Impacts of Climate Change on Lake Ecology

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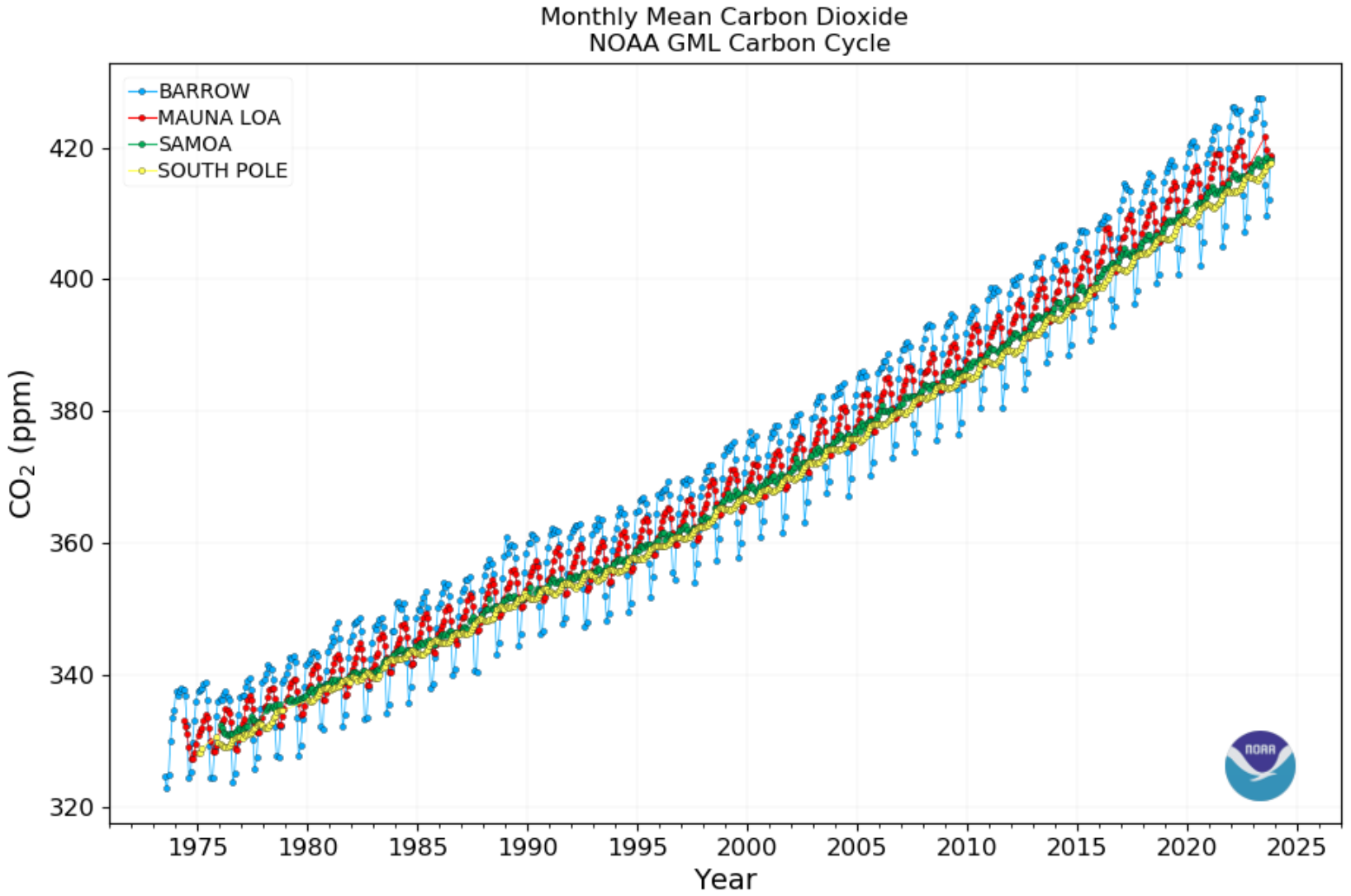
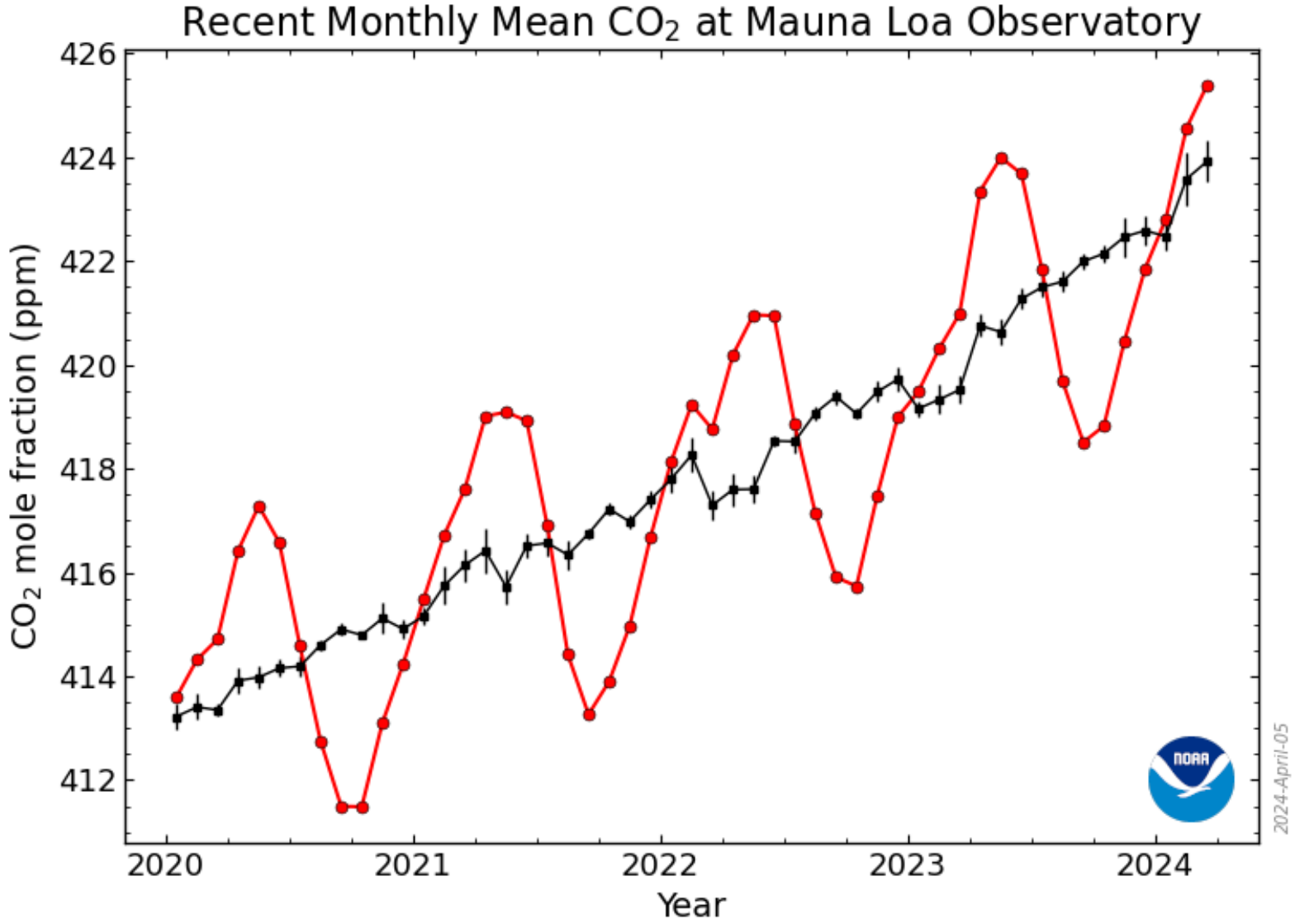
Climate Change



Atmospheric carbon dioxide mixing ratios determined from the continuous monitoring programs at the 4 Baseline Observatories. Contact: Dr. Arlyn Andrews, NOAA Global Monitoring Laboratory, Boulder, Colorado, arlyn.andrews@noaa.gov, https://gml.noaa.gov/ccgg/.



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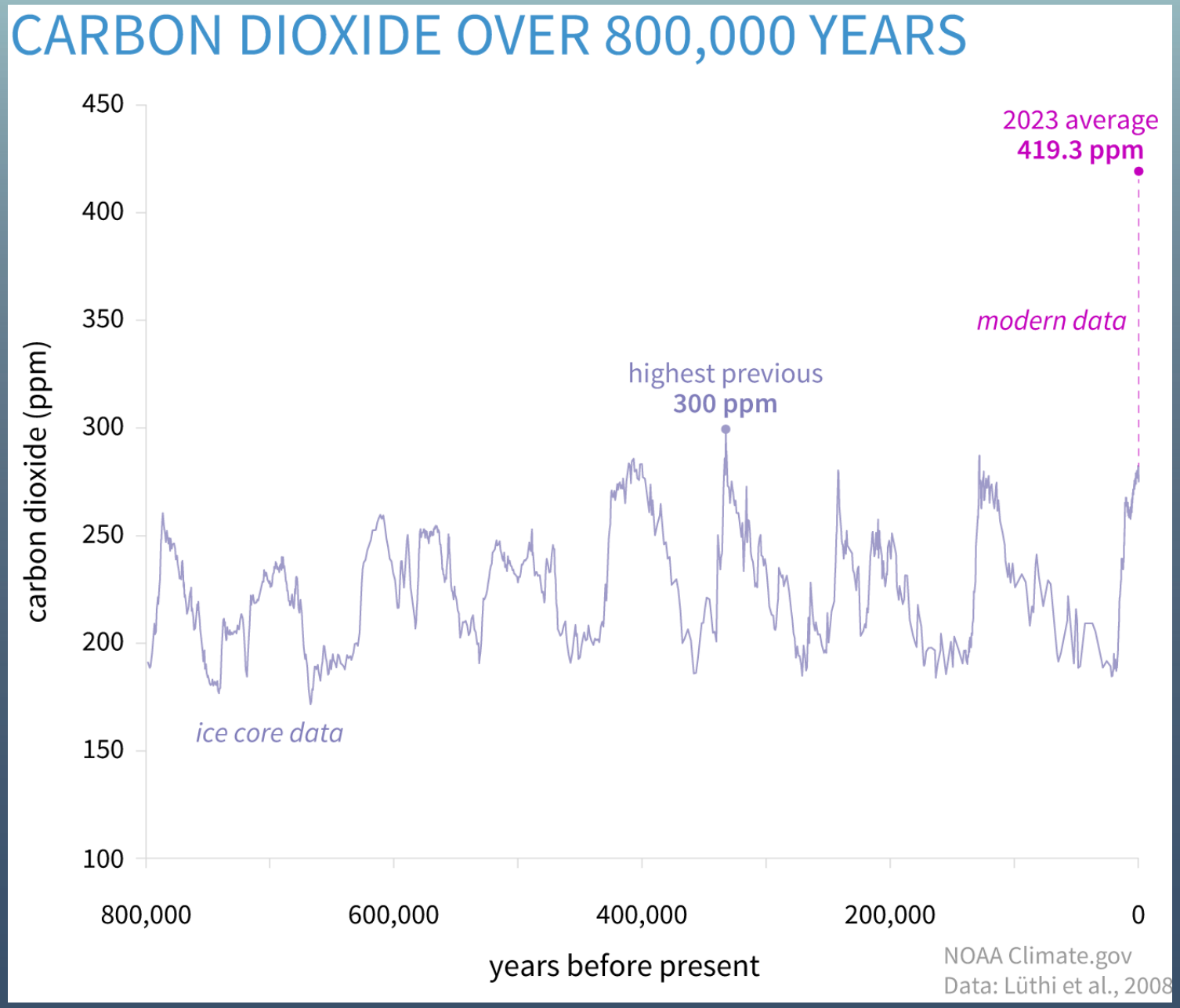
CARBON DIOXIDE OVER 800,000 YEARS



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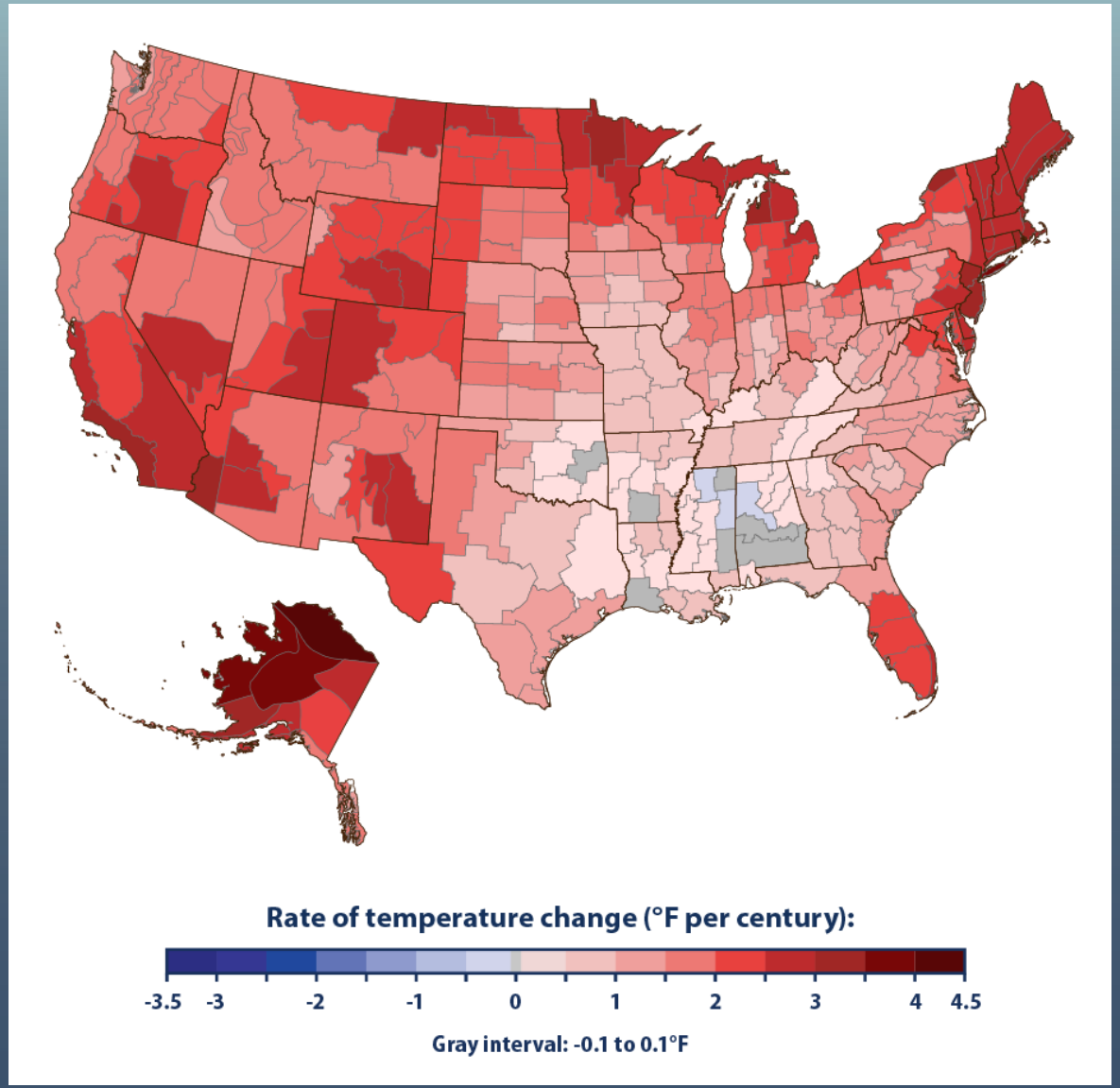
Temperature Change

- ✓ 1901 – 2021
- ✓ Increase rate of change in New England / Mid-Atlantic, Northeast Minnesota



Source: NOAA

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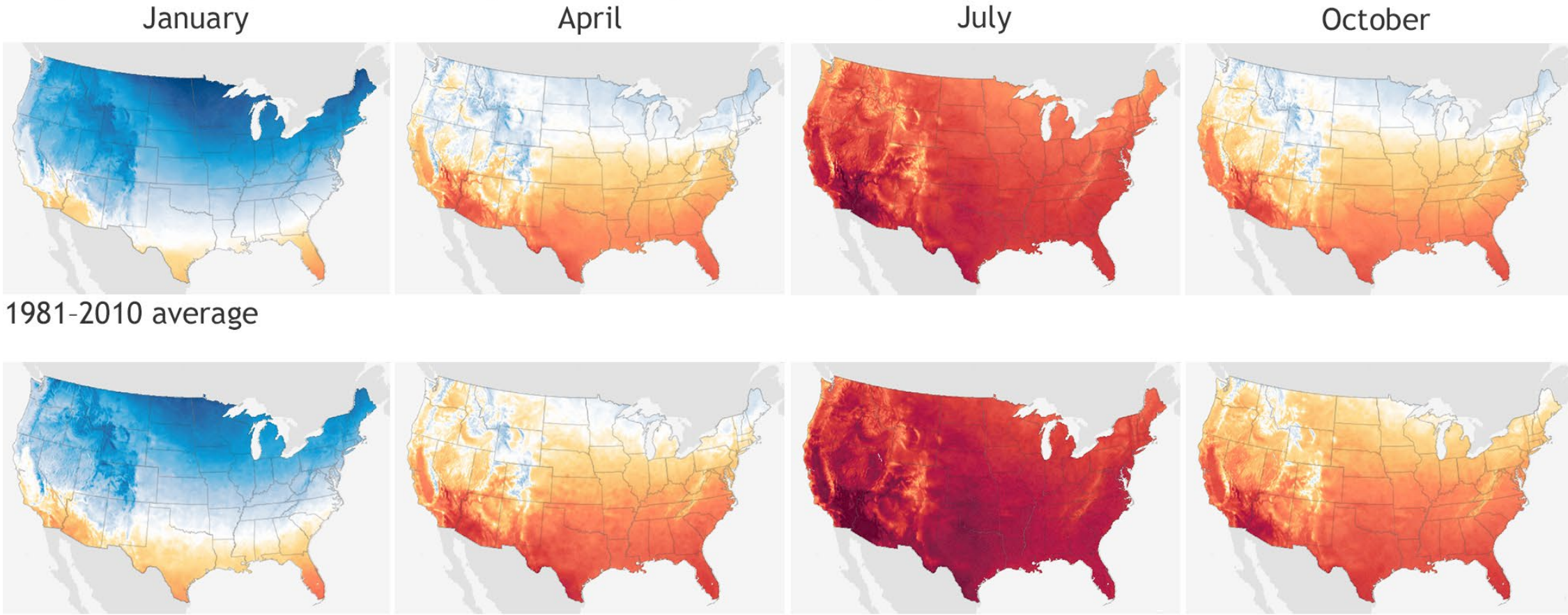
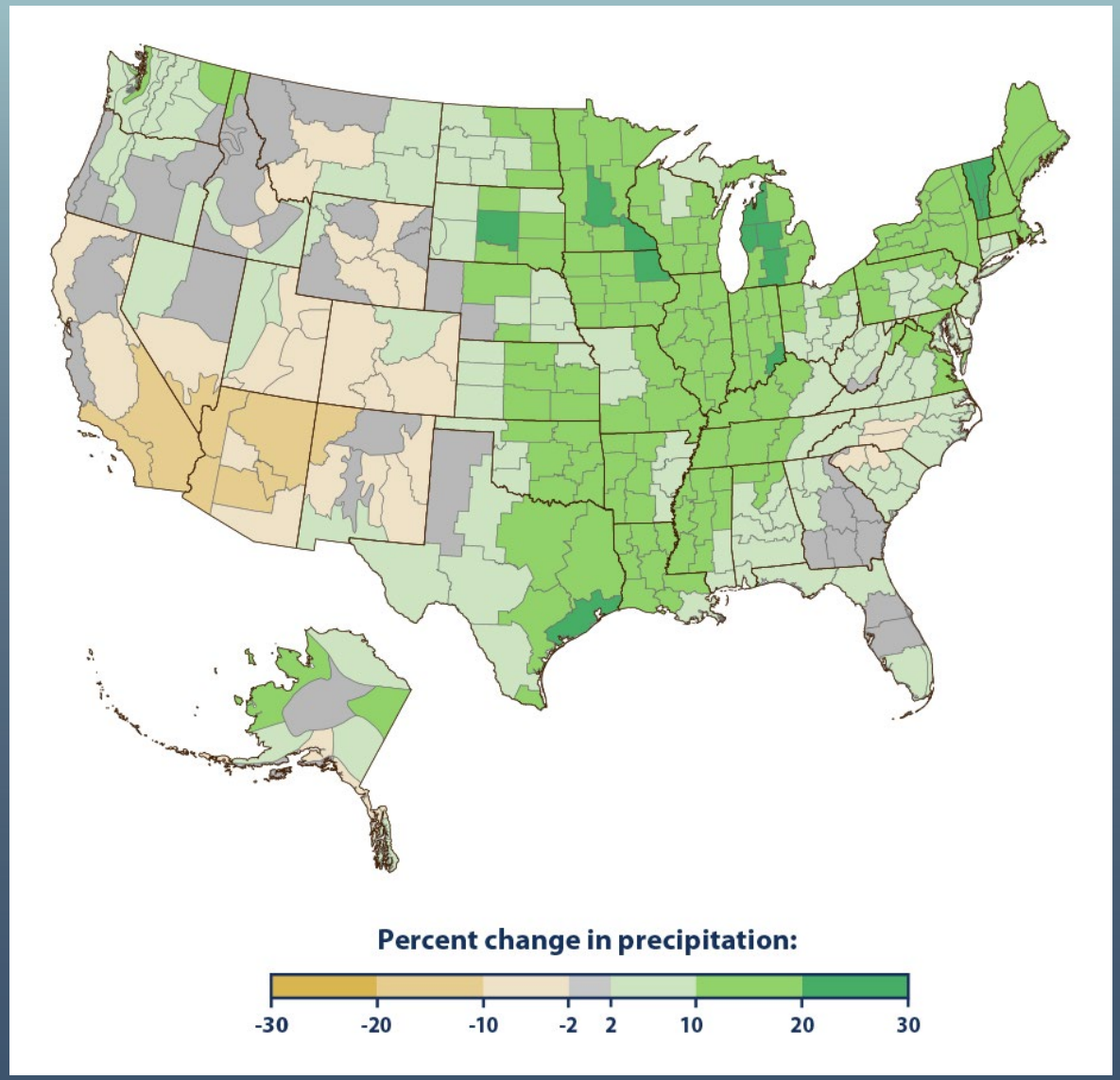
Projected changes in U.S. temperatures by mid-century



Precipitation Change

- ✓ 1901 – 2021
- ✓ Increase in Mississippi River Basin, New England, and Mid-Atlantic
- ✓ Contiguous US – 0.20" increase per decade



Source: NOAA

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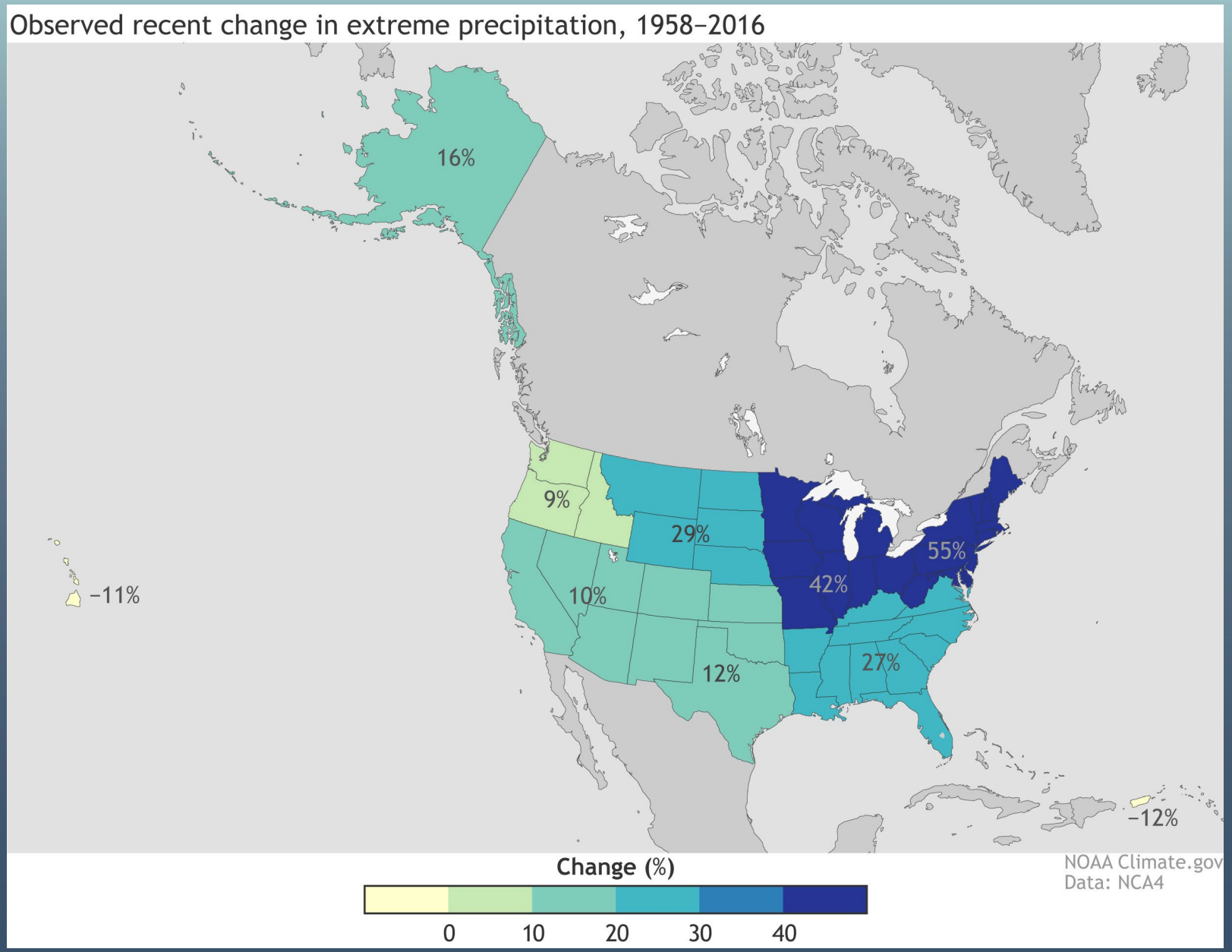
Recent Changes in Extreme Precipitation



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Source: NOAA

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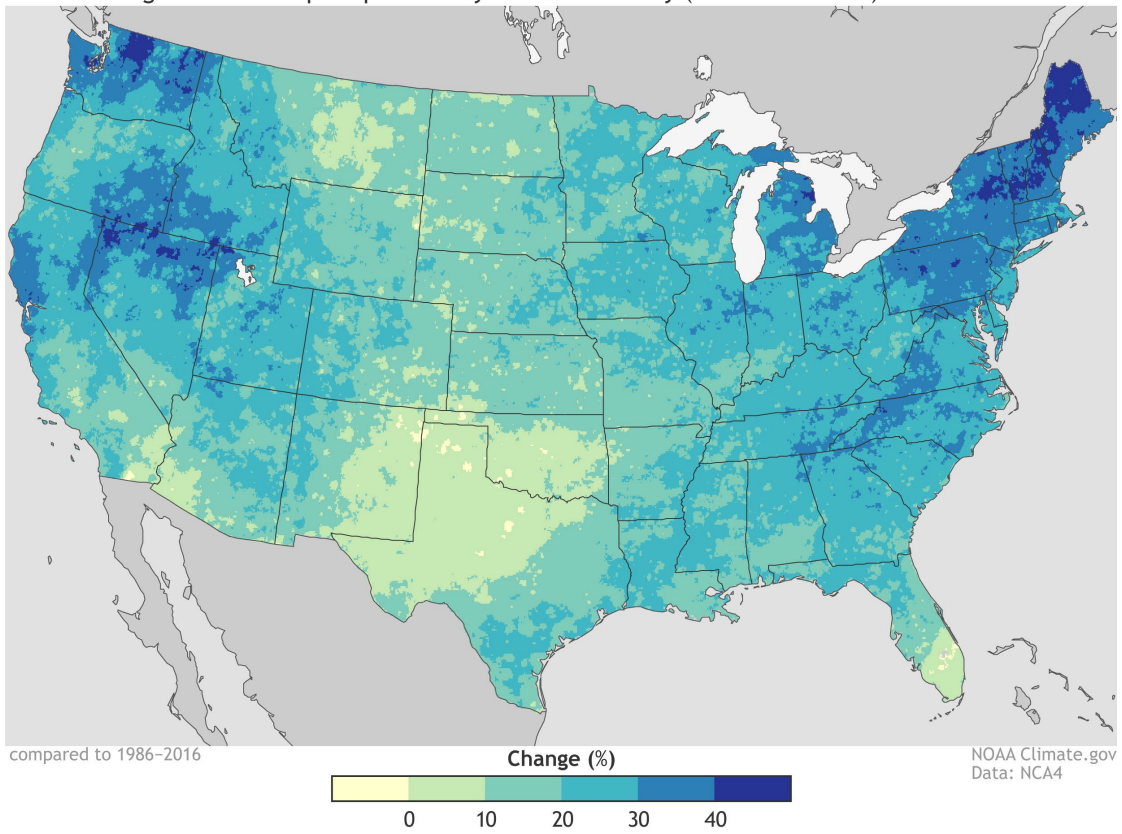
Future change in extreme precipitation by late 21st century (lower emissions)



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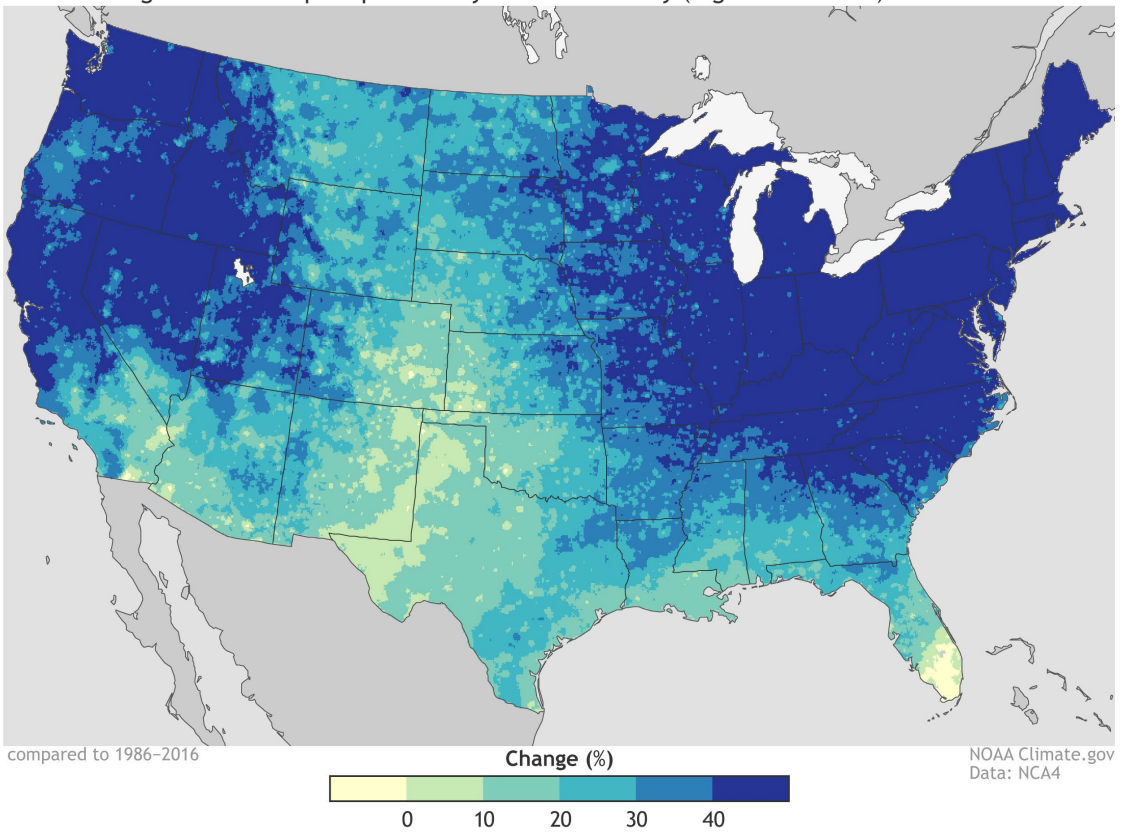


Source: NOAA

Direct & Indirect Effects

Heat

- ✓ Warming temperatures
- ✓ Loss of ice cover
- ✓ Increase in evaporation
- ✓ Changes in mixing regimes
- ✓ Reductions in level
- ✓ Increased primary productivity
- ✓ Reduced ability to hold oxygen
- ✓ Changing fishery communities

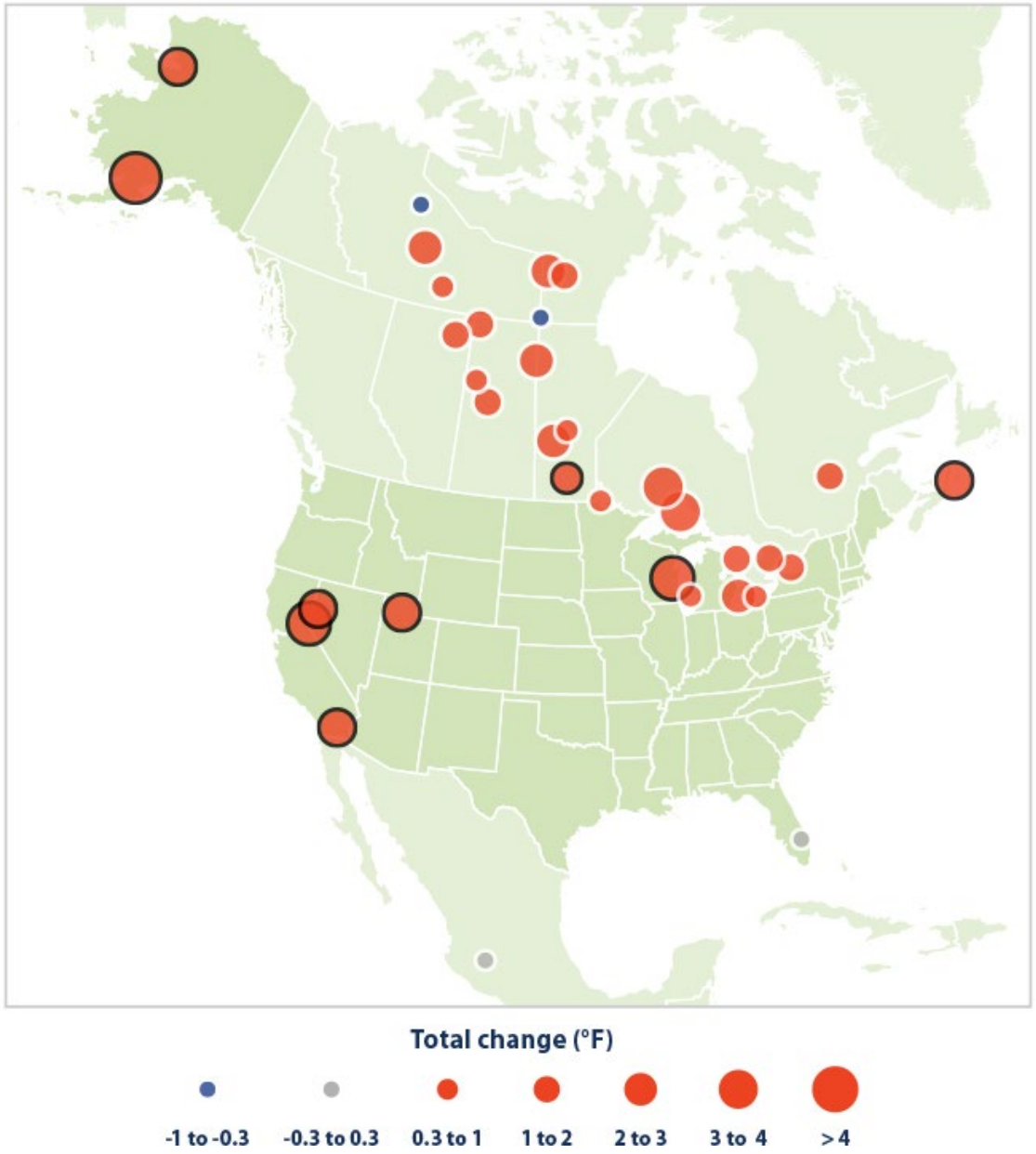
Rainfall

- ✓ Increased stream discharge
- ✓ Changed stormwater flow / management
- ✓ Increase in NPS pollutant loading
- ✓ Changes in lake level
- ✓ Wetland habitat changes

Invasive Species

- ✓ Latitudinal migration
- ✓ Range retraction
- ✓ Increase in flood dispersal
- ✓ Construction of new reservoirs
- ✓ Increased global trade

Heat



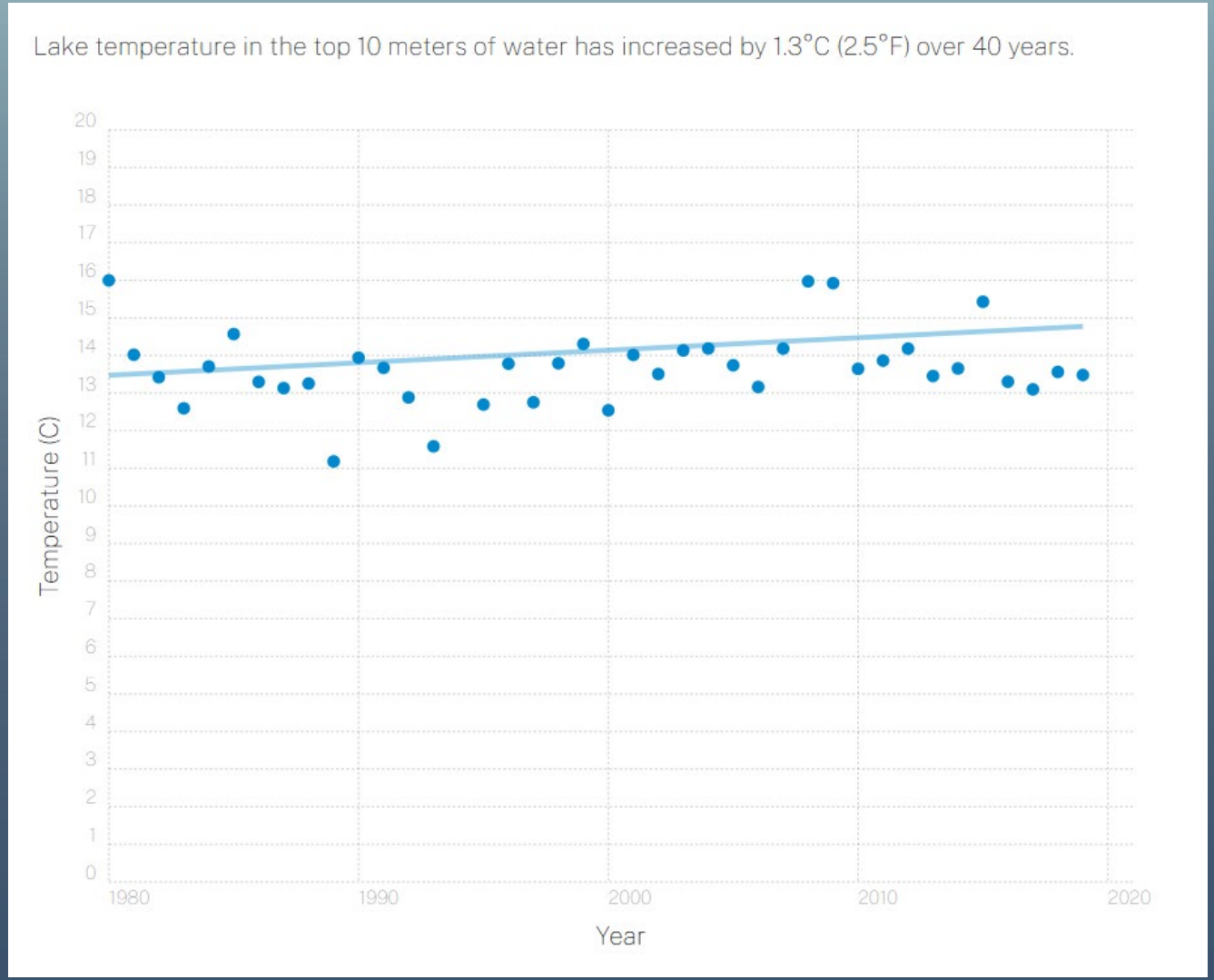
Lake Temperature Change

- 1985 – 2009
- Satellite measures of surface water temperature change
- Sharma, et al., 2015

Lake George Temperature

Temperature in Upper 10 m
+1.3°C over 40 years

Source: The Jefferson Project



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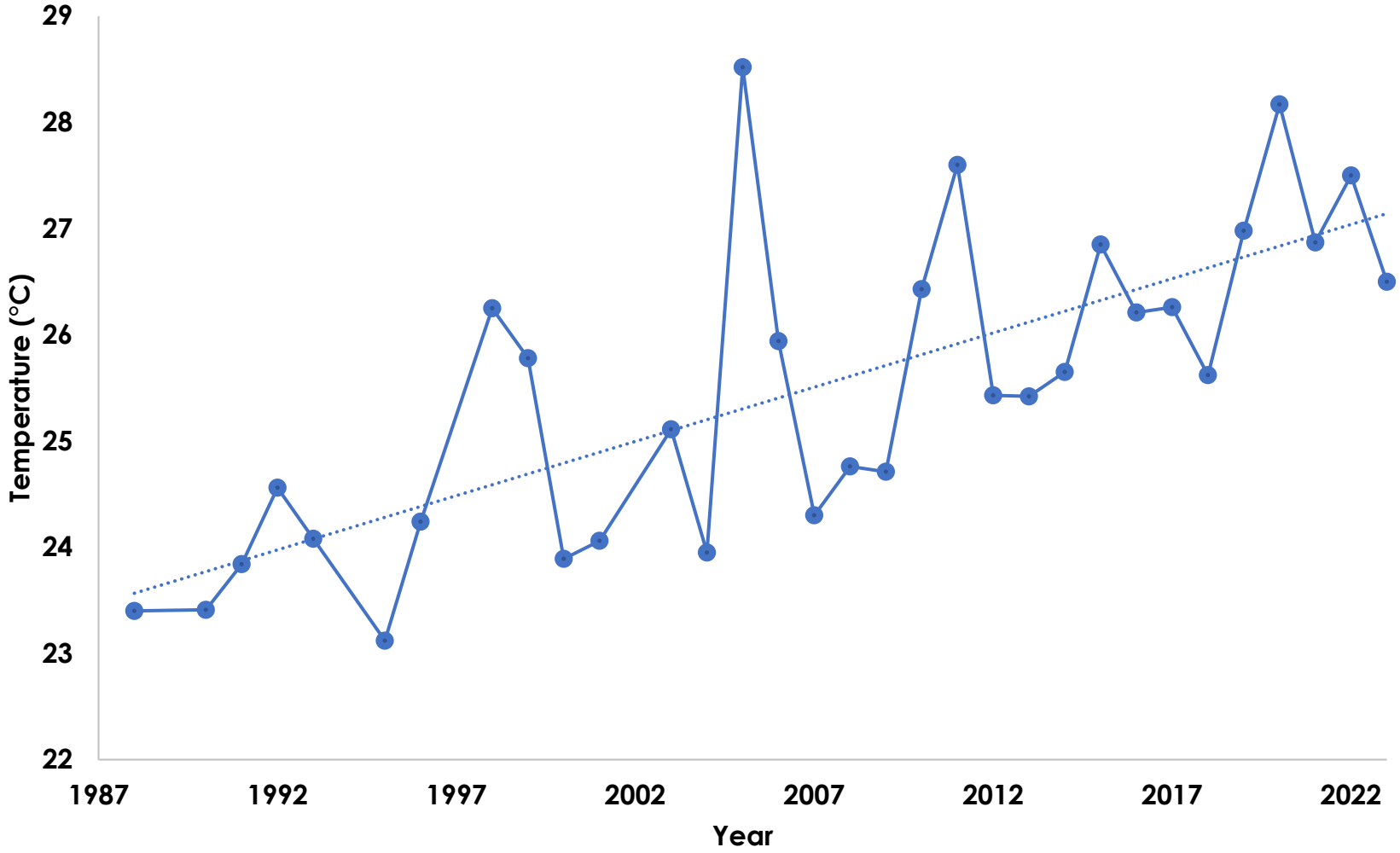

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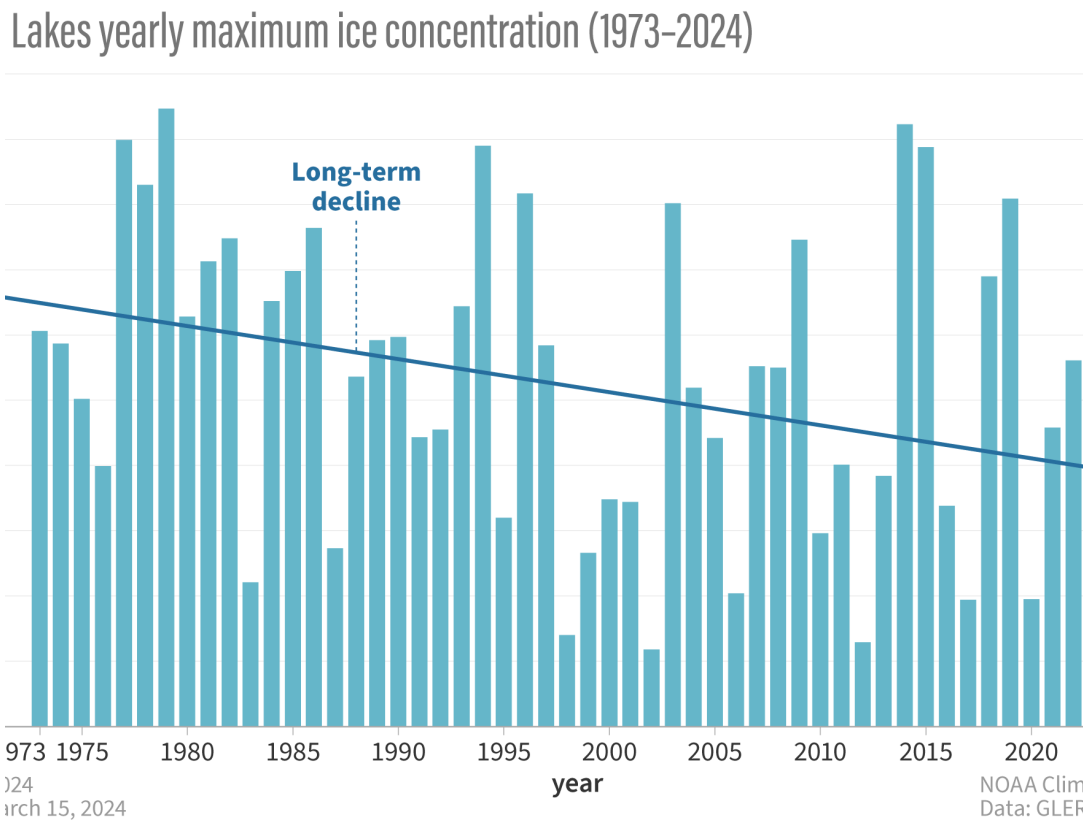
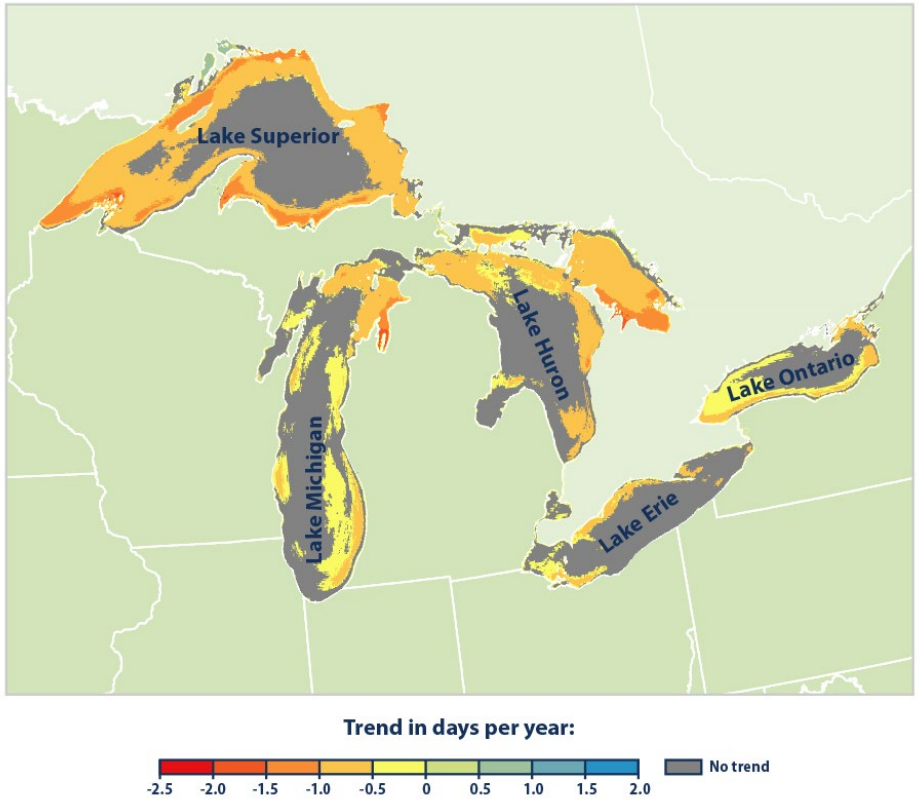
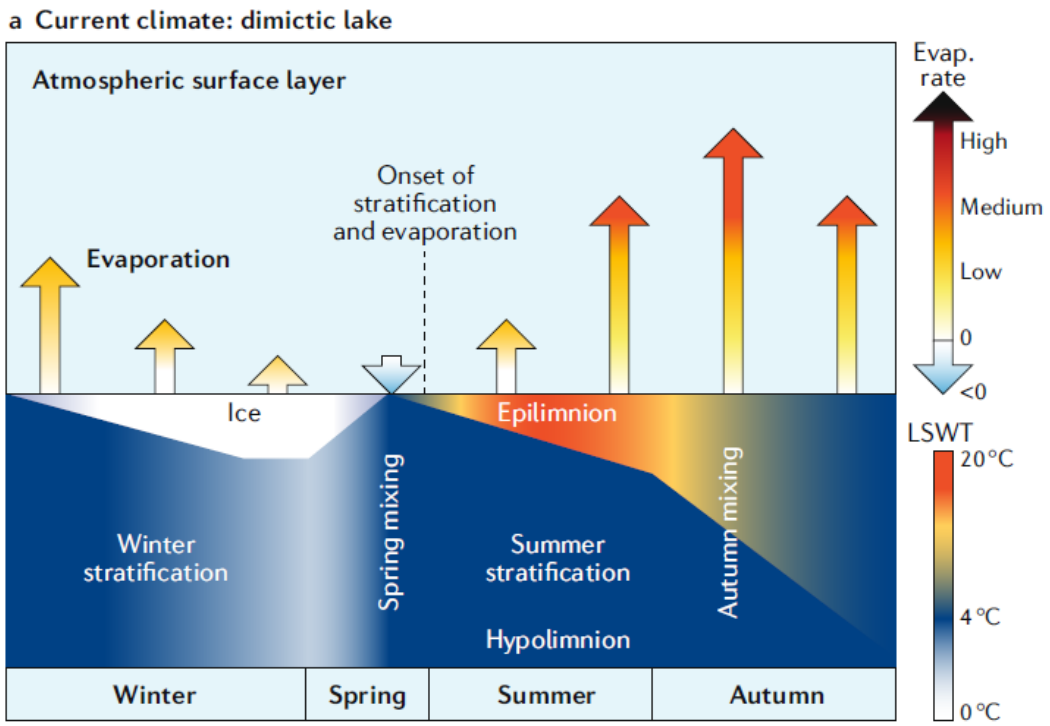
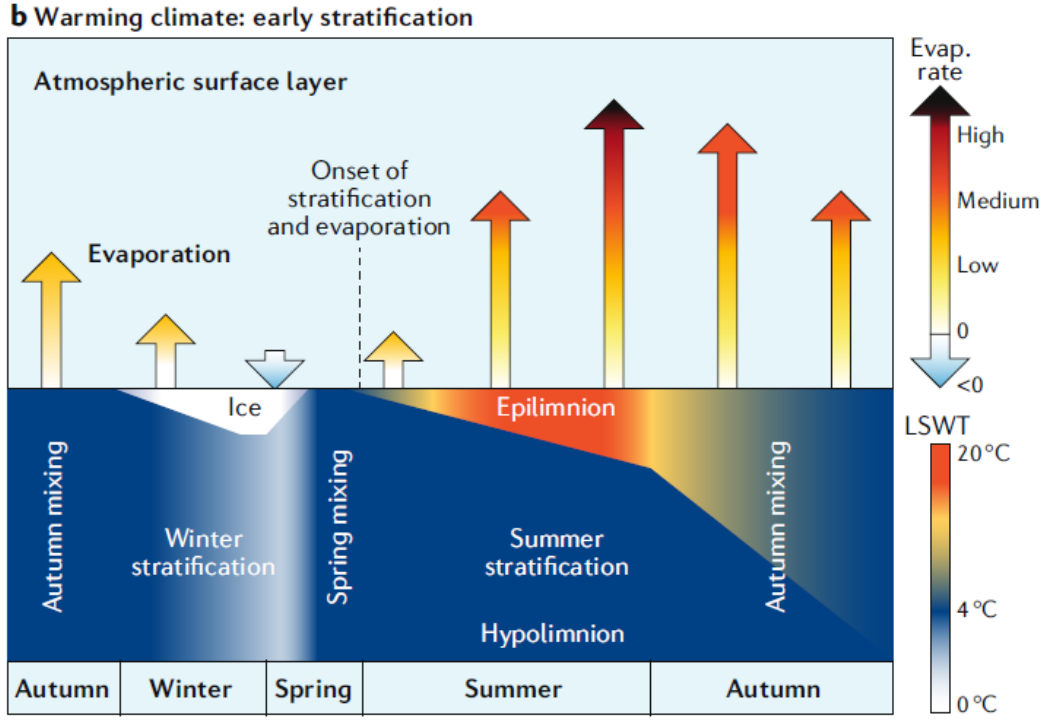
Ice Cover


Lakes yearly maximum ice concentration (1973–2024)
Long-term decline
973 1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
year
024
arch 15, 2024
NOAA Clim
Data: GLER


Lake Superior
Lake Huron
Lake Michigan
Lake Ontario
Lake Erie
Trend in days per year:
-2.5
-2.0
-1.5
-1.0
-0.5
0
0.5
1.0
1.5
2.0
No trend

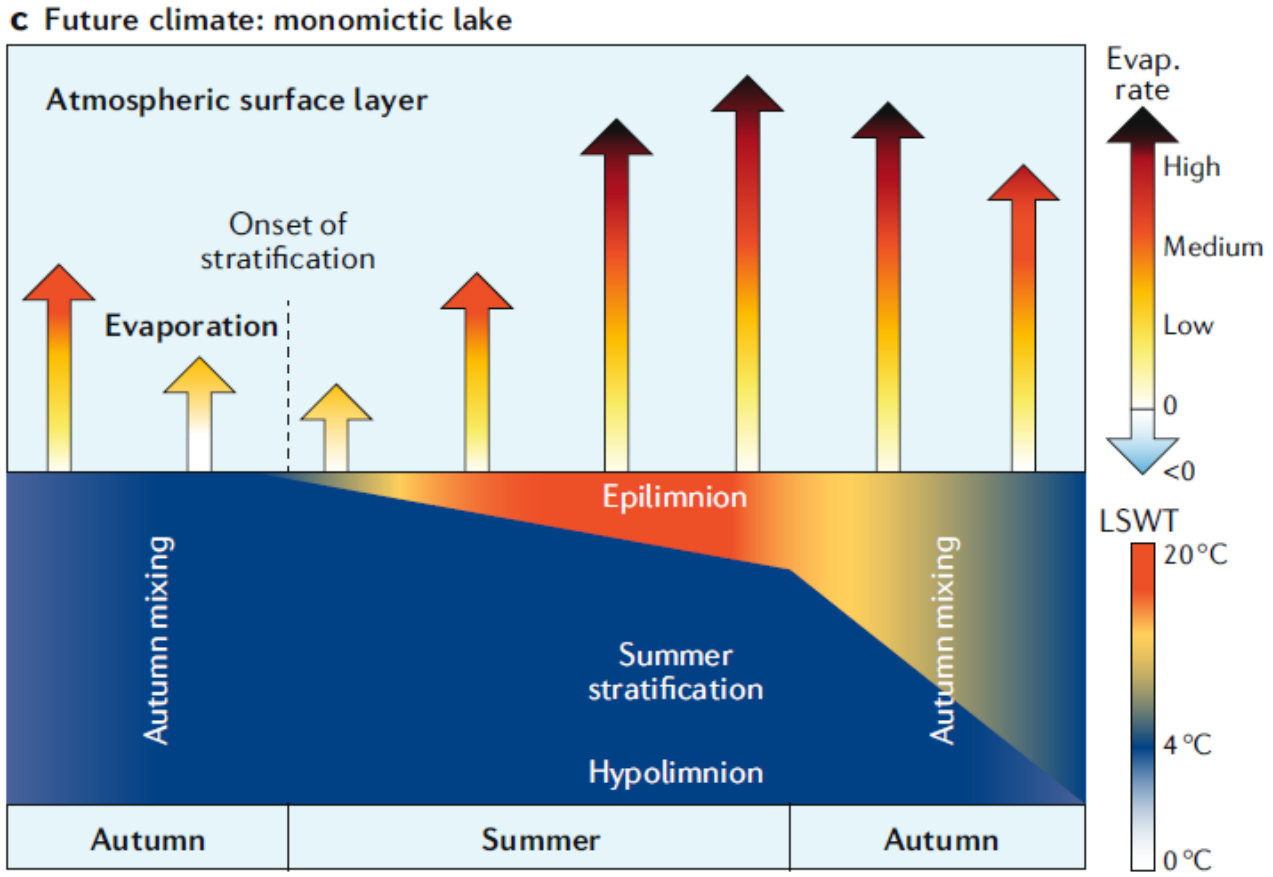
Thermal and Mixing Regimes





Source: Woolway, et al., 2020

Thermal and Mixing Regimes - Future



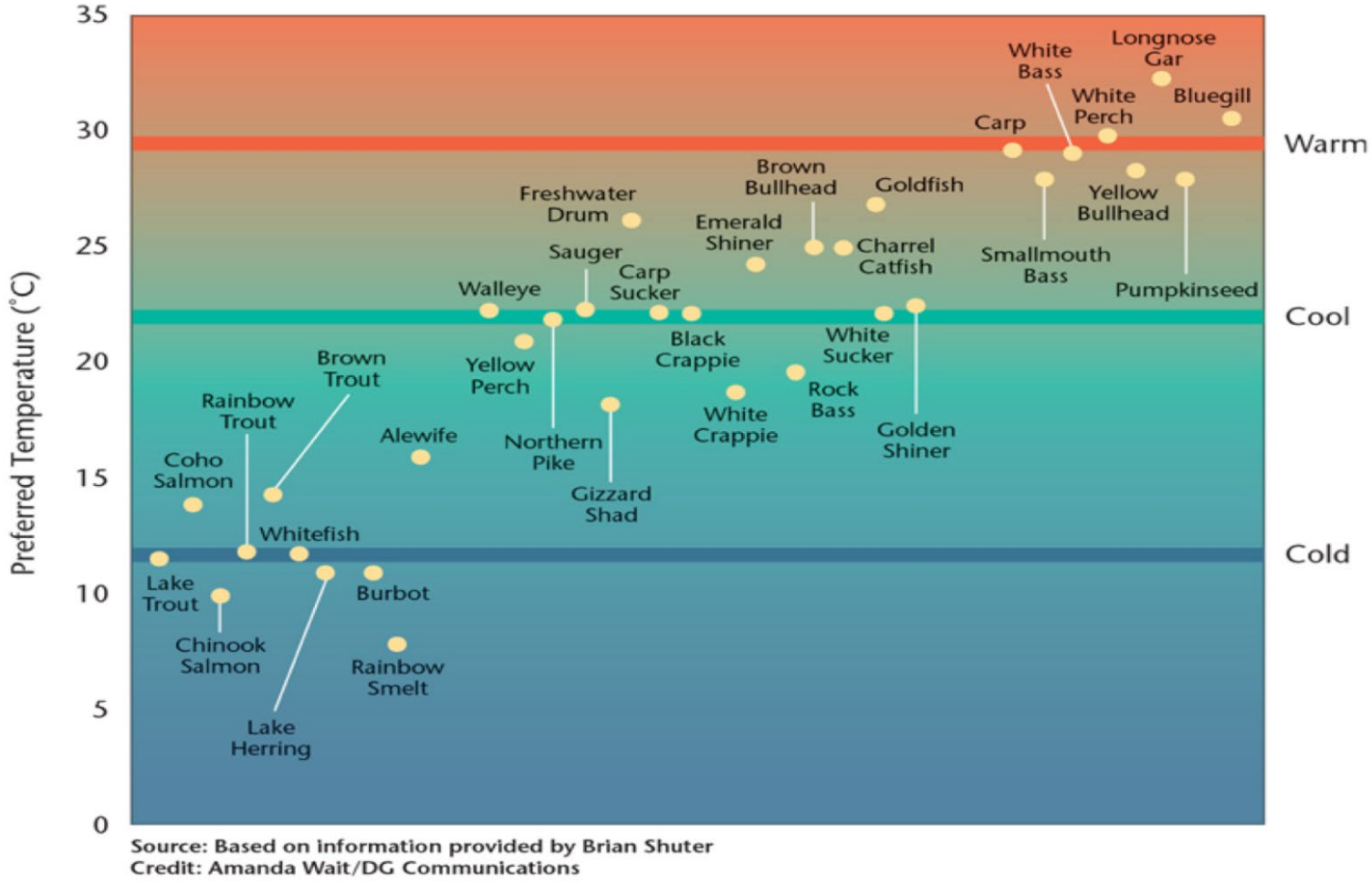
Source: Woolway, et al., 2020

Fish Distributions

FIGURE 23

Temperature Groupings of Common Great Lakes Fish

from page 53



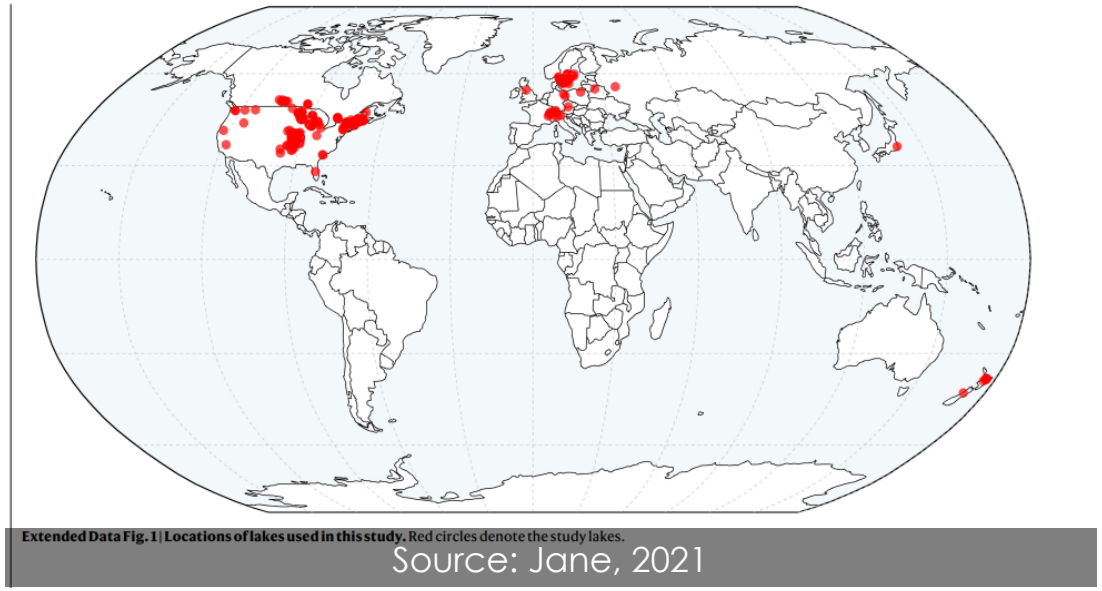
Source: Based on information provided by Brian Shuter
Credit: Amanda Wait/DG Communications

Dissolved Oxygen Depletion

- Jane et al., (2021) looked at 393 lakes with over 45,000 DO/Temperature profiles from 1941 to 2017

- 6% reduction in surface DO and 19% reduction in deep DO

- DO declines in lakes 2.8 to 9.3 times greater than in ocean environments



Extended Data Fig. 1 | Locations of lakes used in this study. Red circles denote the study lakes.

Source: Jane, 2021

Precipitation

Lake Levels

Source: dailyinterlake.com

Source: LCBP

Source: mprnews.org

Shoreline Erosion

Increased Discharge / Nutrient Loading

April 5, 2005 Taughannock Creek photo by Bill Hecht

April 5, 2005 CAYUGA LAKE view south from Townline Road, photo by Bill Hecht

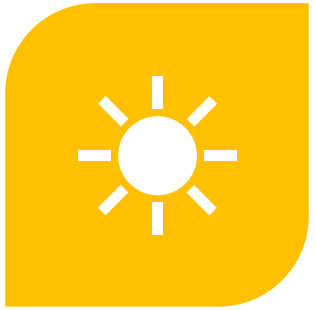
Source: usra.edu

Invasive Species

Vector and Habitat Changes

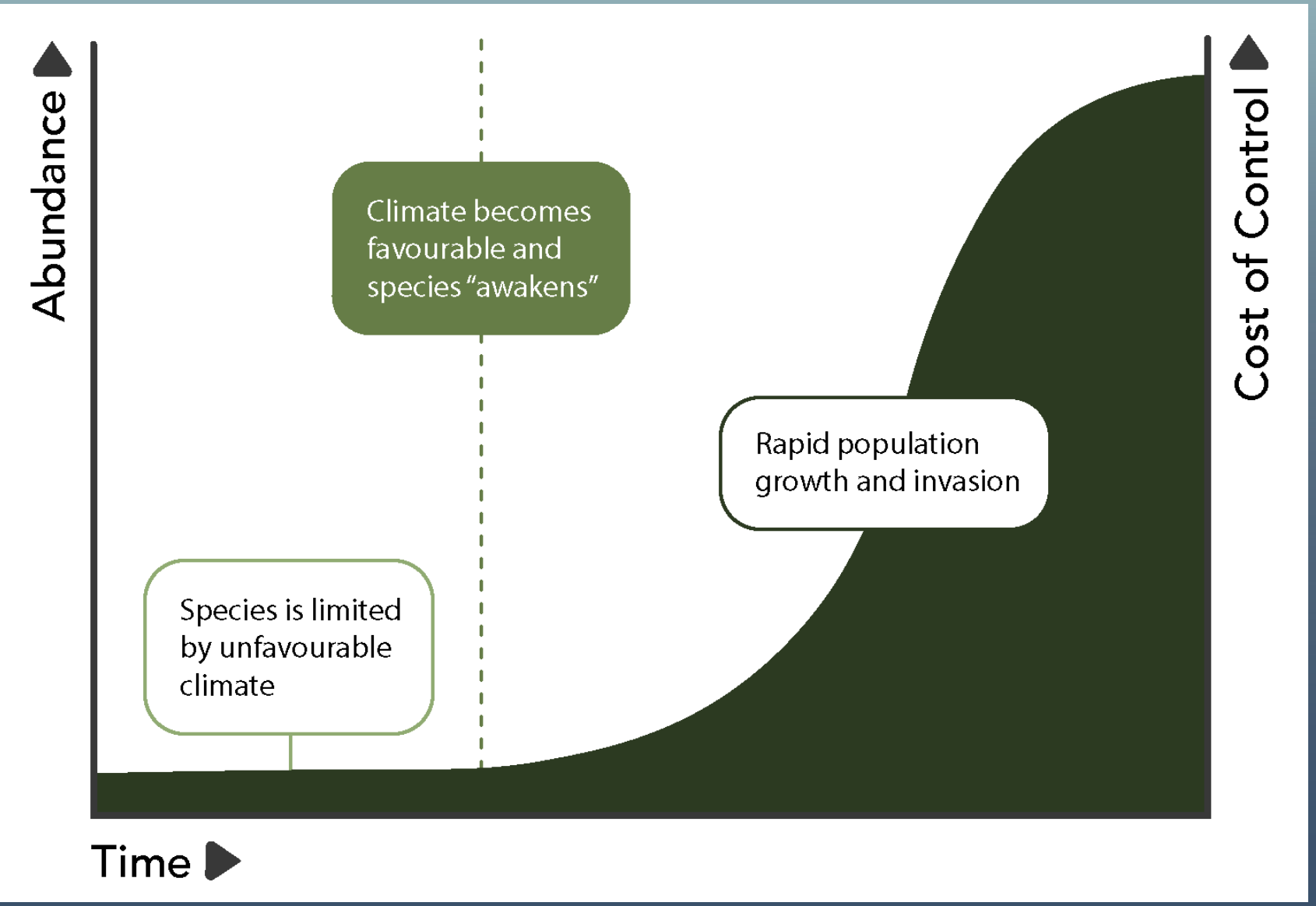
INCREASED FLOODING – MORE DISPERSAL

REDUCED COLD TEMPERATURE ALLOW NORTHERN MIGRATION



INCREASED HEAT IN SOUTHERN RANGE CAUSES NATIVES TO RETRACT NORTH

INCREASED RESERVOIR CONSTRUCTION / RECREATION AS HOTSPOTS

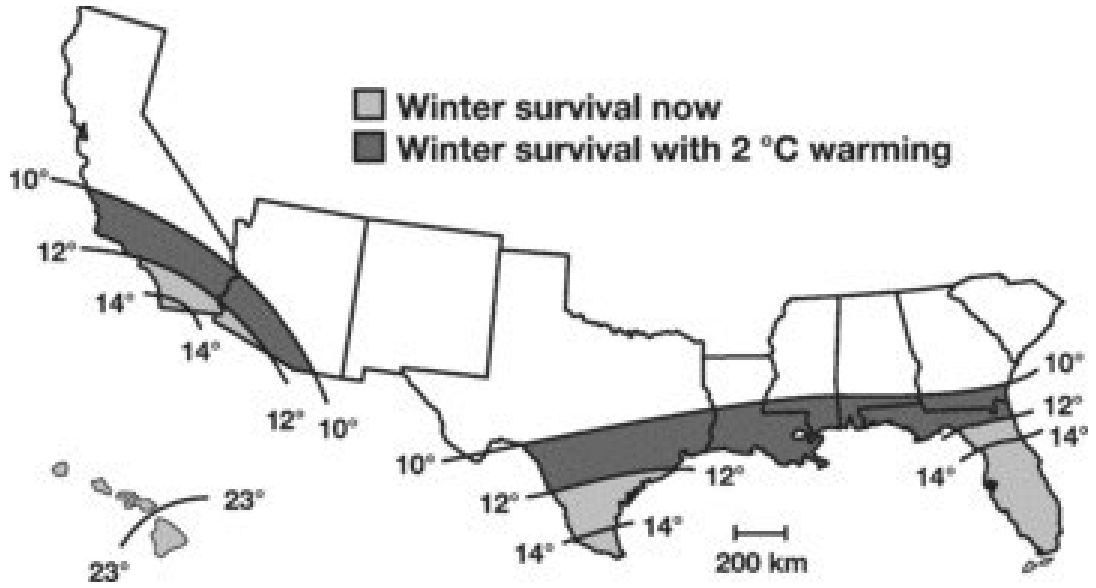


Source: ICAIS

Plankton

Source: Michigan State University

Migration



Source: Bennett et al., 1997

Source: SC Fish Keeping

Source: tnic.org

Source: tnic.org

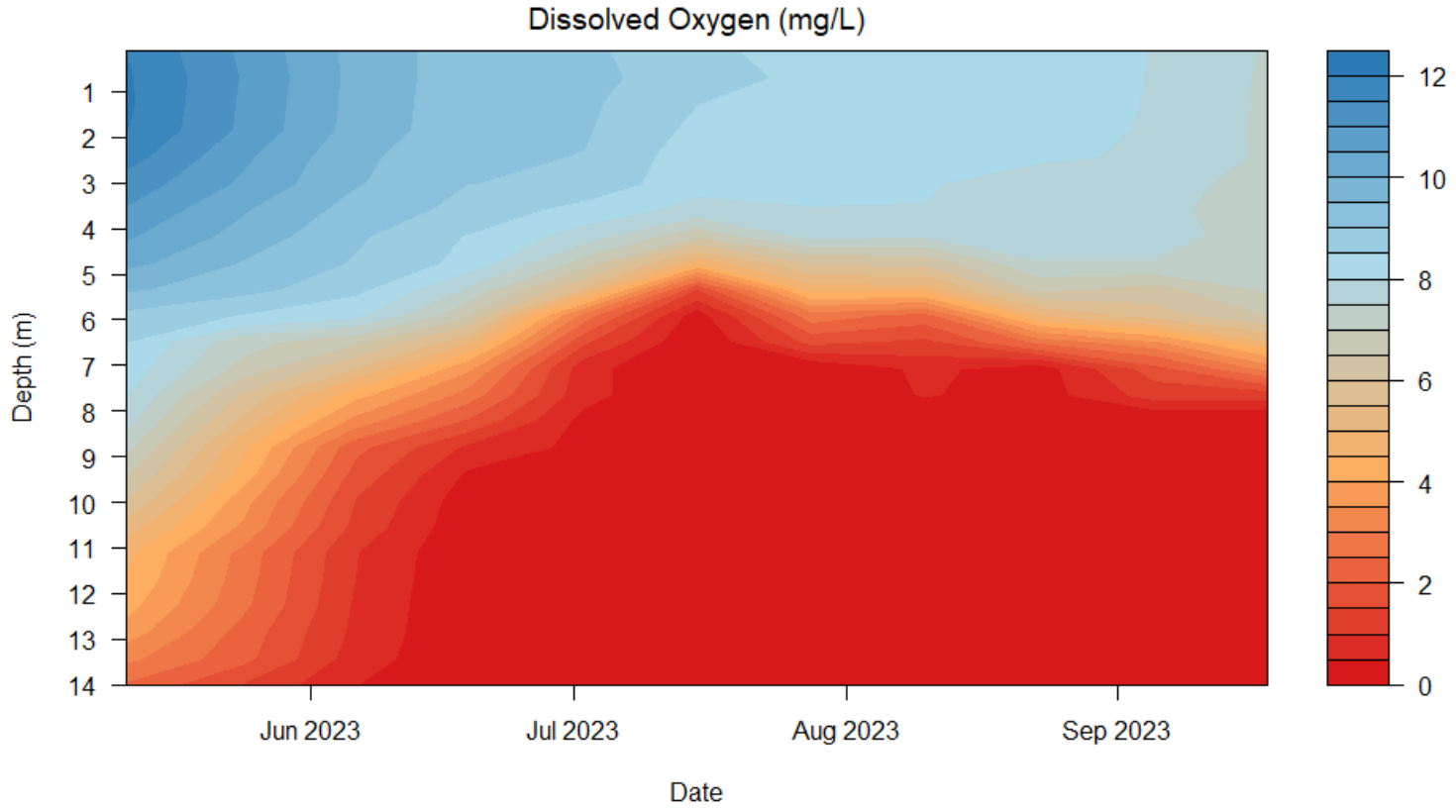
Source: Wilfredo Robles

Source: Troy Evans

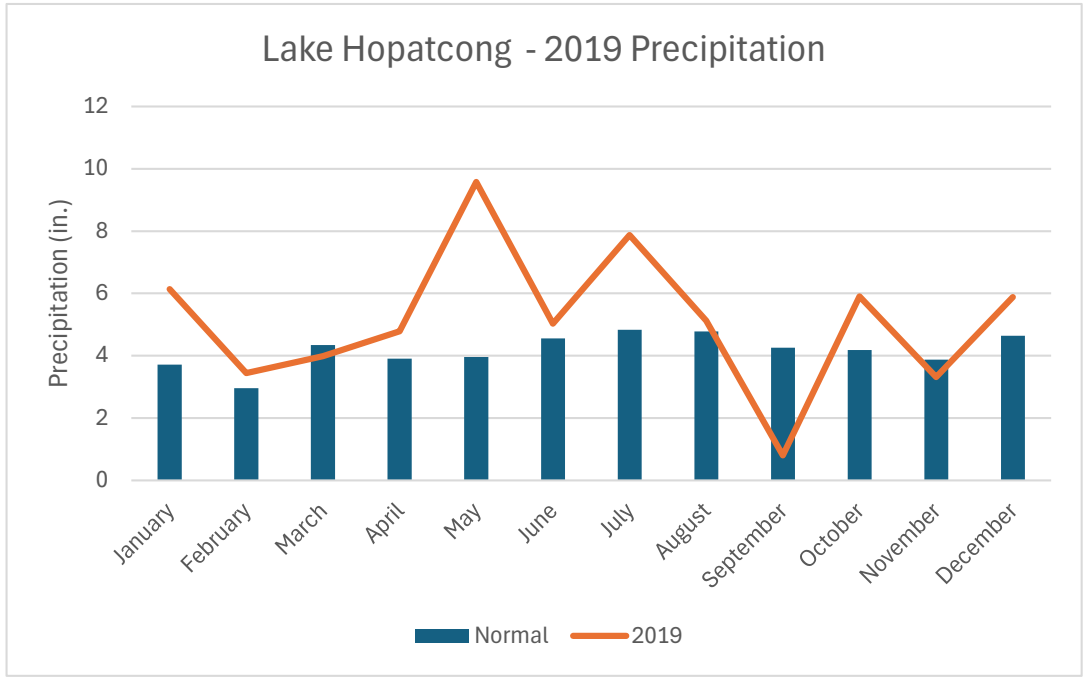
Source: tnic.org / Richard Old

Implications for Management

Increasing Anoxia

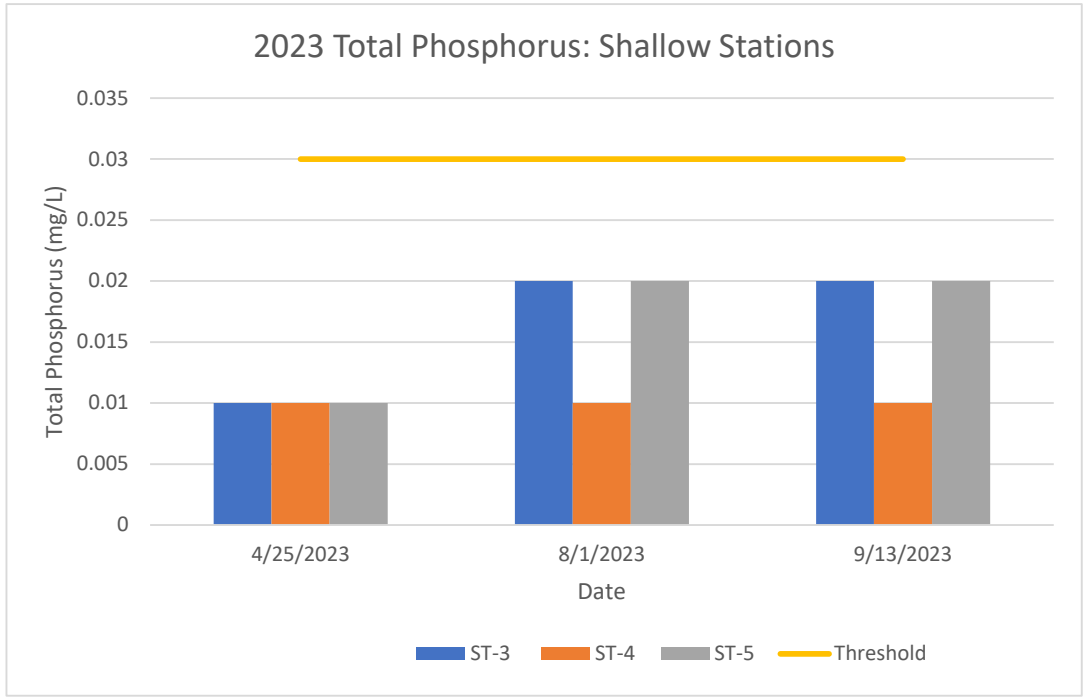


Heavy Rainfall / HABs



Source: NJDEP

Late-Season HABs / Low P

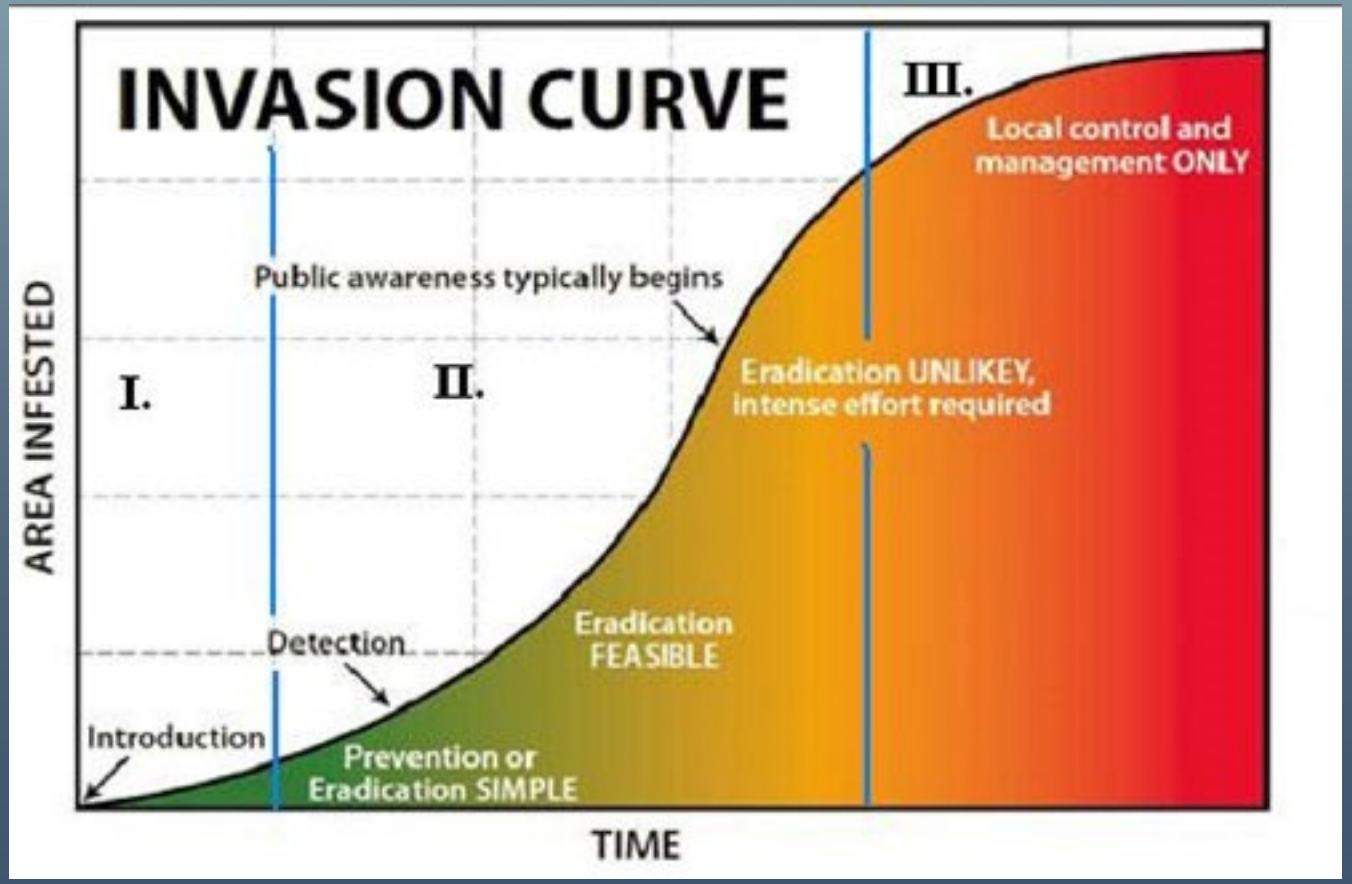


Stormwater Design for the Future

- NJ Inland Flood Protection Rule
- Requires use of projected precipitation when calculating flood elevations
- Design Flood Elevation
  - 3’ above FEMAs current 100-year flood elevation

Invasive Species

- ✓ Education and dissemination of knowledge of potential new invaders
- ✓ Frequent monitoring to detect new populations
- ✓ Plan in place to address new detections



Source: Cornell Cooperative Extension

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QUESTIONS?

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THANK YOU!

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