Mechanisms underlying *Microcystis* spp. toxigenic fraction and microcystin production

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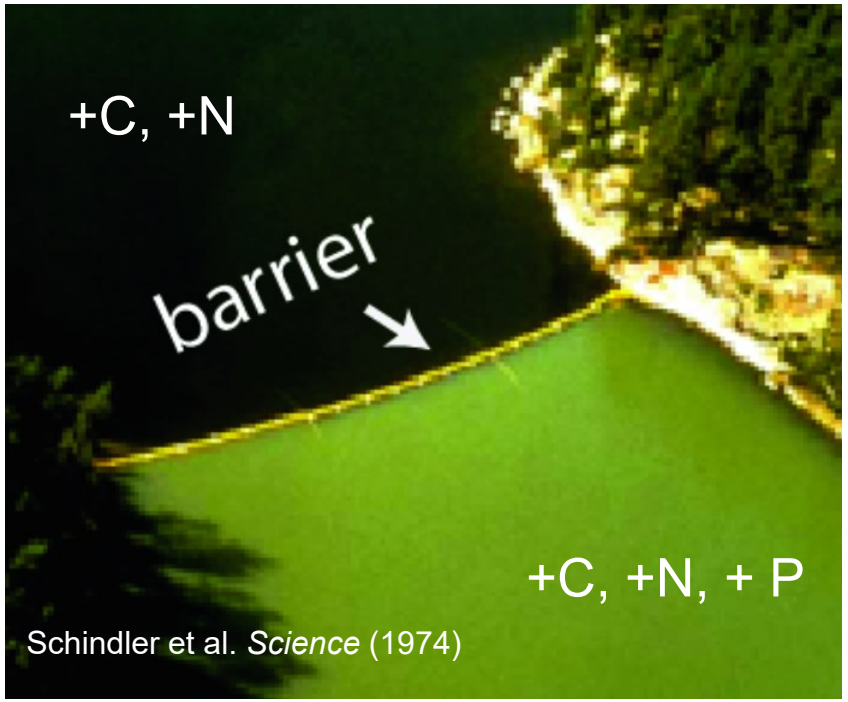
Managing cyanobacterial harmful algae blooms

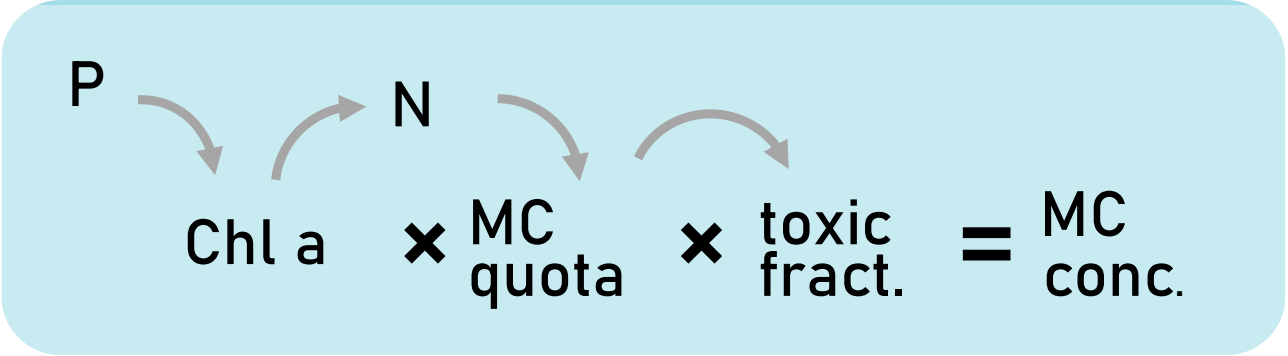
- CyanoHABs are a threat for drinking water supply
- *Microcystis* produces toxin microcystin (MC)
- Common management strategy is to reduce nutrient input
- Successful bloom control in both cases:
  1. dual reduction of nitrogen (N) and phosphrous (P) or
  2. more common P only reduction (e.g. Lake Erie)

But what about the toxins?



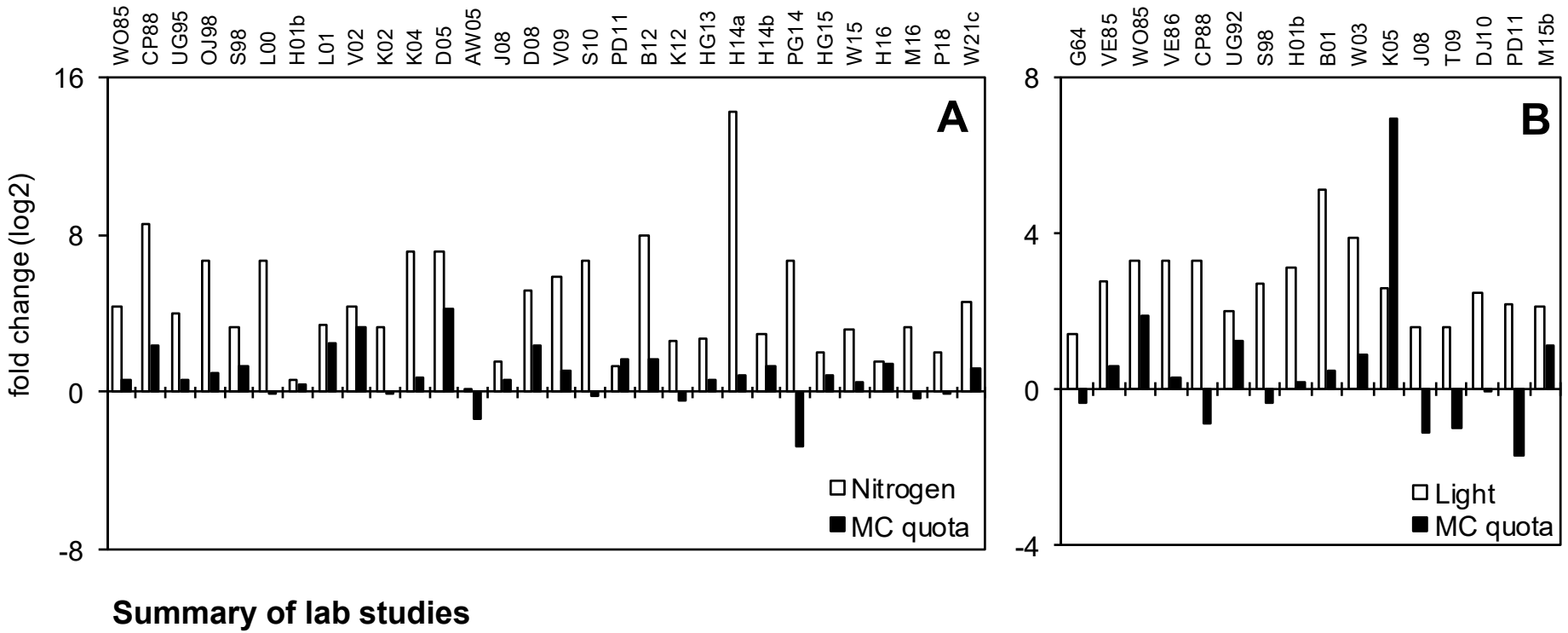
Conceptional model

- Previous assumption: toxins reduce proportionally to biomass
- But: 1. Communities consist of several toxin-producing or non toxin-producing strains
  2. Toxigenic strains produces varying amount of toxins
- P only reduction decreases biomass but releases resources as N and light



Evidence from lab studies

- High N and light availability increases MC cell quota
- Toxigenic strains benefit from high MC cell quota
- Higher NO3 concentration correlate higher toxigenic fraction

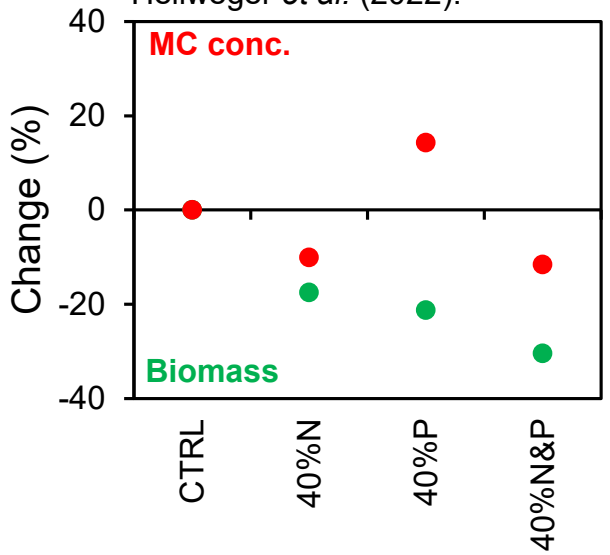


Summary of lab studies

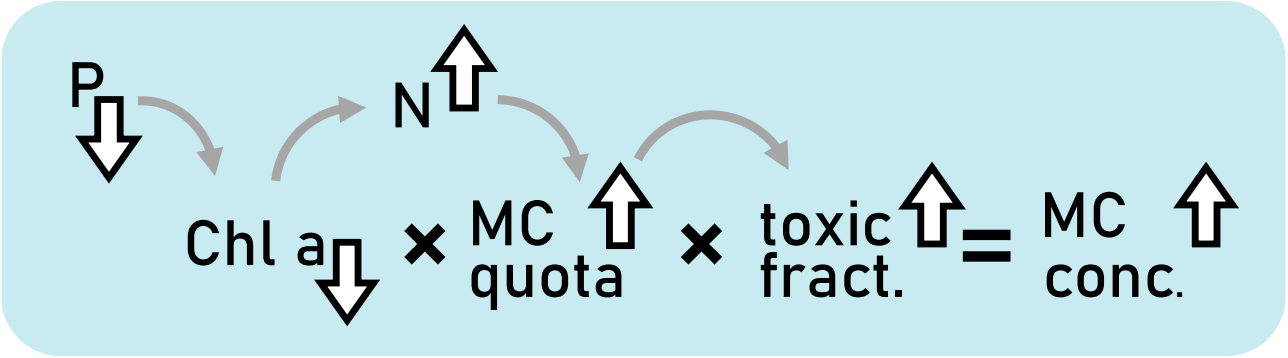
Evidence from modeling approach

- Mechanism implemented in an agent based model
- Application to Lake Erie
- Predicted that P only reduction increases MC concentrations
- Higher MC quota and toxigenic fraction counteract decreasing biomass
- Model critizised in scientific community
- To verify, application to eight other cases
- Good tool to develope hypothesis and understand mechanism
- **Need for field data to support or refute mechanism**

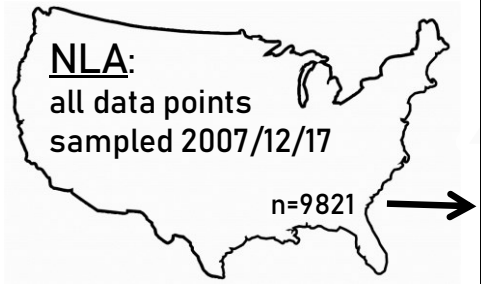
Hellweger *et al.* (2022).



Management scenarios.

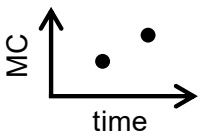


Evidence from field data



data points with MC
n=1999

Lake X



Time pairs: change within a lake

All time pairs
n=453

Dual reduction:
TP and TN change in same direction
n=297

P only reduction:
TP and TN change in opposite directions
n=156

P limited:
TP and biomass change in same direction
n=72

Not P limited:
TP and biomass change in opposite directions
n=84

South Lake

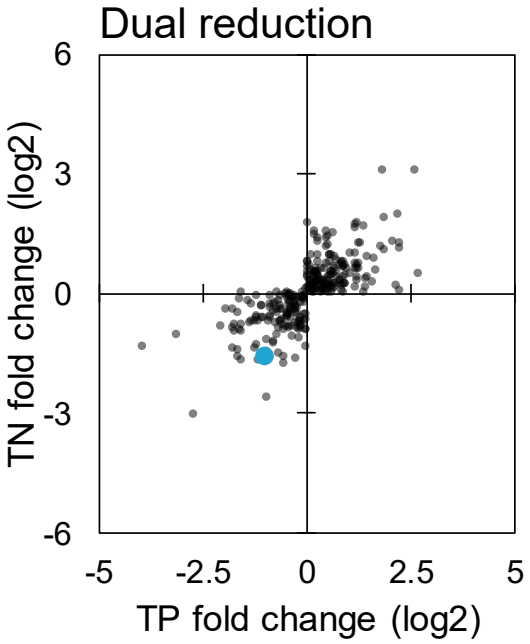
TP 2012 = 0.52 µM

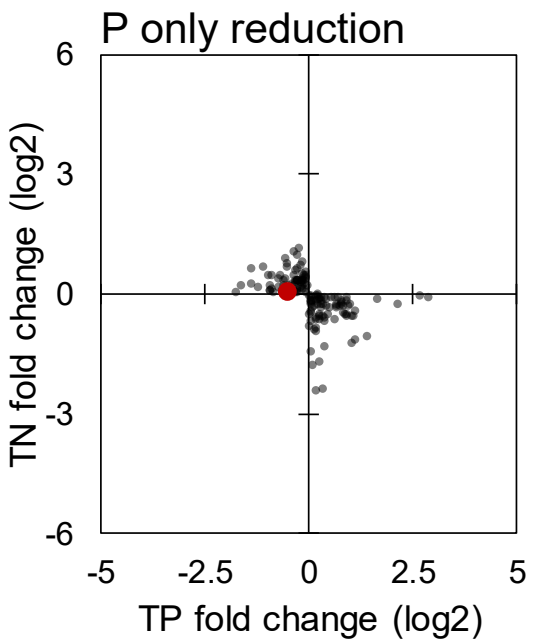
TP 2007 = 1.06 µM

TP: log2(0.52/1.06) = **-1.02**
TN: log2(4.9/14.4) = **-1.49**

Lyman Lake

TP: log2(0.16/0.23) = **-0.53**
TN: log2(0.67/0.62) = **0.09**

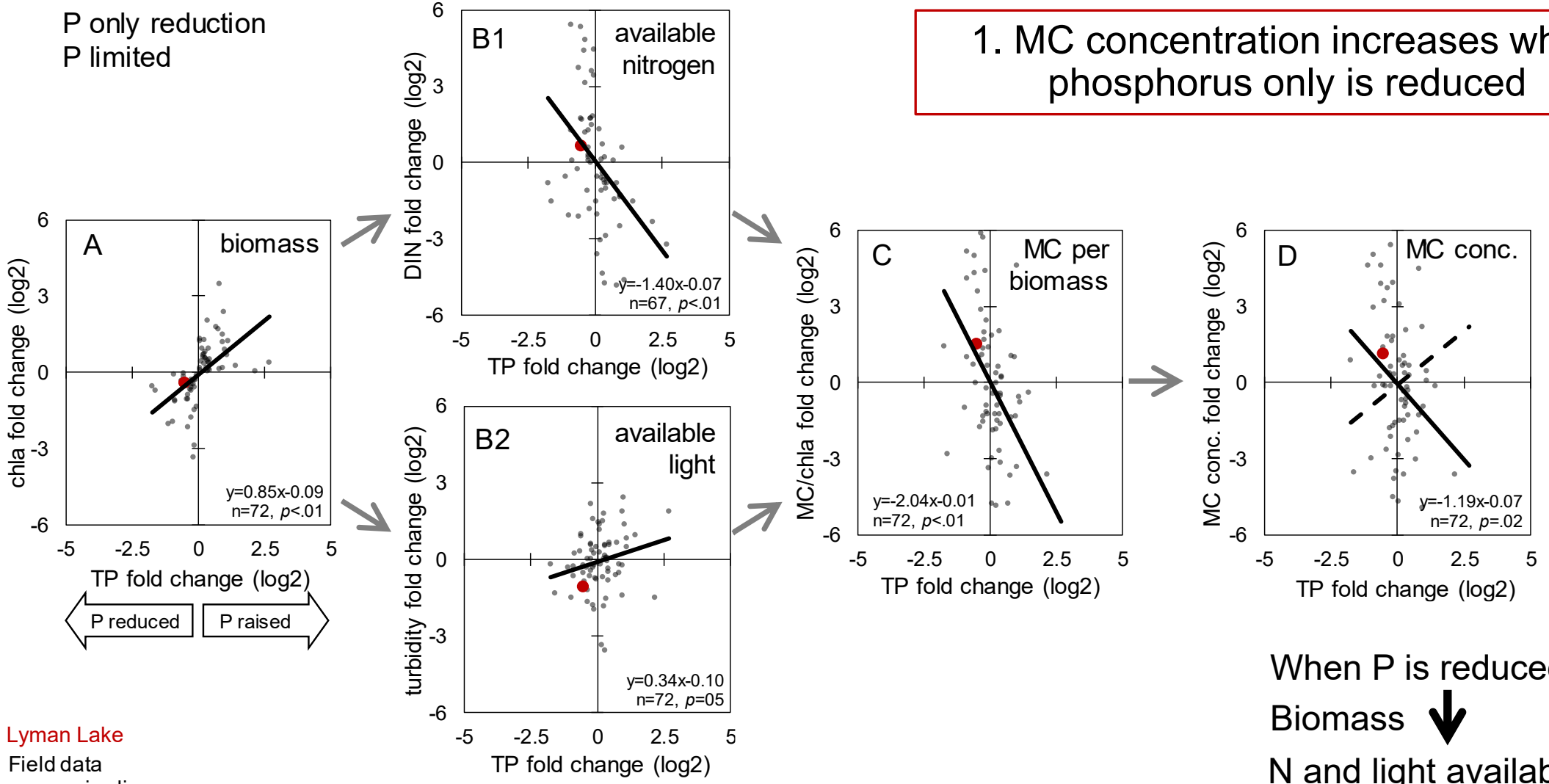




- Natioal Lakes Assessment: Large survey of US lakes
- Sampling frequency every five years
- Parameters include TP, TN, biomass, MC concentration, etc.

Change in TP vs. change in phytoplankton parameter

P only reduction
P limited



1. MC concentration increases when phosphorus only is reduced

Legend:

- Lyman Lake
- Field data
- regression line
- theoretical line
- logic causation

When P is reduced:

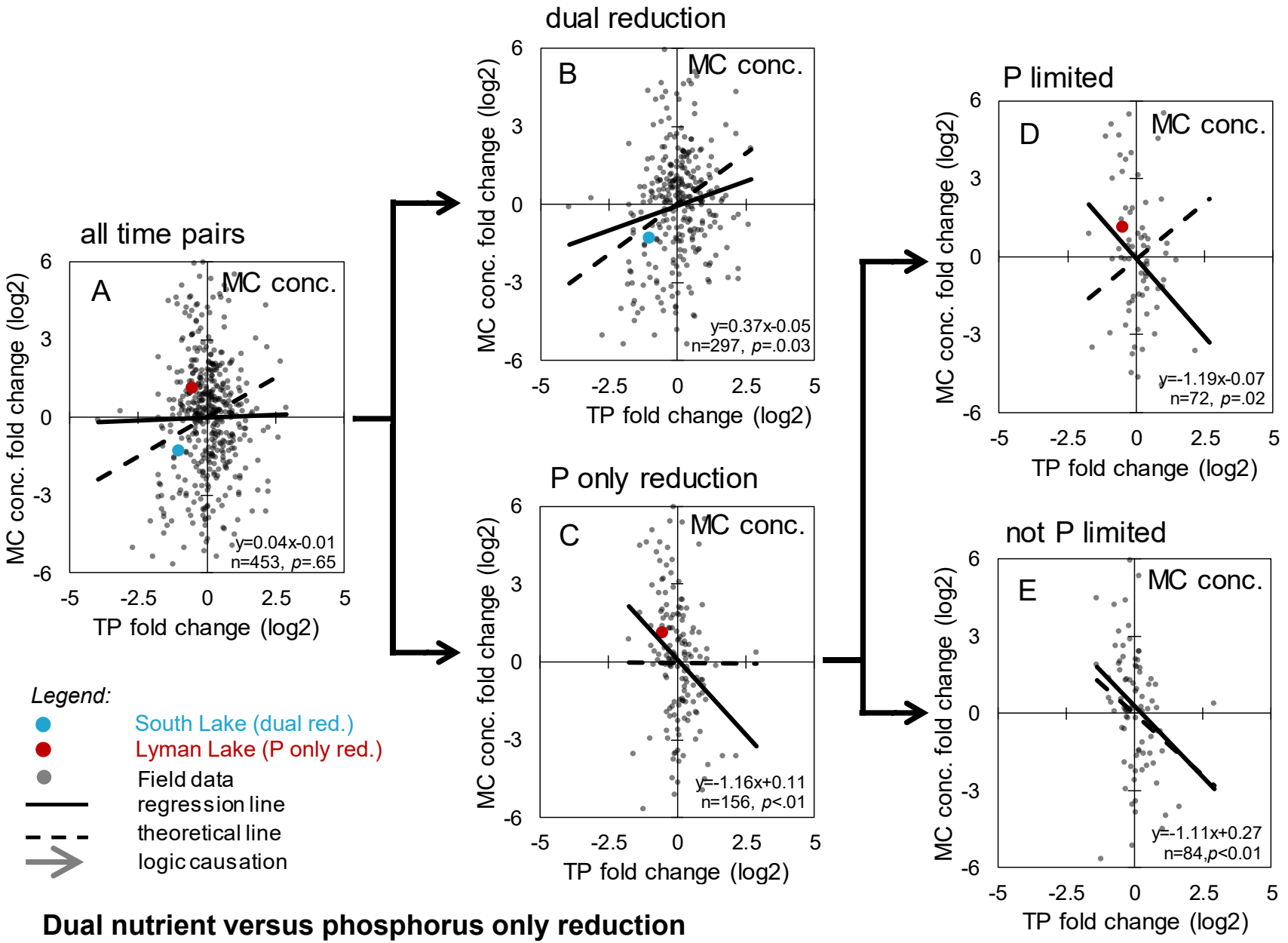
Biomass ↓

N and light availability ↑

MC per biomass and MC concentration ↑

Schampera et al., submitted, pre-print: Lake toxin concentrations increase when phosphorus is reduced | Research Square

Change in TP vs. change in MC concentrations



1. MC concentration increases when P only is reduced
2. But: MC concentrations decrease along with biomass under dual nutrient reduction

Dual nutrient versus phosphorus only reduction

Schampera et al., submitted, pre-print: Lake toxin concentrations increase when phosphorus is reduced | Research Square

1. Model predicts: MC concentrations increase when P only is reduced
But: dual nutrient reduction decreases MC concentration together with biomass

2. Field data support model predictions

Thank you!

DFG

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