Climate Change and Our Lakes: What It Means for New Hampshire

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Where are we Going Today?

- Climate Change Overview: What is involved?
- Pleasant Lake: an example of NH lakes
- Climate change

  1) Warming (increasing temperatures)

  2) Precipitation: Extreme events (droughts, floods)
- Consequences for lakes
- The path forward?

Climate Change

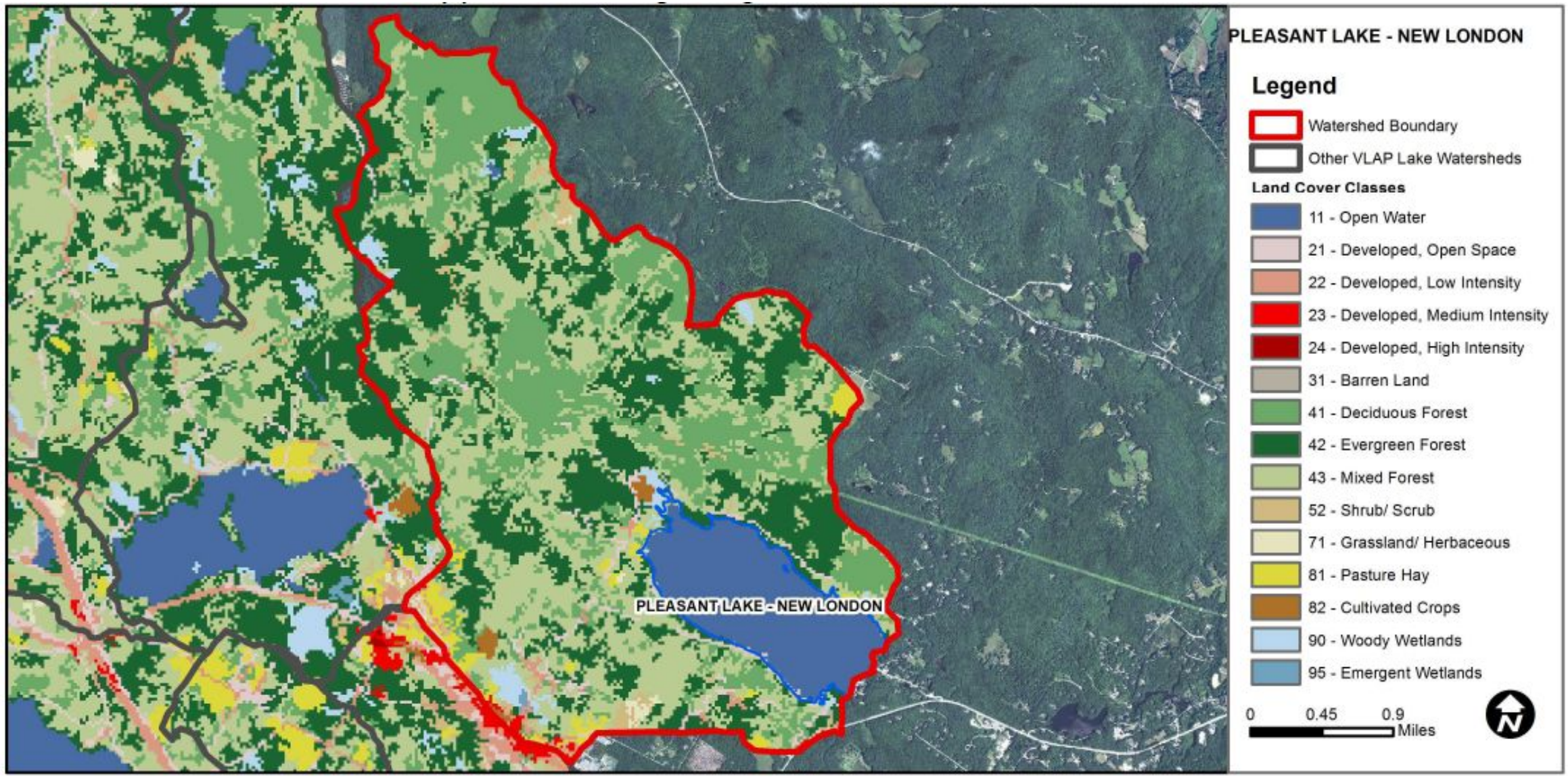
1) **Warming**: warmer air and water temperatures

2) **Extreme precipitation events**: droughts, floods

How is climate change influencing NH lakes?

Pleasant Lake: New London, NH

Pleasant Lake Watershed ***(all lakes have a watershed!)***



Pleasant Lake: New London, NH

One of the gems of NH lakes

1) It is **a headwater lake** (no other upstream lakes in the watershed to contaminate it)
2) There is **minimal human development** in the watershed
3) It is **deep** – Maximum depth is 28.6 m (94 feet)
4) It is **clear** – Secchi transparency is ~ 5-6 meters (~16-20 feet)
5) On average, it has **low phosphorus**, a key nutrient that stimulates cyanobacteria blooms, and **low chlorophyll**, an indicator of total algae (including cyanobacteria)
6) Residents care about the lake, and most want to be good lake stewards

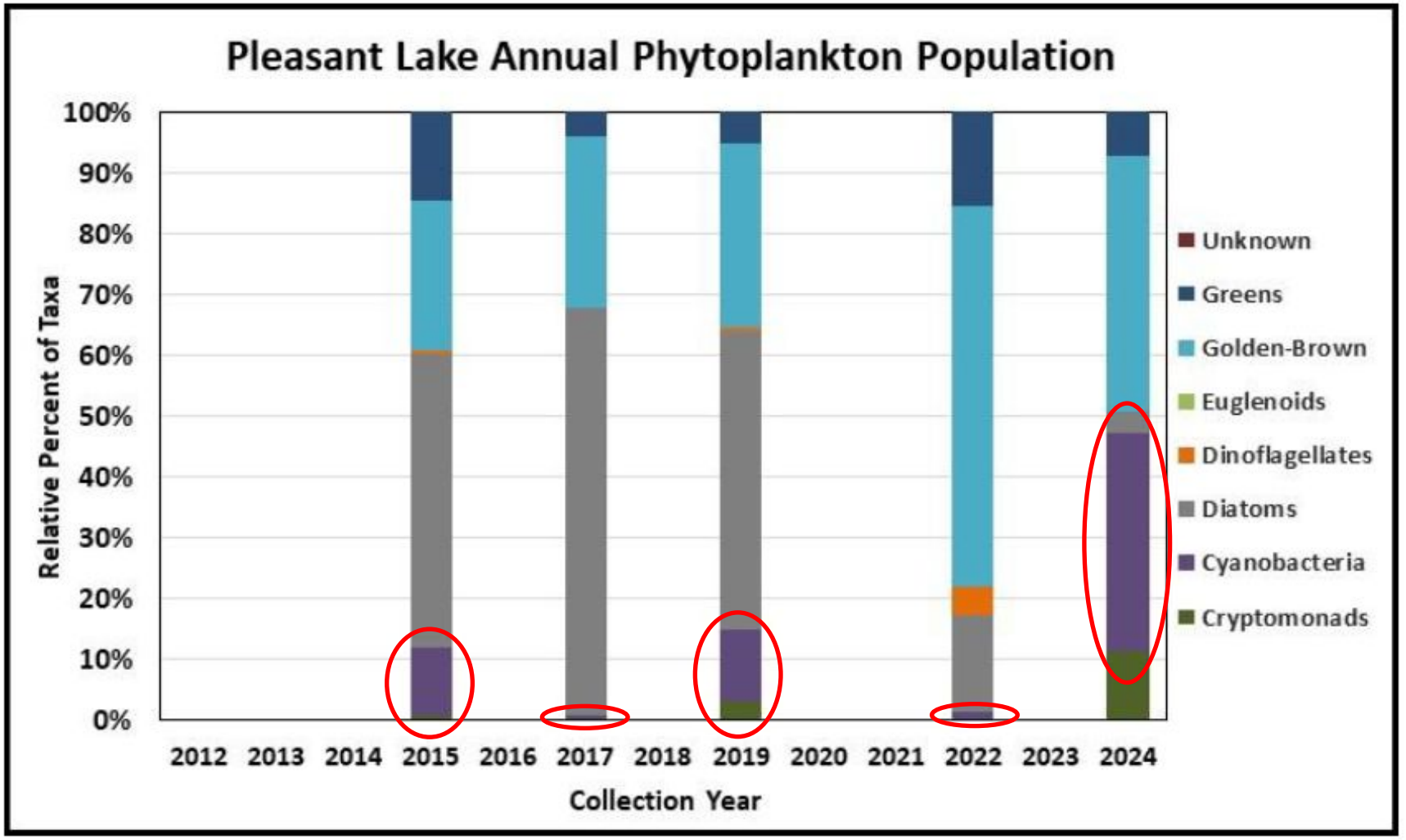
Why, then, is Pleasant Lake experiencing harmful cyanobacteria blooms?

Pleasant Lake: Why Recent Cyanobacteria Blooms?

?

Could climate change play a role in the recent cyanobacteria blooms in Pleasant Lake?

Pleasant Lake phytoplankton (purple is Cyanobacteria)

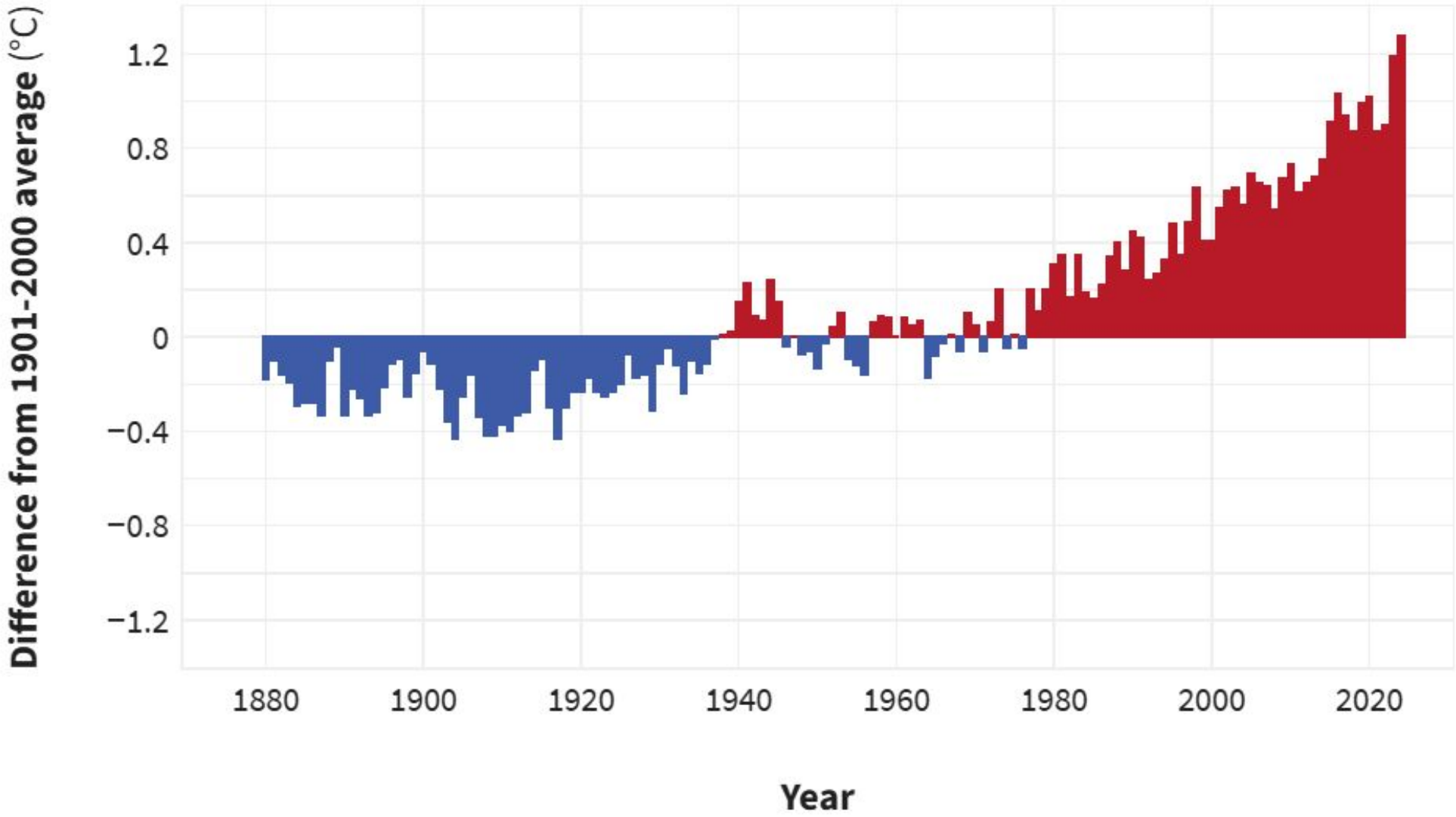


Cyanobacteria were relatively rare until 2024

Warming

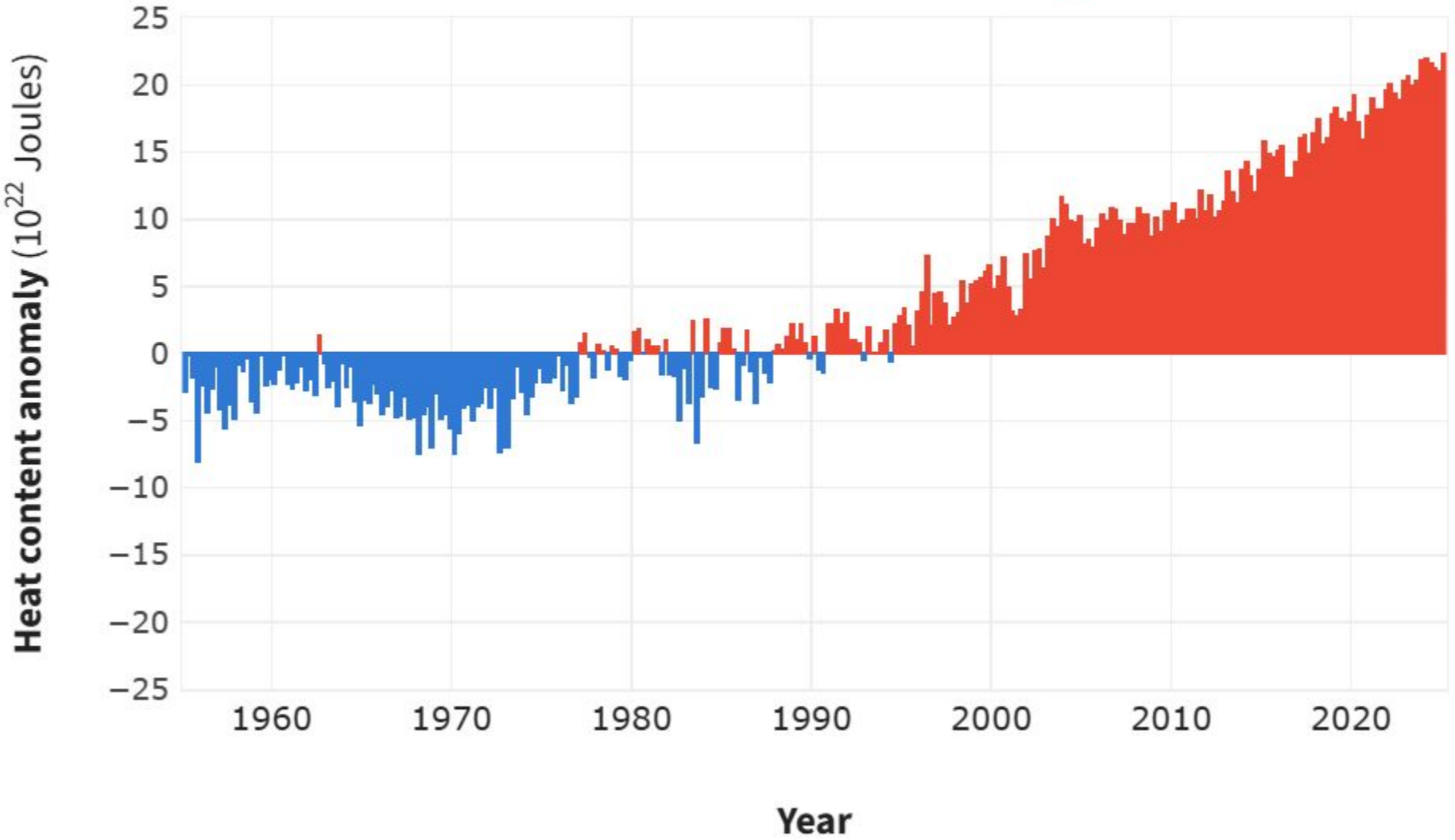
GLOBAL AVERAGE SURFACE TEMPERATURE

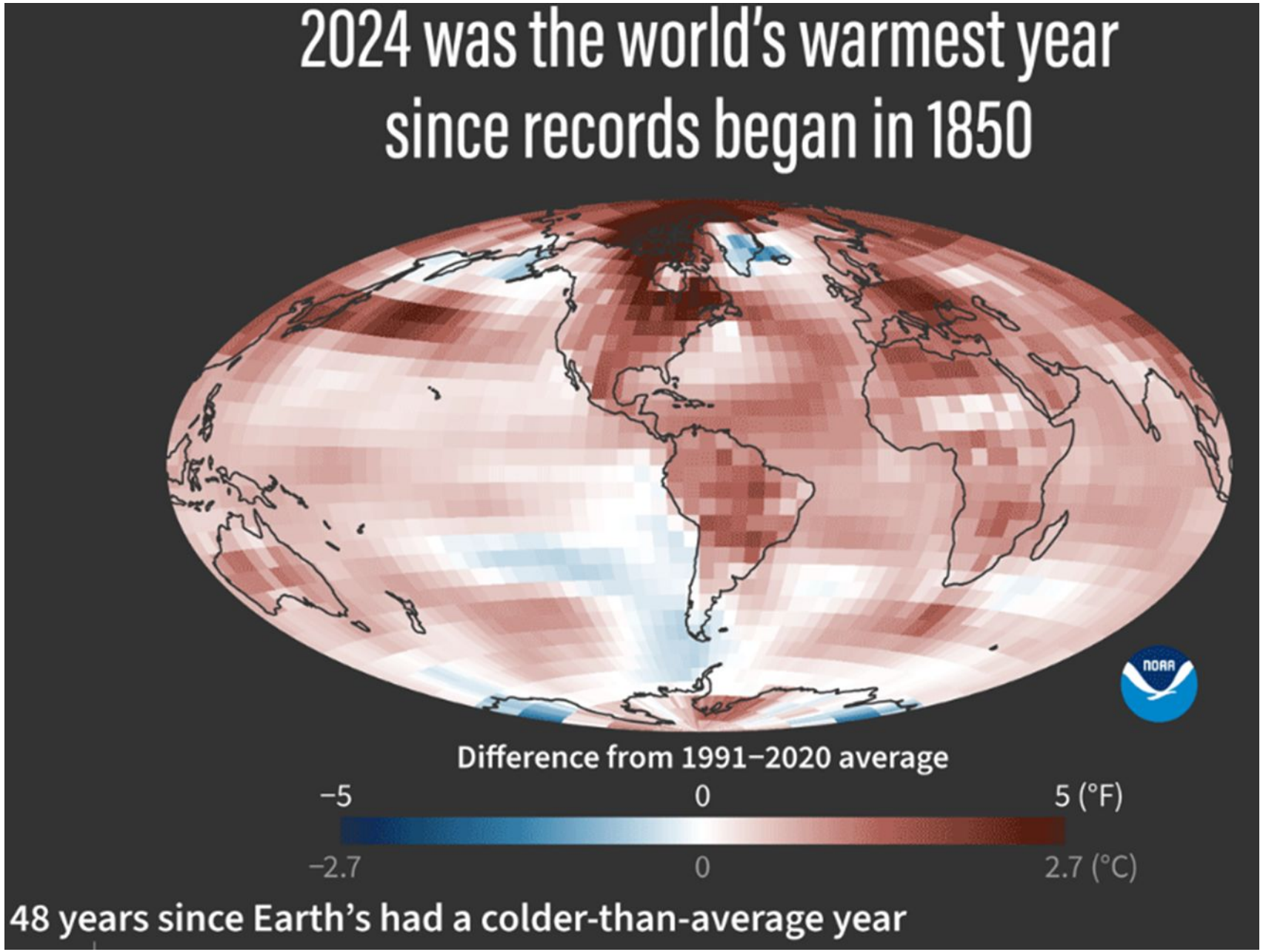
Climate.gov
SCIENCE & INFORMATION FOR A CLIMATE-SMART NATION

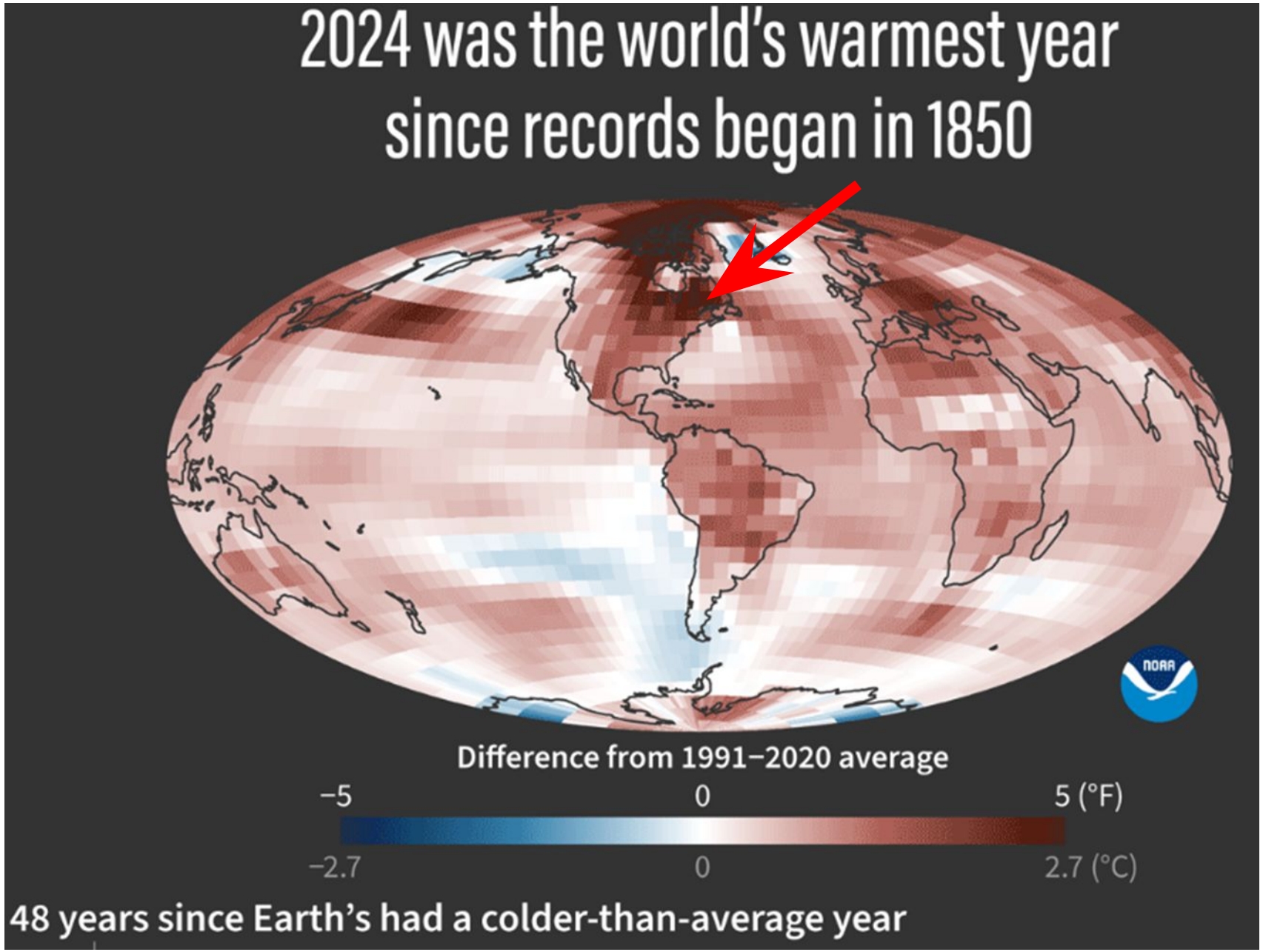


OCEAN HEAT COMPARED TO AVERAGE

Climate.gov
SCIENCE & INFORMATION FOR A CLIMATE-SMART NATION




2024 was the world's warmest year since records began in 1850
NOAA
Difference from 1991–2020 average
−5
0
5 (°F)
−2.7
0
2.7 (°C)
48 years since Earth's had a colder-than-average year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−5
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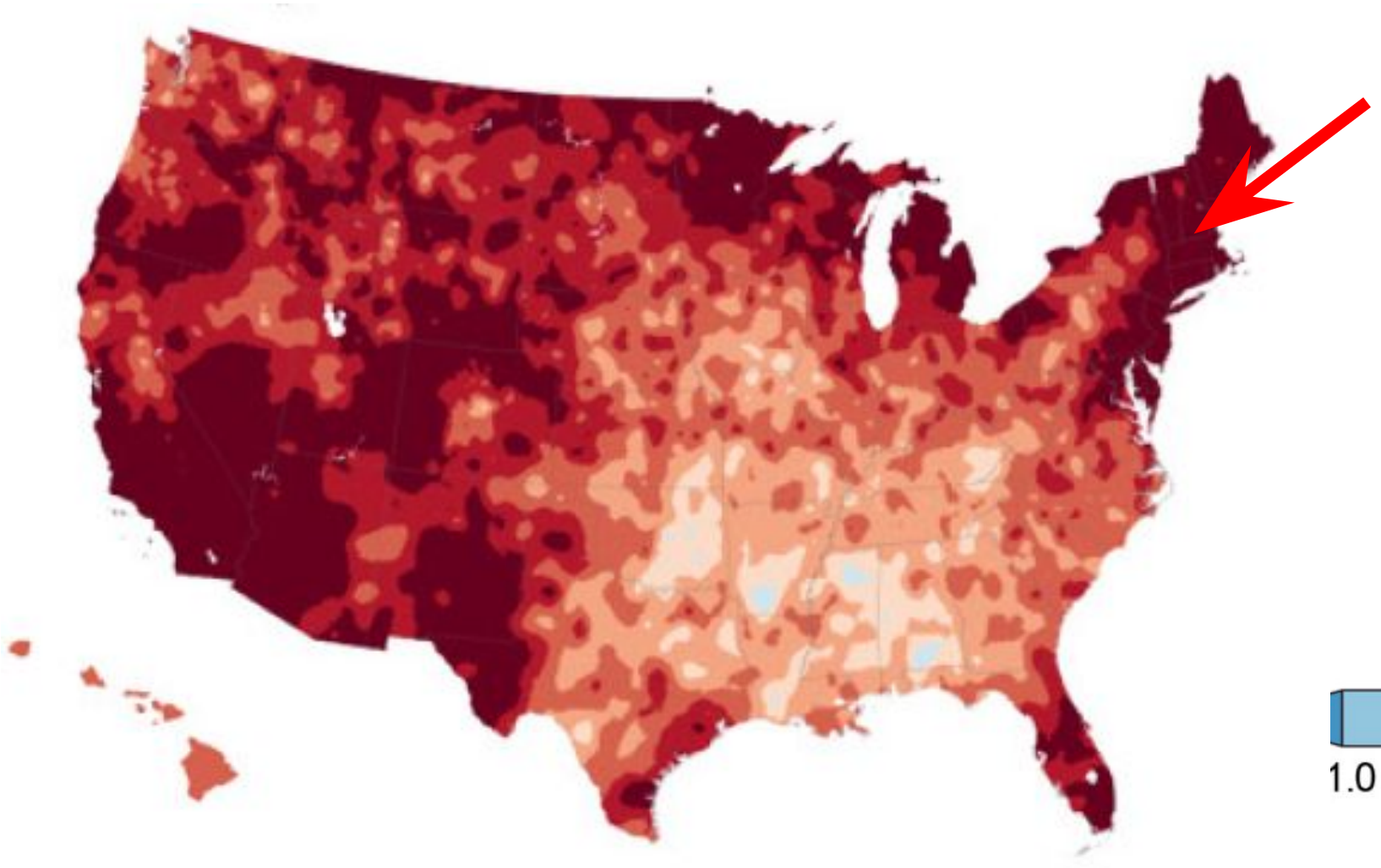
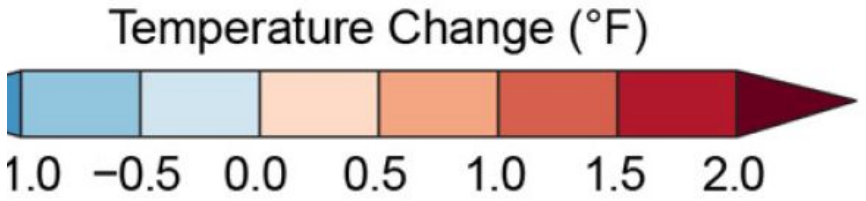
Climate Warming in the USA – NH Warming Rapidly



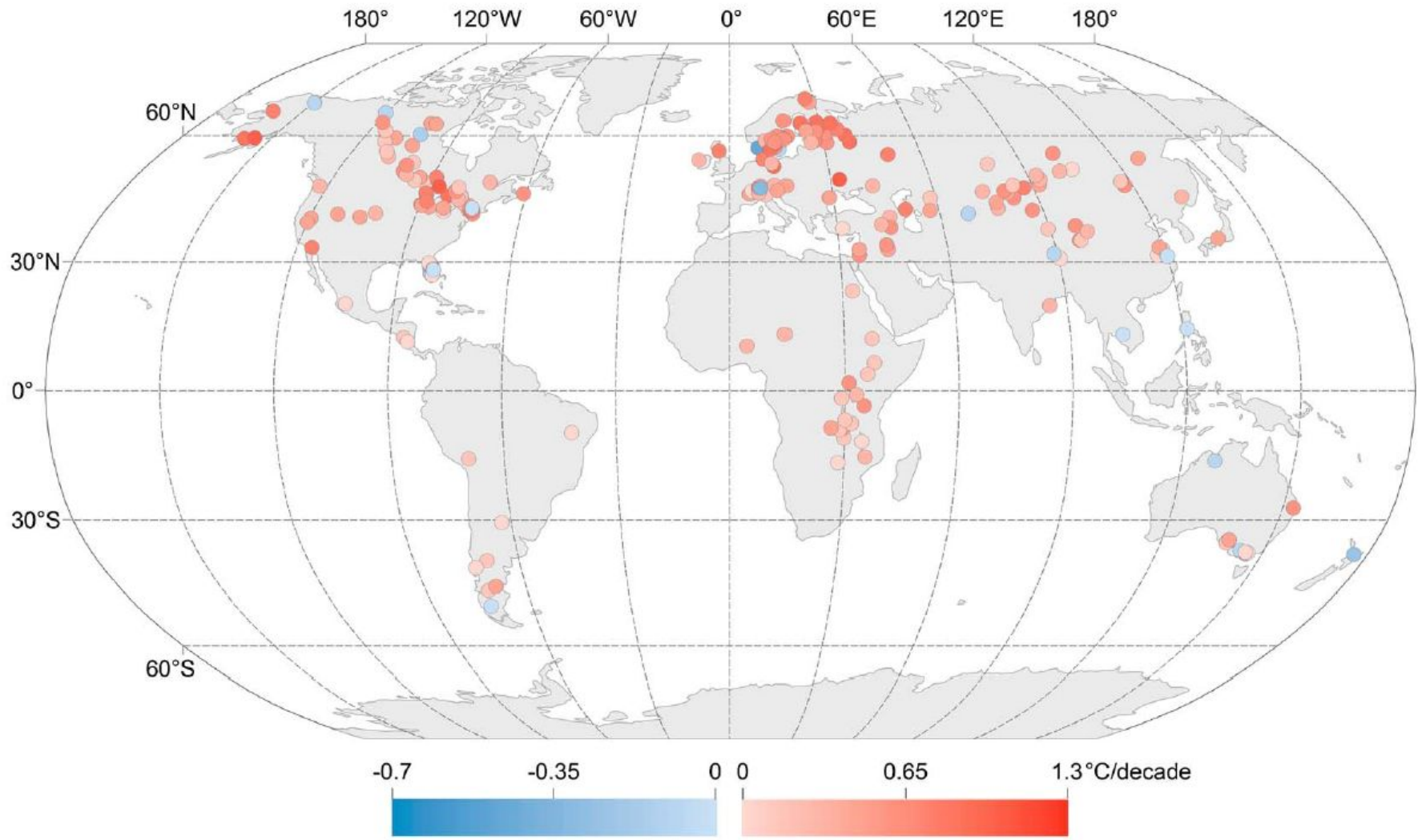
2002 – 2021

vs.

1901 - 1960



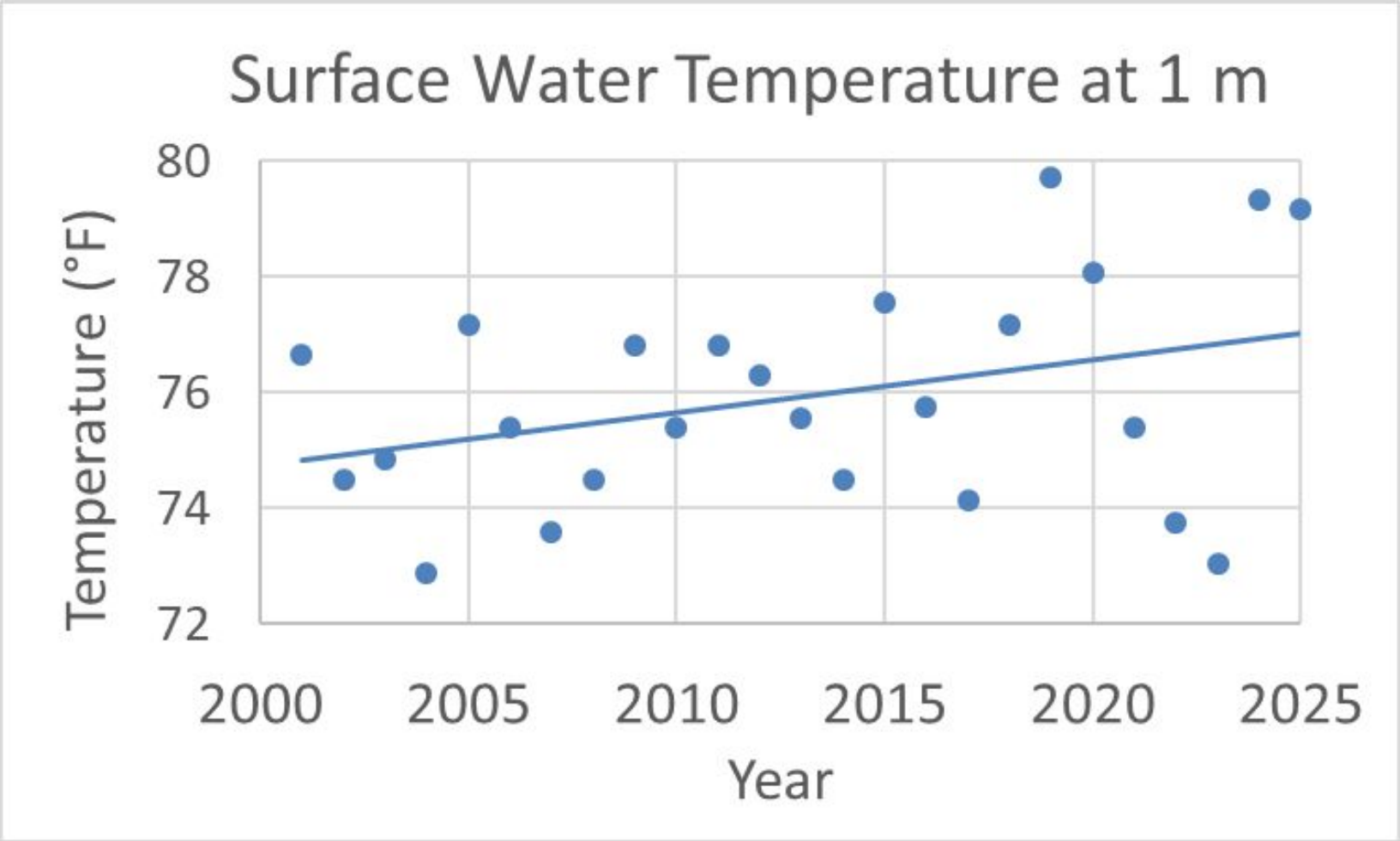
Lake Surface Water Temperatures are Warming even More Rapidly



Trends in lake summer surface temperatures from over 250 globally-distributed lakes (1985 to 2009)

Pleasant Lake Maximum Surface Water Temperature

Increased by ~2°F in the past 25 years (75° □ 77°F).



Average increases in temperature per decade:

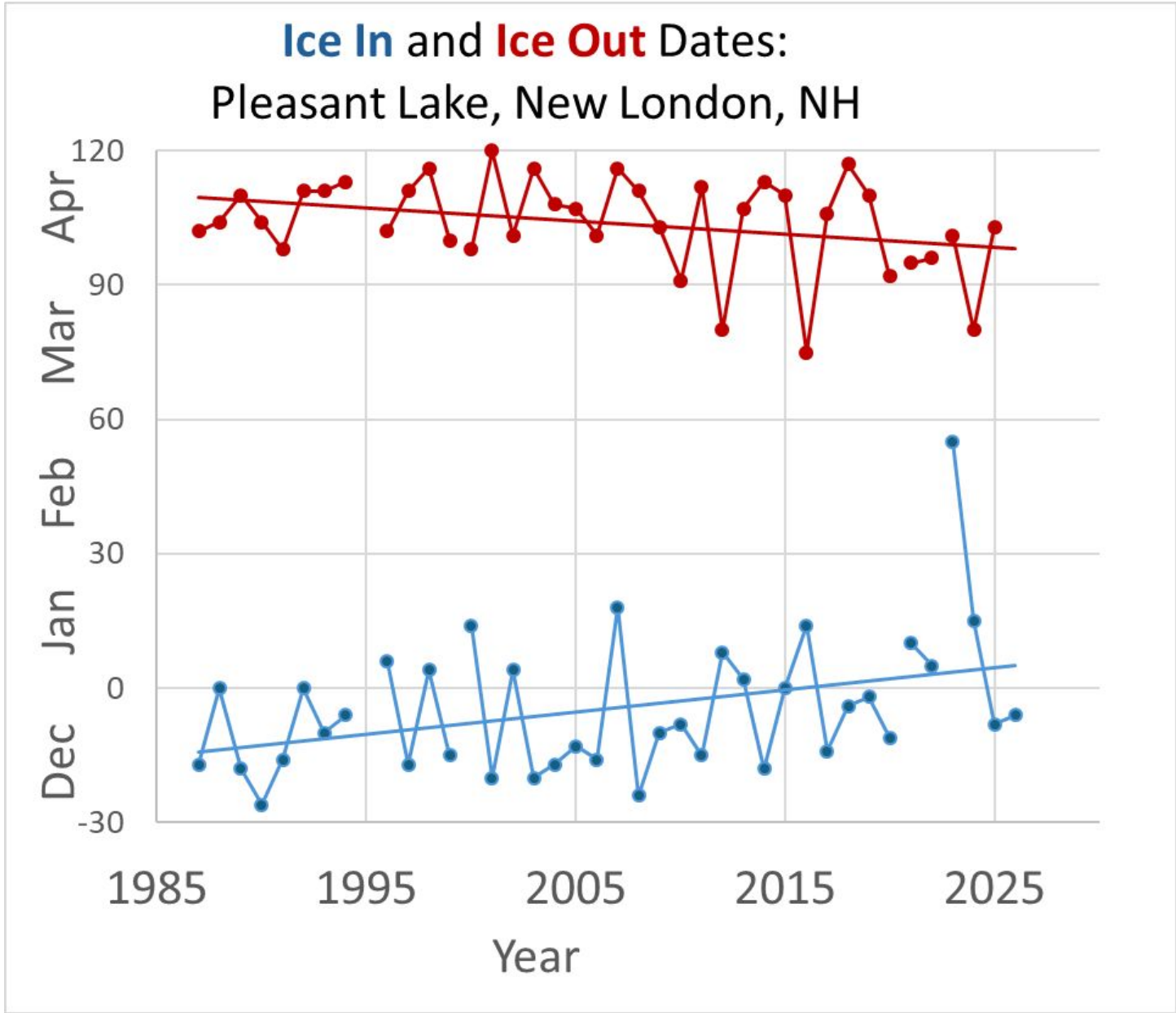
Global air temperatures: **0.45°F***

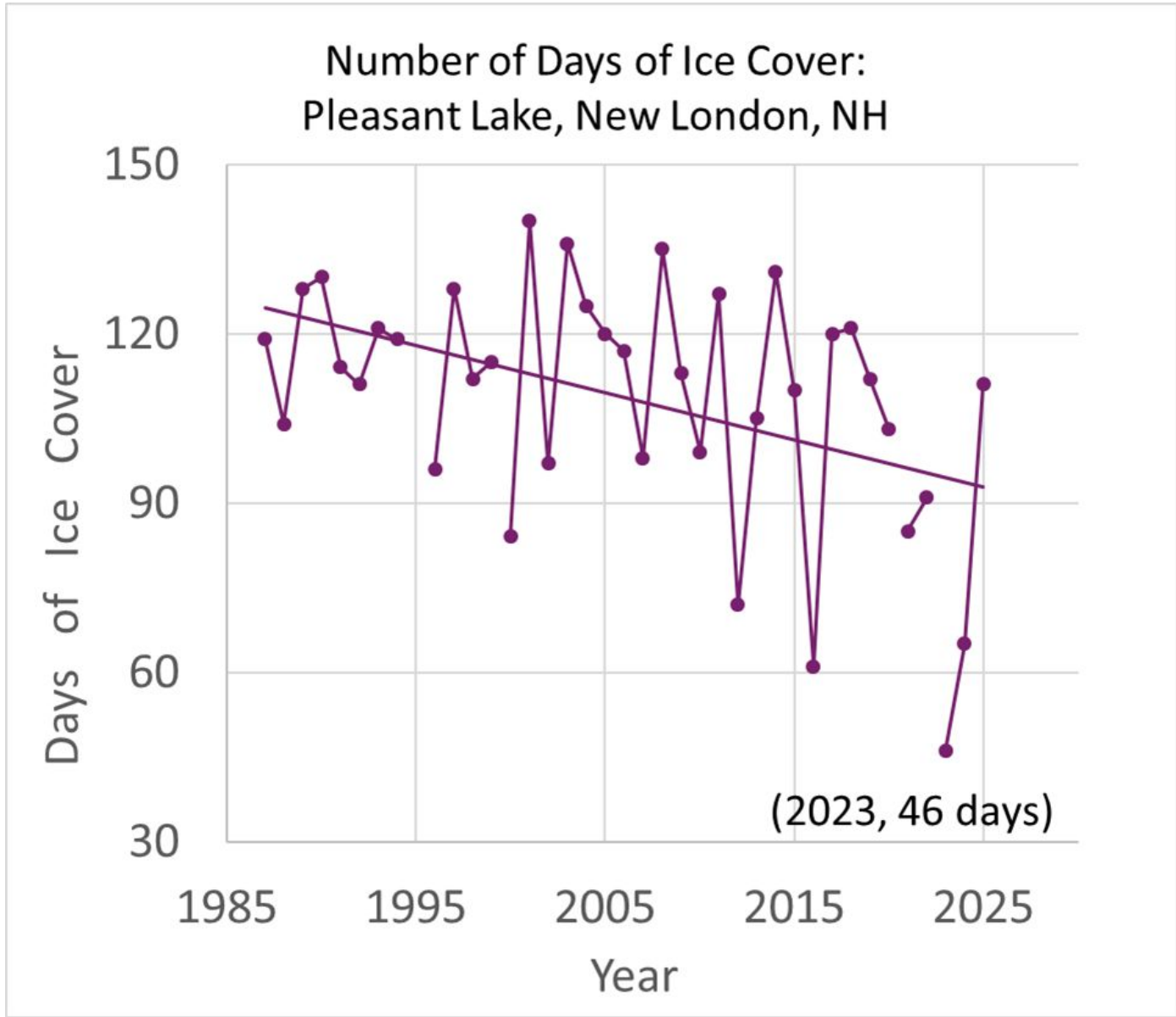
Ocean surface temperatures: **0.22°F***

Lake summer surface water temperatures: **0.61°F****

Pleasant Lake, NH surface water temperature: **0.9°F*****

* per decade, 1979-2012
**235 globally distributed lakes, per decade, 1985 – 2009.
*** per decade, 2005 - 2025


Ice In and Ice Out Dates:
Pleasant Lake, New London, NH
120
90
60
30
0
-30
Apr
Mar
Feb
Jan
Dec
1985
1995
2005
2015
2025
Year


Number of Days of Ice Cover:
Pleasant Lake, New London, NH
150
120
90
60
30
Days of Ice Cover
1985
1995
2005
2015
2025
Year
(2023, 46 days)

Implications of Shorter Periods of Ice Cover:

1) Increased sunlight entering the lake promotes warming of the water, and sunlight supports the growth of algae.

2) Exposure to wind increases mixing of nutrients from deeper waters and sediments up into the water column.

3) These conditions ***favor cyanobacteria blooms.***

Warming Summary:

1) NH is warming more rapidly than much of the rest of the USA.

2) Globally, lakes are warming more rapidly than the air or oceans.

3) Ice cover period has decreased by about a month in Pleasant Lake.

Implications of Warming Water Temperatures:

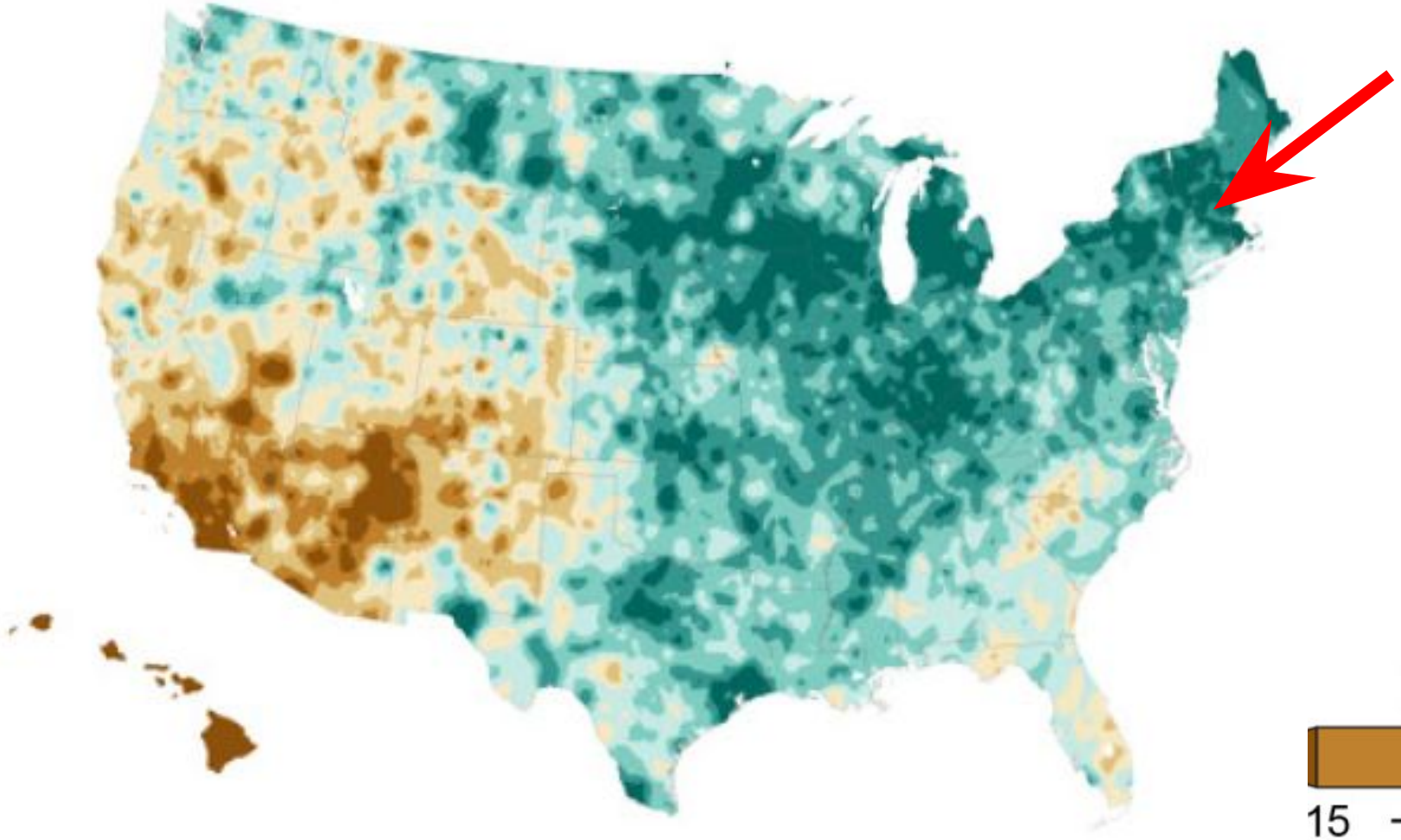
1) Warmer temperatures favor cyanobacteria blooms

2) Shorter periods of ice cover increase sunlight in the lake and promote wind-driven mixing of nutrients to the surface, *conditions which also favor cyanobacteria blooms*

Extreme Events

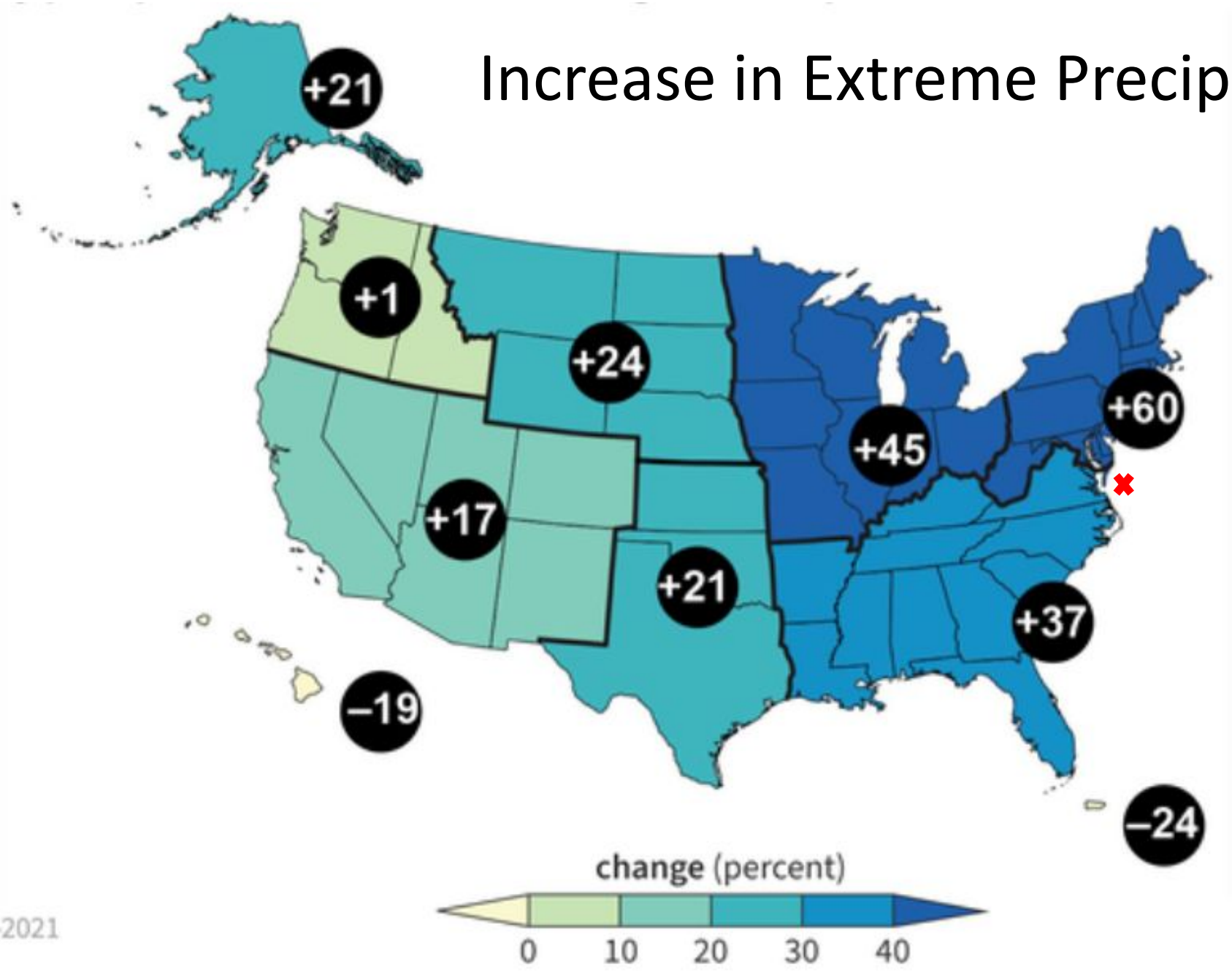
(Droughts, Storms, Floods)

Precipitation Change in the USA – NH is Getting Wetter

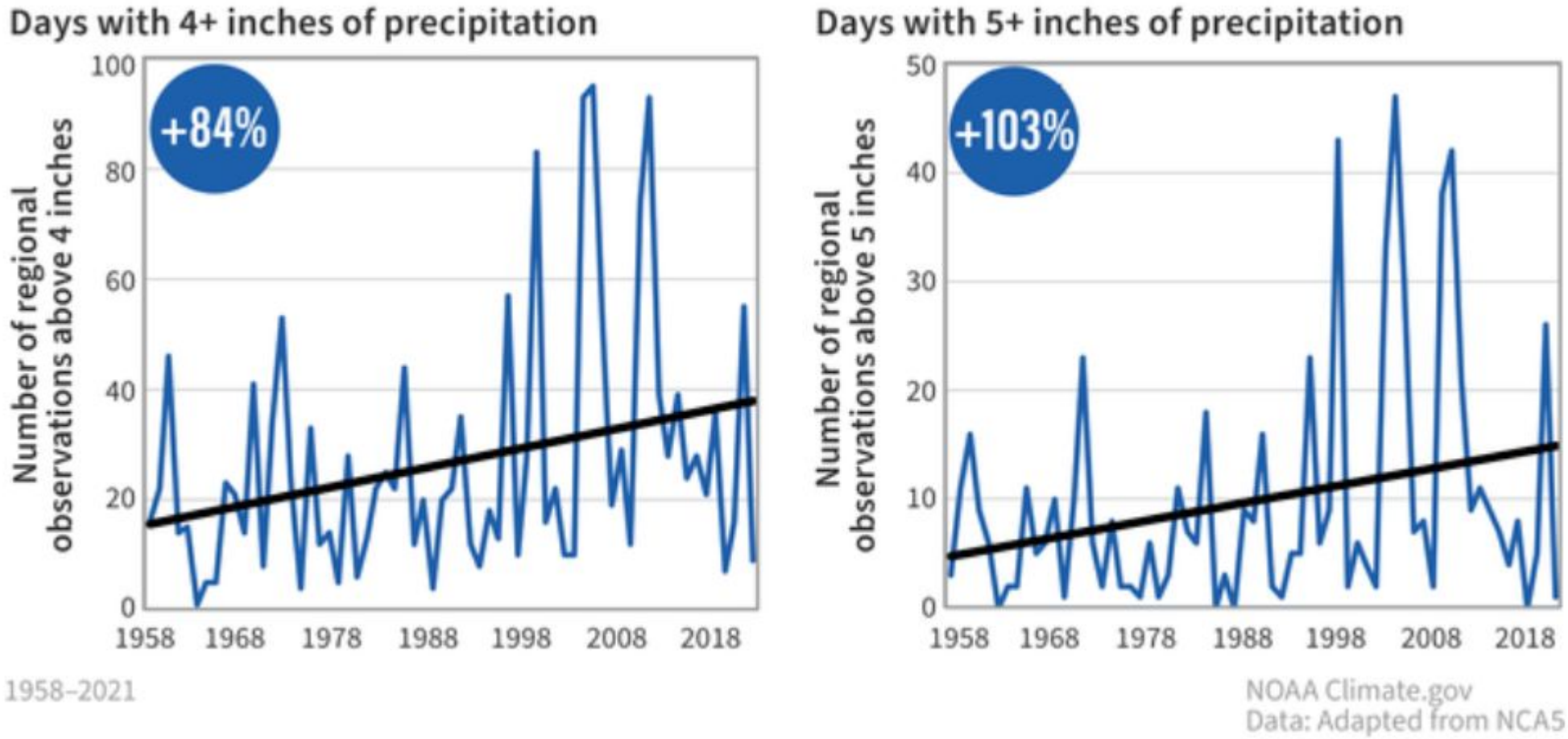


2002 – 2021
vs.
1901 - 1960

Increase in Extreme Precipitation Events



Number of Days with Extreme Precipitation in Northeastern USA



June 3, 2025

October 7, 2025

2025

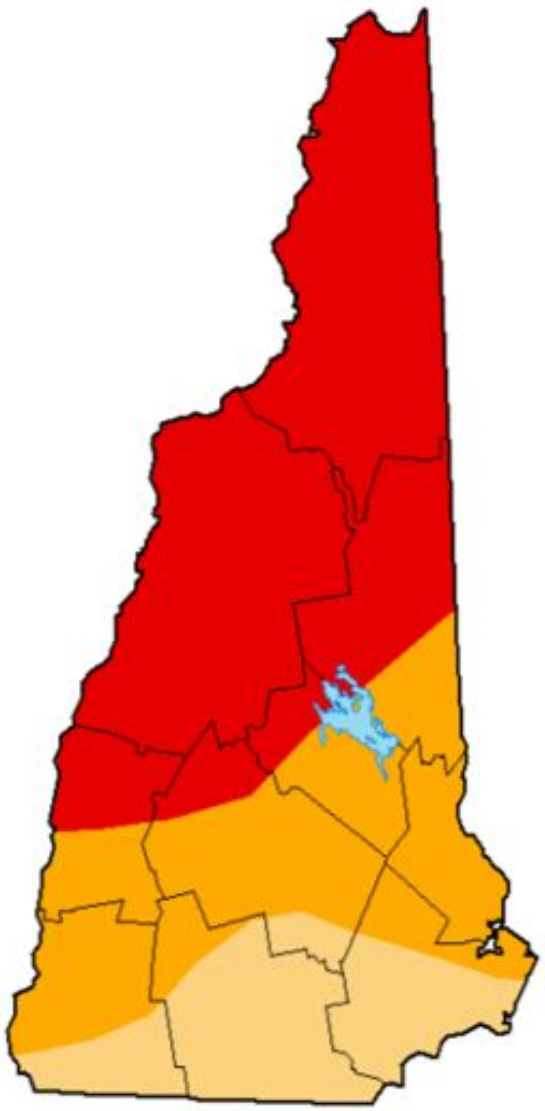
Driest summer on record in NH

Moderate to extreme drought

Over 1,000 wells went dry

Drought Intensity

- None
- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought



As NH drought continues, state opens emergency assistance program for well owners

New Hampshire Public Radio | By Mara Hoplamazian
Published January 12, 2026 at 4:00 PM EST

Extreme Events Summary:

1) NH is getting wetter more rapidly than most of the USA

2) NH is experiencing a greater increase in extreme precipitation events than most of the USA

What are the effects of these extreme precipitation events?

Science
AAAS

By **Frankie Schembri**

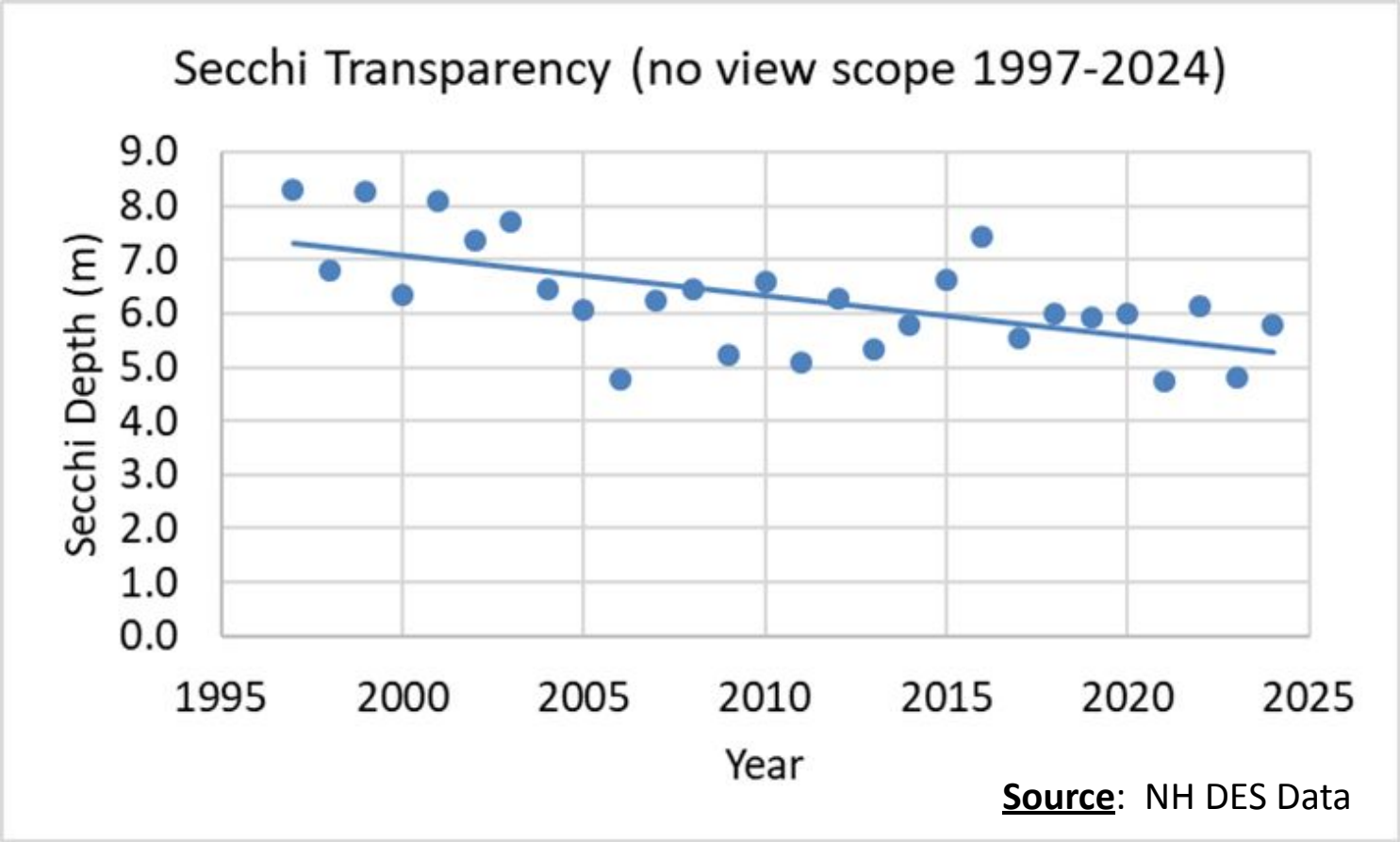
IN DEPTH

SEVERE WEATHER

Deadly storms break records, damage facilities

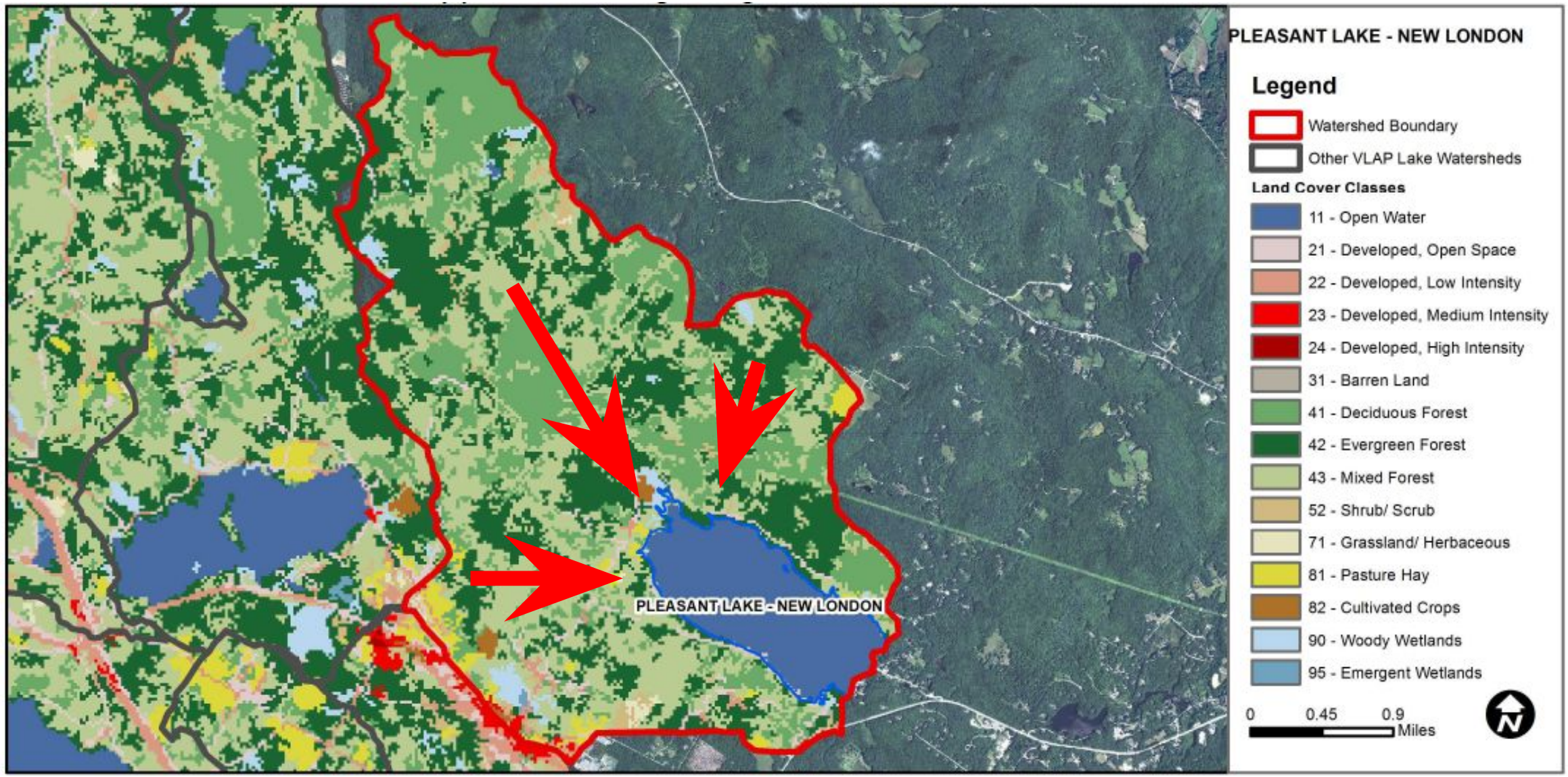
Florence and Mangkhut hold lessons for future disasters, and omens of growing severity

Pleasant Lake Water Transparency: Why is it Decreasing?



Transparency decreased from ~ 7-8+ m in ~2000, to 4-6 m in 2020s.

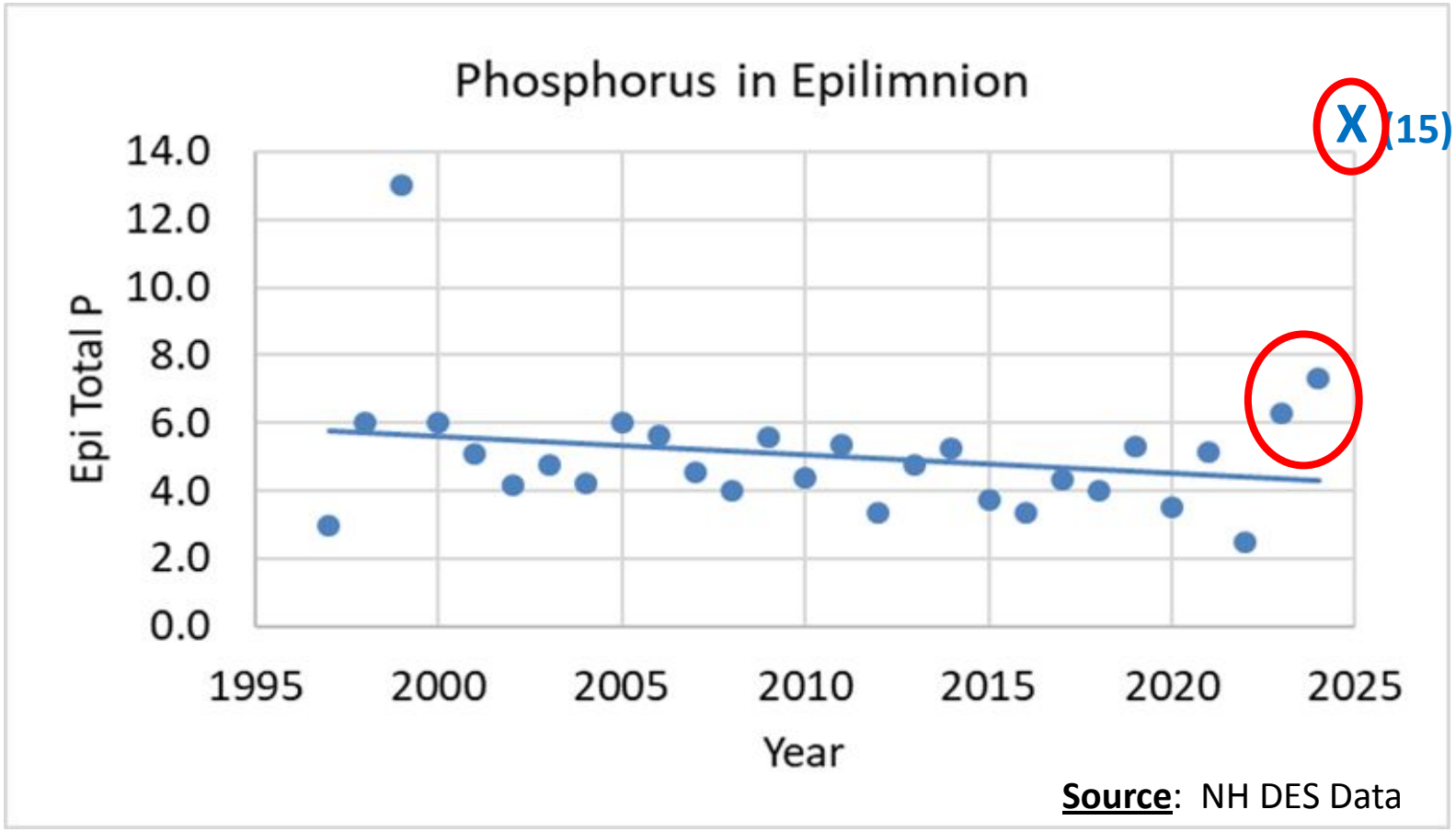
Pleasant Lake Watershed



Total Phosphorus (µg/L) in Pleasant Lake Tributaries Before and After a 1.5” Rainstorm June 20, 2024

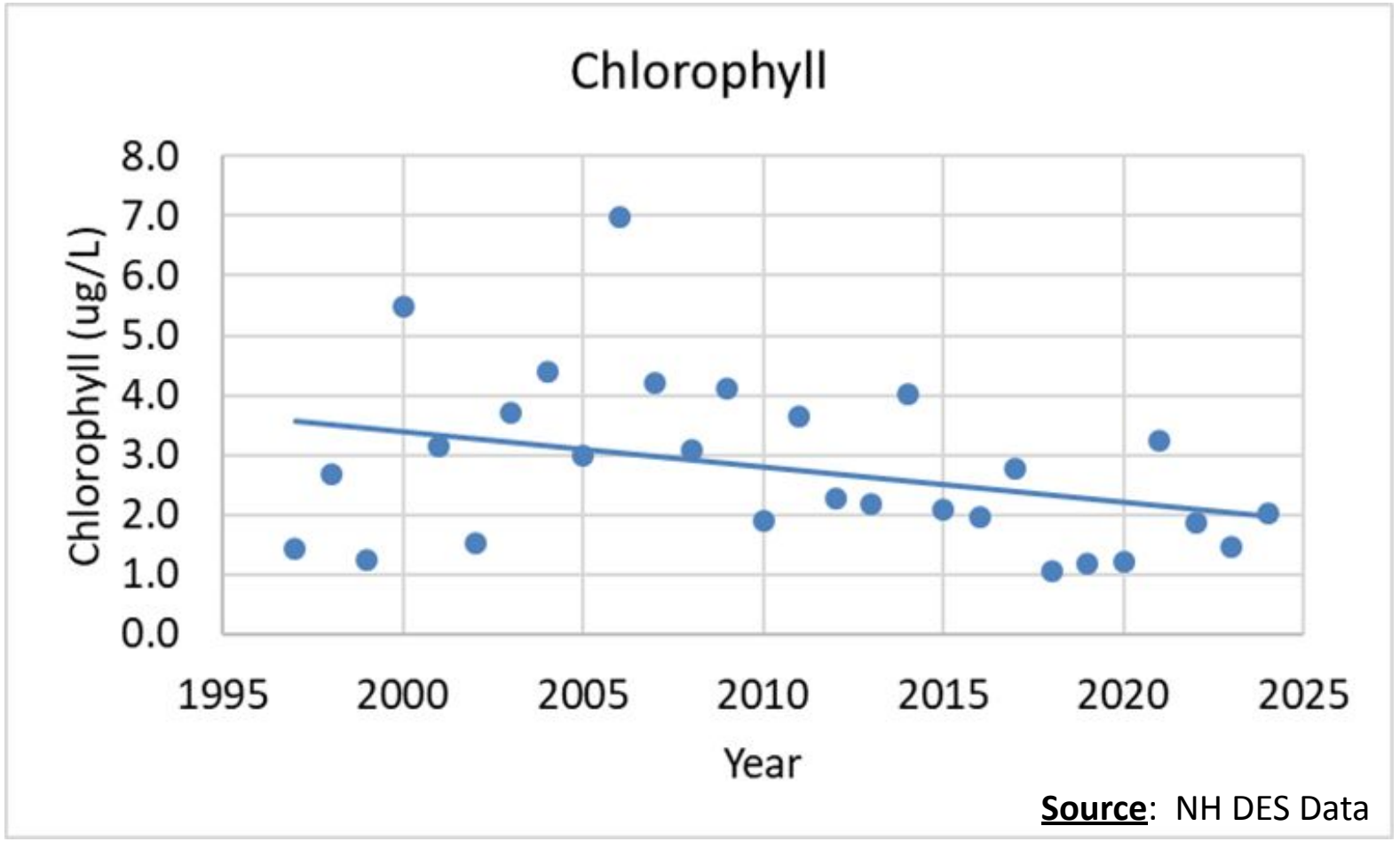
Tributary	Before Storm	After	Factor
Great Brook	30	91	**3.0**
Little Brook	13	123	**9.5**
White Brook	23	146	**6.3**
Red Brook	35	108	**3.1**
Bunker Rd/Elkins	45	168	**3.7**
Fire Pond	83	198	**2.4**

Pleasant Lake Total Phosphorus (TP) in surface waters



Average TP in the surface waters (epilimnion) has been stable or decreasing, except in the past three years, when TP has increased (red ovals – blue X is June 2025 epi-meta-hypo average – off the chart at 15. A level of 12 (ug/L) is a **eutrophic** lake where there are high nutrients and more frequent cyanobacteria blooms).

Pleasant Lake Chlorophyll (proxy for phytoplankton)

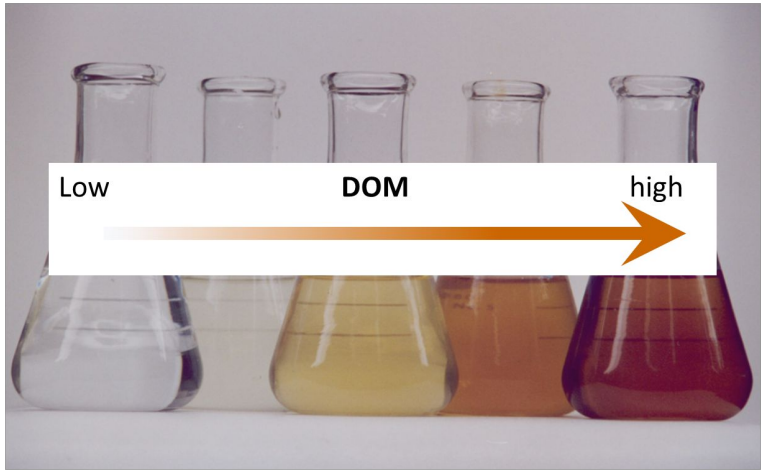


Source: NH DES Data

Dissolved Organic Matter (DOM): What is It?

□ Largely Terrestrial in Origin □ Browning of Lakes

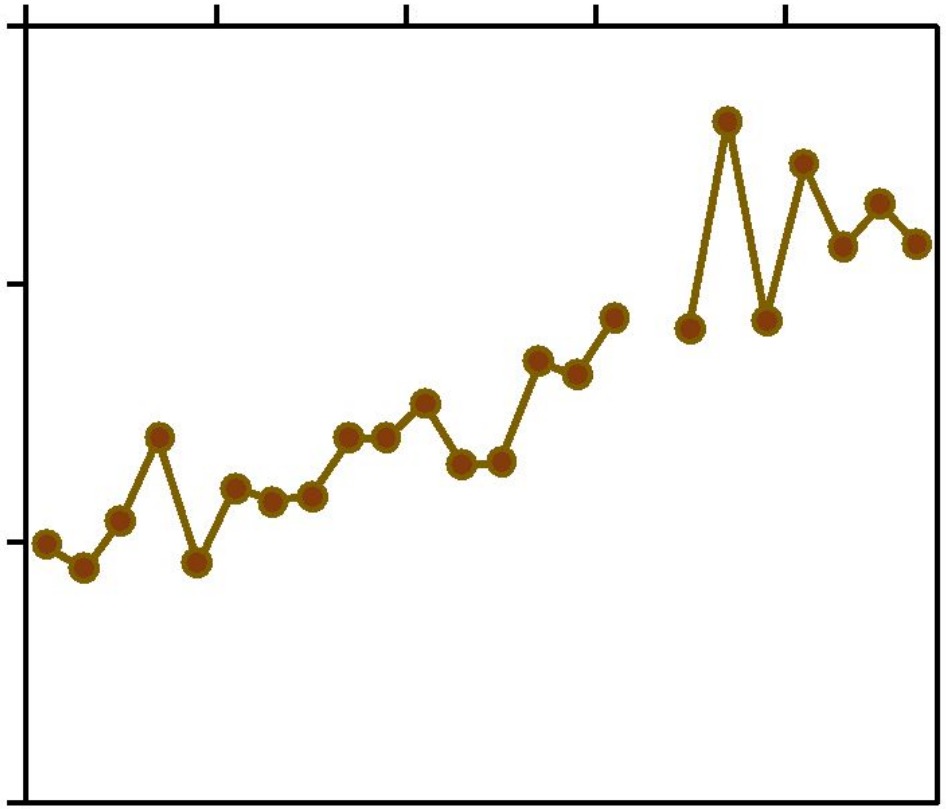
Decomposition: **Incomplete □ DOM**
Precipitation: **flushes DOM to lakes**



Manitowoc River
flowing into
Lake Michigan
following
heavy rain event

Note brown = high
dissolved organic matter
from river (left)
and runoff (right)

Increase in Dissolved Organic Matter
Lake Giles, Pennsylvania, USA

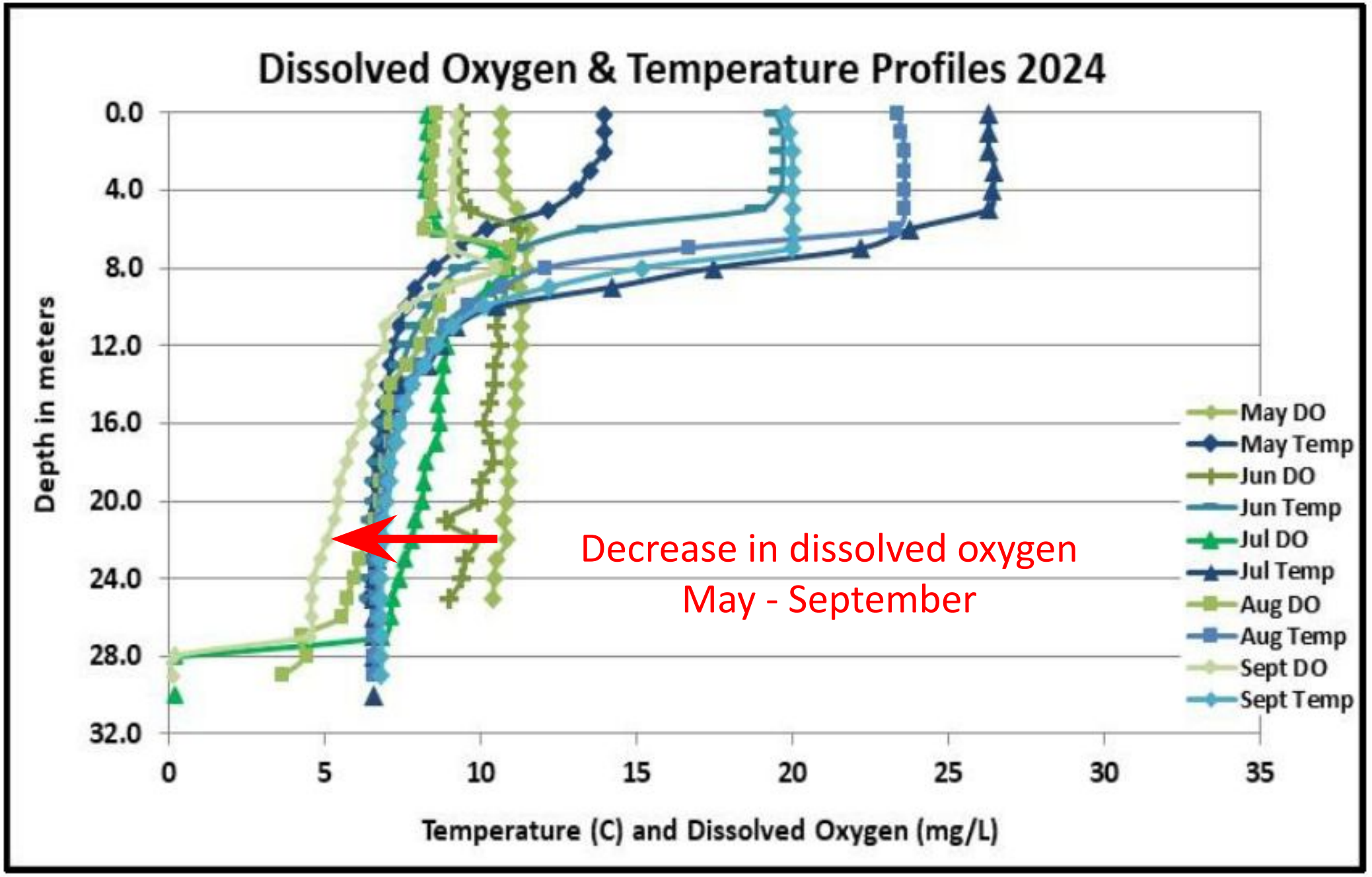


Implications of Decreased Water Clarity:

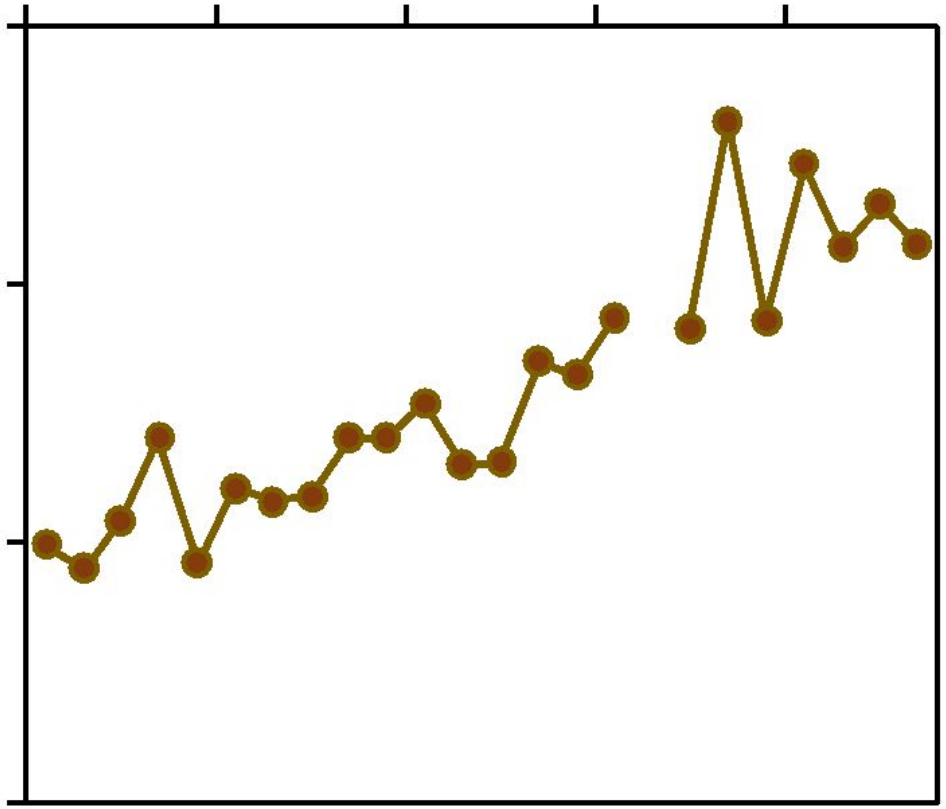
- Not enough light for photosynthesis in deep waters depletes deepwater oxygen.

- Low oxygen increases internal loading of phosphorus from the sediments into the lake in a dangerous feedback loop that **can lead to a critical tipping point.**

- Over the past ~80 years, world-wide, dissolved oxygen concentrations in lakes are decreasing 3 – 9 times faster than in oceans.

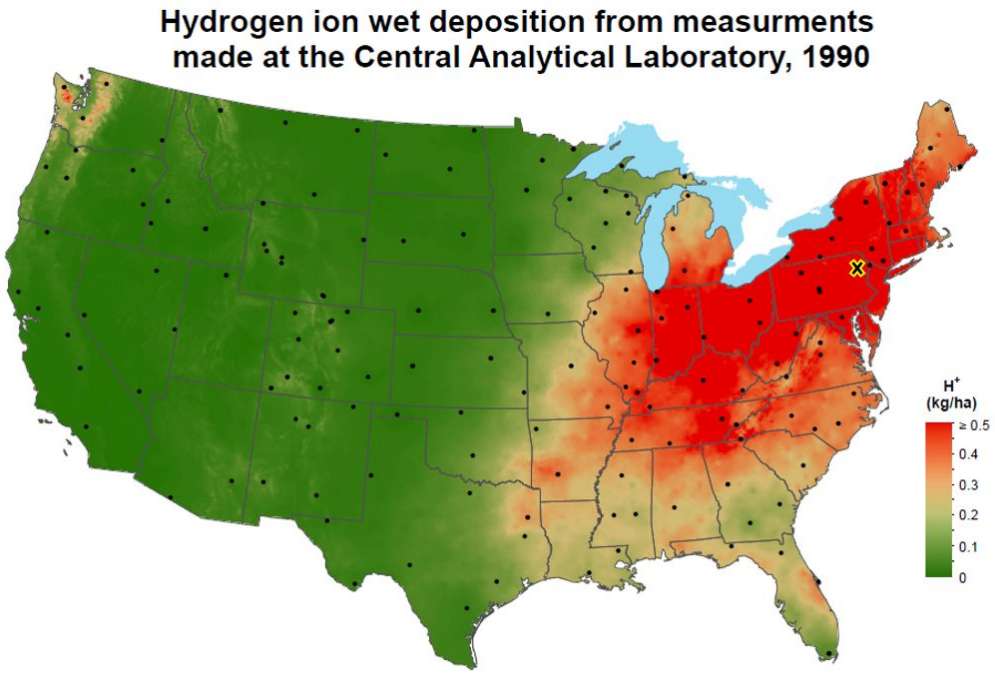

Dissolved Oxygen & Temperature Profiles 2024
Depth in meters
0.0
4.0
8.0
12.0
16.0
20.0
24.0
28.0
32.0
0
5
10
15
20
25
30
35
Temperature (C) and Dissolved Oxygen (mg/L)
Decrease in dissolved oxygen
May - September
May DO
May Temp
Jun DO
Jun Temp
Jul DO
Jul Temp
Aug DO
Aug Temp
Sept DO
Sept Temp

Increase in Dissolved Organic Matter
Lake Giles, Pennsylvania, USA



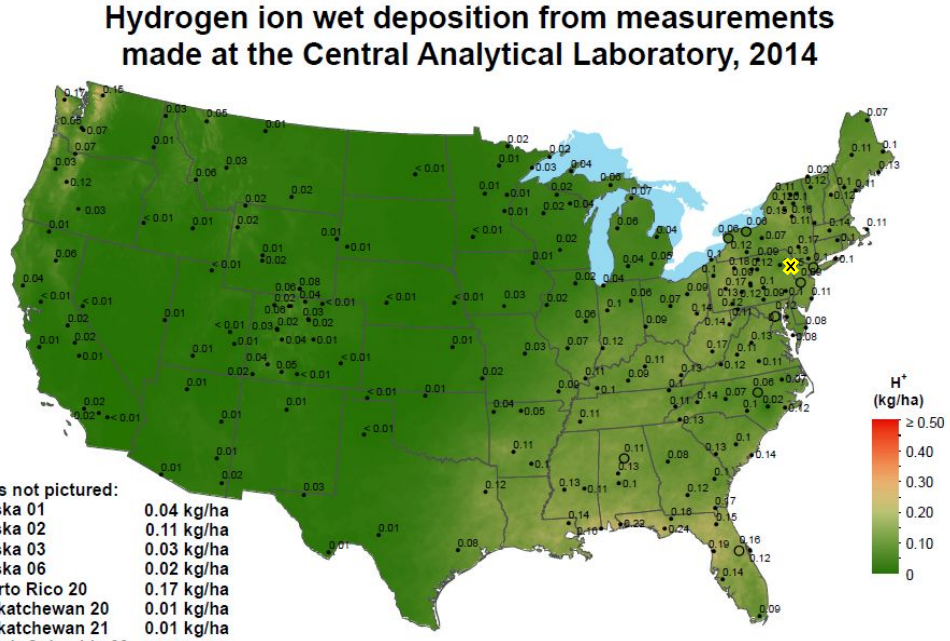
Recovery from Acid Deposition ("Acid Rain")

1990



National Atmospheric Deposition Program/National Trends Network
http://nadp.isws.illinois.edu

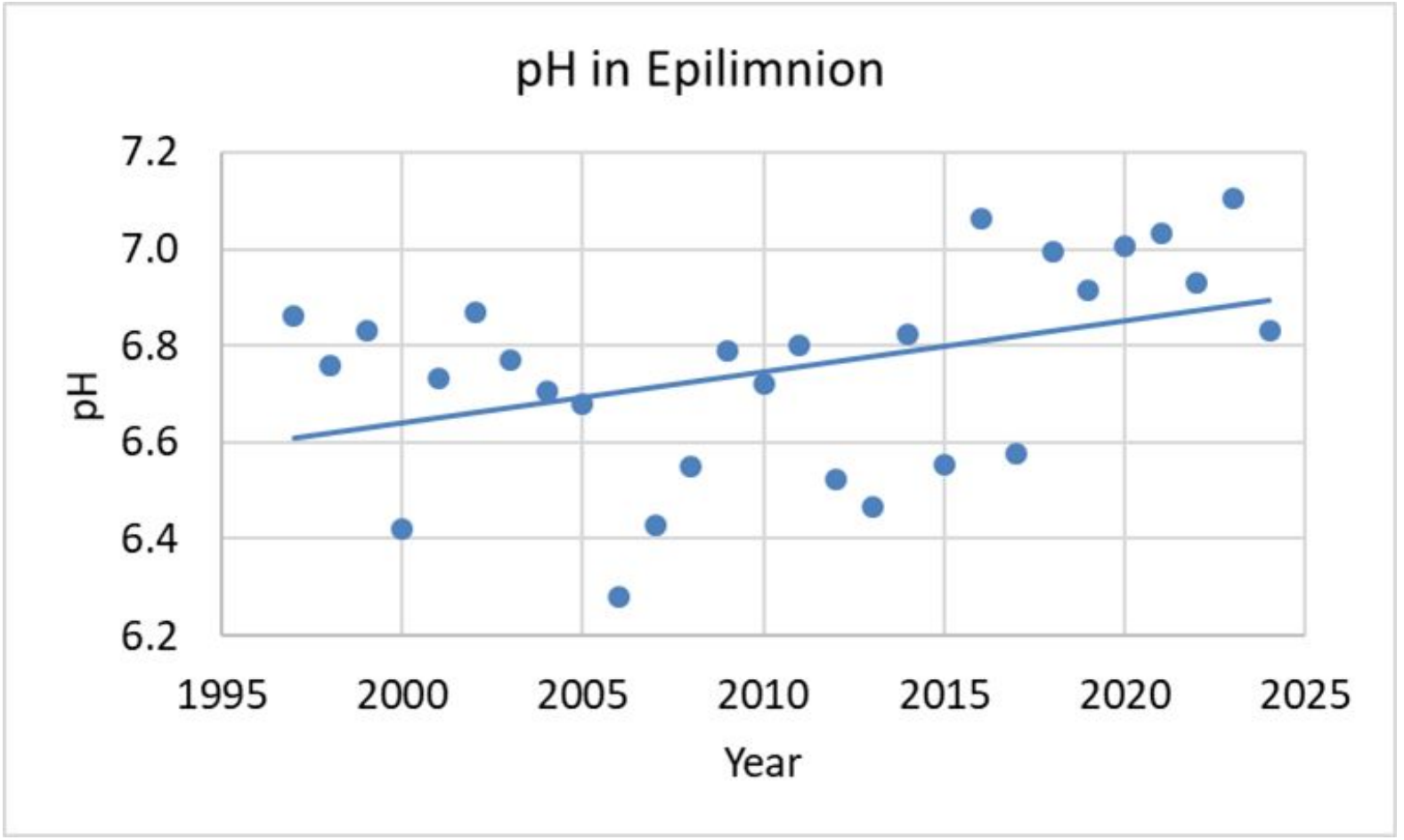
2014



Sites not pictured:	
Alaska 01	0.04 kg/ha
Alaska 02	0.11 kg/ha
Alaska 03	0.03 kg/ha
Alaska 06	0.02 kg/ha
Puerto Rico 20	0.17 kg/ha
Saskatchewan 20	0.01 kg/ha
Saskatchewan 21	0.01 kg/ha
British Columbia 22	0.67 kg/ha
British Columbia 23	0.09 kg/ha
British Columbia 24	0.14 kg/ha

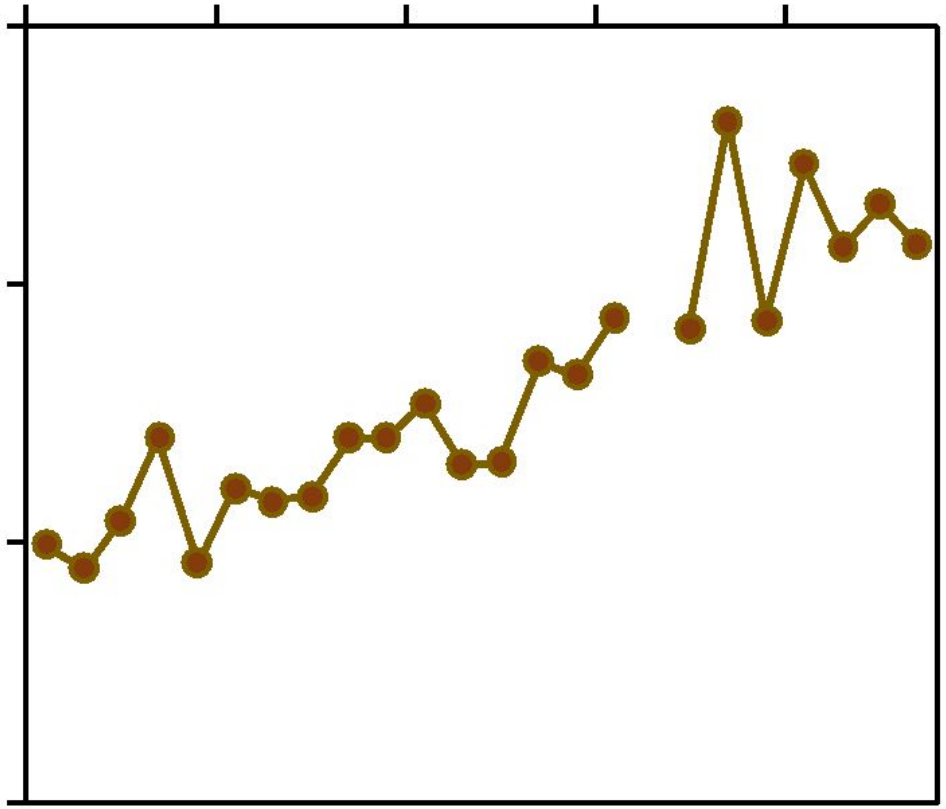
National Atmospheric Deposition Program/National Trends Network
http://nadp.isws.illinois.edu

Pleasant Lake pH

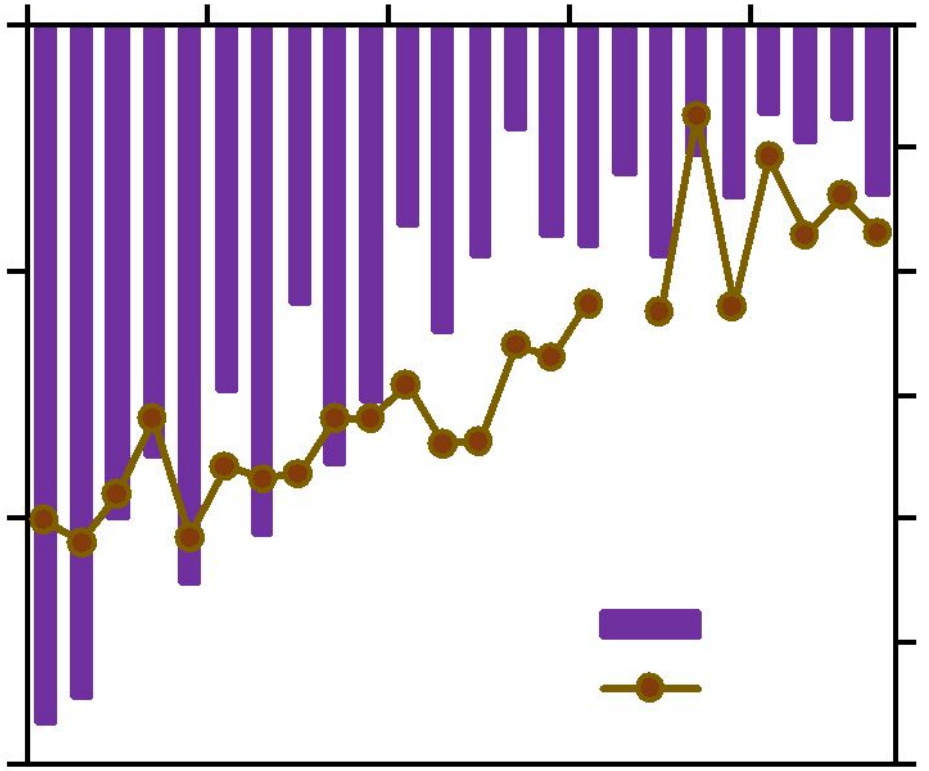


Increase in pH reflects decrease in acid deposition (“acid rain”) due to Clean Air Act amendments.

Increase in Dissolved Organic Matter
Lake Giles, Pennsylvania, USA



Browning Decreases UV exposure:
reduces solar disinfection of pathogens in surface waters



Implications of Browning for Invasive Mosquitoes

Aedes aegypti

(Yellow Fever Mosquito)

- Vectors of Zika, dengue, chikungunya, other viruses
- Live near, prefer to feed on people

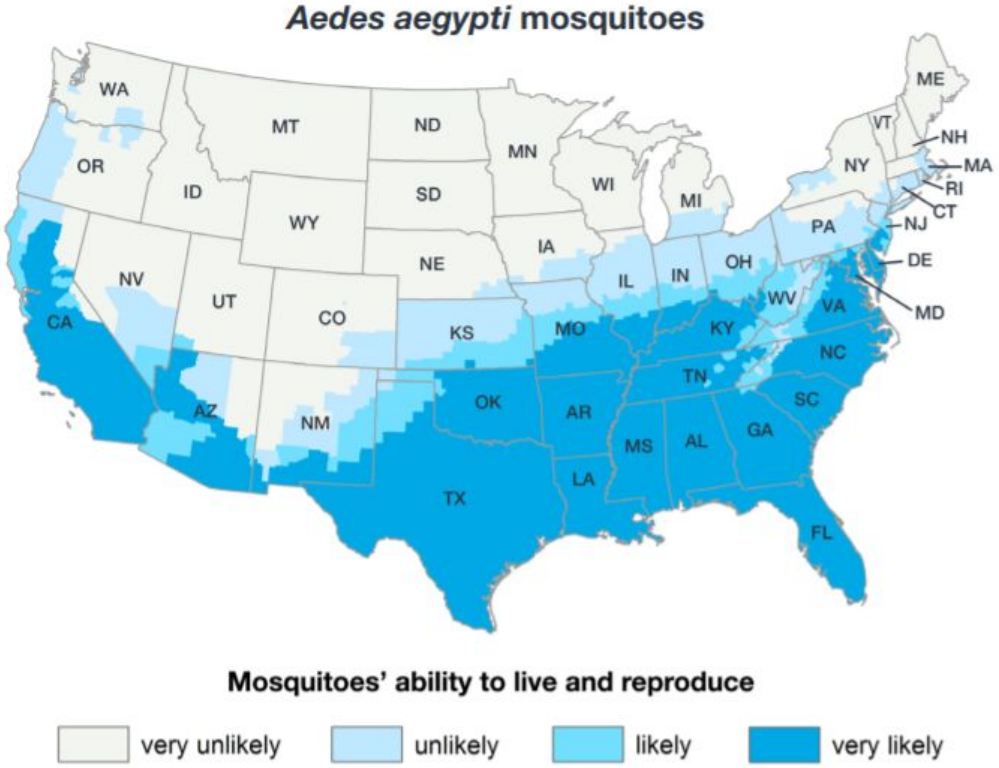
Aedes albopictus

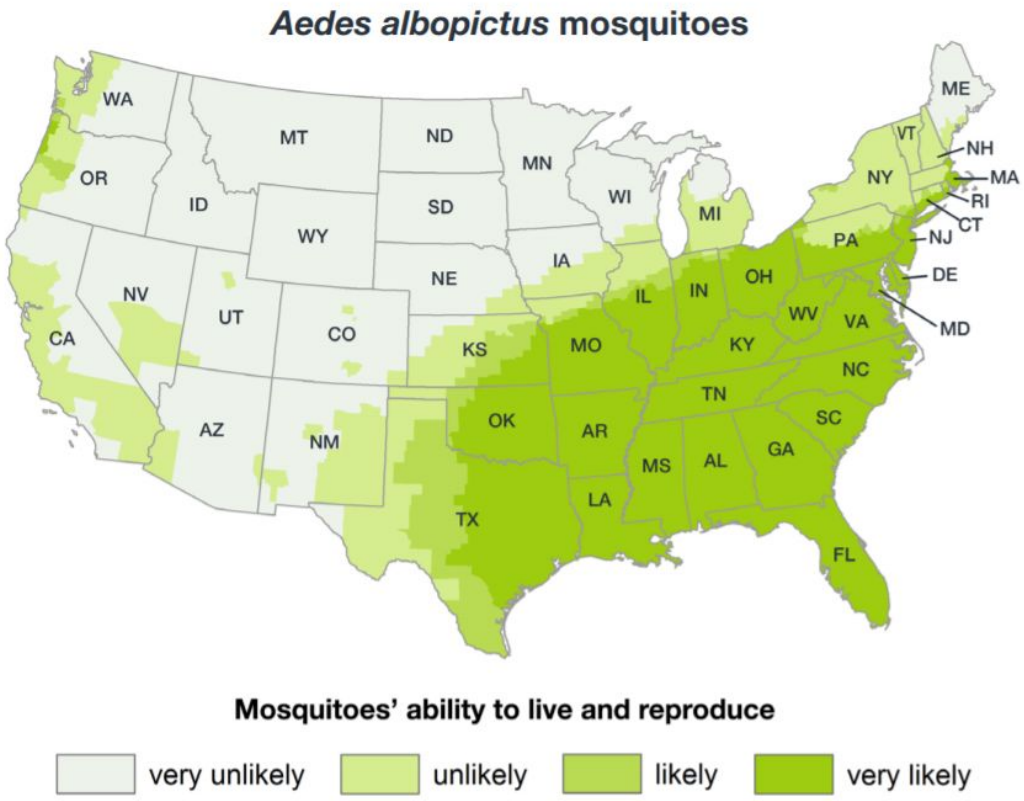
(Asian Tiger Mosquito)

- Vectors of Zika, dengue, chikungunya, other viruses
- Feed on animals and people

Center for Disease Control 2017.

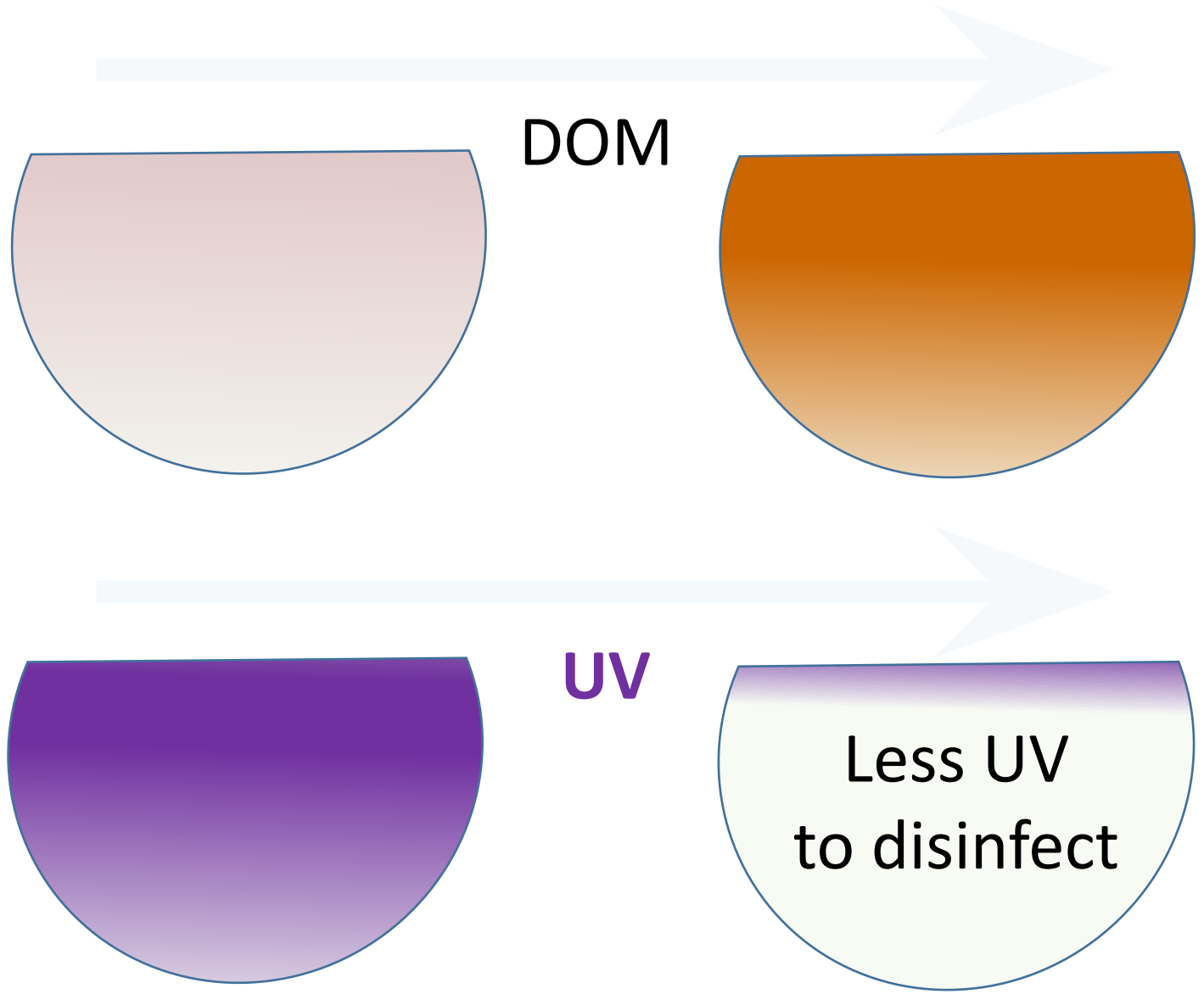
CDC 2017 range maps



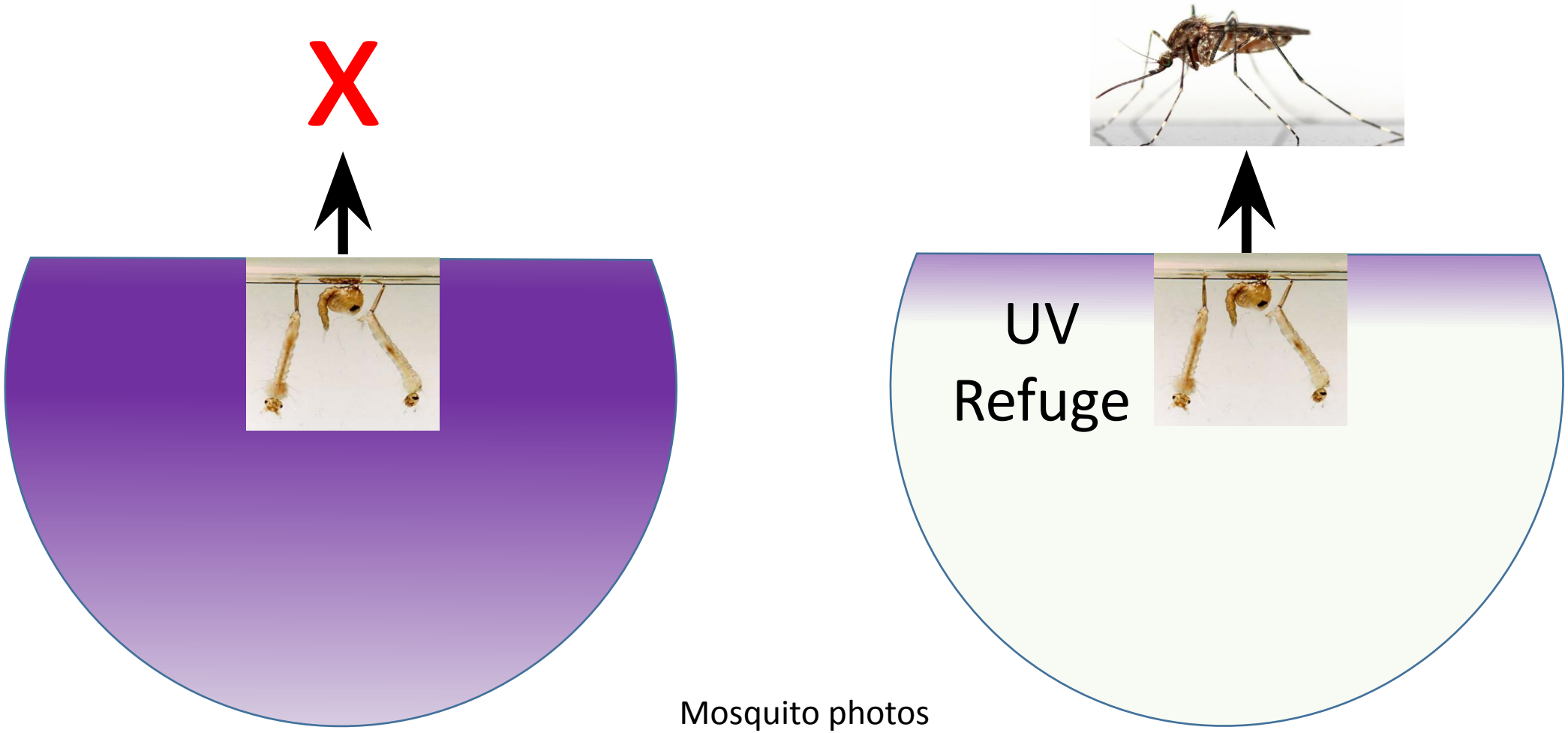


Center for Disease Control 2017. https://www.cdc.gov/zika/vector/range.html

Effects of browning on UV Radiation in Lakes



Effects of UV Radiation on Adult Emergence



Mosquito photos
adult: https://www.popsci.com/how-mosquitoes-fly,
larvae pupa: https://ask.extension.org/questions/268027

Implications of Increased Extreme Precipitation:

Increases runoff into lakes, which causes:

- Elevated **nutrient** and **DOM** inputs from the watershed

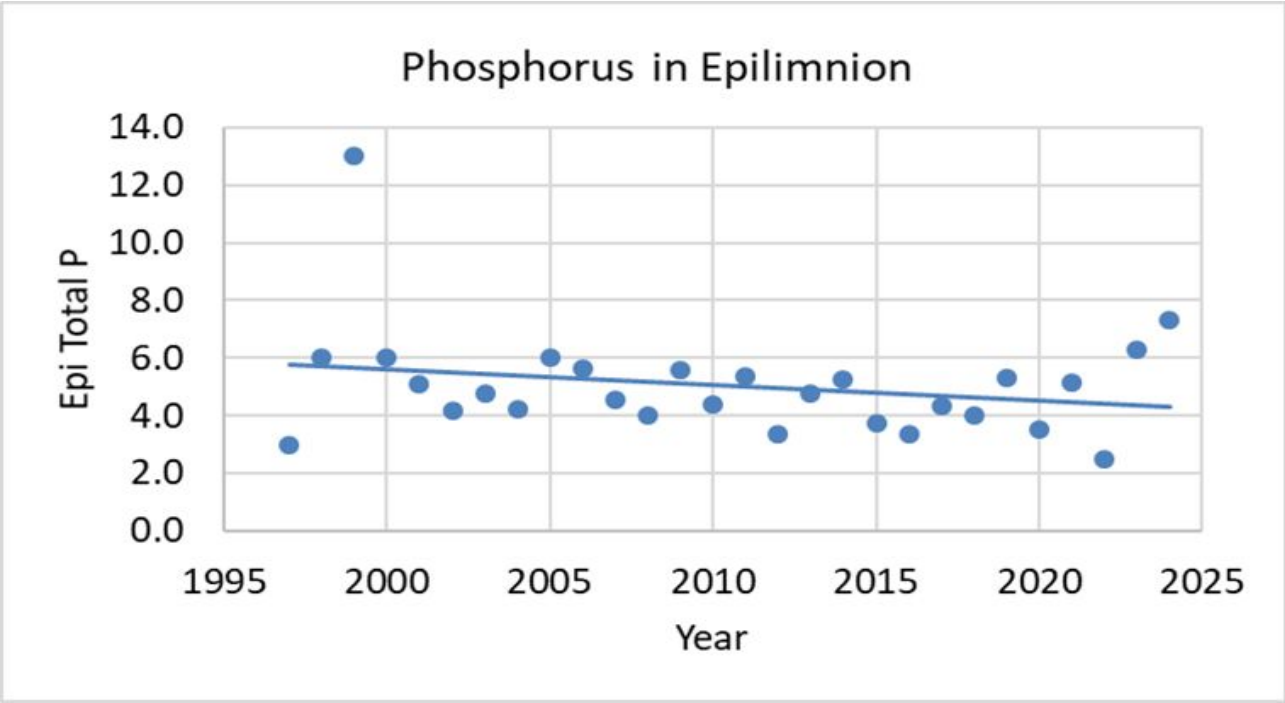
- **Decreased water clarity, which can deplete deepwater oxygen**, increasing internal loading of phosphorus from the sediments into the lake in a dangerous feedback loop **and a potentially irreversible tipping point.**

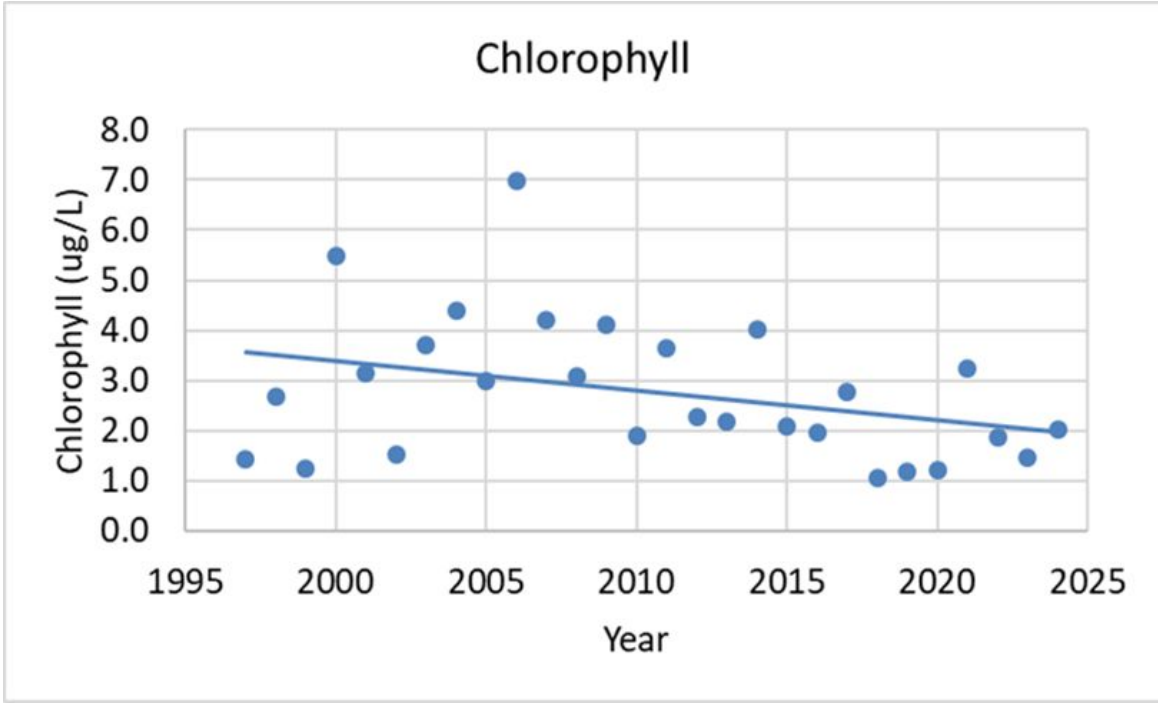
Pleasant Lake: Why?

?

Could climate change play a role in the recent cyanobacteria blooms in Pleasant Lake?

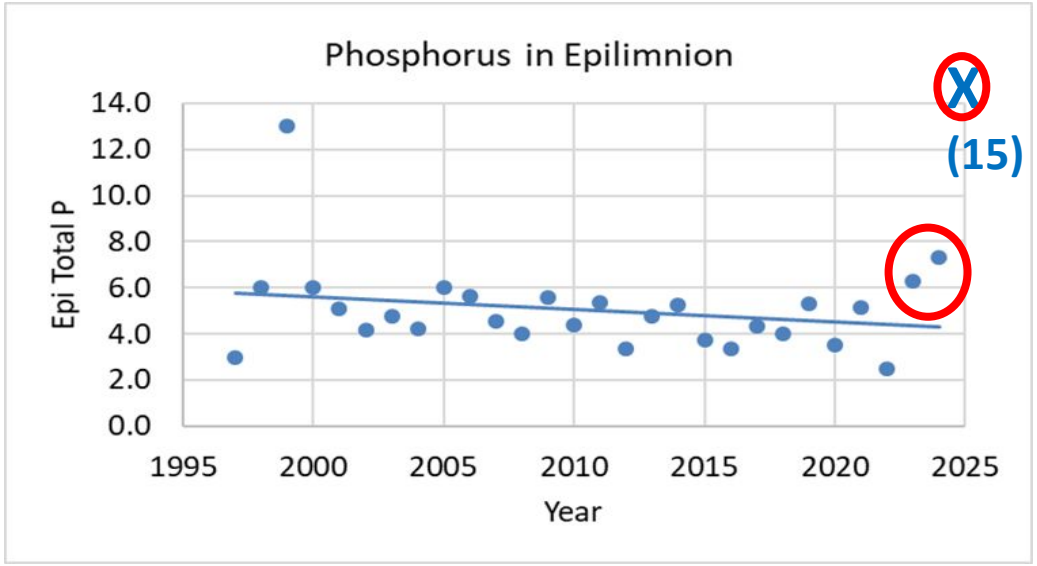
Pleasant Lake Long-Term Trends Are Favorable



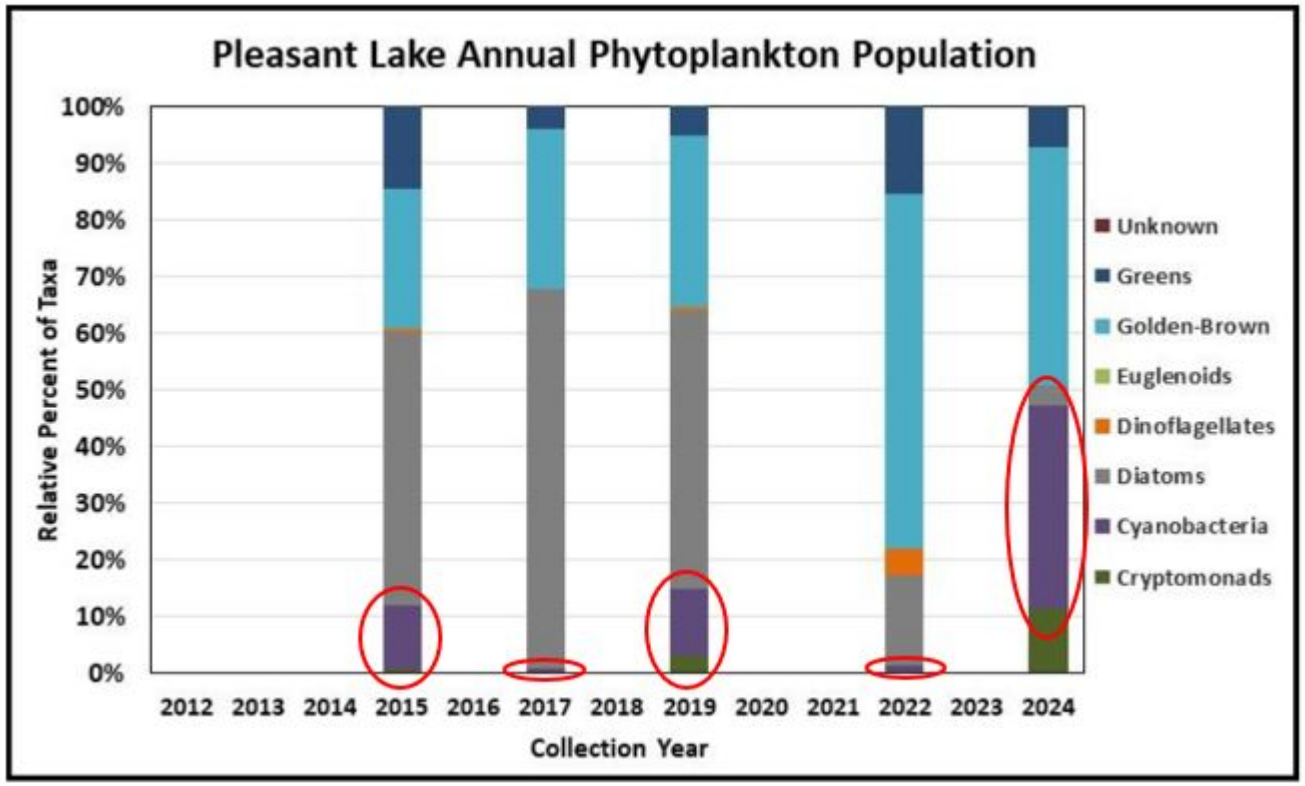


Source: NH DES VLAP Data

Pleasant Lake Short-Term “Signals” Suggest a Tipping Point



(purple is Cyanobacteria)



Source: NH DES Data

The Path Forward?

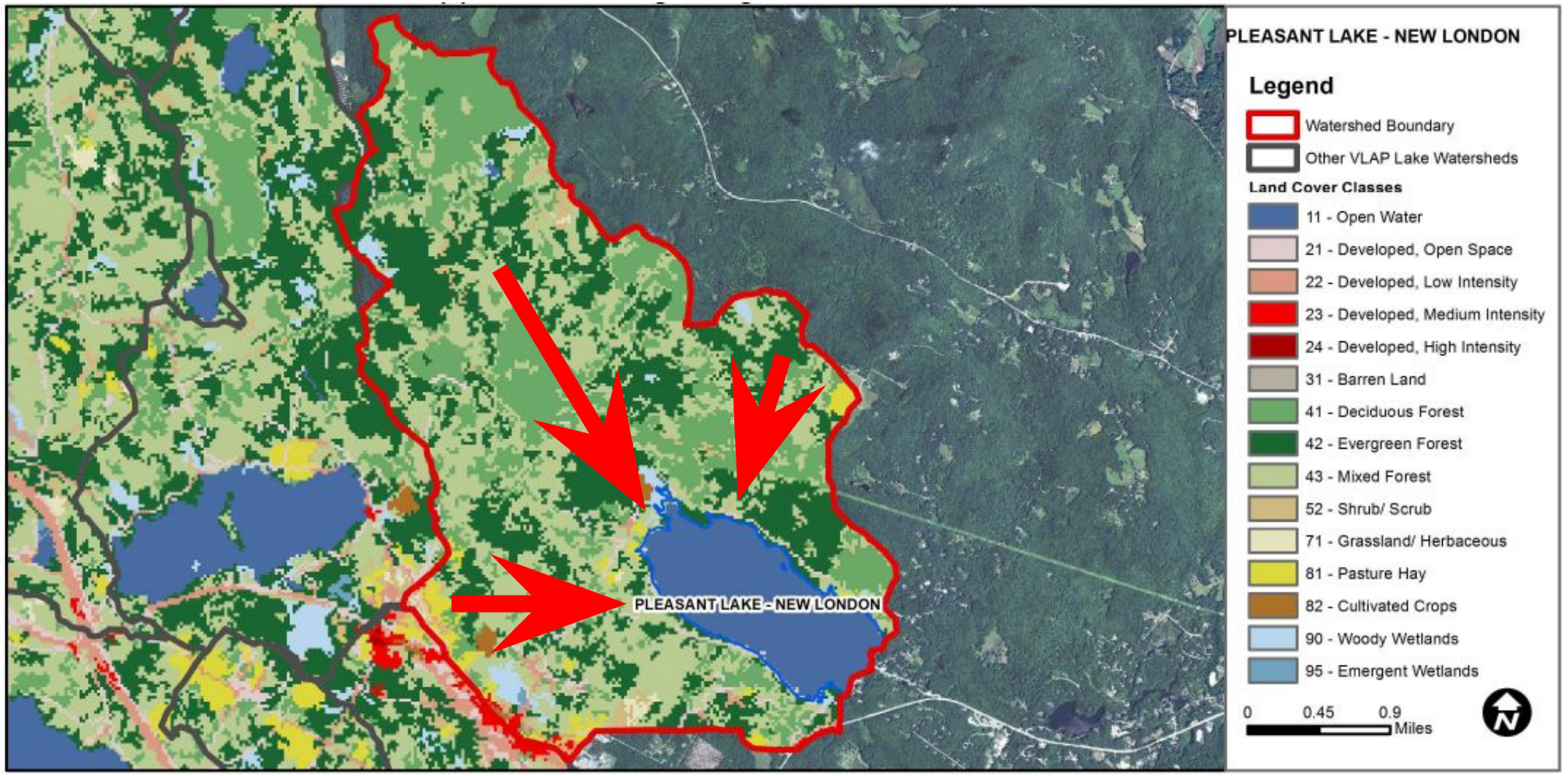
What can we do to address warmer waters?

1) We **can't** change global temperature trends in the short-term – this is a global policy issue.

2) We **can** eliminate the use of dock de-icers, which keep water open around docks and near the shorelines.

Reduced ice cover increases sunlight and wind-driven mixing of nutrients into the surface waters. These conditions favor cyanobacteria blooms, **which can occur even in the winter (e.g. Partridge Lake in northern NH).**

What can we do to Address Effects of Increased Storm Events?



We can Promote Good Lake Stewardship in the Watershed

Native plants, no lawns
Avoid fertilizers
Good septic maintenance
Minimize impervious surfaces
No dock de-icers

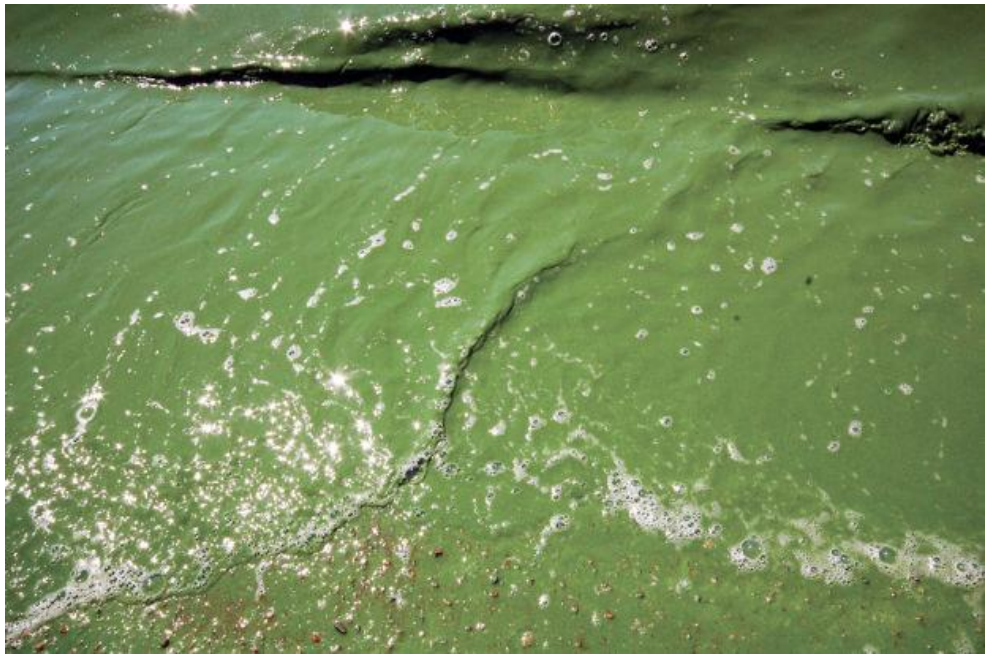
Watershed Management Decisions

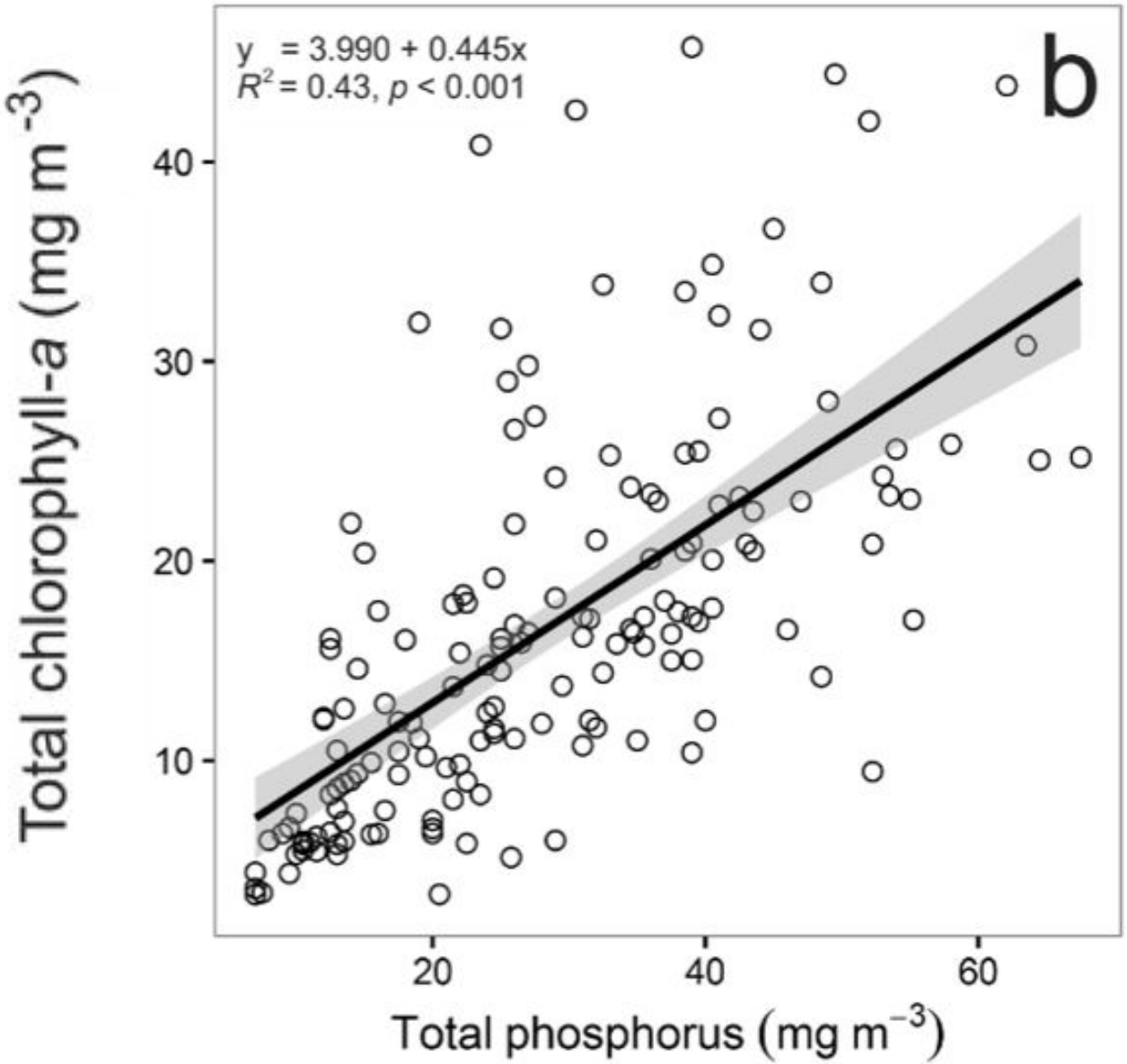
Lawn & garden fertilizers
Leaky septic systems
Impervious surfaces
(driveways, buildings)
Dock de-icers

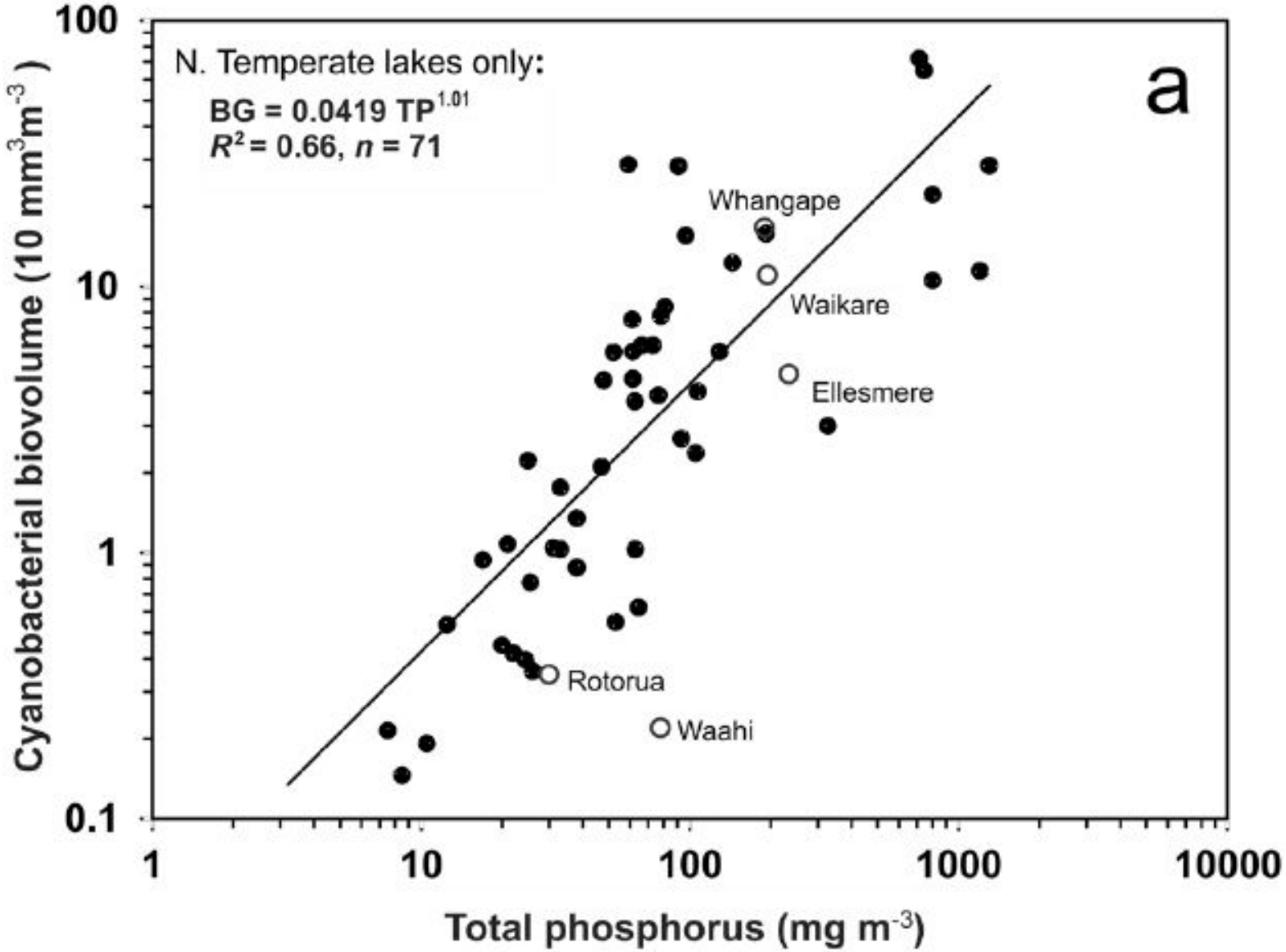
Good Lake Stewardship?

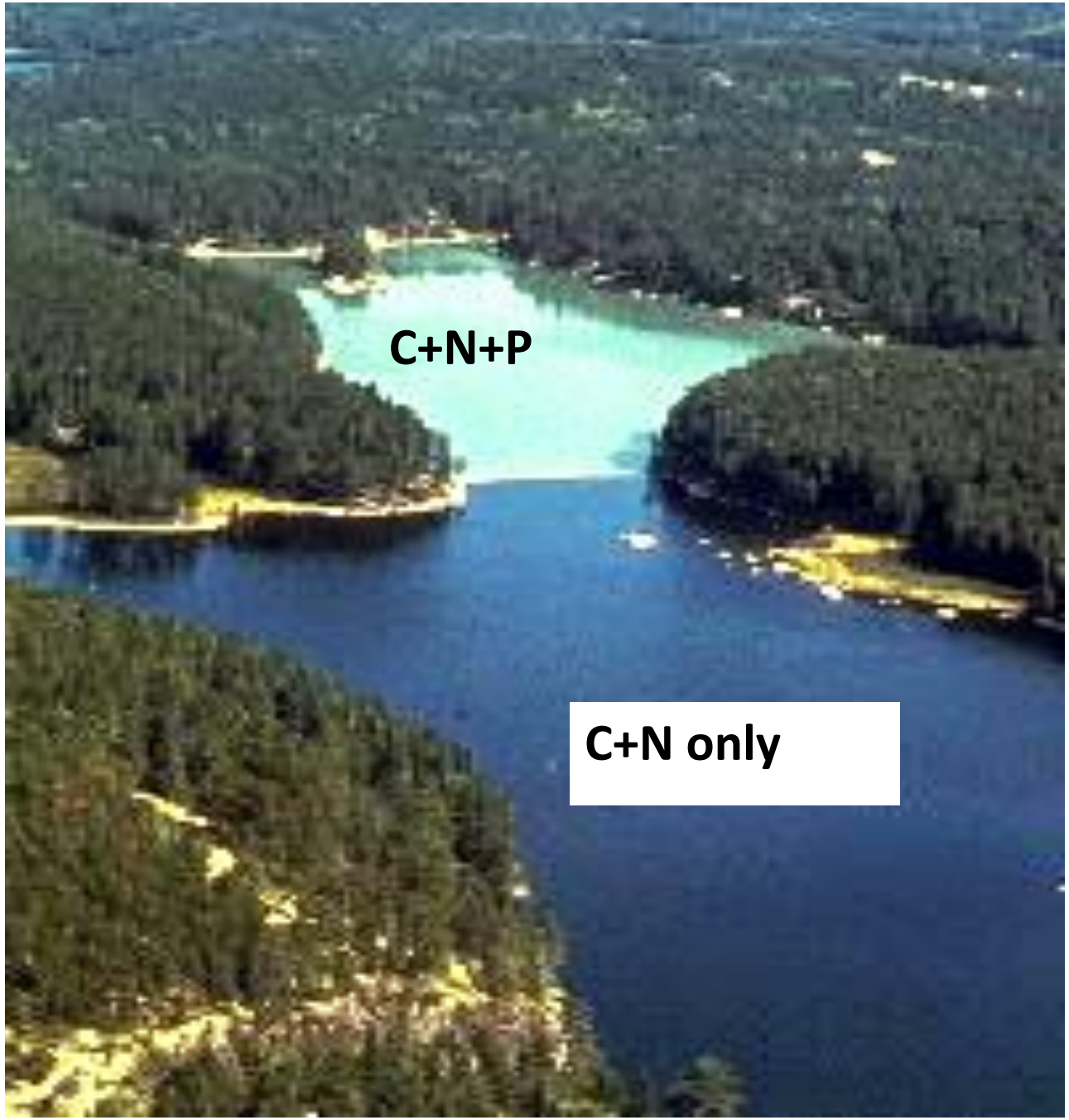
YES **NO**

?




y = 3.990 + 0.445x
R^2 = 0.43, p < 0.001
b
Total chlorophyll-a (mg m-3)
10
20
30
40
20
40
60
Total phosphorus (mg m−3)

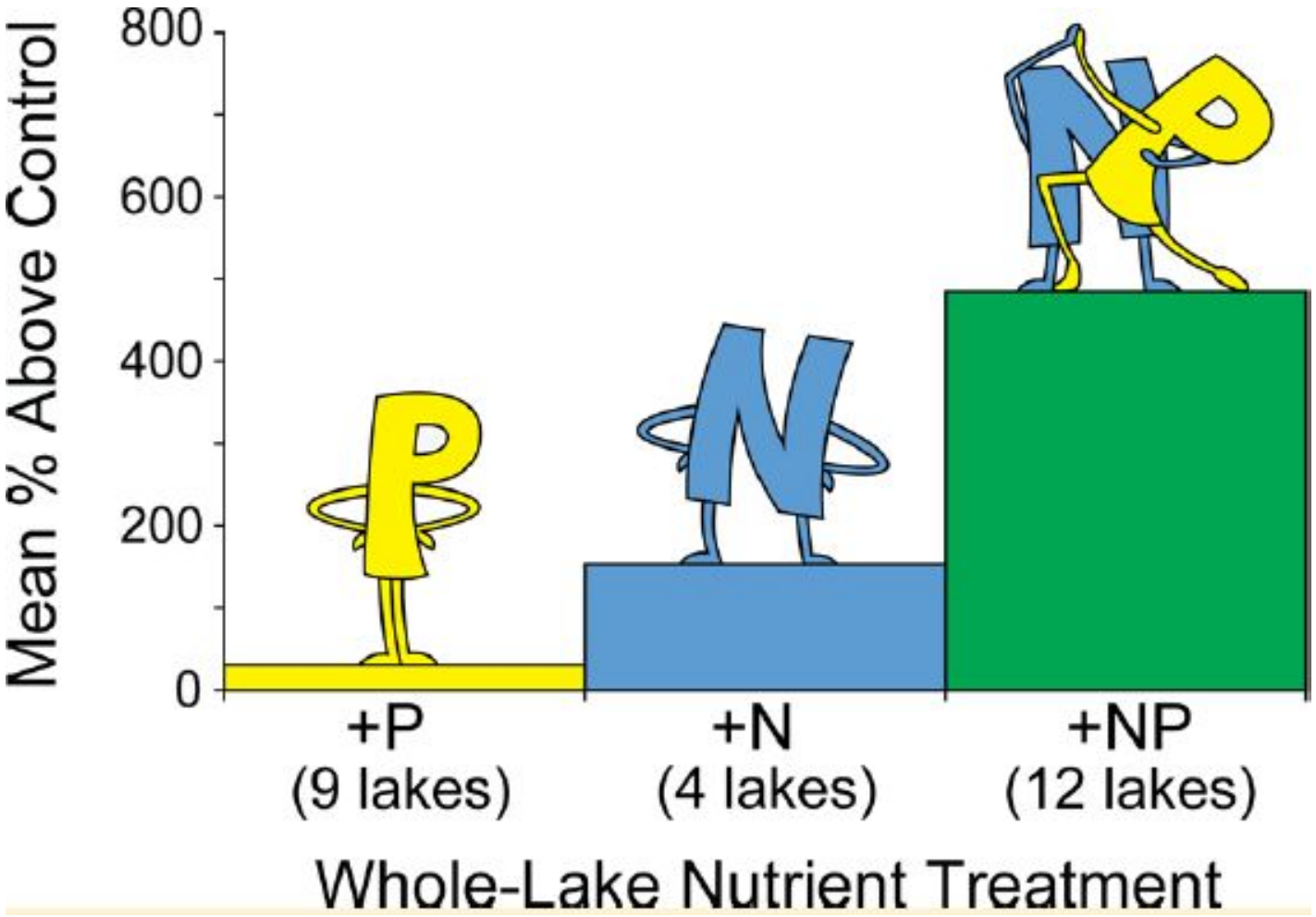

N. Temperate lakes only:
BG = 0.0419 TP^1.01
R² = 0.66, n = 71
a
Whangape
Waikare
Ellesmere
Rotorua
Waahi
Cyanobacterial biovolume (10 mm³m⁻³)
Total phosphorus (mg m⁻³)
100
10
1
0.1
1
10
100
1000
10000



Whole-lake experiment with nutrient addition

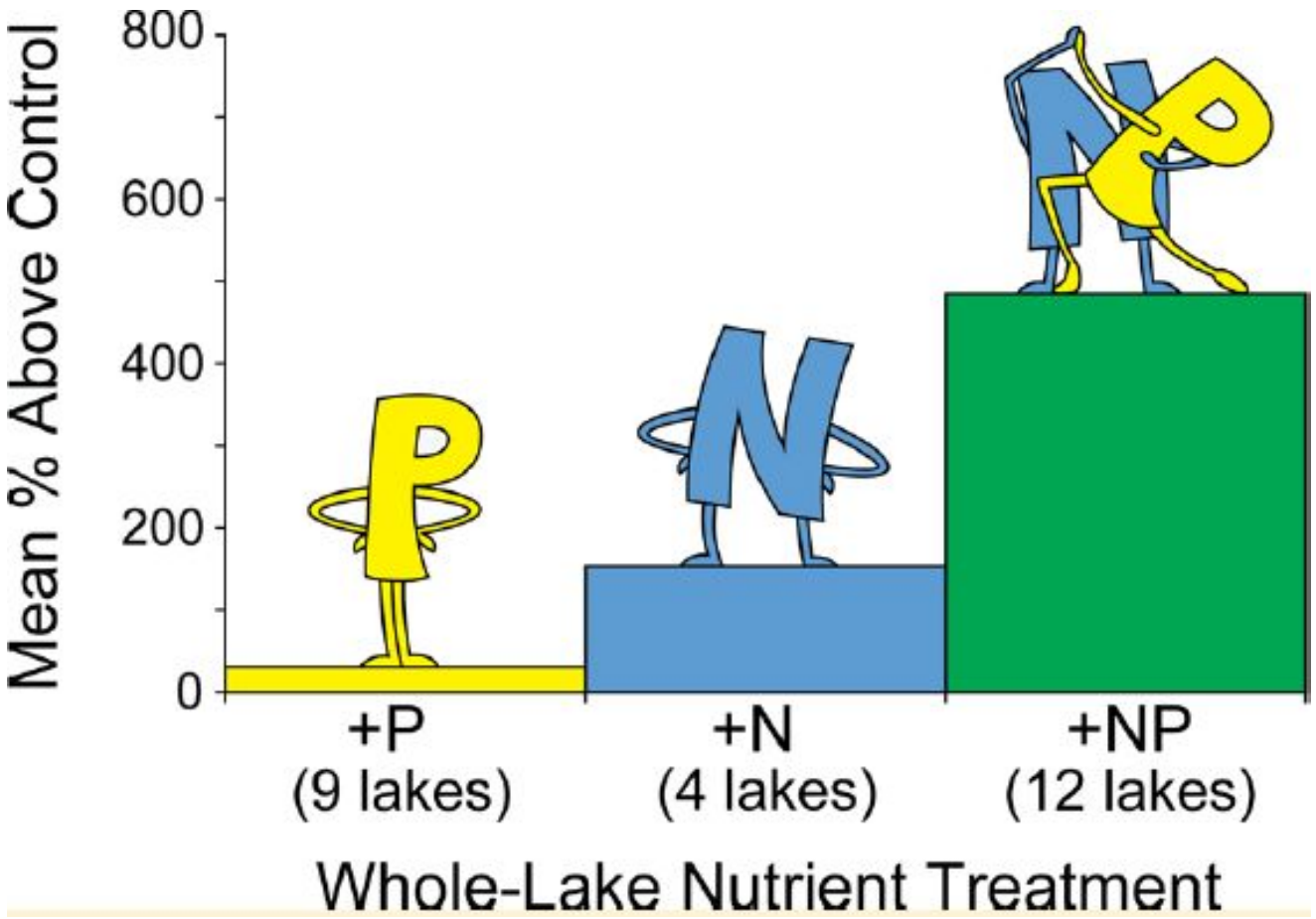
(Schindler 1974 Science 184:897)

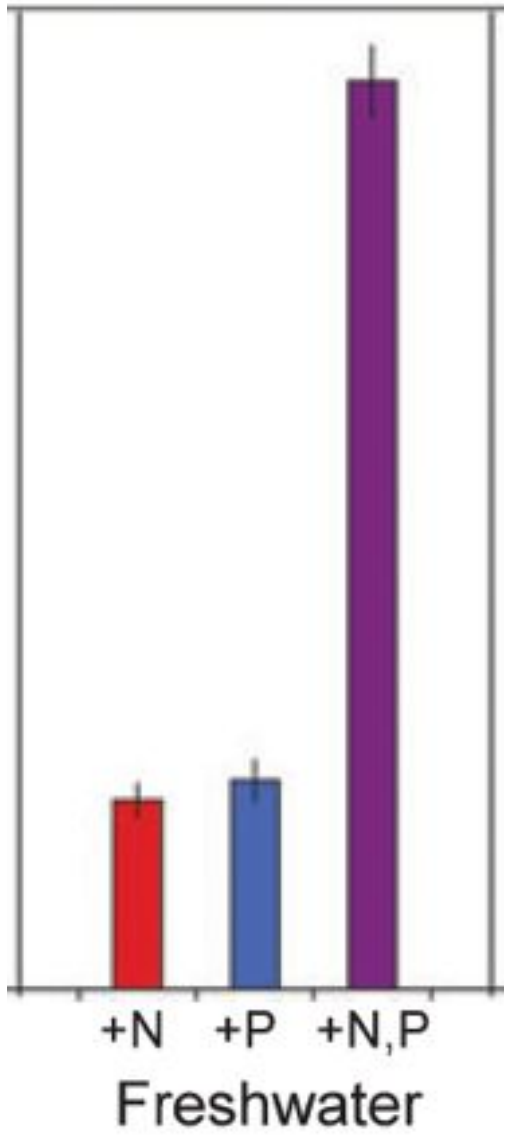
Nitrogen is important too!



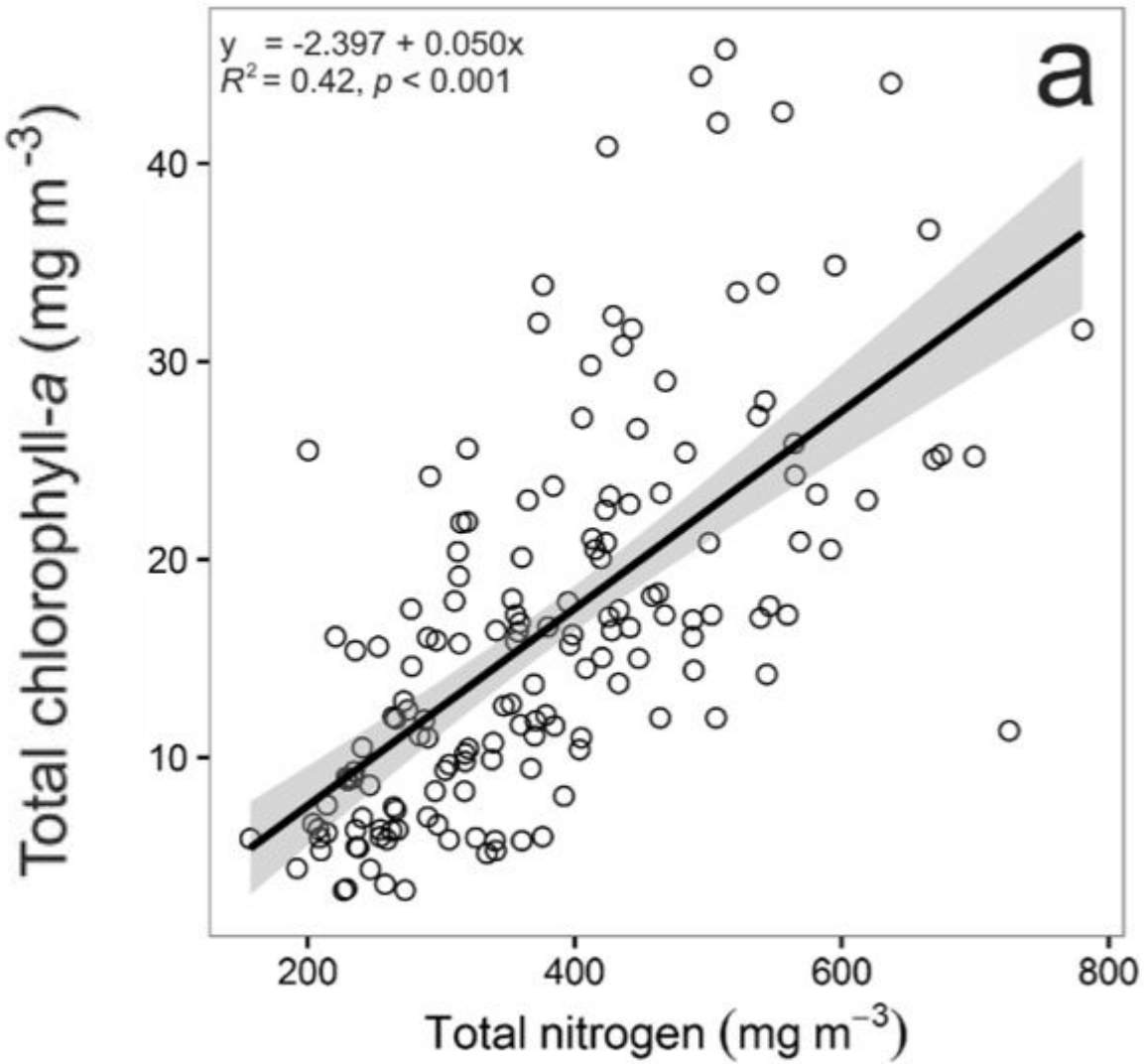
"It takes two to tango!"

Nitrogen is important too!





500+ Smaller Experiments


y = -2.397 + 0.050x
R^2 = 0.42, p < 0.001
a
Total chlorophyll-a (mg m-3)
40
30
20
10
200
400
600
800
Total nitrogen (mg m−3)

Steps to Fight Climate Change in NH Lakes

- **Avoid use of fertilizers**: nitrogen and phosphorus
- **Avoid lawns**: use native plants with deeper roots, no nutrients needed
- **Maintain your septic system**: pump & inspect every ~3 years, repair as needed
- **Avoid the use of dock de-icers**: they increase lake exposure to:
  - Wind-driven mixing of nutrient-rich sediments up into the lake
  - Increase exposure to sunlight, which warms waters and promotes algal growth
- **Avoid the use of wake-boats**: they stir up sediments and more nutrient-rich waters from deeper in the lake

Steps Taken By Pleasant Lake Protective Association

- **NH DES VLAP Monitoring**: Monthly sampling center lake:
  - Dissolved oxygen & temperature profiles, Secchi transparency, pH, ANC, conductivity, turbidity, total phosphorus, chloride
- **Plankton Sampling:** Monthly sampling of phytoplankton and zooplankton, counted by Ken Wagner.
- **Cyanobacteria Sampling:** Weekly sampling for potentially toxic species with Greenwater Labs, Florida
  - Quick turnaround – 1-2 days
  - Potential to test immediately for toxins
- **Watershed Management Plan:** Application submitted.

Partnership with Subtidal for Buoy: Continuous Monitoring for Cyanobacteria

Above the surface: waves & light dynamics

At the surface & just above the sediment: phycocyanin (cyanobacteria), chlorophyll-a (algae), temperature, dissolved oxygen, and turbidity

Integrated weather data: wind speed and direction, rainfall, and air temperature

What this helps reveal: estimated toxicity risk, shoreline aggregation hotspots, stratification / mixing / turnover, bottom hypoxia, sediment resuspension, rainfall / watershed-linked bloom activity, surface and bottom blooms, and other lake-specific dynamics.


Questions?