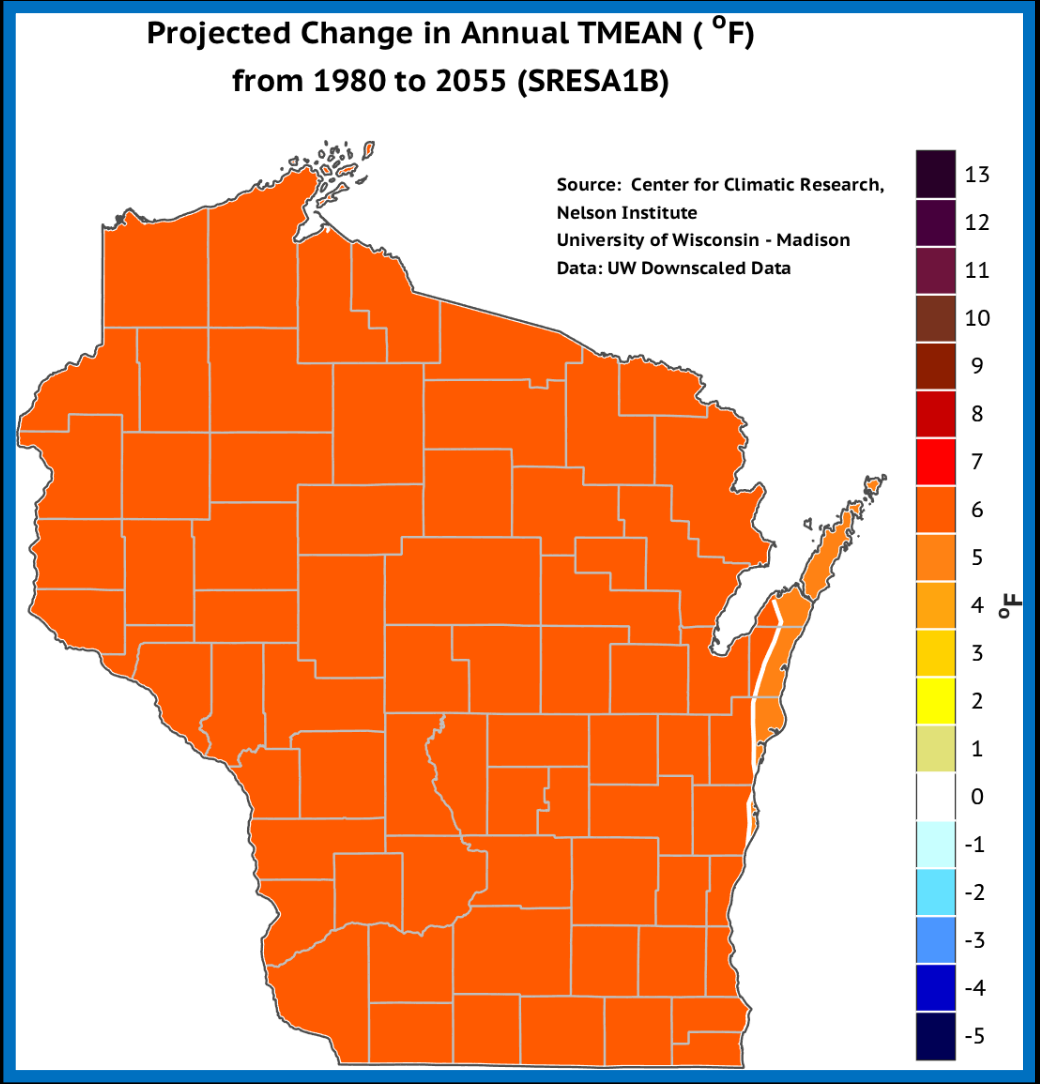
Increase in 2” rainfalls
(days/decade) 1950 to 2006

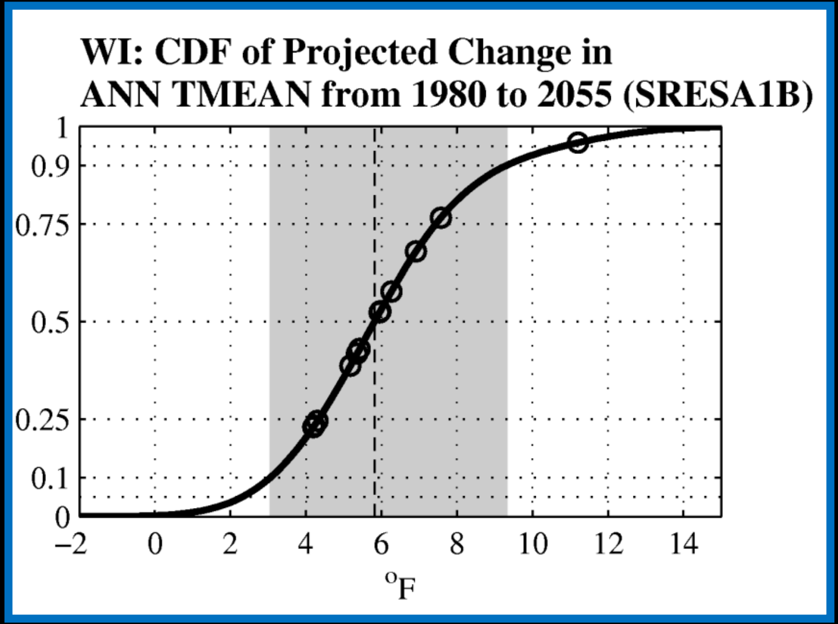


↑3.5 days to ↓1.5 days (regionally variable)

Slide from Katie Hein, WDNR

Climate Change – what can we expect?

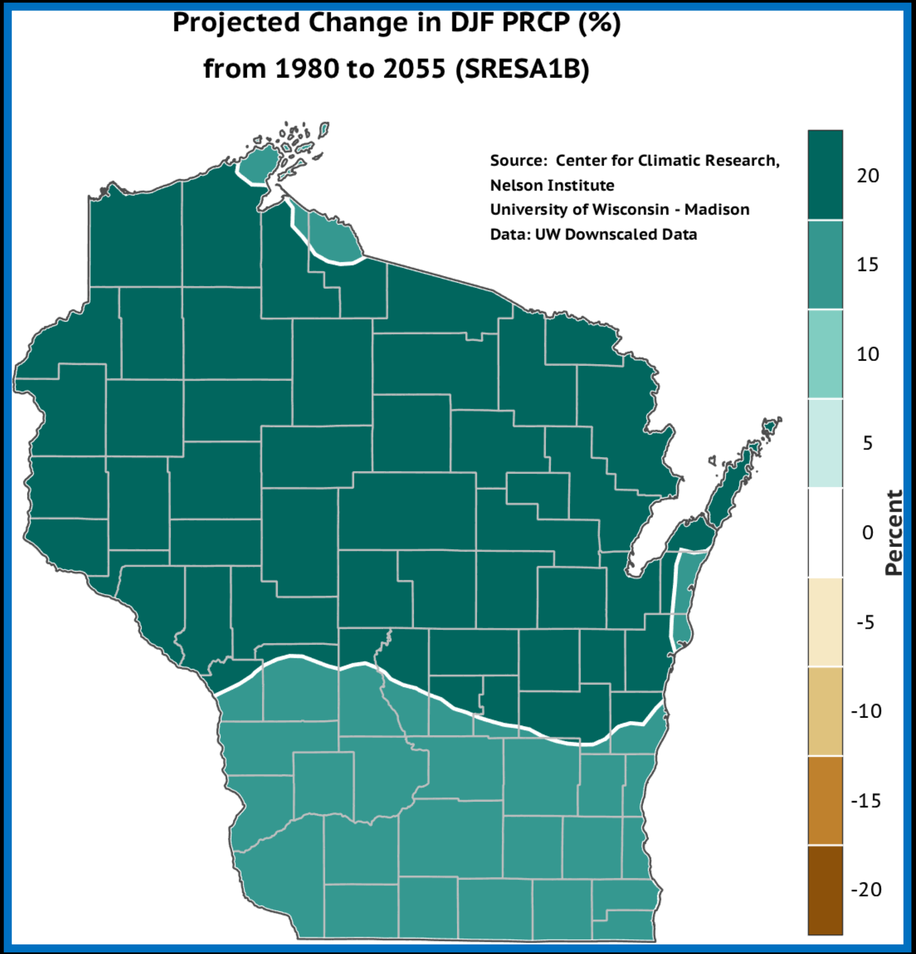


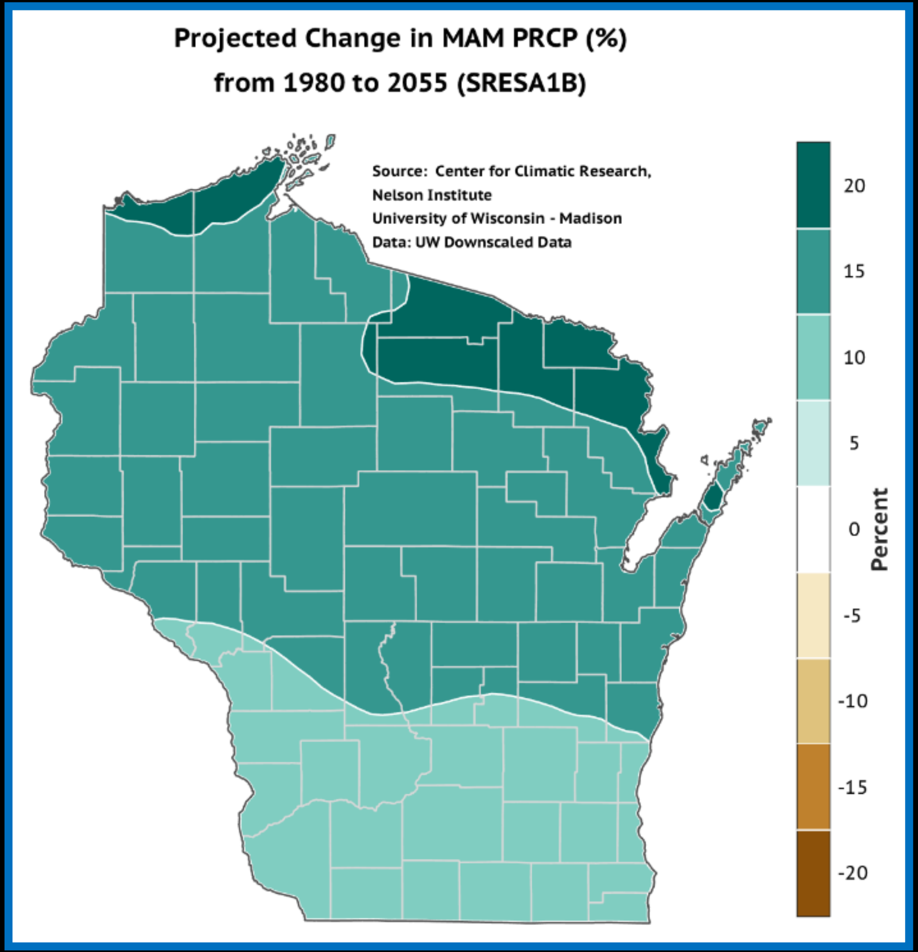


Wisconsin is expected to warm by 3°– 9°F by mid-21st century

Slide from Dan Vimont, WICCI

Climate Change – what can we expect?

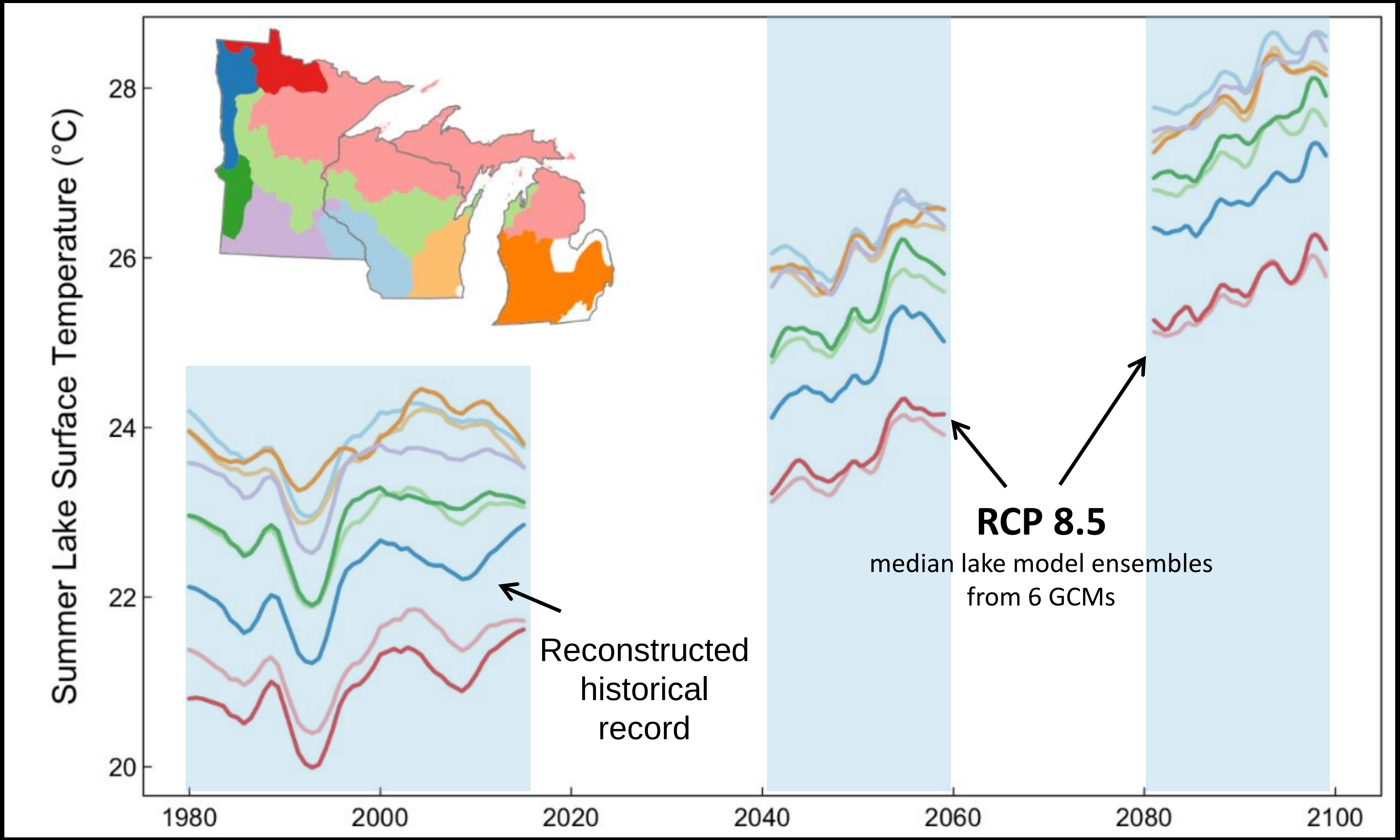




Robust increase in precipitation during winter and spring

Climate Change – lakes

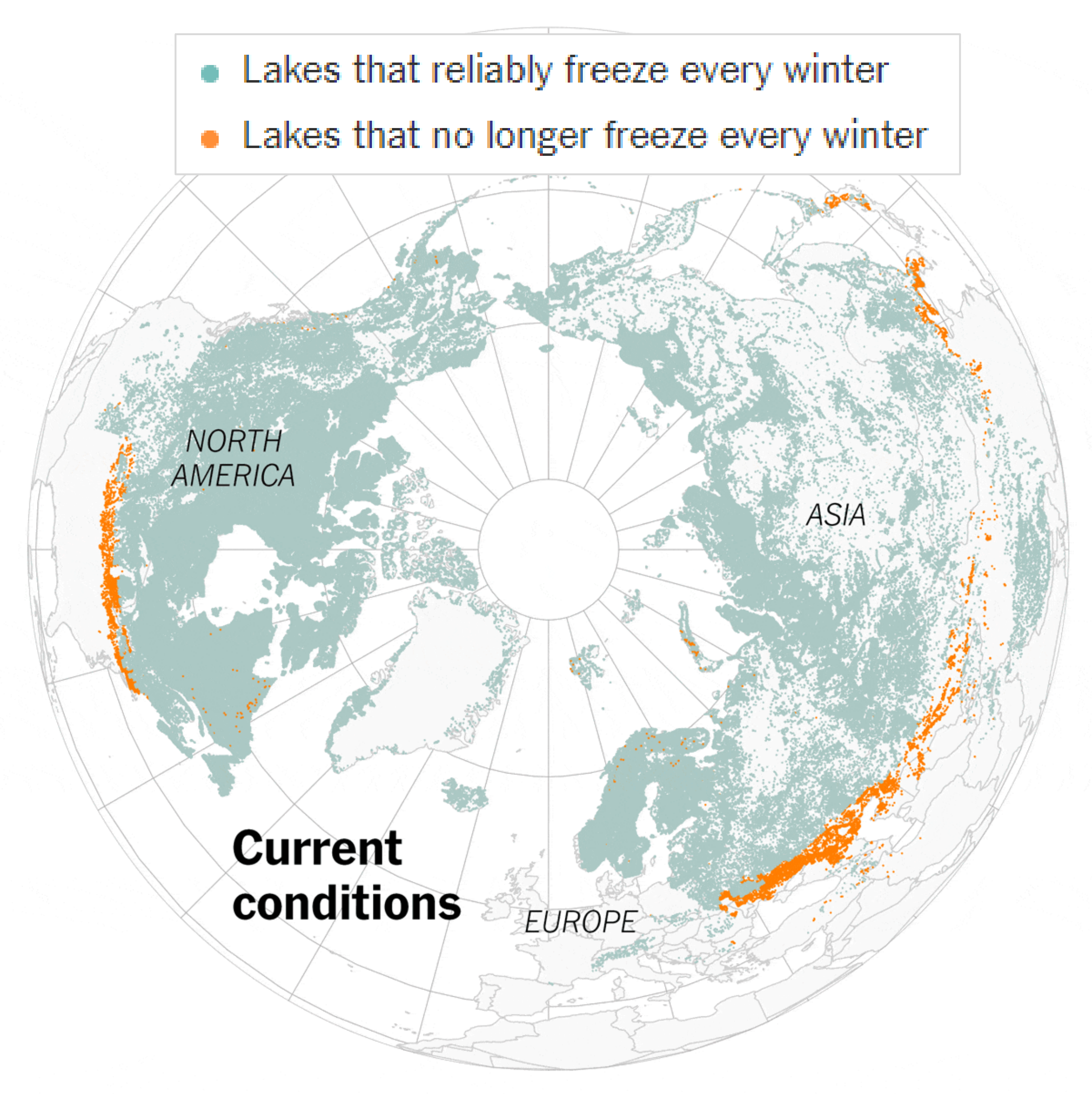
Climate Change – lakes



lake water temperature increasing

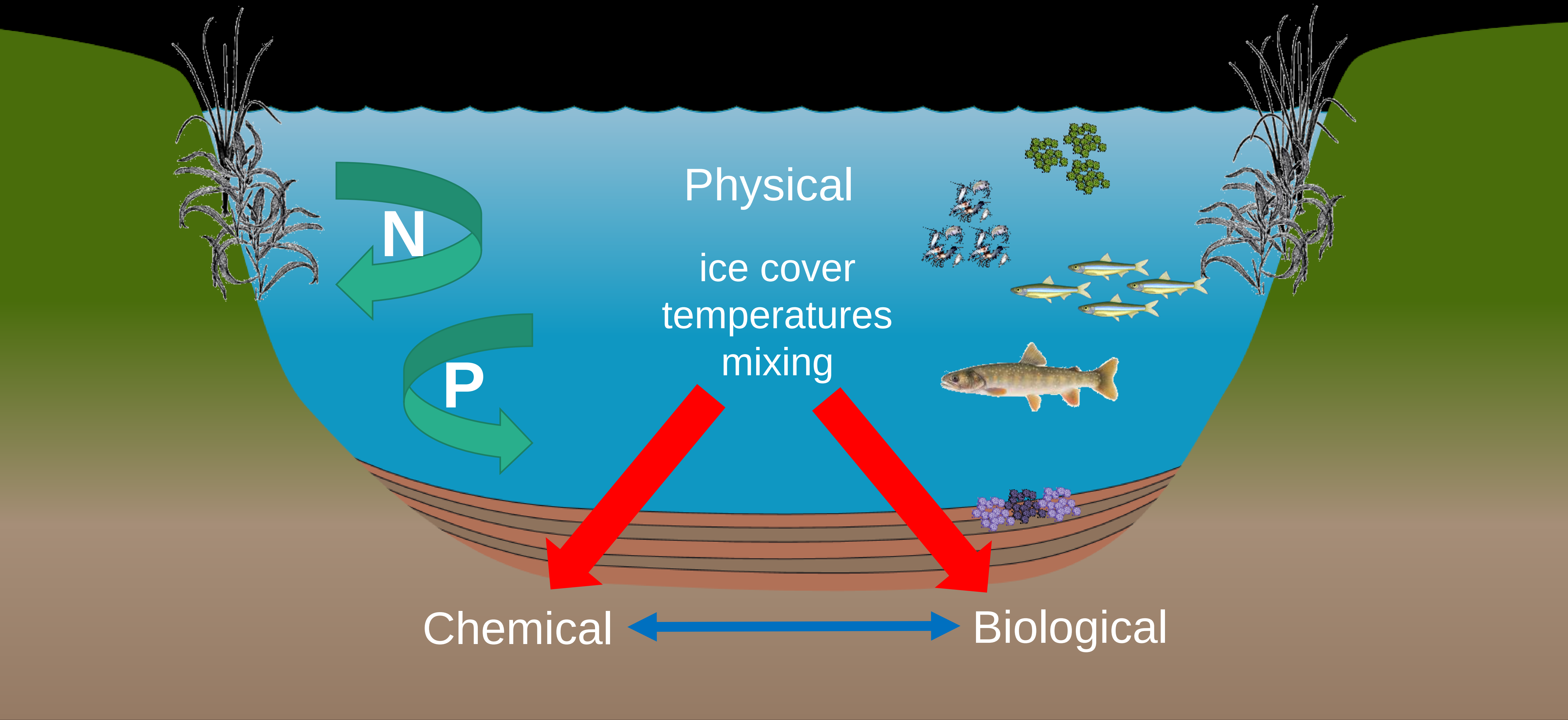
figure from Gretchen Hansen, UMN

Climate Change – lakes



loss of ice cover period

Climate Change – lakes



Climate Change

- What does this mean for Wisconsin lakes?
- What can we do about it?

Climate Change and Inland Lakes Workshop

- Hosted by Wisconsin Initiative on Climate Change Impacts
- 52 attendees
  - 16 organizations

WISCONSIN INITIATIVE ON CLIMATE CHANGE IMPACTS

Joe Nohner | MDNR

Climate Change and Inland Lakes Workshop

lake levels

water quality

aquatic invasive species

fisheries

Magee et al (*in review*)

Climate Change and Inland Lakes Workshop

1. What are recent advances in our scientific understanding of the theme since the first WICCI report?
2. What knowledge gaps exist and what future steps should be taken to better understand how climate change will impact inland lakes?
3. What adaptation strategies can be identified to reduce inland lake vulnerability to climate change?

Eric Olson

Climate Change Impacts – Lake Levels

Lake Levels

- spatially variable
- lake levels influence water clarity

Climate Change Impacts – Water Quality

Lake Levels

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Water Quality

- climate change → lower water quality
- P not the only variable to consider

Climate Change Impacts – AIS

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Aquatic Invasive Species

- range expansions as temperatures warm
- increased impact of invaders

Climate Change Impacts – Fisheries

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- spatially variable
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Water Quality

- climate change → lower water quality
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Aquatic Invasive Species

- range expansions as temperatures warm
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Fisheries and Native Aquatic Species

- climate change → bad for cold-water fish
- species interactions ???

Climate Change and Inland Lakes Workshop

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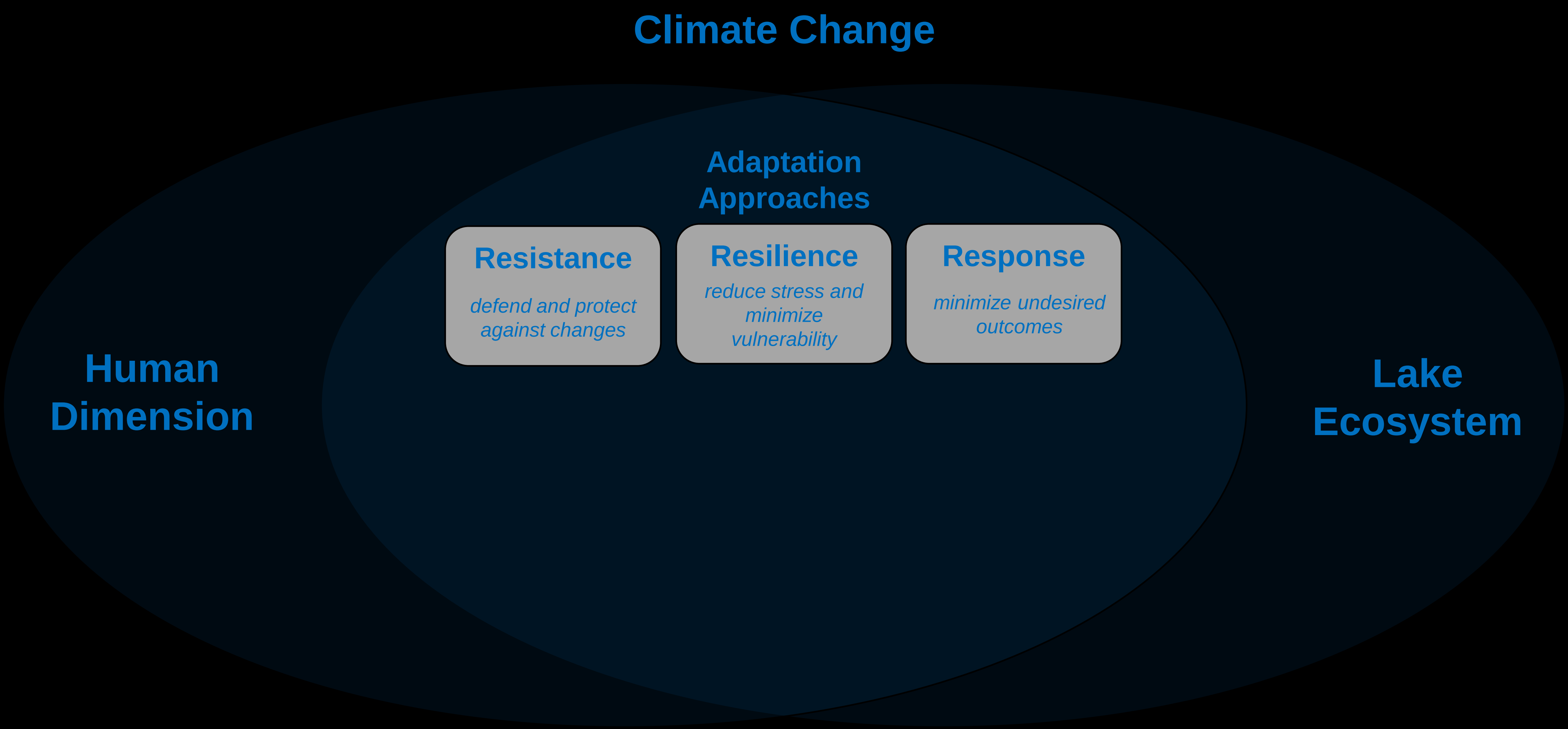
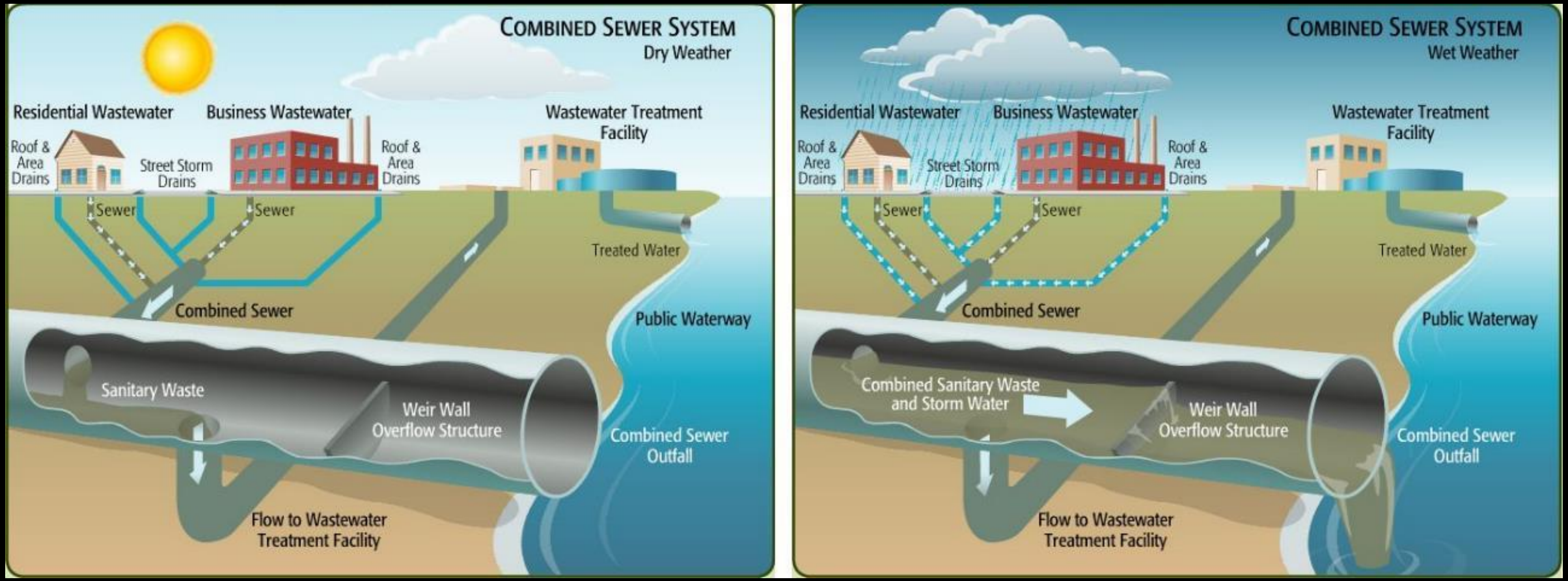
Climate Change Adaptation



Resistance

defend high value lakes against changes caused by climate

Eliminating or reducing combined sewer overflow (CSO)



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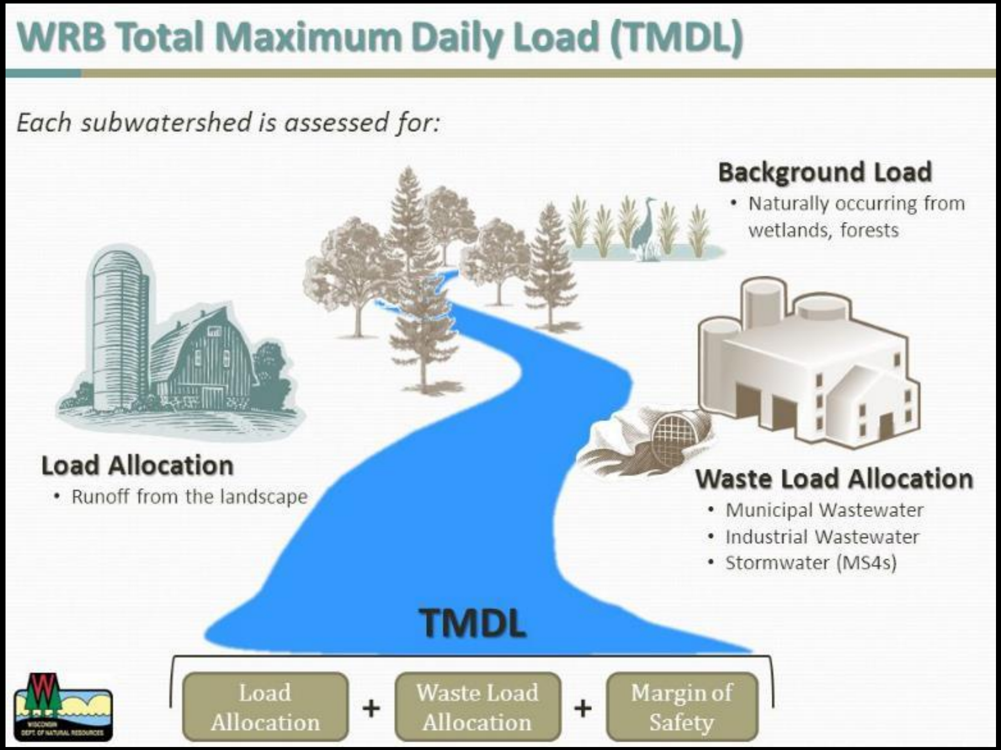
TMDL implementation



Resilience

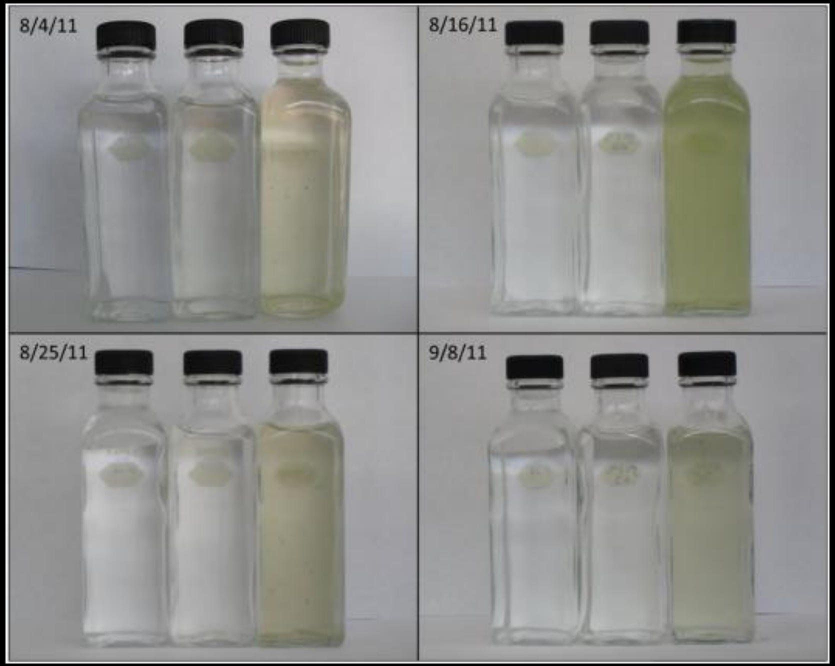
Improve the capacity of the lake to return to prior conditions; reduce stress and minimize vulnerabilities

Wetland protection and restoration

Response

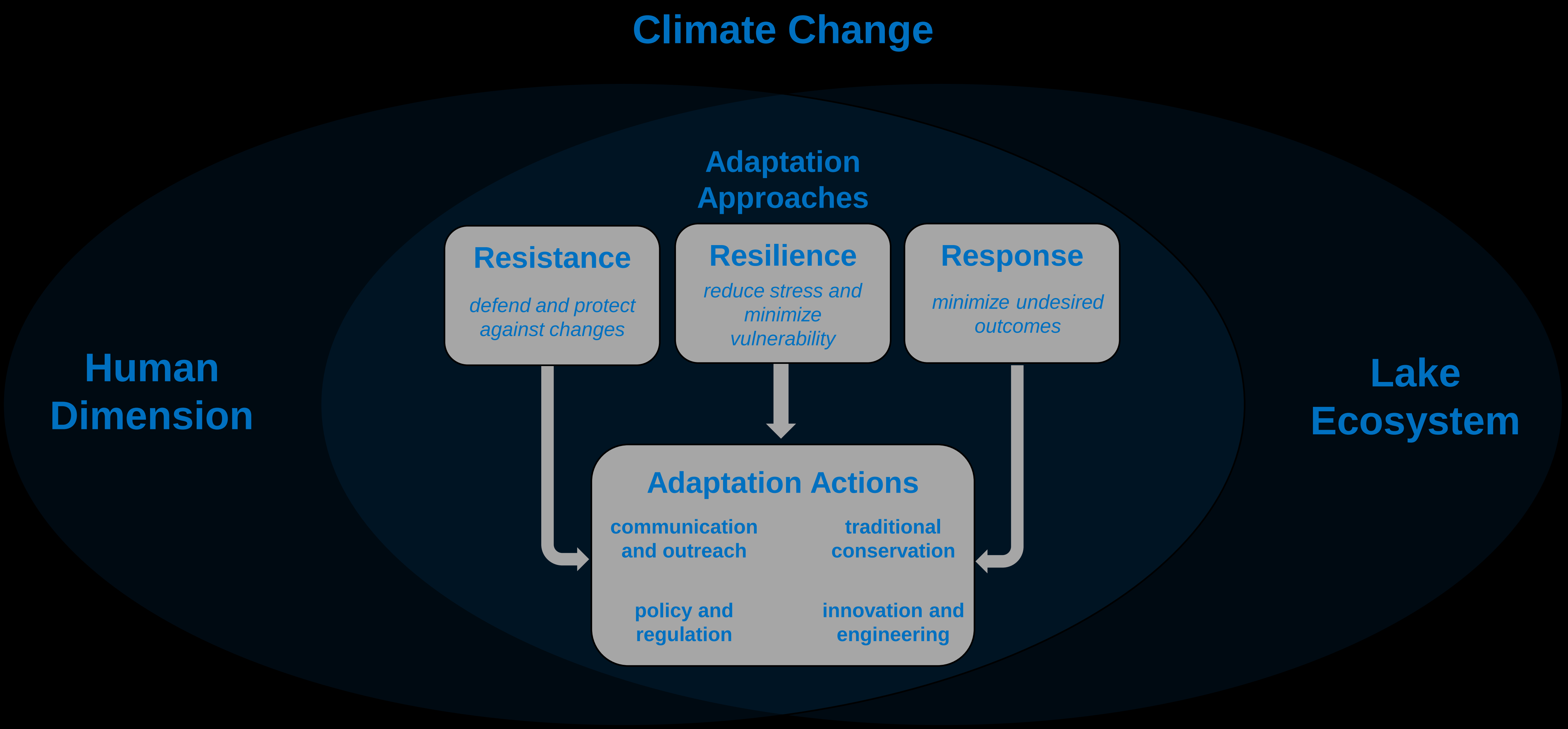
intentionally accommodate change, but minimize undesired outcomes

Water Exclosure Treatment System (WETS) to minimize beach closures



Reimer et al., 2018

Climate Change Adaptation



Adaptation Actions

Communication	Communicate climate change impacts to stakeholders and manage expectations for resource use in the future

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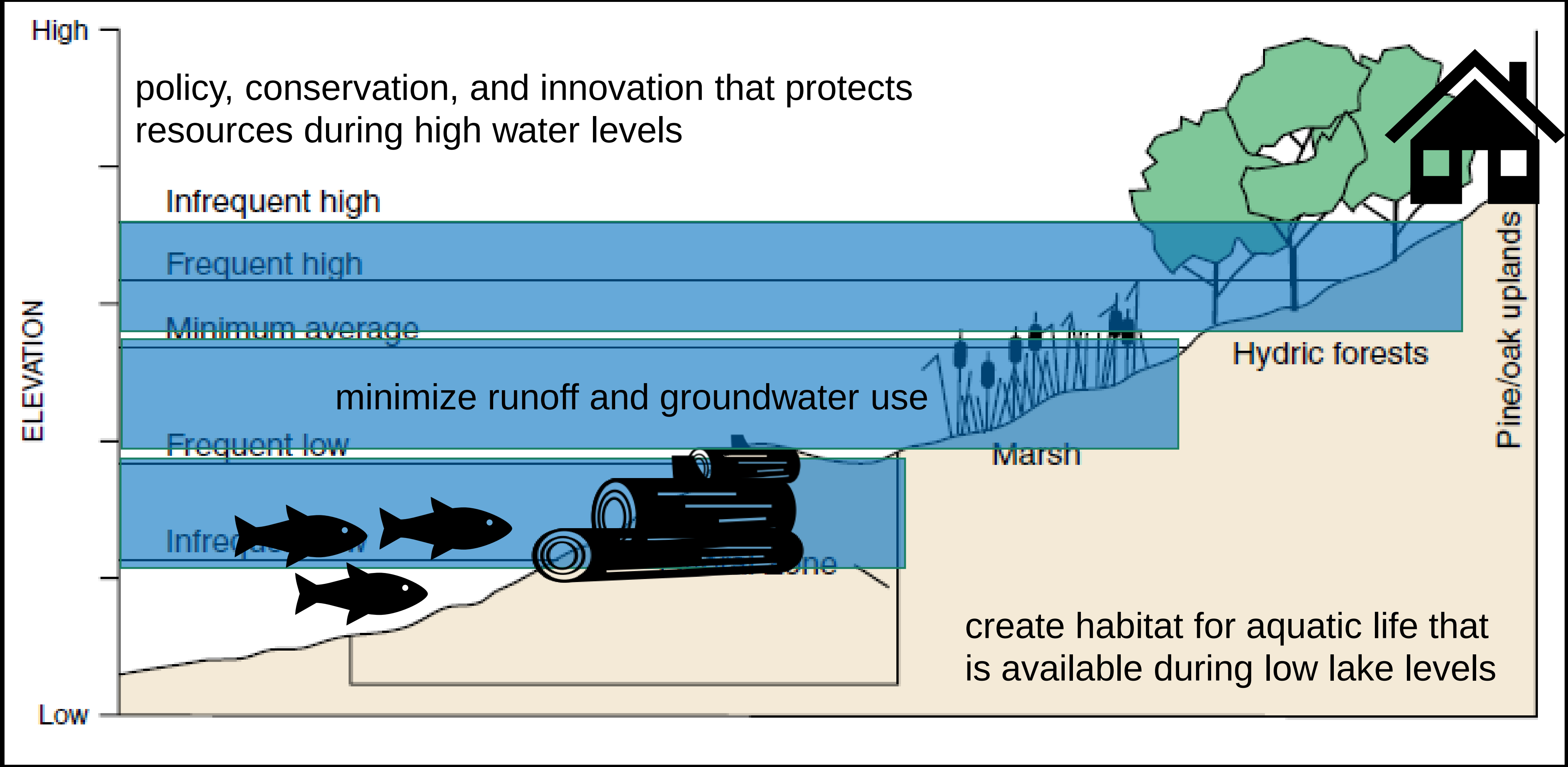
Adaptation Actions

Communication	Communicate climate change impacts to stakeholders and manage expectations for resource use in the future
Policy	Rules and Regulations that adapt to climate changes by requiring adaptations that promote resistance and resilience on a structural level
Conservation	Traditional conservation practices on the landscape that build resilience within the system
Engineering	New and innovative technologies that act to respond to climate changes to reduce negative impacts to the lake resource.

Adaptation Actions

Communication	• Monitor and define the range of lake levels expected • Identify seepage lakes in the state with large lake level fluctuations • Shift cultural norms regarding idyllic lake shorelines to include natural vegetation and minimize human structures
Policy	• Set zoning regulations that protect the riparian zone from development • Set insurance policies based on future climate projections to minimize building below the high-water mark • Promote voluntary practices that protect undeveloped shorelines and wetlands • Limit groundwater extraction to maintain minimum lake levels during drought • Incentivize agricultural and urban development practices that minimize water use and encourage water infiltration
Conservation	• Protect and restore wetlands and lake habitat in riparian and littoral zones • Add woody and other habitat to deep water so it is available when lake levels are low • Protect woody and other habitat stranded above water so it is available when lake levels rise • Tailor agricultural practices to local climate and geology to conserve water and minimize drawdown in lakes
Engineering	• Build adaptable/temporary structures, such as rolling or floating piers • Enhance water infiltration in the watershed and in the riparian to minimize flooding after extreme precipitation events • Manage lake levels with dams to anticipate future highs and lows • Pump water out of seepage lakes when water is too high • Design infrastructure to accommodate extreme events

Adaptation Actions



modified from McGrail et al. 1998

Adaptation Actions

Communication	● Address disconnect between stakeholders who value high water quality, but dislike management and regulations ● Develop community connectedness with stakeholders ● Draw input from lake associations to drive large preventative measures at the local level ● Increase communication with stakeholders about drivers of water quality and how climate change may affect drivers ● Communicate economic advantages of improved water quality to businesses and other stakeholders
Policy	● Incentivize companies and farmers to reduce nutrients runoff in the watershed ● Continue implementation of total maximum daily load (TMDL) programs ● Reevaluation of water quality standards and permitting standards to reduce phosphorus, chloride, and fecal contaminants ● Remove combined storm overflows in urban areas ● Improve stormwater regulations and enforce management practices that reduce runoff and nutrients in urban areas
Conservation	● Best management practices for nutrient reductions ● Wetland protection and restoration ● Reduce application of road salt during winter months ● Saturated buffers to reduce phosphorus and nitrate loads entering streams from tile-drained agricultural fields
Engineering	● Maintain beach usage through enclosed swimming and treatment systems ● Artificial aeration to prevent anoxic conditions to sustain well-oxygenated waters for cold-water fisheries ● Increase green infrastructure ● Dredging of legacy phosphorus in impacted stream reaches ● Constructed water treatment wetlands and detention ponds

Adaptation Actions

precipitation → water clarity algal blooms

Projected Change in Annual Average Precipitation (inches) from 1980 to 2055

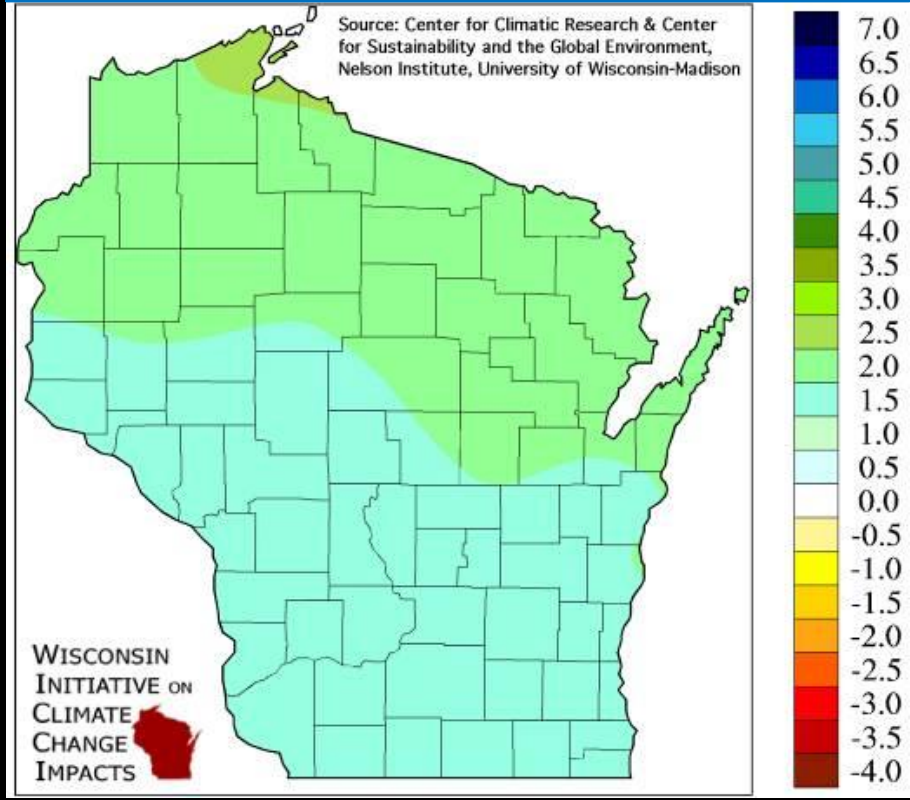
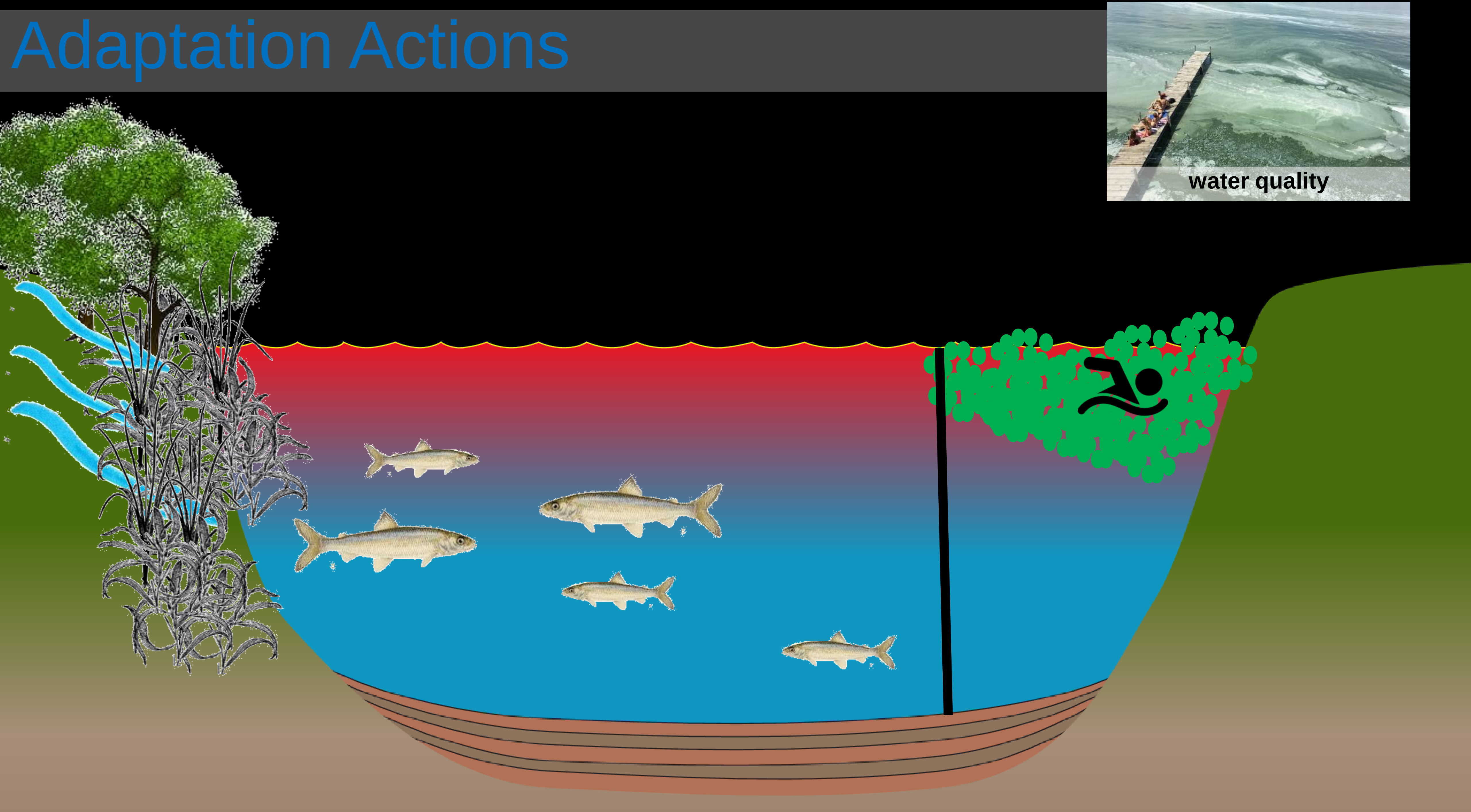
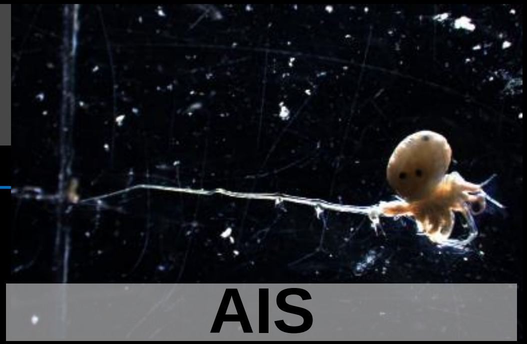


Photo: Melvin McCartney, Lake Monona, June 2006

Adaptation Actions

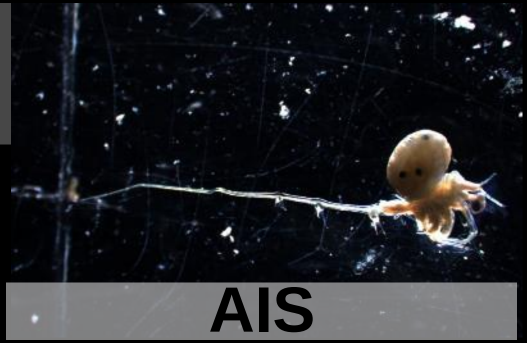


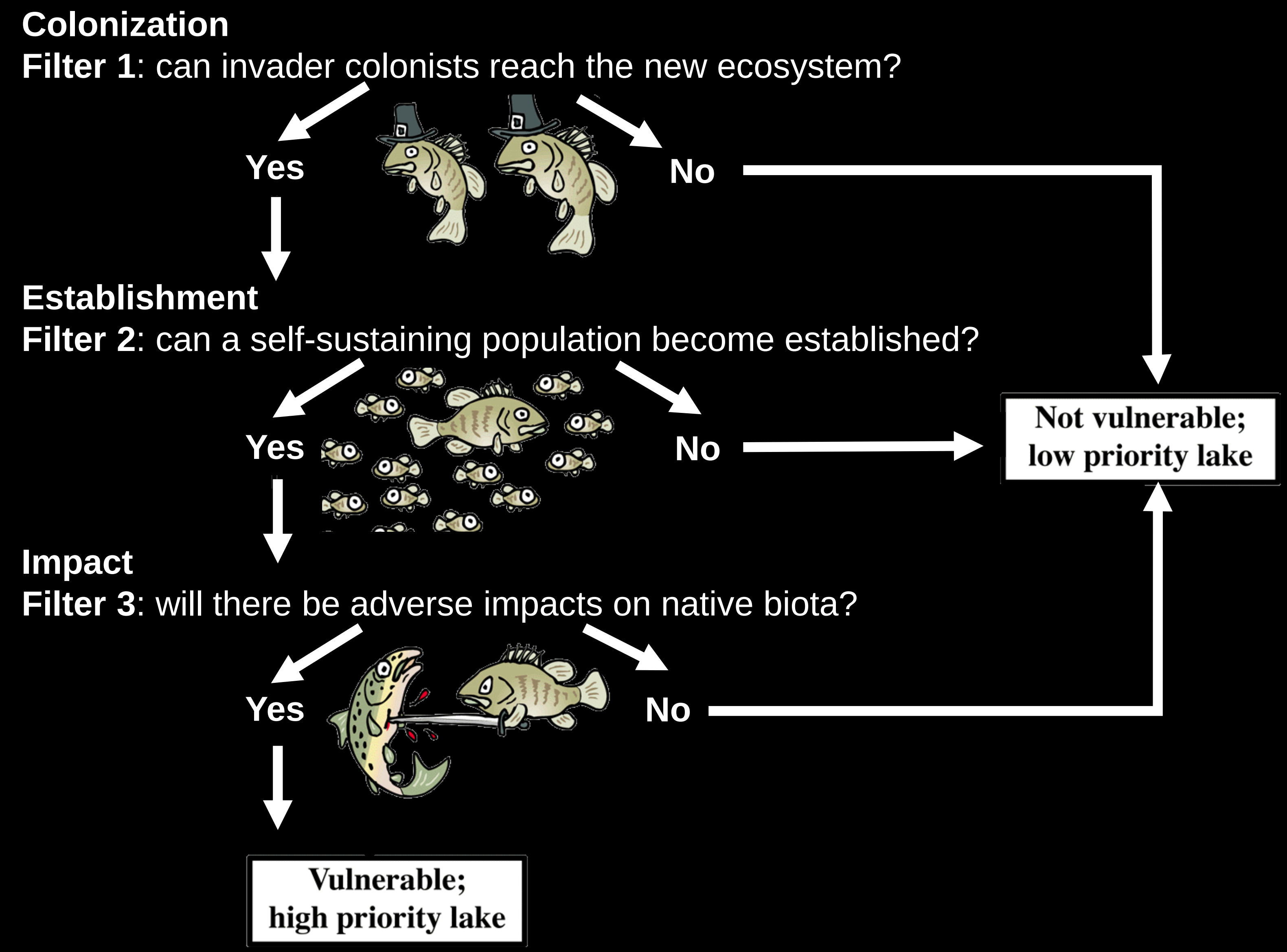
Adaptation Actions



<table>
<tr><td>Communication</td><td>Continue outreach efforts to maintain 100% compliance
Expand youth education and community-based social marketing
Develop simple and consistent messaging
Better articulation of socioeconomic impacts of invasion
Advertise the successes of outreach efforts in preventing invasions</td></tr>
<tr><td>Policy</td><td>Develop proactive long-term monitoring and studies
Develop regulations that close existing and potential future transport vectors
Proactively incorporate AIS management into regulation regarding water quantity management
Incentivize invasive species harvest at the edge of invasion
Adjust ballast water regulations to decrease risk of invasion
Alter standards for boat manufacturers that require design for AIS prevention and decontamination</td></tr>
<tr><td>Conservation</td><td>Promote strategies to increase general health (i.e., resilience) of lakes and reduce AIS impacts
Develop local-scale prediction and prevention strategies
Use long-term monitoring to identify changes in AIS distributions, pathways, and impacts as climate changes
Improved detection methods to identify and manage AIS before they become established
Develop biological control programs for common AIS species
Provide funding and resources for communities and lake associations to control AIS at the local level</td></tr>
<tr><td>Engineering</td><td>Recreational boat and shipping vessel decontamination
Ballast water treatment
Changing watercraft design to make AIS prevention easier
Fish passage barriers</td></tr>
</table>

Adaptation Actions





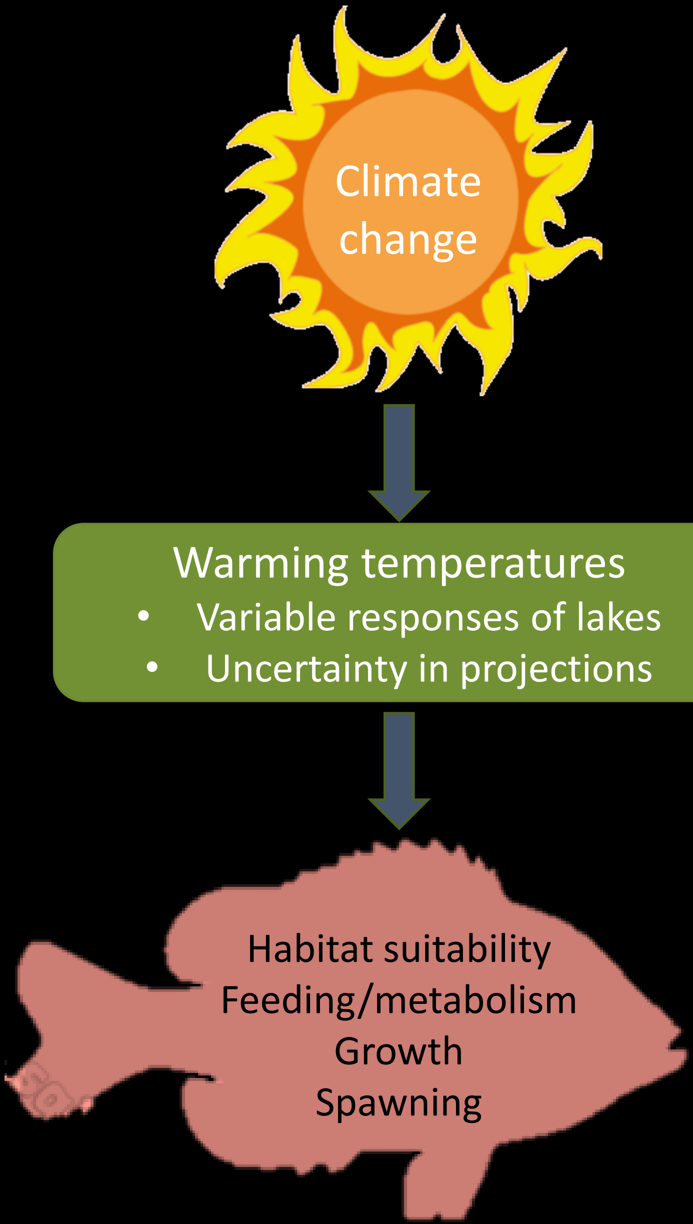
Climate impacts all steps of the invasion process

Vander Zanden et al. 2004 Ecological Applications 14: 132-148

Adaptation Actions

Communication	• Coupled natural-human systems studies enhancing understanding of human role on fisheries systems under climate change • Outreach on the safe operating space concept • Encourage and/or enhance manager and stakeholder partnerships • Increased transparency in scientific and management basis for regulations • Set realistic expectations and goals for fish communities based on lake conditions
Policy	• Harvest regulations (length and bag limits, closed seasons) to reduce exploitation rates • Stock appropriate genetic strains to maintain local adaptation • Cost-benefit analysis of stocking policies for maintaining the fishery • Alter inland fishery management to what the lake can currently support • Increase protection of forested watersheds
Conservation	• Continue long-term monitoring programs of sentinel lakes • Purchase land in watersheds of resilient lakes with high-value fisheries • Add structural habitat that is resilient to water level fluctuations • Reduce nutrient loading in watersheds to reduce anoxic conditions and maintain available cold- and cool-water fish habitat • Stock genetically resilient strains
Engineering	• Artificial aeration of lakes with low dissolved oxygen to provide refugia for cold-water fish species

Adaptation Actions

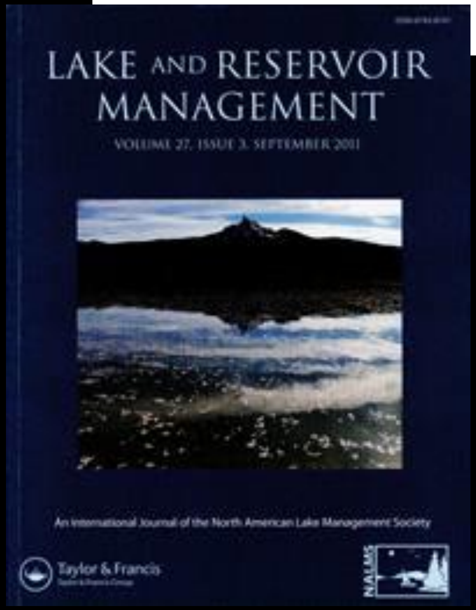


slide from Gretchen Hansen

Resources

Scientific advances and adaptation strategies for Wisconsin lakes facing climate change

Madeline R. Magee*[1,2], Catherine L. Hein[2], Jake R. Walsh[1], P. Danielle Shannon[3,4], M. Jake Vander Zanden[1], Tim B. Campbell[5,6], Gretchen J.A. Hansen[7], Jennifer Hauxwell[5], Gina D. LaLiberte[2], Timothy P. Parks[8], Greg G. Sass[9], Christopher W. Swanston[5,10], Maria K. Janowiak[5,10]



Wisconsin's climate is changing, and our lakes will continue to experience direct and indirect impacts from these changes.

This publication provides guidance on how **climate changes will alter our lake ecosystems,** and how **lake managers can prepare for and adapt to** those changes.

Scenarios of a State of Change: Lakes

Wisconsin has 15,074 documented lakes, ranging in size from one acre lakes to the 137,708-acre Lake Winnebago. Almost 3 percent of Wisconsin's area – nearly a million acres – is lakes. These lakes are integral to the cultural identity of our state.

However, Wisconsin's climate is changing, and warmer temperatures and changes in precipitation will bring changes to our lakes.

Look inside for a snapshot of what we can expect from Wisconsin's climate and weather by the year 2050, and how lake managers can adapt to these changing conditions.

Acknowledgements

Wisconsin Initiative on Climate Change Impacts

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- Samantha Oliver, Patricia Moran, Robert Wakeman, Catherine Hein, Greg Sass, Tim Parks, Tim Campbell, Gina LaLiberte
- Daniel Vimont, Katie Hein, Jake Vander Zanden, Gretchen Hansen, Lisa David, Jordan Read, Wes Larson, Nels Paulson, P. Danielle Shannon, Peter Jacobson

Workshop Co-Sponsors

Questions?

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