Again Hazardous Algal Blooms (HABs): Why might this be happening? What can we do?

Norman Yan & Neil Hutchinson
Friends of the Muskoka Watershed

Algal blooms were a problem in the past

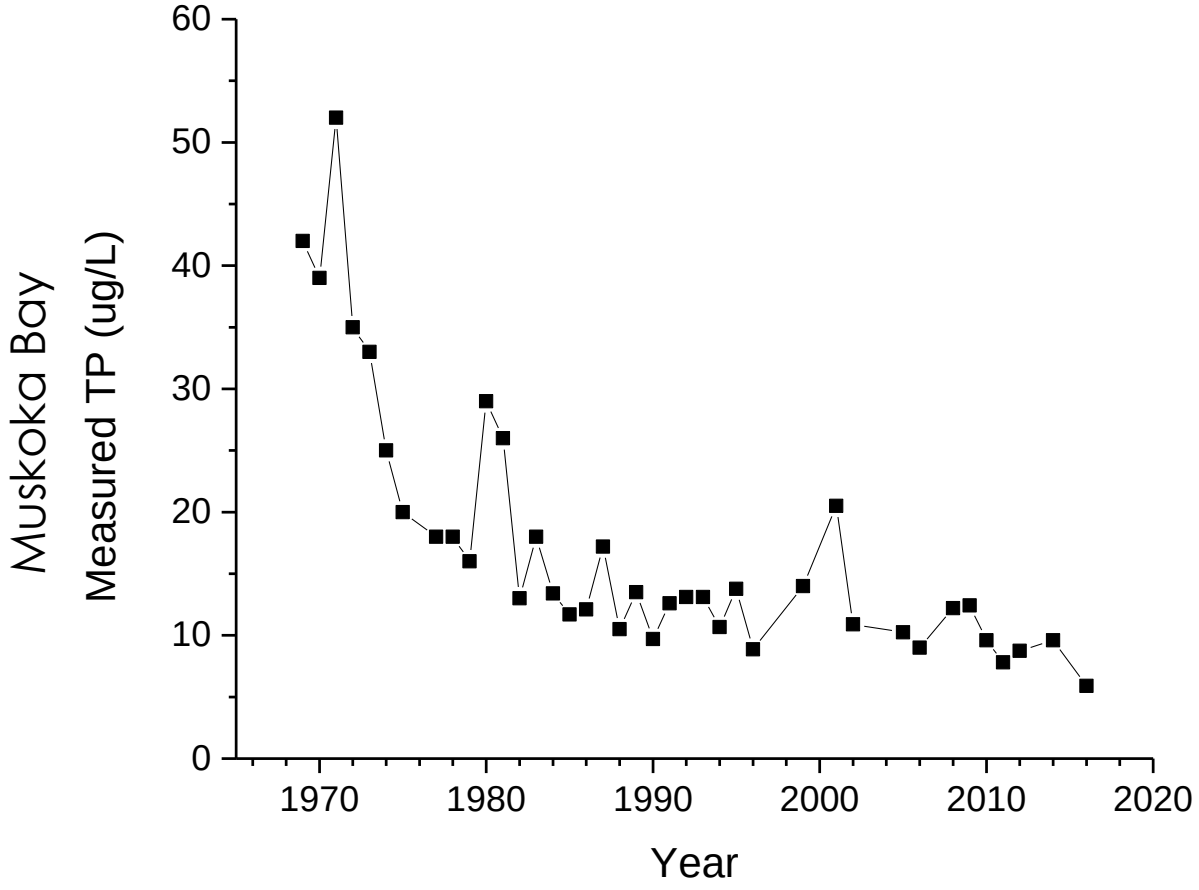
Friends of the Muskoka Watershed

Image: Tom Archer, Encyc. Brit.

Limnologists “proved” that too much Phosphorus (P) was the cause, back then

Lake 226 in the Experimental Lakes Area

So we reduced P input to lakes globally: and TP levels in lakes fell (e.g. Muskoka Bay)



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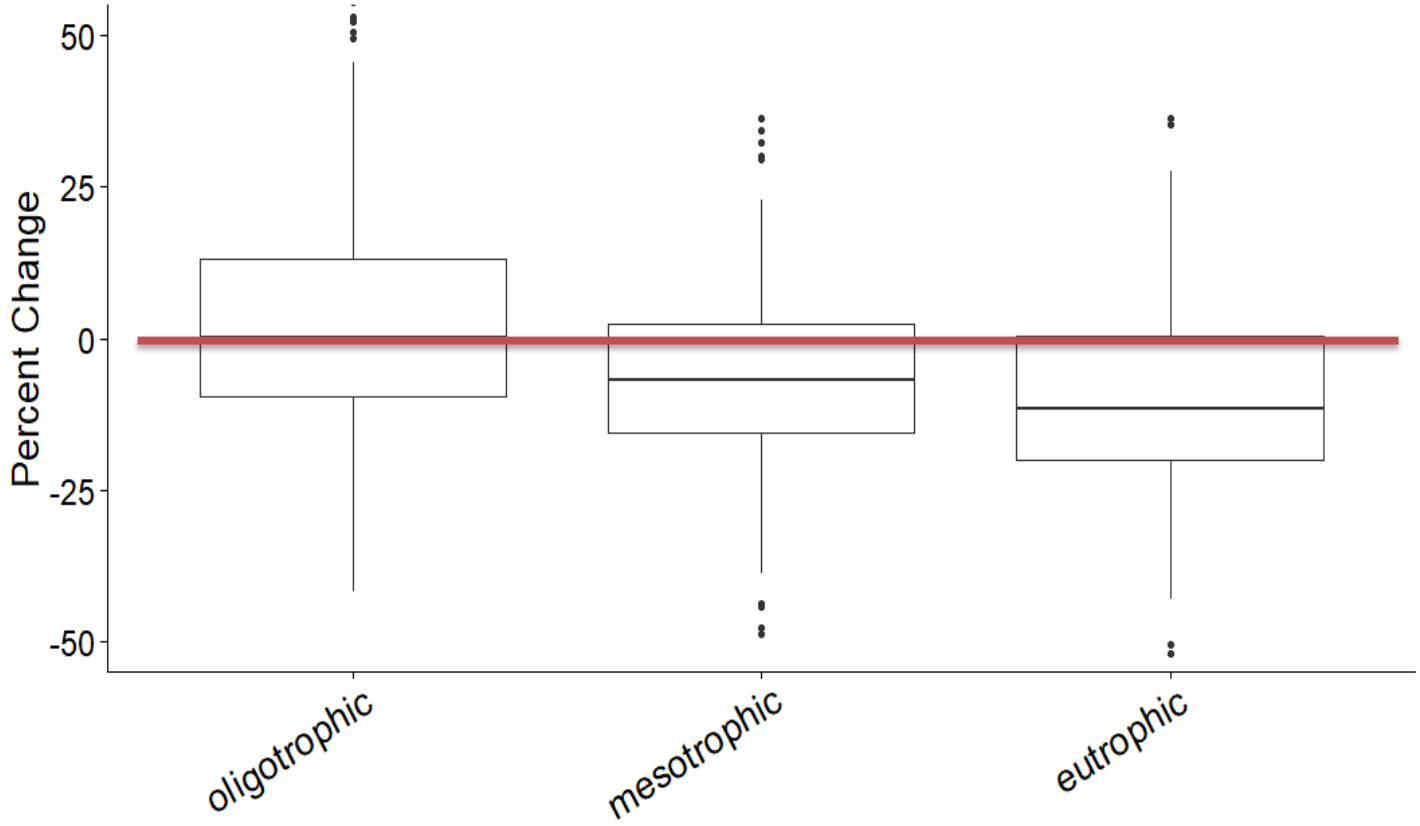
And in many other more TP-enriched lakes (% change in TP since 2005-2009)

(n = 636 lakes, Favot et al 2023*)



*Favot et al. 2023 Lake Reserv. Managm)

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And then this happened
in Dickson Lake, Algonquin Park in 2014*
a troubling mystery

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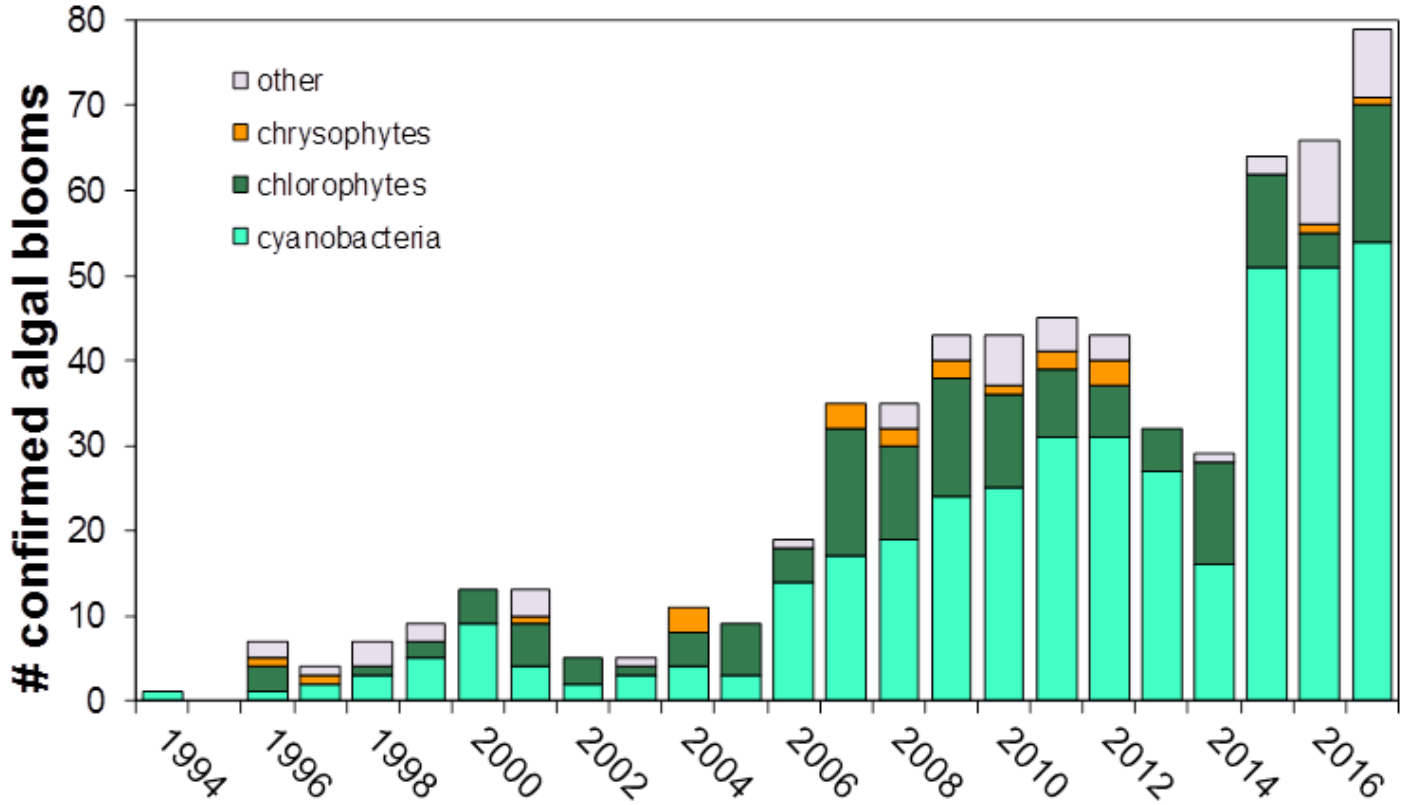
*Favot et al. 2019 J. Paleolim

Algal blooms are on the rise despite falling or steady levels of P



Source: Claire Holeton via A. Paterson, MECP
And Favot et al. 2023

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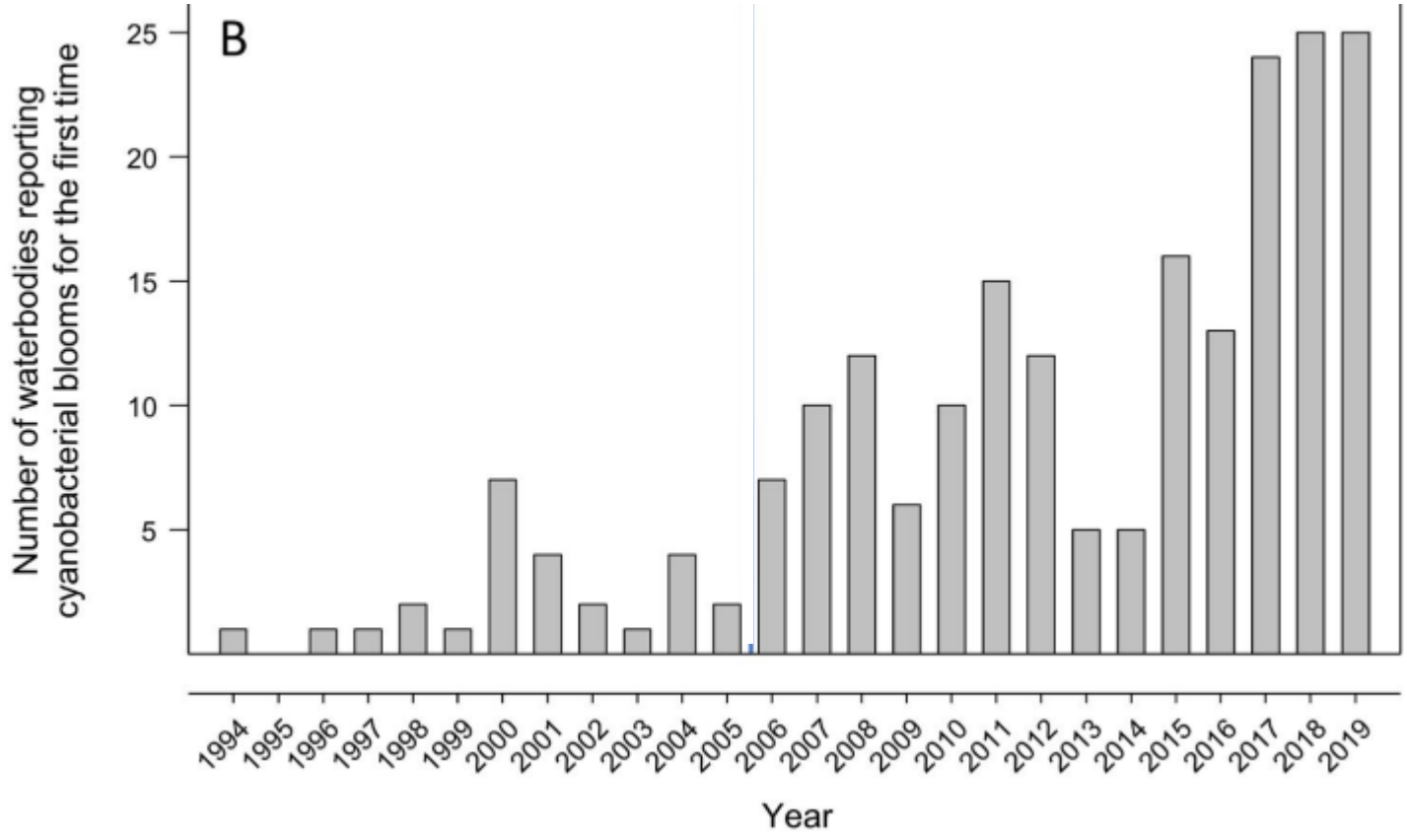
And more lakes are seeing their first ever algal blooms *



*Favot et al. 2023

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Might multiple stressors interacting with climate change have increased the risk of algal blooms?

- Algal blooms are influenced by:
  - species habitat preferences: turbulence, chemistry, oxygen and temperature
  - Algal growth rates linked to phosphorus supply
  - Algal death rates linked to grazing by zooplankton

Consider a good lawn

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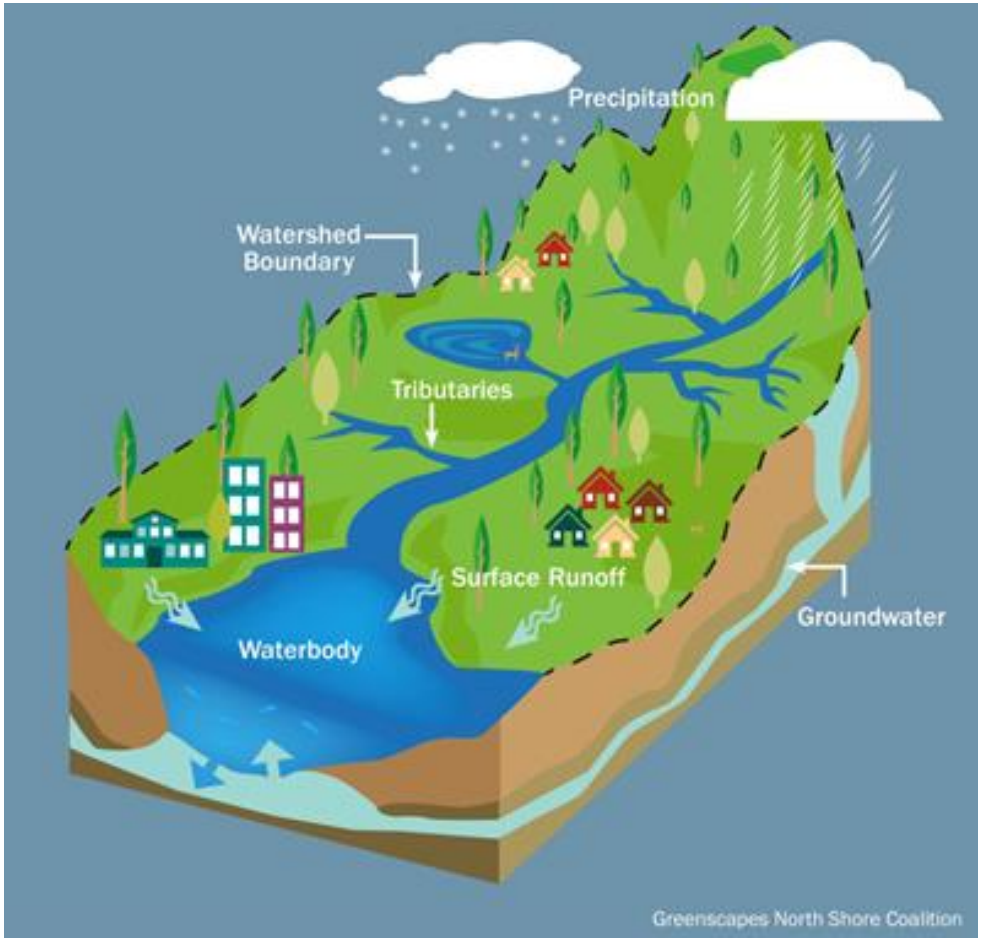
Where do lakes get their phosphorus?



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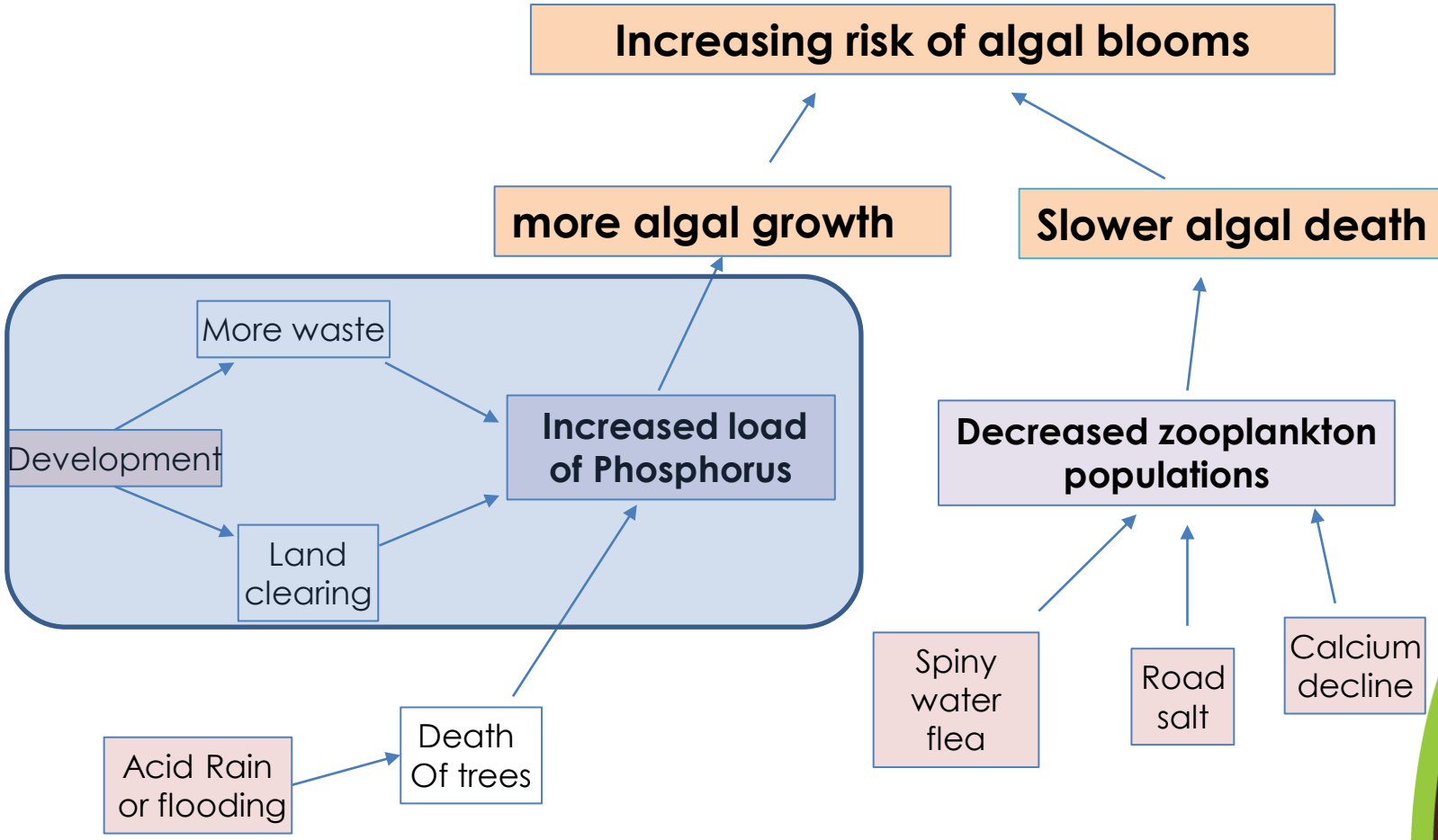
Images from Greenscapes North Shore Coalition

And zooplankton are the “mowers”

Image from Utah State U



Linking new threats other than climate change to algal blooms

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The spiny water flea has spread rapidly

Images from SLELO PRISM

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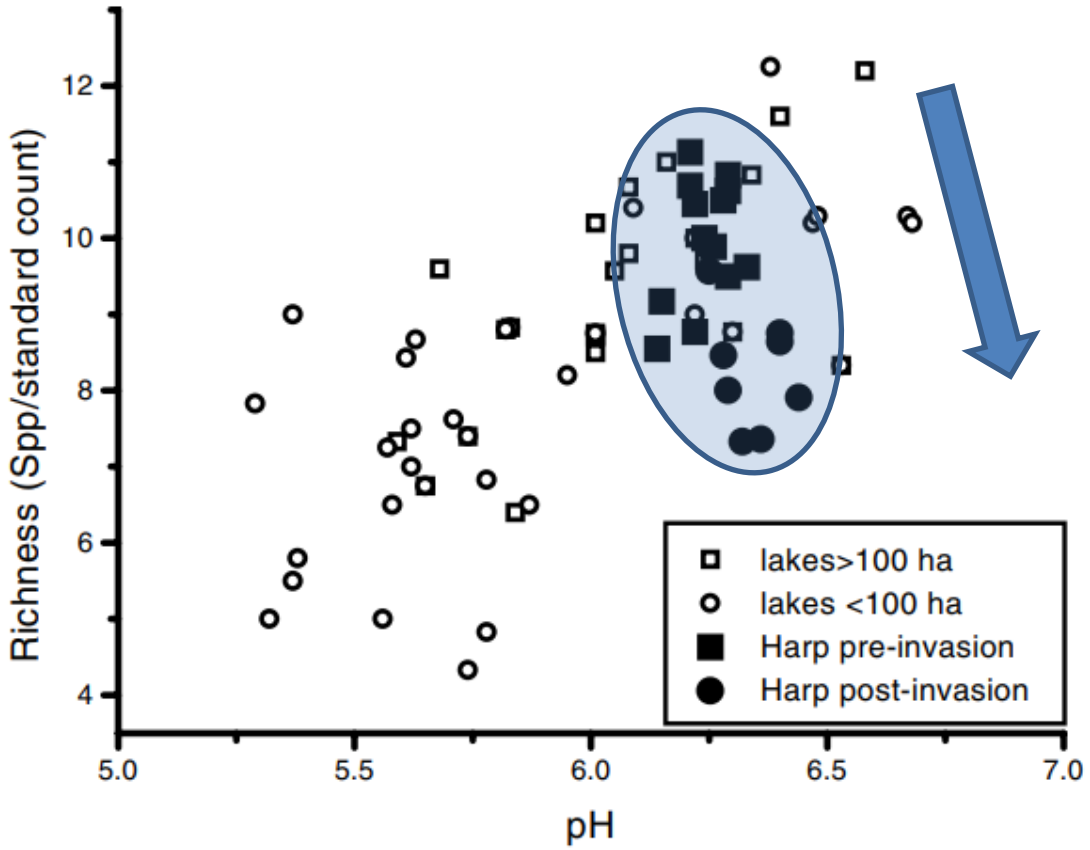
It eliminates key herbivorous zooplankton
(e.g. in Harp Lake lowering zooplankton richness by 40%)*



Yan et al. 2002 Ecol. Lett.

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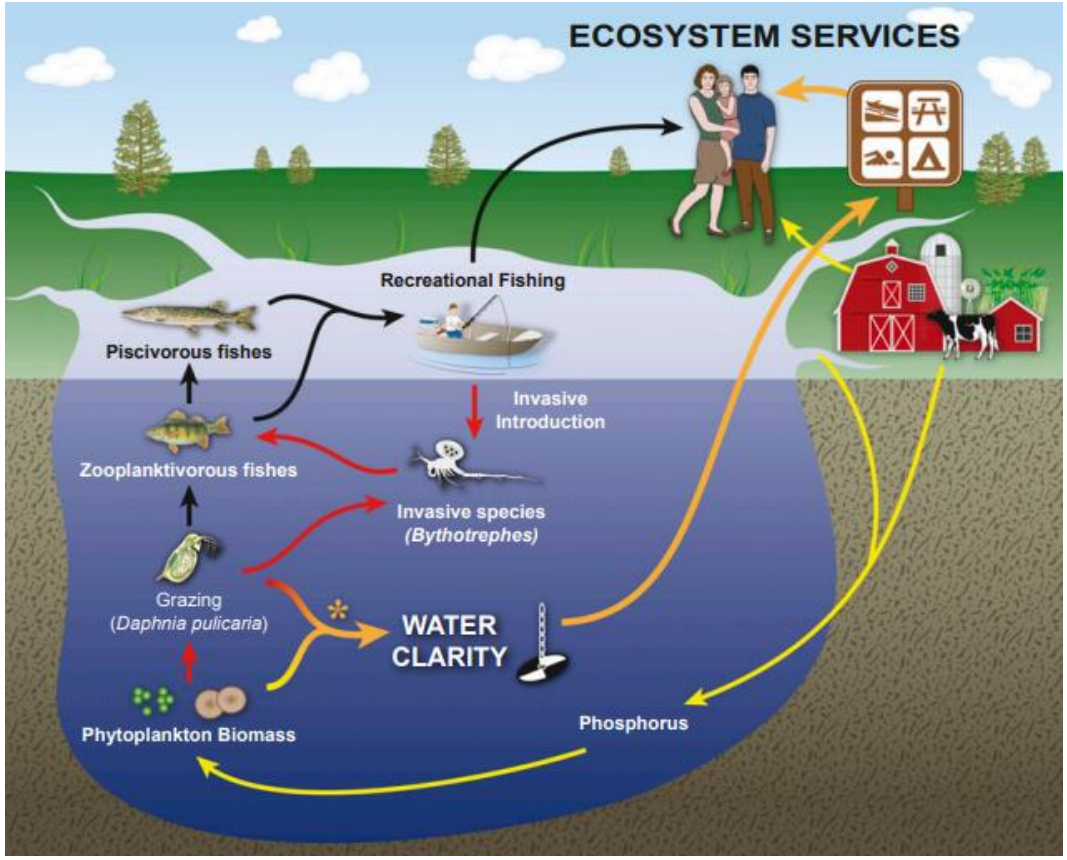
In Lake Mendota, WI, it would cost $140M to restore water clarity lost after *Bythotrephes* invaded*



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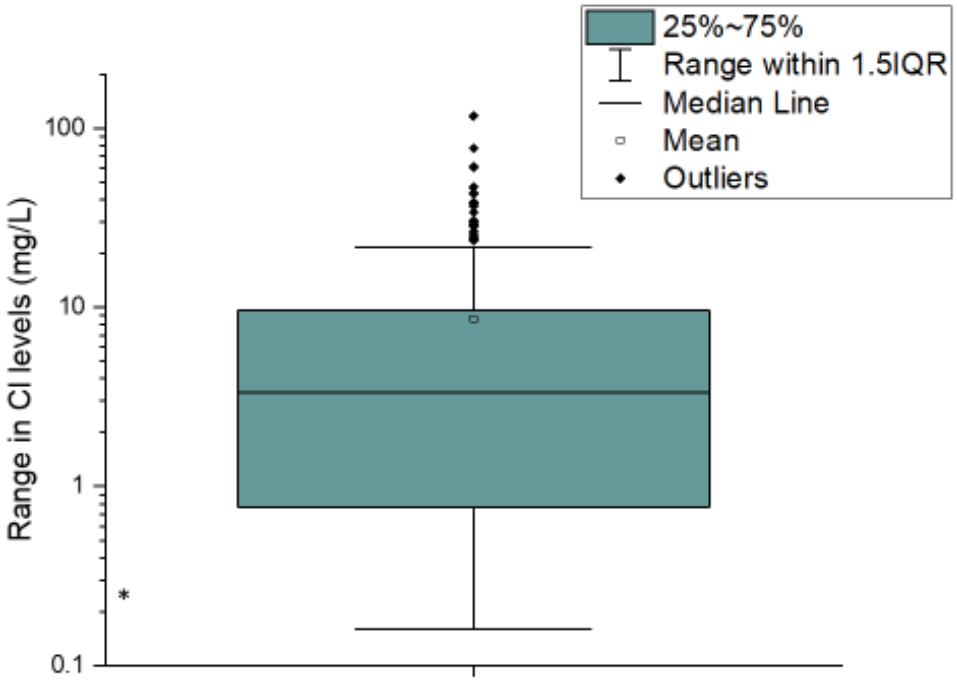
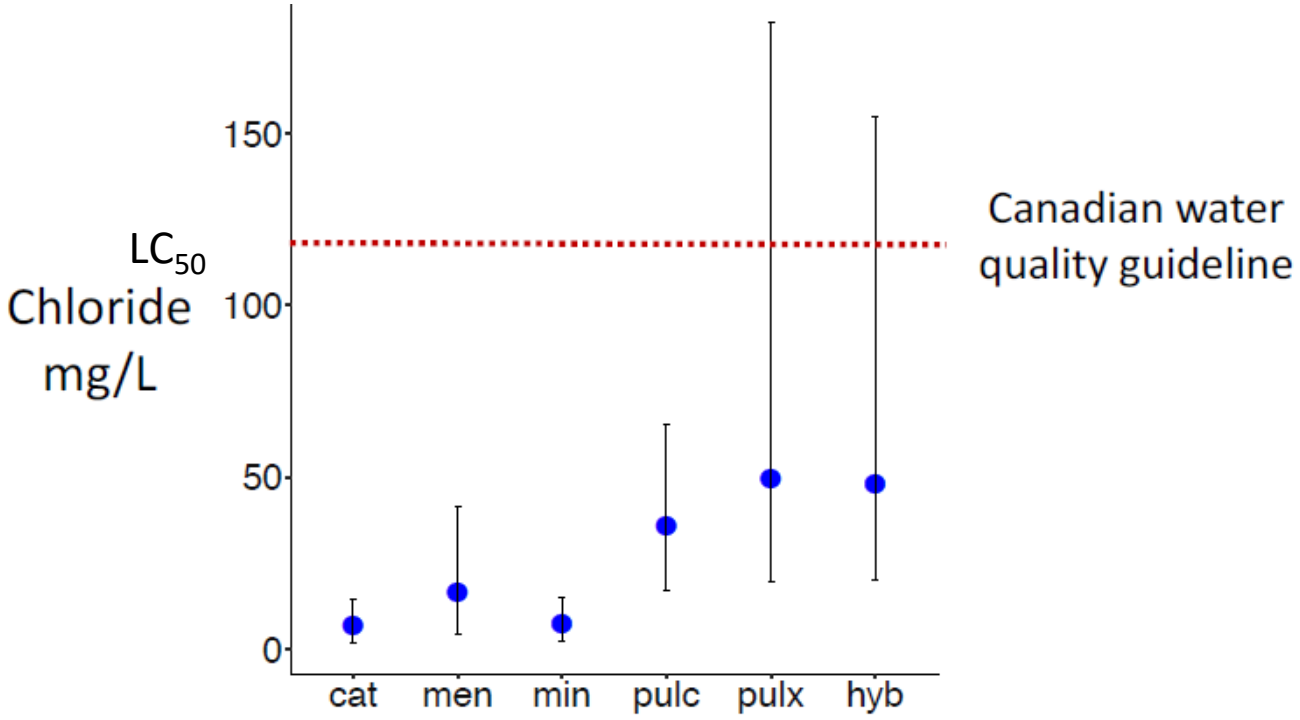
*Walsh et al 2015 PNAS

And there is now a 700 fold range in Chloride levels in Muskoka lakes, because of road salt with 25% of lakes above 10 mg/L*



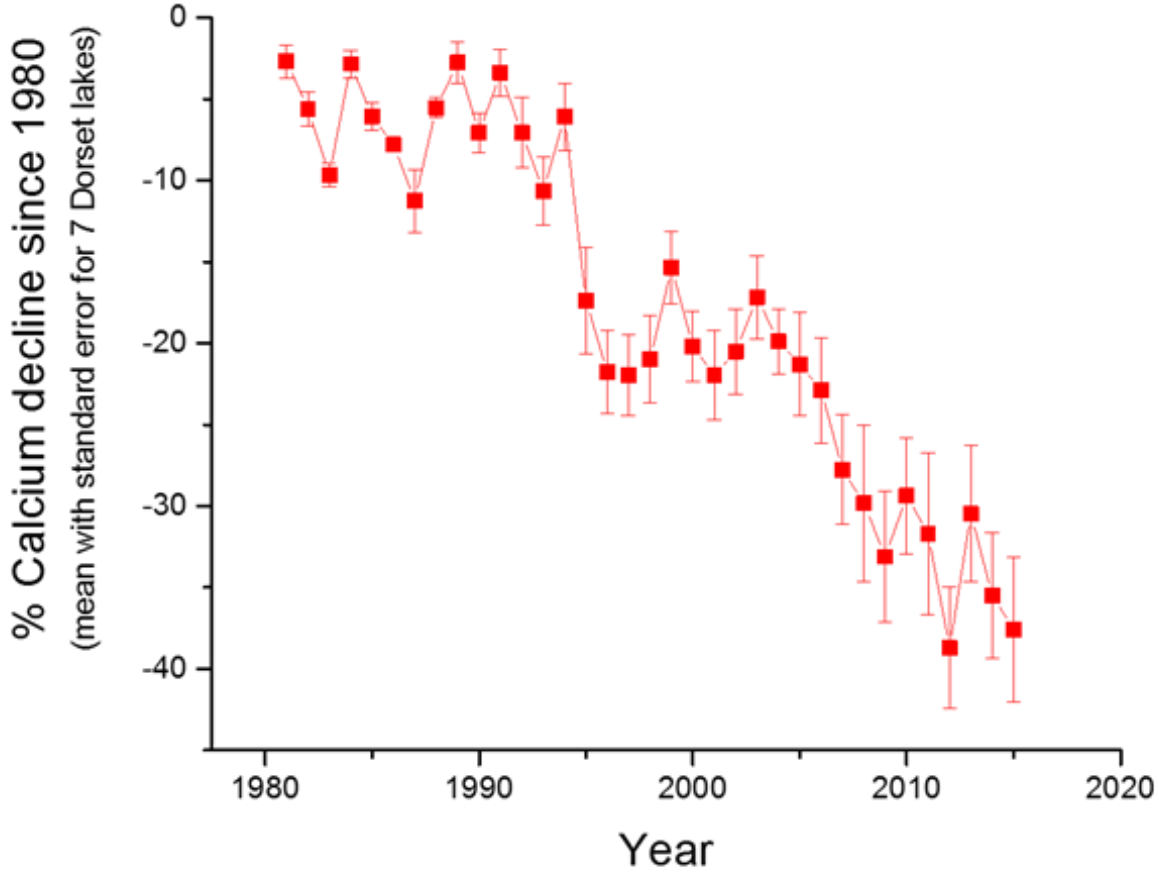
*data from the District of Muskoka's Water Quality Monitoring Program
Summarized in Yan 2020 10 Key questions about road salt

10-20 mg/L of Chloride is toxic to key water fleas (21 day LC_{50} in soft-water at high food)*



* Arnott et al ES&T 2020

And calcium levels have fallen to damaging levels in about half of Muskoka's lakes (graph is for DESC A lakes)*



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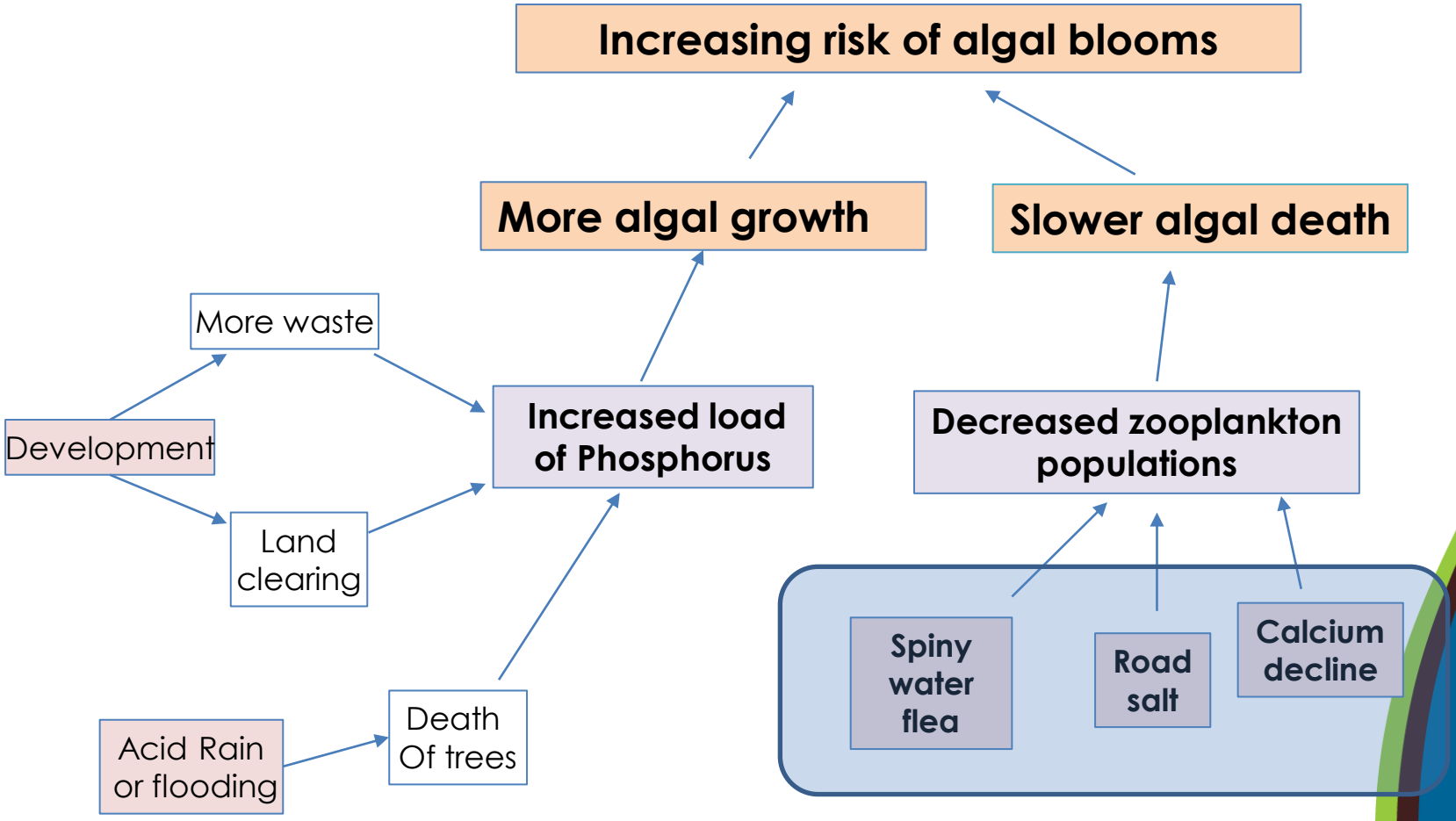
*From Paterson MECP DESC



Linking new threats other than climate change to algal blooms

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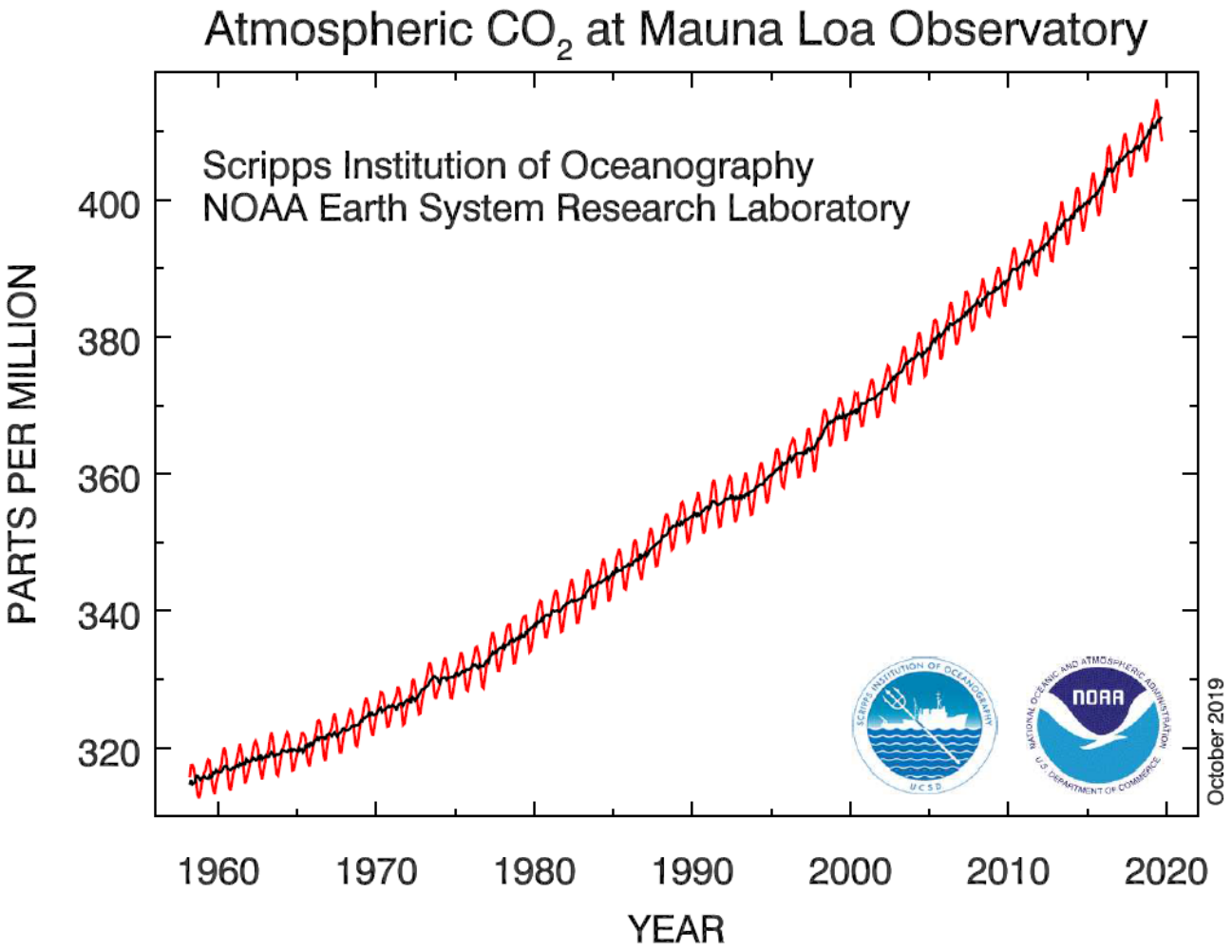
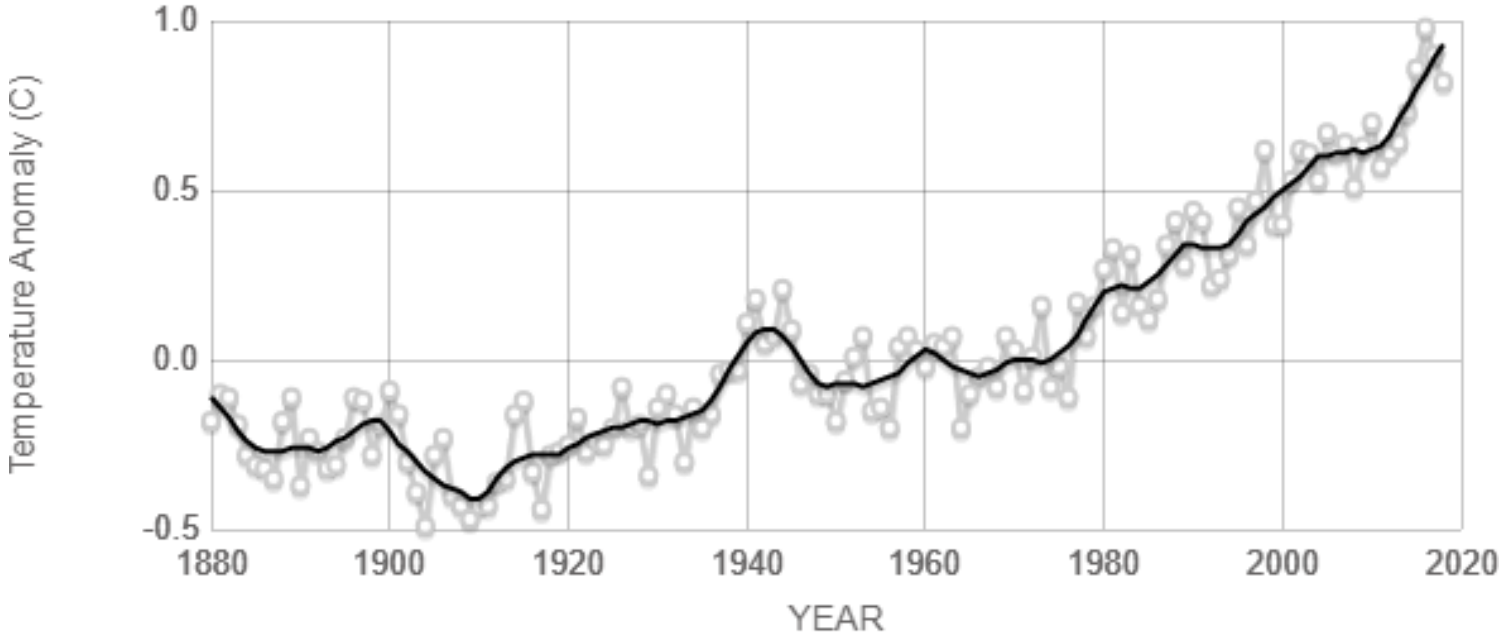
But atmospheric CO_2 levels are rising



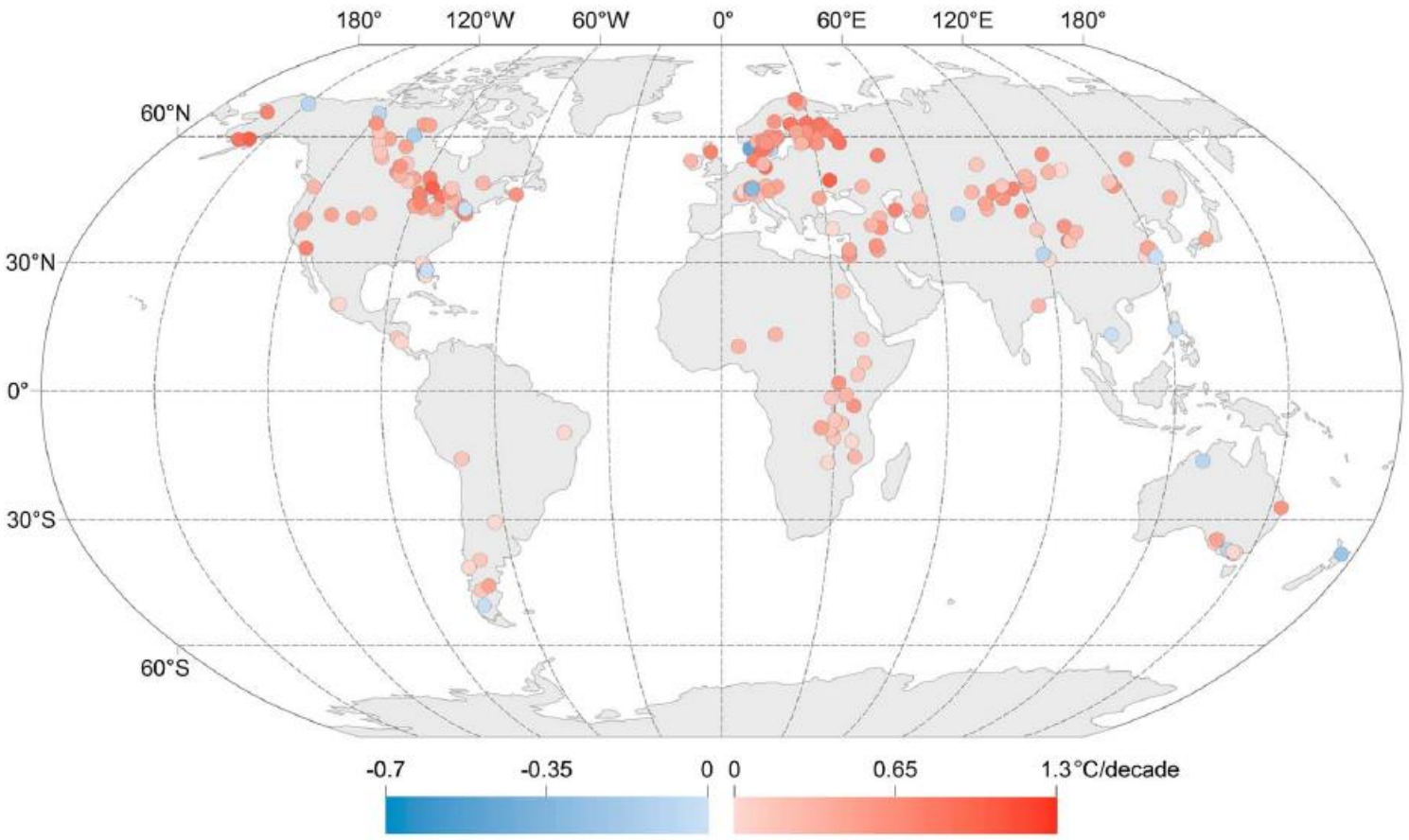
Raising global air temperatures*
(compared to 1950 to 1980 mean)



Source: climate.nasa.gov

*Source: climate.nasa.gov

And lake surface waters are warming (from 1985 to 2009 in 240 lakes)



*O'Reilly, Sharma et al. 2015 Geophys. Res Lett.

Spring floods can be severe

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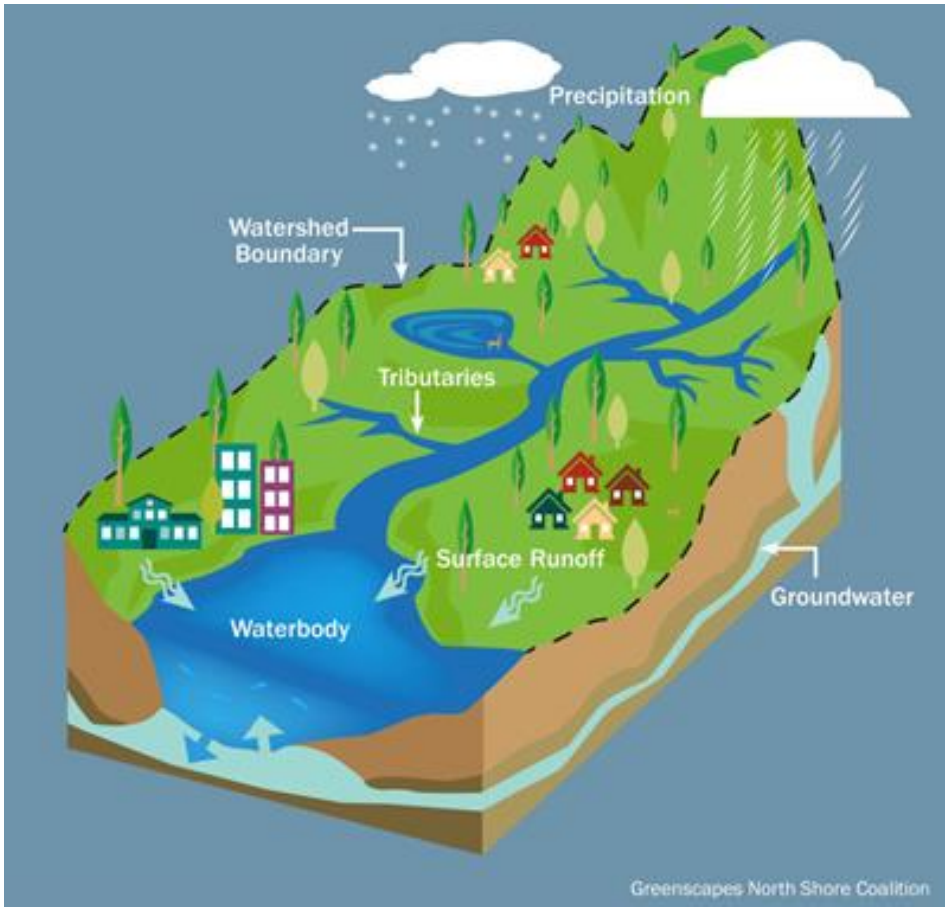
Image from Toronto.com

Flooding may also increase erosion and nutrient supply

More erosion may lead to more P supply



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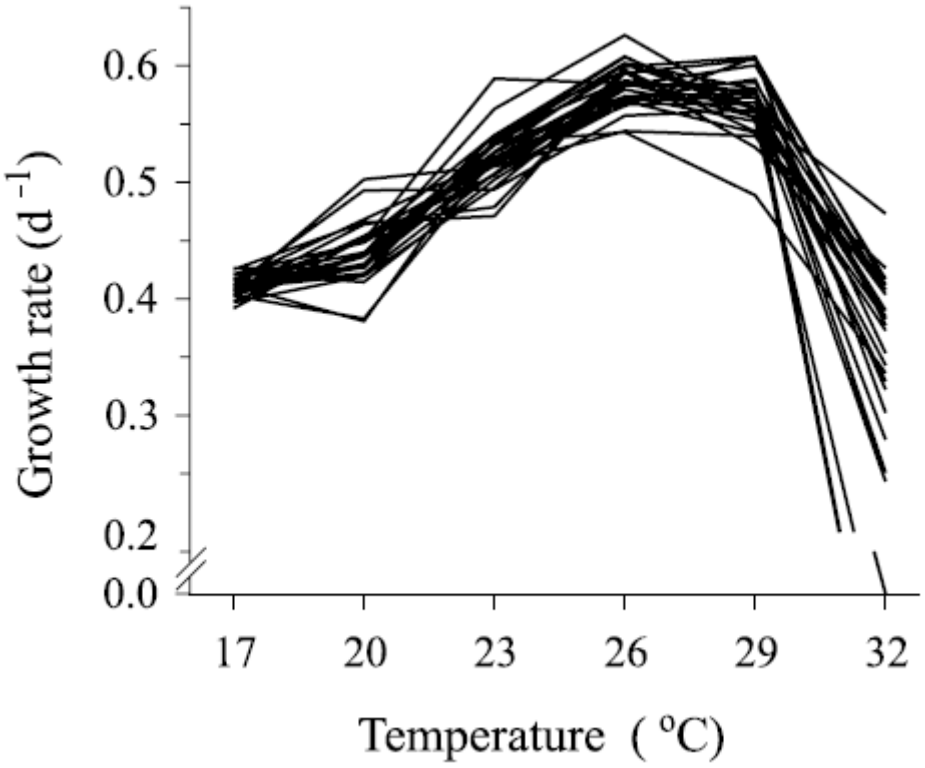
Images from Greenscapes North Shore Coalition

Daphnia suffer in water >28 degrees

growth vs. temperature for *Daphnia magna**



*Lampert 2006 Pol. J. Ecol

With more lake-effect snow there is more use of salt in Muskoka

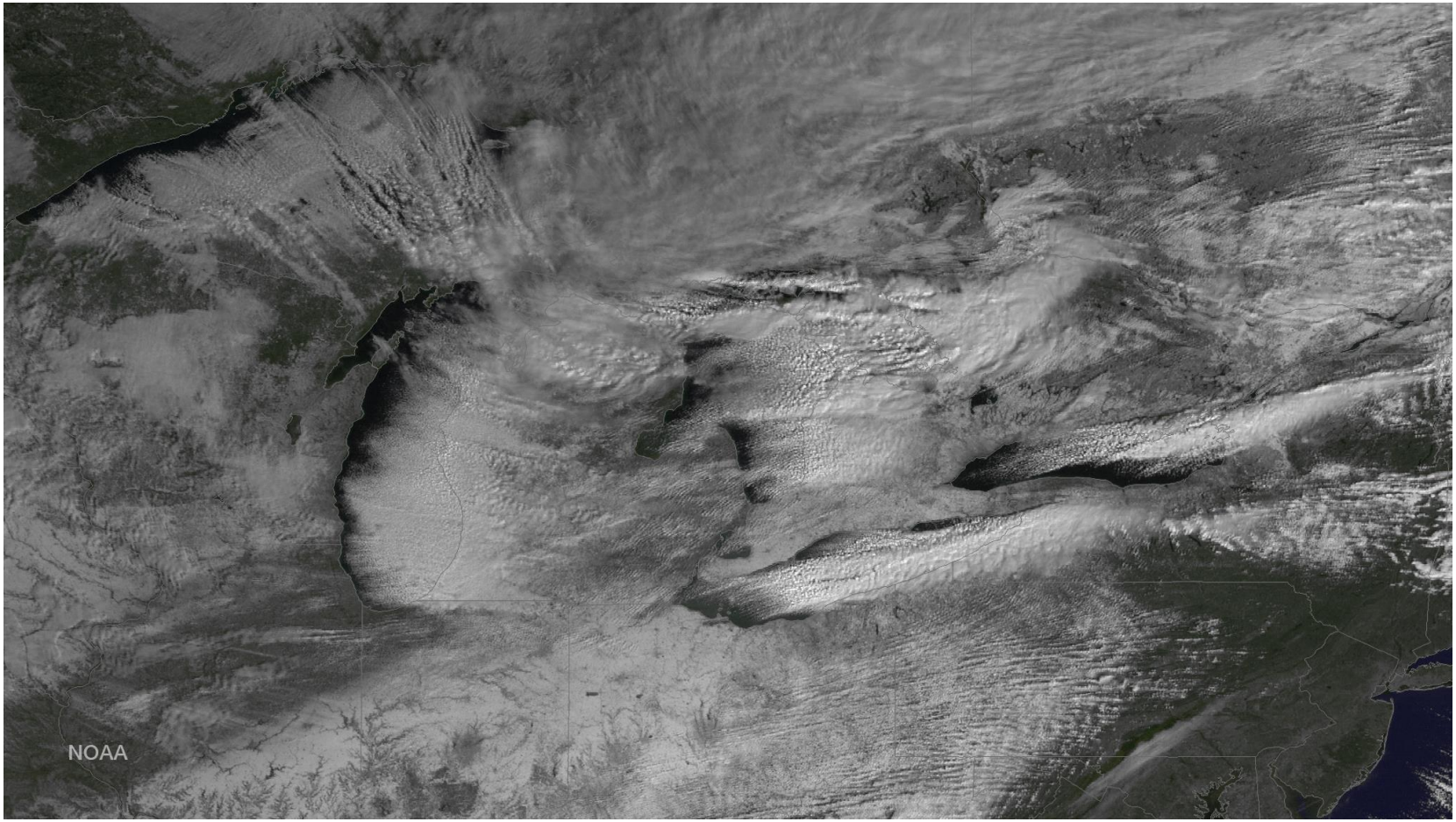
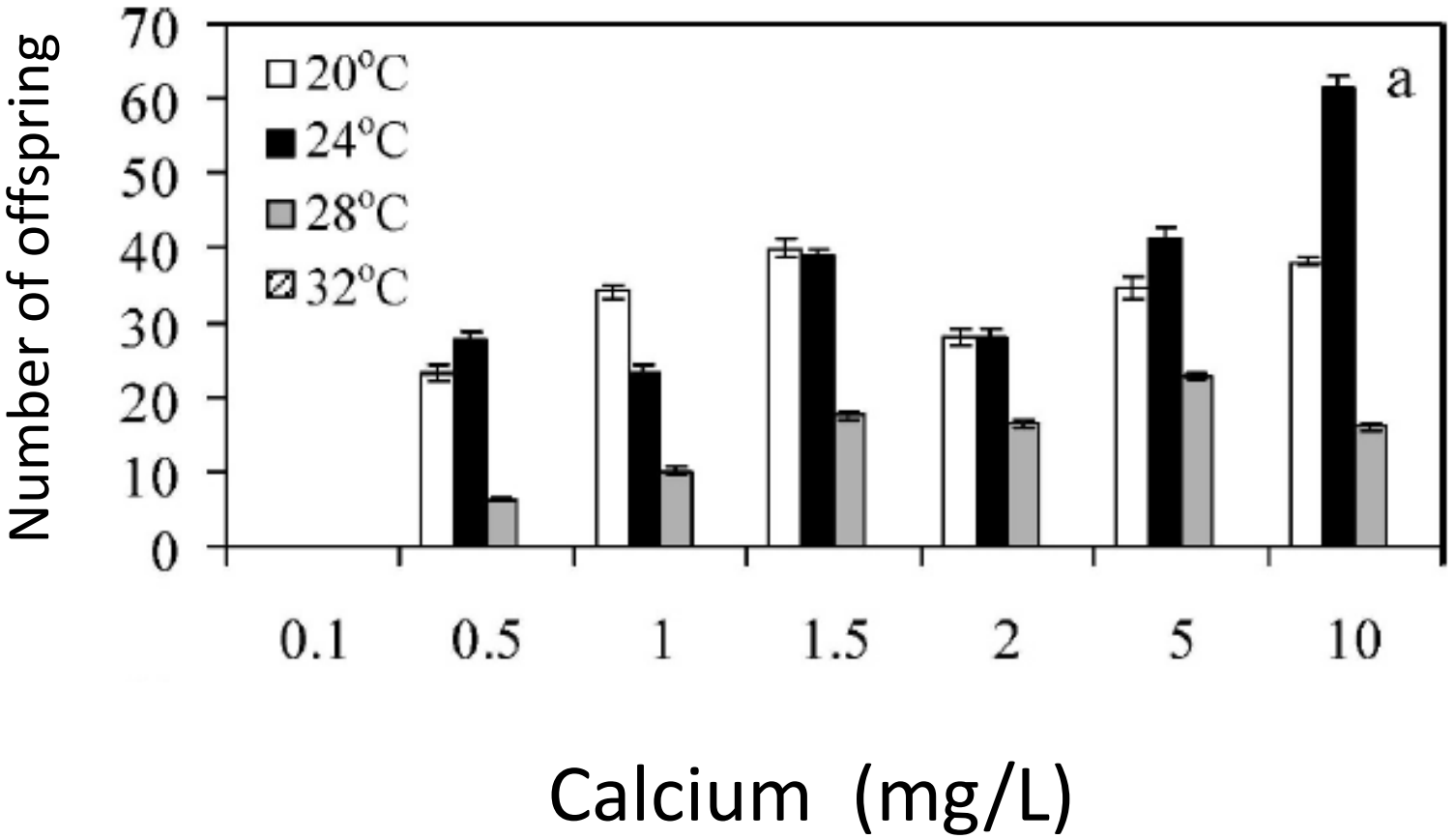


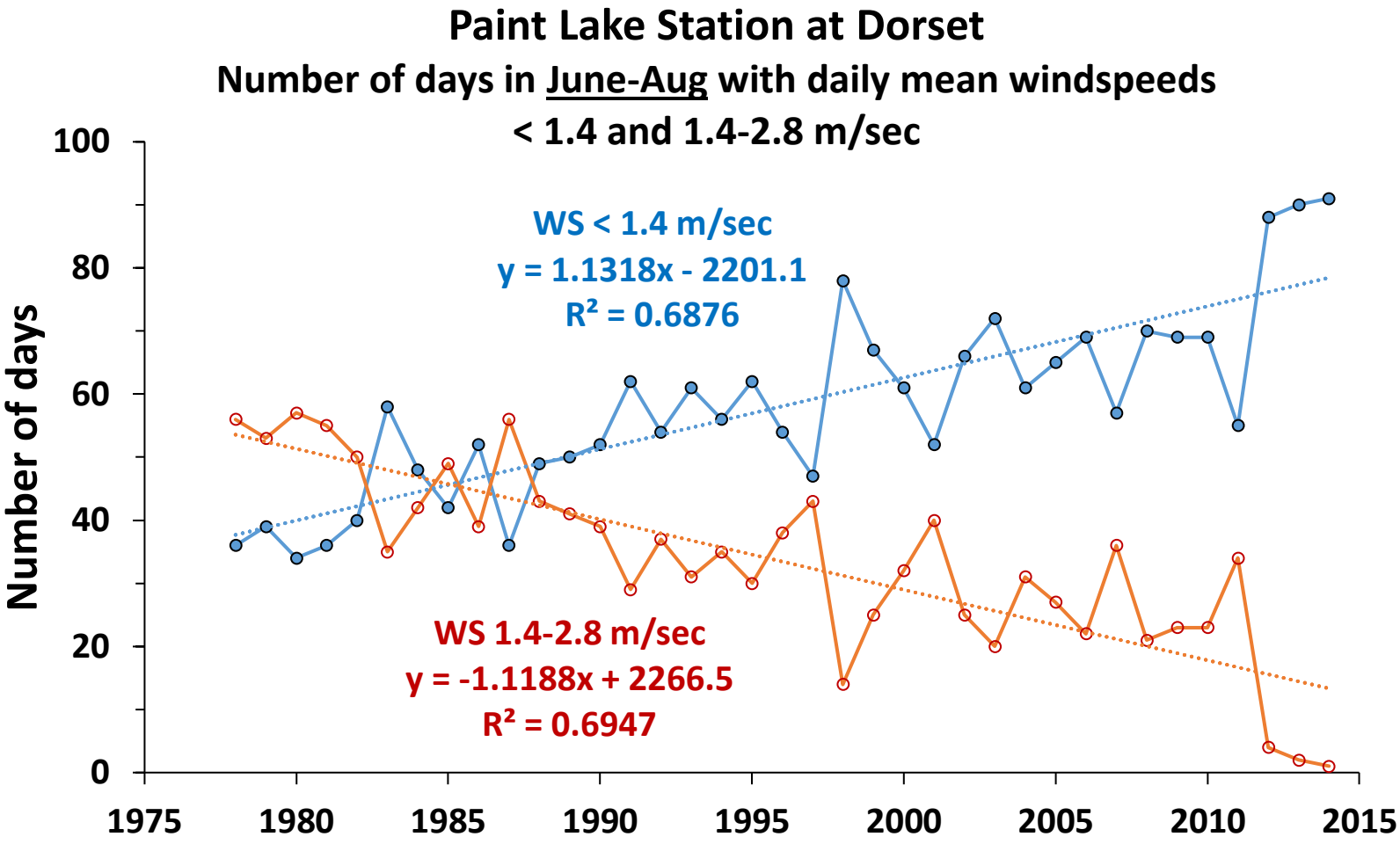
Image from NOAA

High temperatures interact with other stressors, e.g. increasing low Ca damage to *Daphnia**



*Ashforth and Yan 2008 Limnol. Oceanogr.

Summer wind speeds in Muskoka are falling*, favouring blue-greens



*From Yao MECP DESC and Molot York U

Can we imagine that new lake stressors coupled with climate change lead to novel algal blooms?

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Climate change is likely a threat multiplier for HABs

By damaging animal plankton, that eat algae via

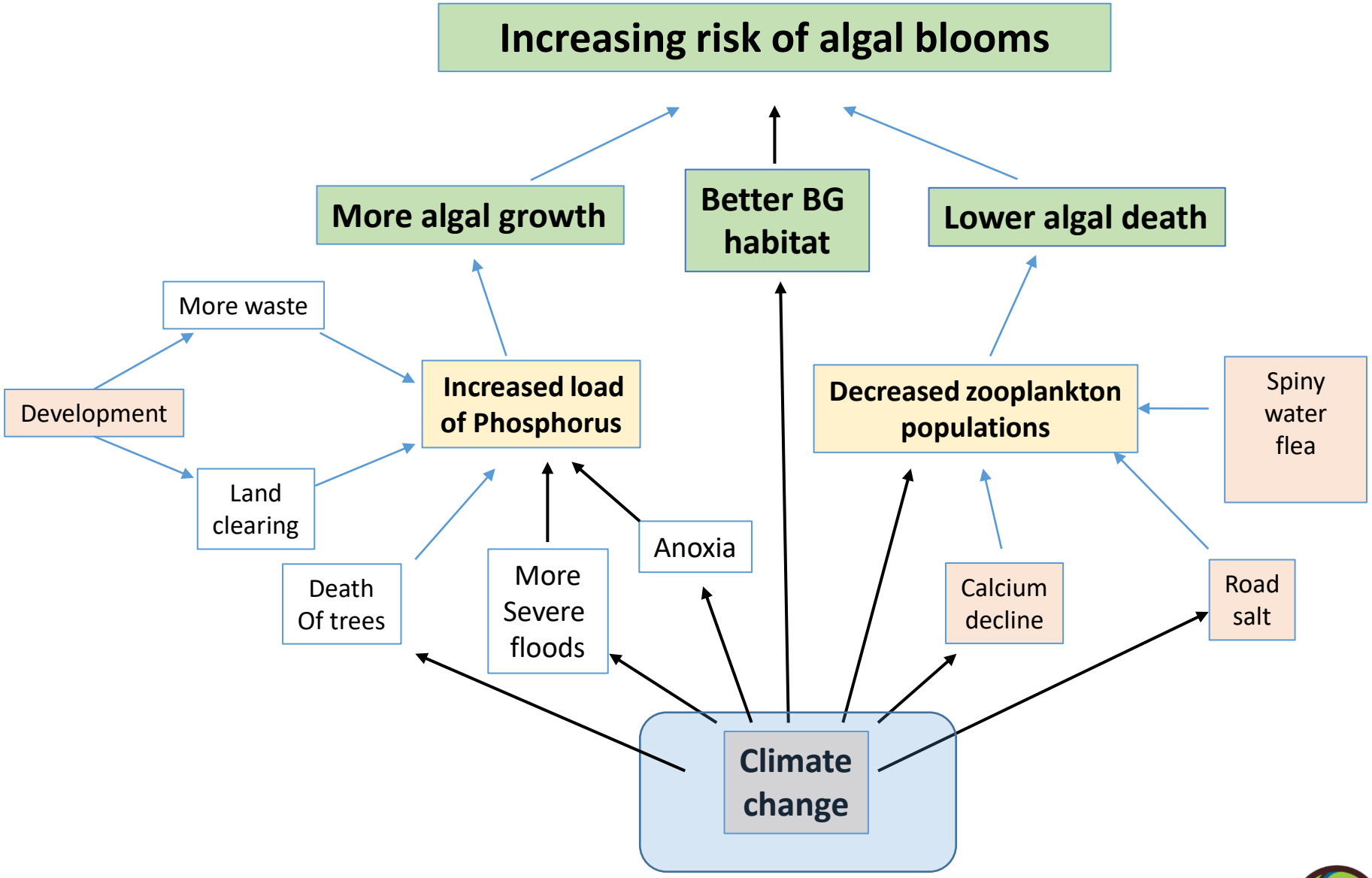
- more salt
- warmer water
- increasing damage from low calcium

Increasing nutrient supply

- more erosion via floods

Improving habitat for blue-green algae

- Warmer water
- Lower wind speeds
- Later fall turnover
- Lower bottom water oxygen in late summer



Linking emerging threats to algal blooms with Climate Change

4: So what should we do

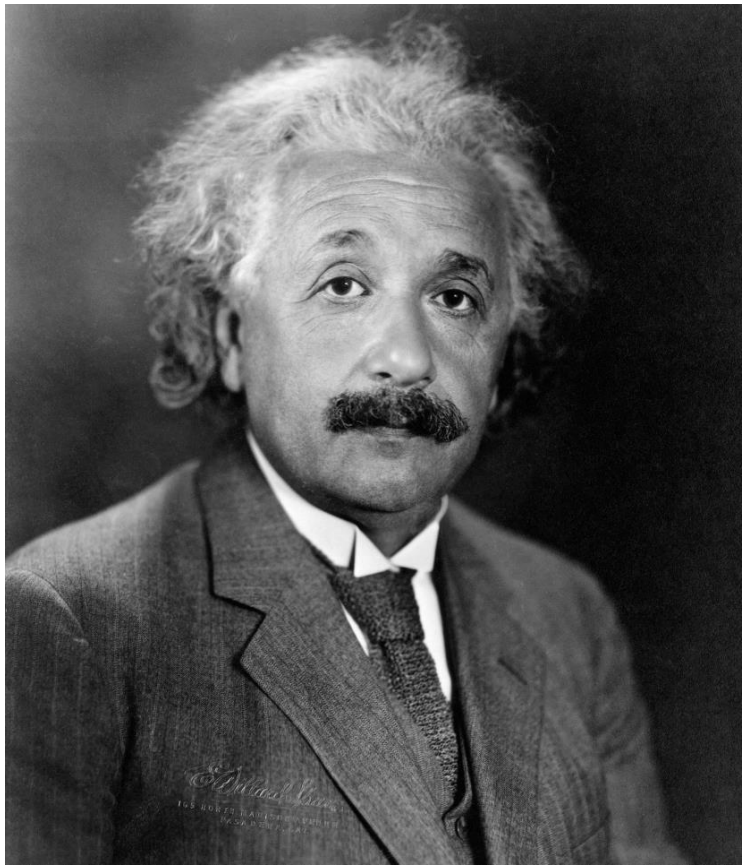
- Fix the problems we do understand
- Study those we don't yet understand
- Protect forests and animal plankton so they can protect the waters we all value

Fix the problems we understand

The problem	The solution
• Faulty septic systems	• Ensure we get them fixed
• Too much salt	• Reduce salt use
• Too many invaders	• Prevent new introductions
• Too little calcium	• Add it, e.g. the ASHMuskoka project

4. from Dr. Einstein

- "If I had an hour to solve a problem, I'd spend 55 minutes thinking about the problem and five minutes thinking about solutions"



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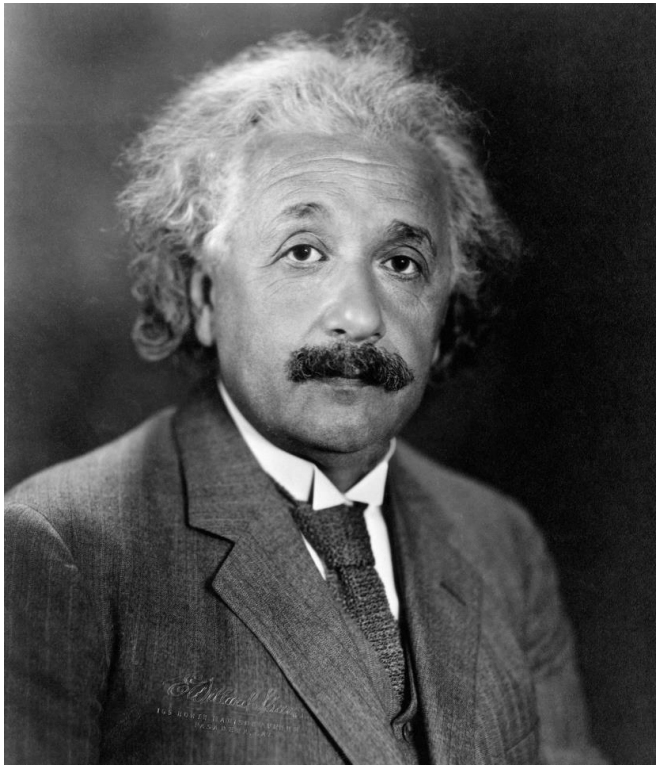
Study the problems we don't understand well enough to manage, e.g. HABs

4. How do we get there?

- "We cannot solve our problems with the same thinking we used when we created them"
- "the only thing more dangerous than ignorance is arrogance"
- "Logic will get you from A to B. Imagination will take you everywhere"



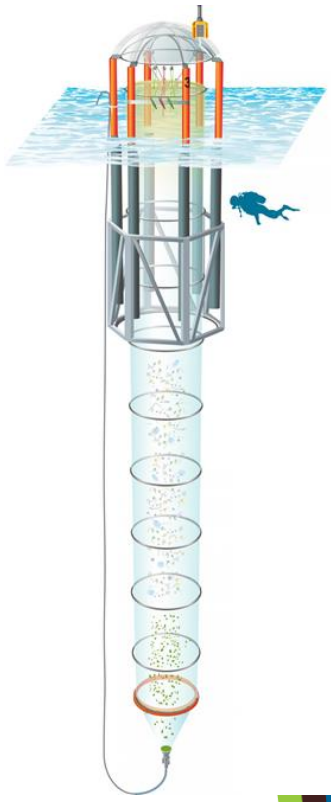
Our current data aren't good enough
We need real-time, continuous lake monitoring in blue-green 'nursery areas'
to identify conditions that precede HABs

More platforms like THELMA – on Harp Lake (DESC)

The causal research idea

- With lake associations volunteers MWC, FMW & a grad student or 2
- Place ~ 10 sensor strings for surface temp and bottom water O_2 and temperature in lakes ranging in vulnerability to HABs, to determine..
- **$Prob_{HAB}$= f(wind, day of fall mixing, surface temperature, bottom O_2, lake depth, grazer density)**
- 1 full time tech-savvy tech and volunteers
- And funding support

And confirm the triggers using engineered ponds or plankton towers or columns to test the probable causes



EAWAG's experimental pond facility

Swiss Federal Institute of Aquatic Science and Technology

The applied solution research idea

- Once the model to predict HABs is verified, and if bottom O_2 is the cause, then
- Install sensor strings in lakes deemed vulnerable, monitored by lake associations.
- And test potential solutions to maintain oxidizing sediments:
  - Nitrate additions
  - Sediment inactivation
  - lake mixers
  - Hypolimnetic aeration

Friends of the Muskoka Watershed

Science Driving Solutions

Our vision:

Healthy Muskoka watersheds forever

Our mission:

To foster the understanding, choices, actions and wise management needed to protect our freshwater ecosystems forever

Our approach:

Science Driving Solutions

Please join us in this work

https://fotmw.org

we are a registered charity

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