Developing Nitrogen Criteria for Sierra Nevada Lakes

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Andi Heard and Dr. James Sickman

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Need for Nitrogen Criteria

1. Air pollution – stressor of high concern in the central and southern Sierra. Increased nitrogen deposition is of particular concern with respect to Sierra Nevada lakes.

2. Sierra Nevada lakes are sensitive to environmental change (highly oligotrophic).

3. Land management agencies are tasked with protecting these ecosystems from stressors that originate outside of protected boundaries and affect resources at landscape scales.

4. Criteria based on measurable ecological effects is an approach managers can take to assess status of resources and communicate it to a broader audience. This approach may be used to influence environmental policy and is an important step towards long-term protection of high-elevation lakes.

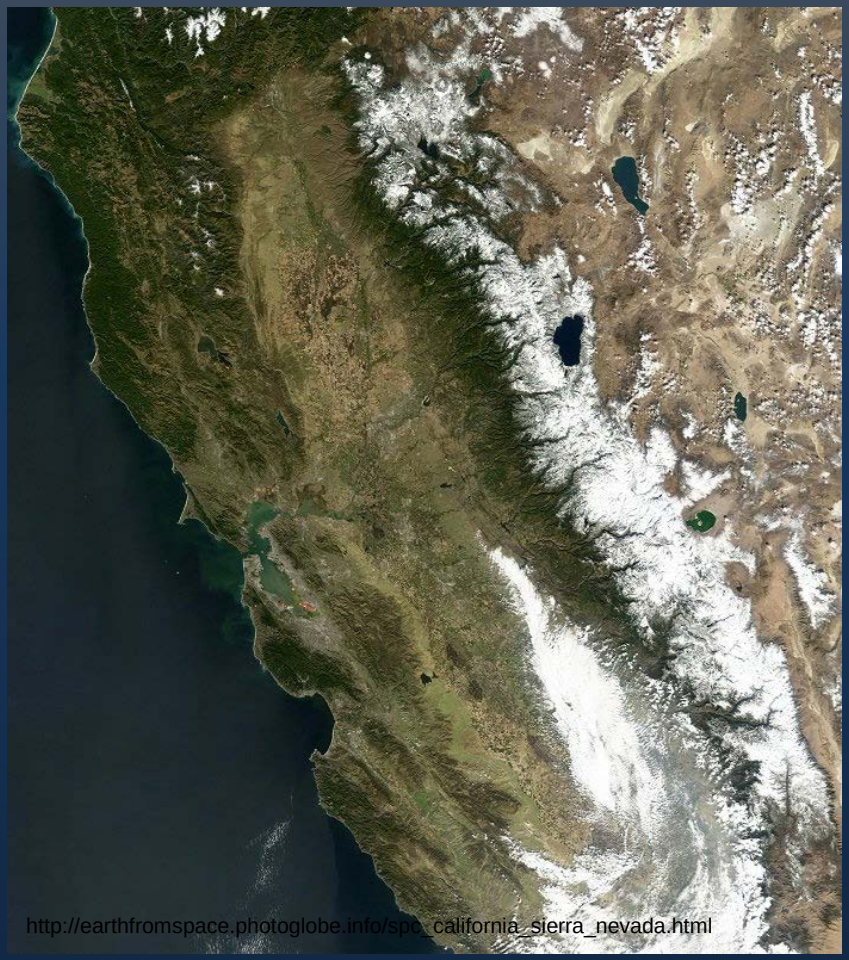
Research Objectives

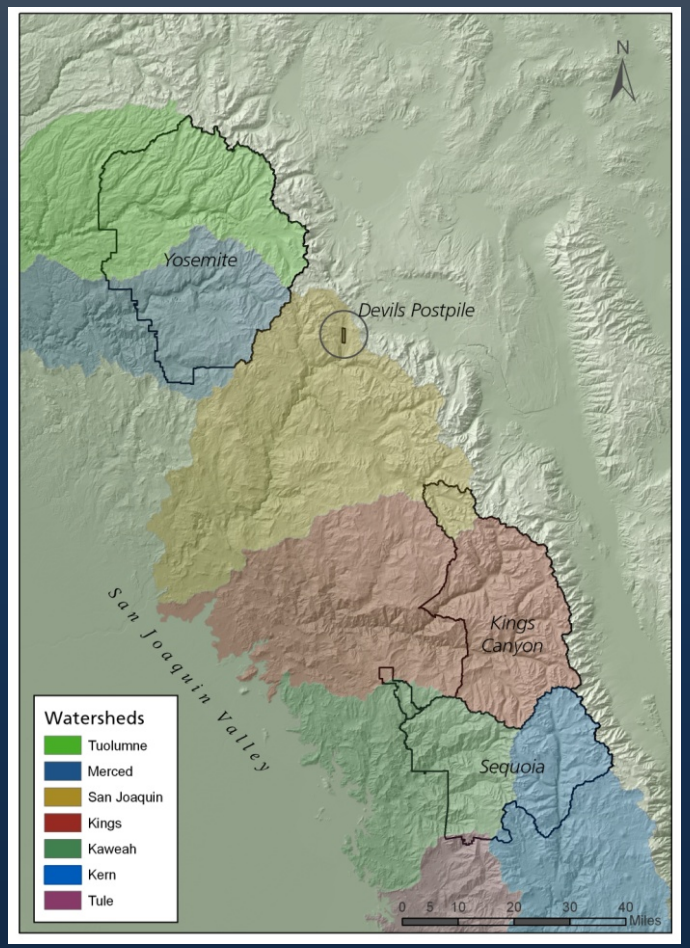
I. Establish nutrient criteria using *in situ* bioassay experiments and phytoplankton growth modeling

II. Apply results from phytoplankton modeling to survey and monitoring data to assess status and trend of lake ecosystems

III. Validate nutrient criteria to assess how broadly it can be applied, how effective a tool it is at identifying lakes affected by anthropogenic nitrogen inputs, and what complexities should be considered when assessing status and trends of nutrient affected lakes

Sierra Nevada – Study Area

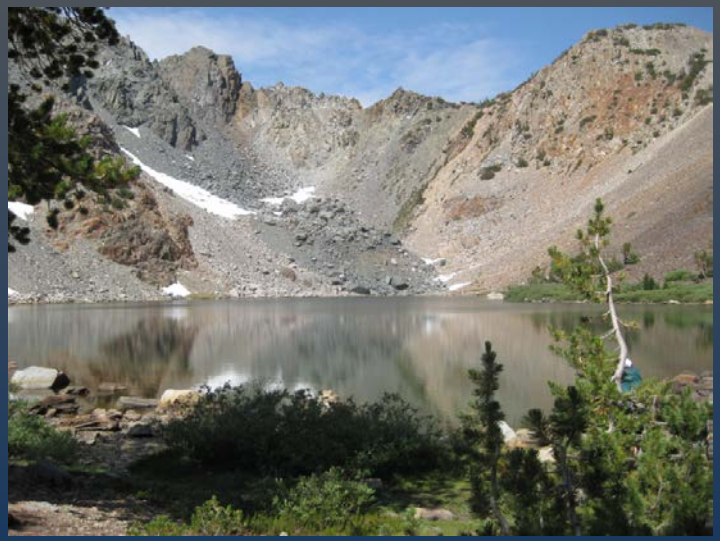




Map by: NPS

Moat

Toiyabe National Forest – east slope



Emerald

Sequoia National Park – west slope

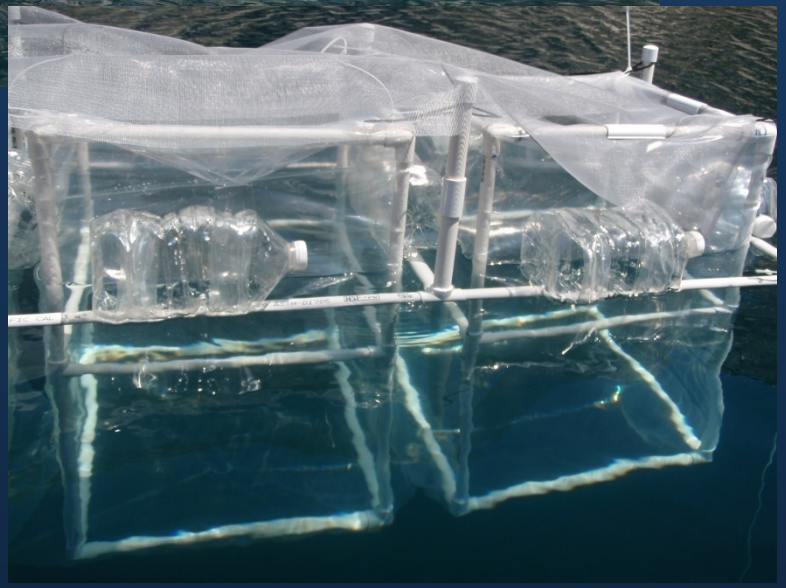
Topaz

Sequoia National Park – west slope

Aster

Sequoia National Park – west slope

Experiments: 2 Scales



- Corral Volume ~ 200 liters
- 16 corrals per site - 2 controls

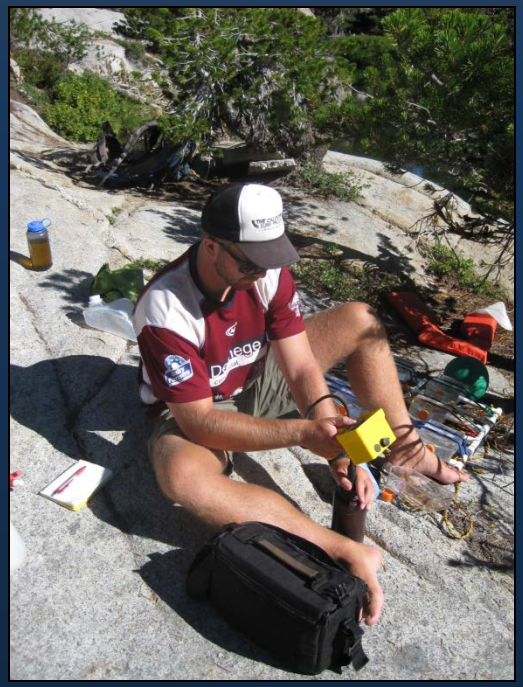
- Cubie Volume ~ 8 liters
- 16 cubies per site - 2 controls

Methods

- Nutrient gradient
  - N Range limnocorrals: 0.500 – 50.0 µmol/l
  - N Range cubies: 0.100 – 15.0 µmol/l
  - N + P experiments: Spiked all cubies with a constant [P]

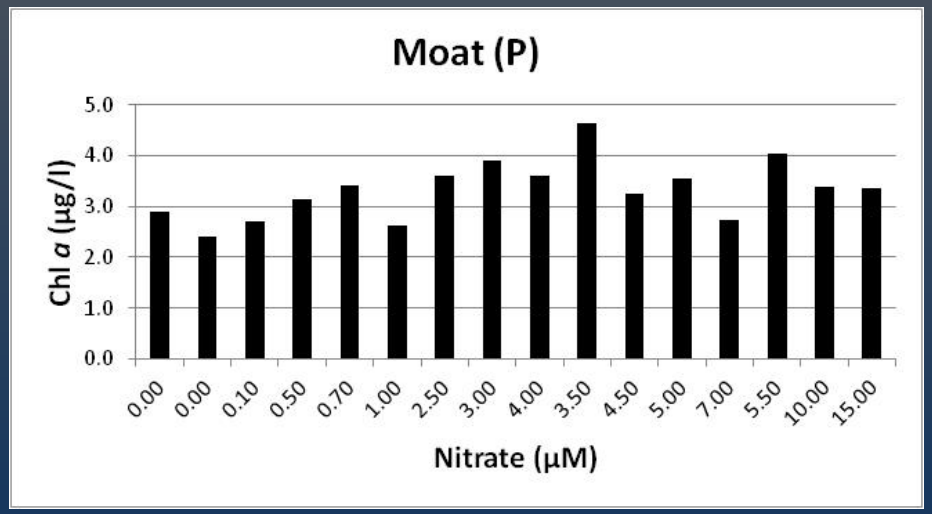
- Phytoplankton response measure
  - Chlorophyll *a*
  - Limnocorrals: extractable Chla (lab)
  - Cubitainers: *in situ* (fluorometer)

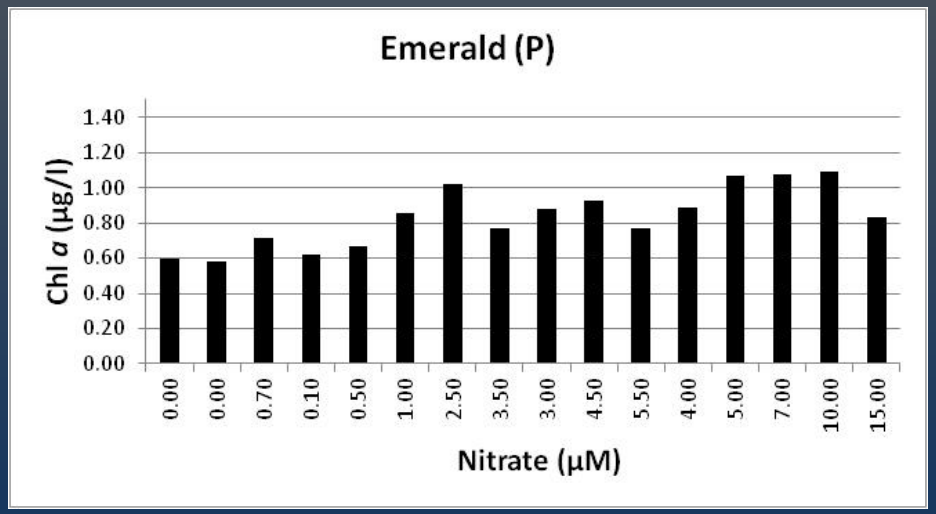
- Phytoplankton growth models:
  - Monod
  - Dose response curves

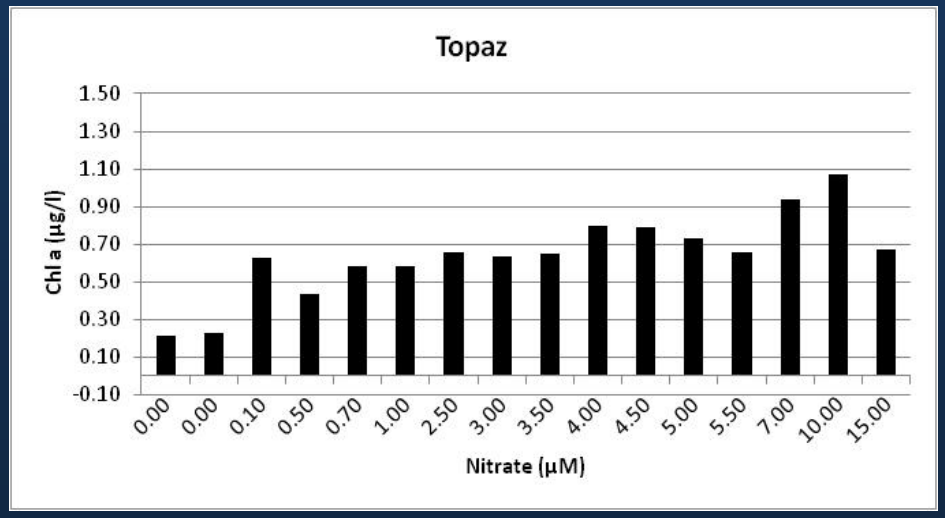


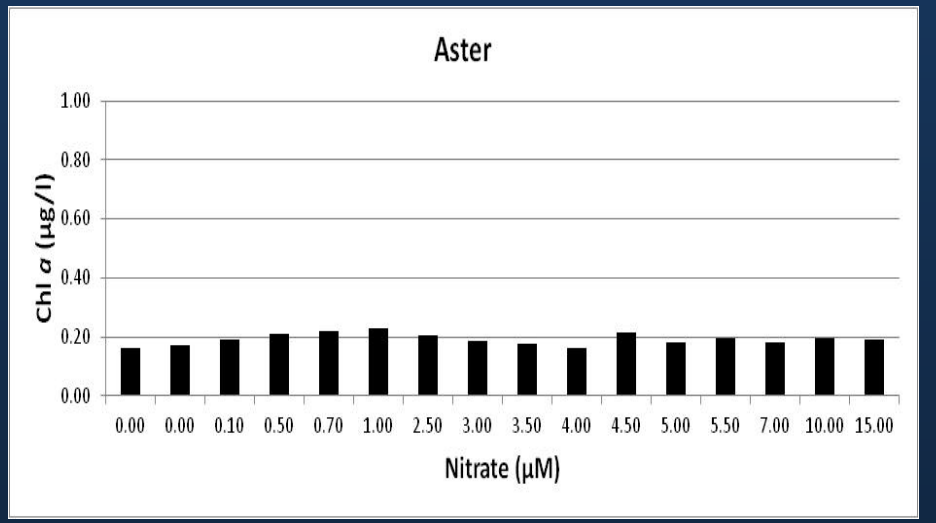
Measuring Chl*a* in the field

Chl*a* Results

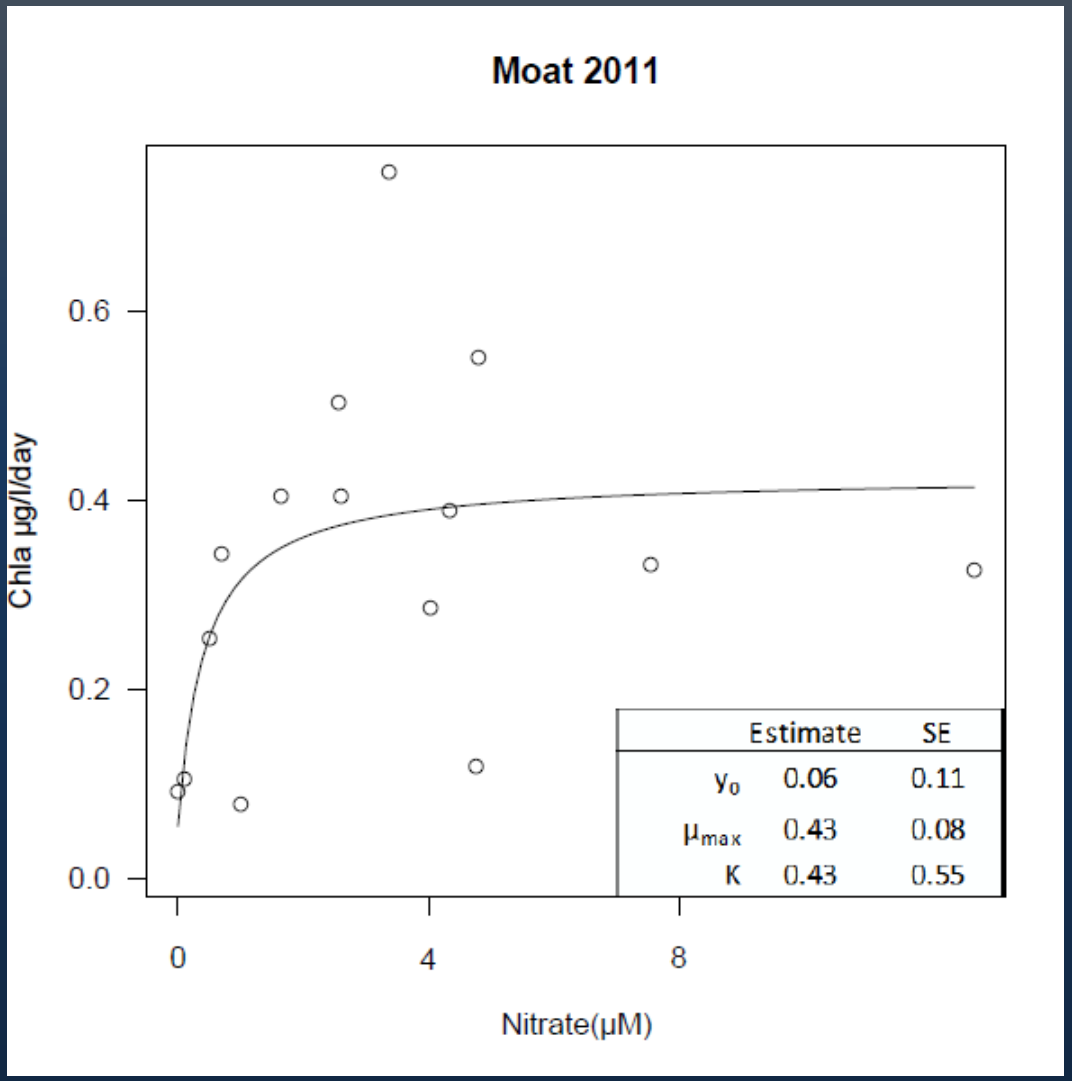




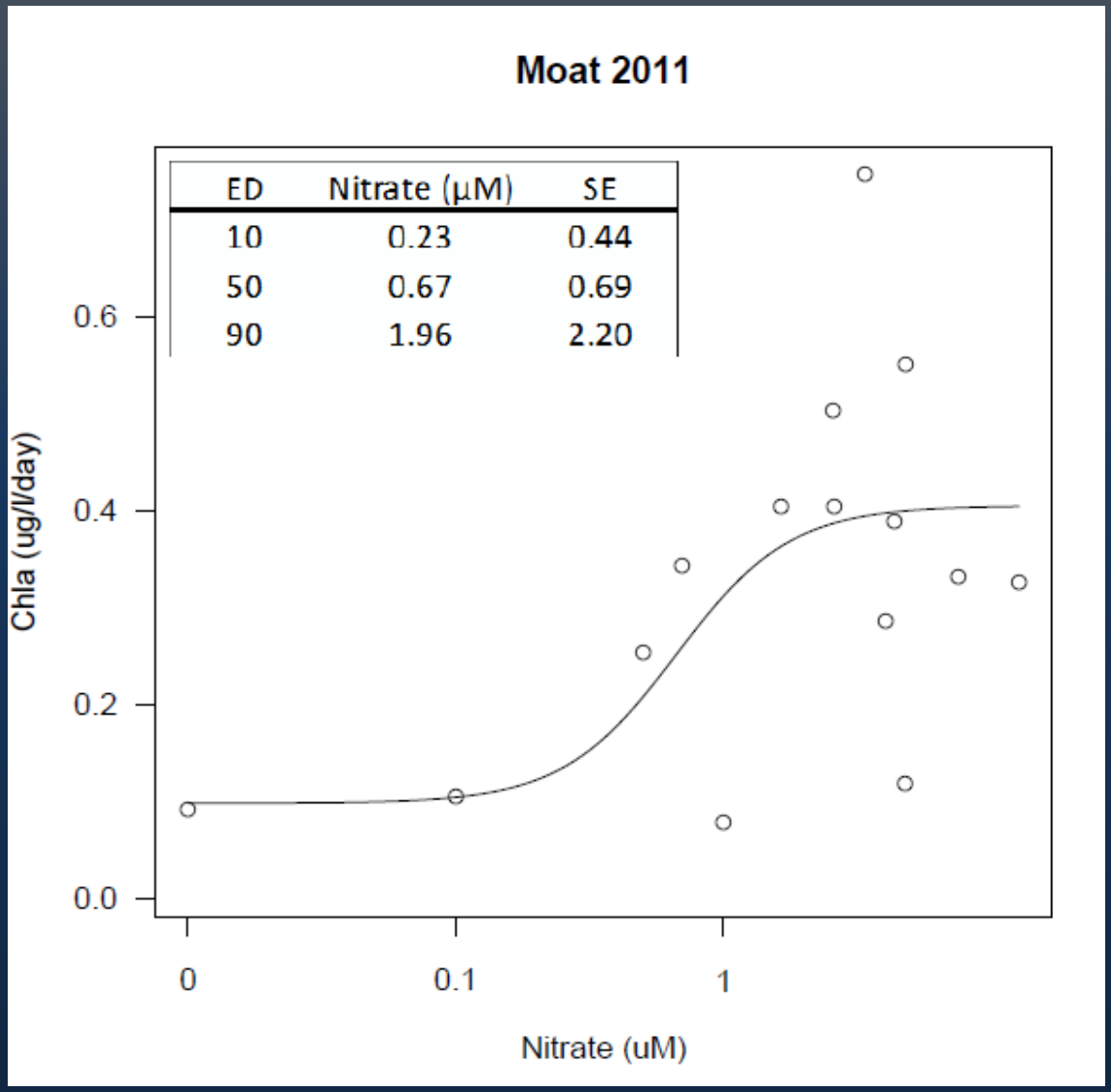




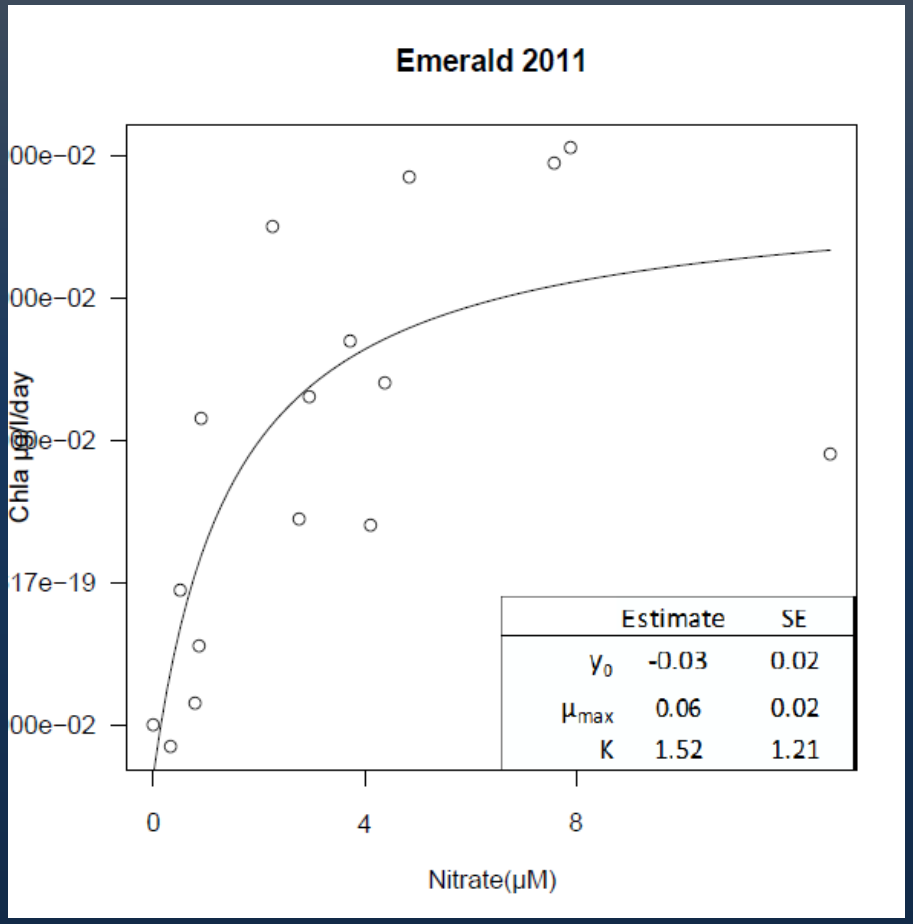
Moat: Monod Model

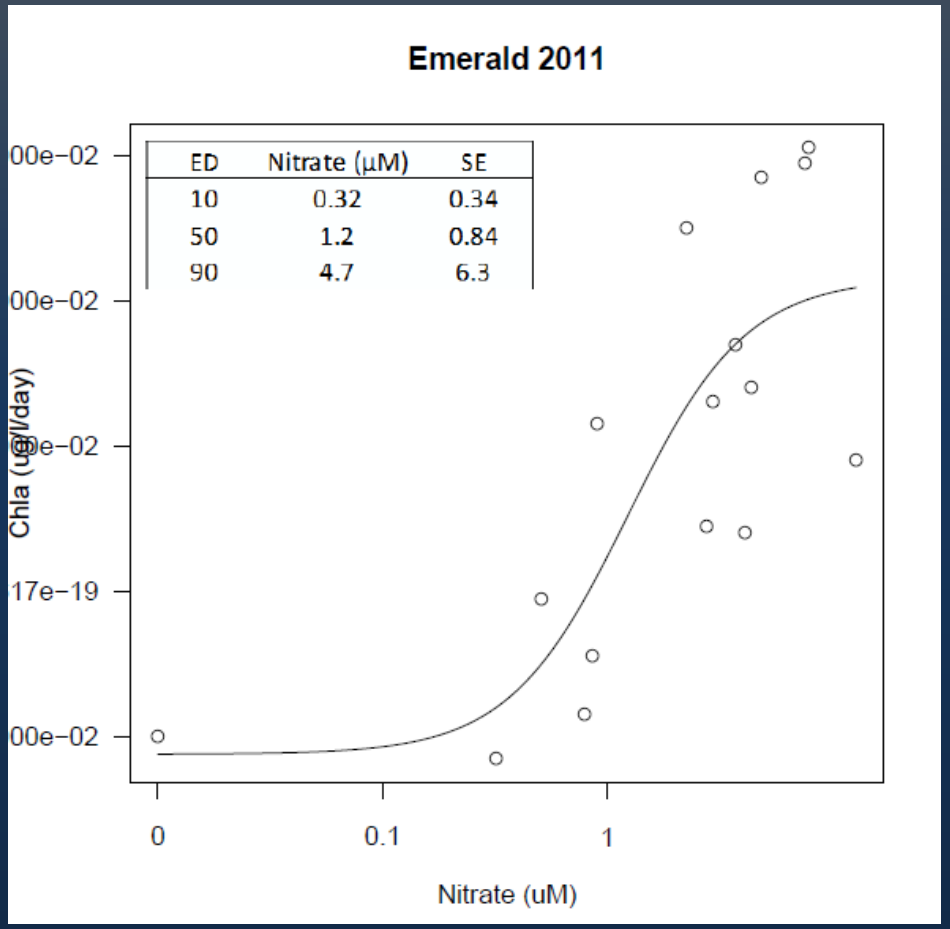


Moat: Dose Response Curve



Emerald


Emerald 2011
00e−02
00e−02
e−02
17e−19
00e−02
Chla µg/l/day
Estimate SE
y_0 -0.03 0.02
μ_{max} 0.06 0.02
K 1.52 1.21
0
4
8
Nitrate(µM)

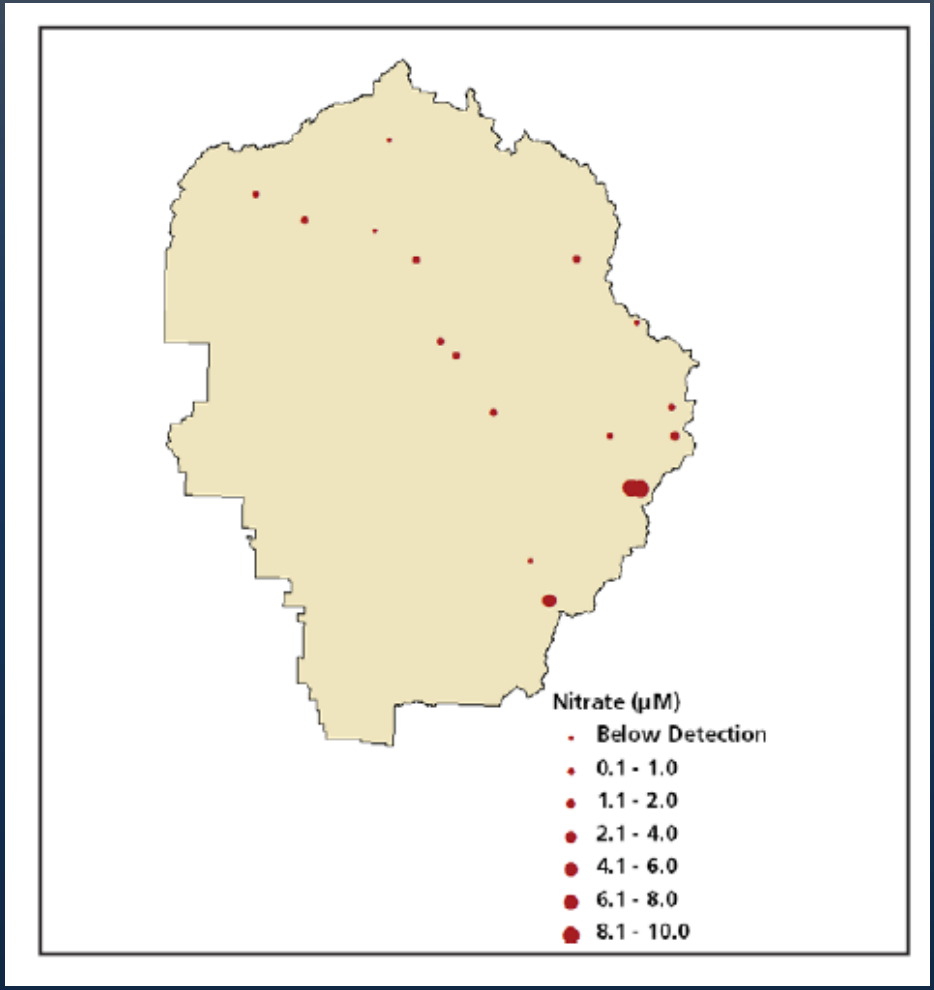

Emerald 2011
00e−02
00e−02
e−02
17e−19
00e−02
Chla (ug/l/day)
ED Nitrate (µM) SE
10 0.32 0.34
50 1.2 0.84
90 4.7 6.3
0
0.1
1
Nitrate (uM)

Criteria Estimates

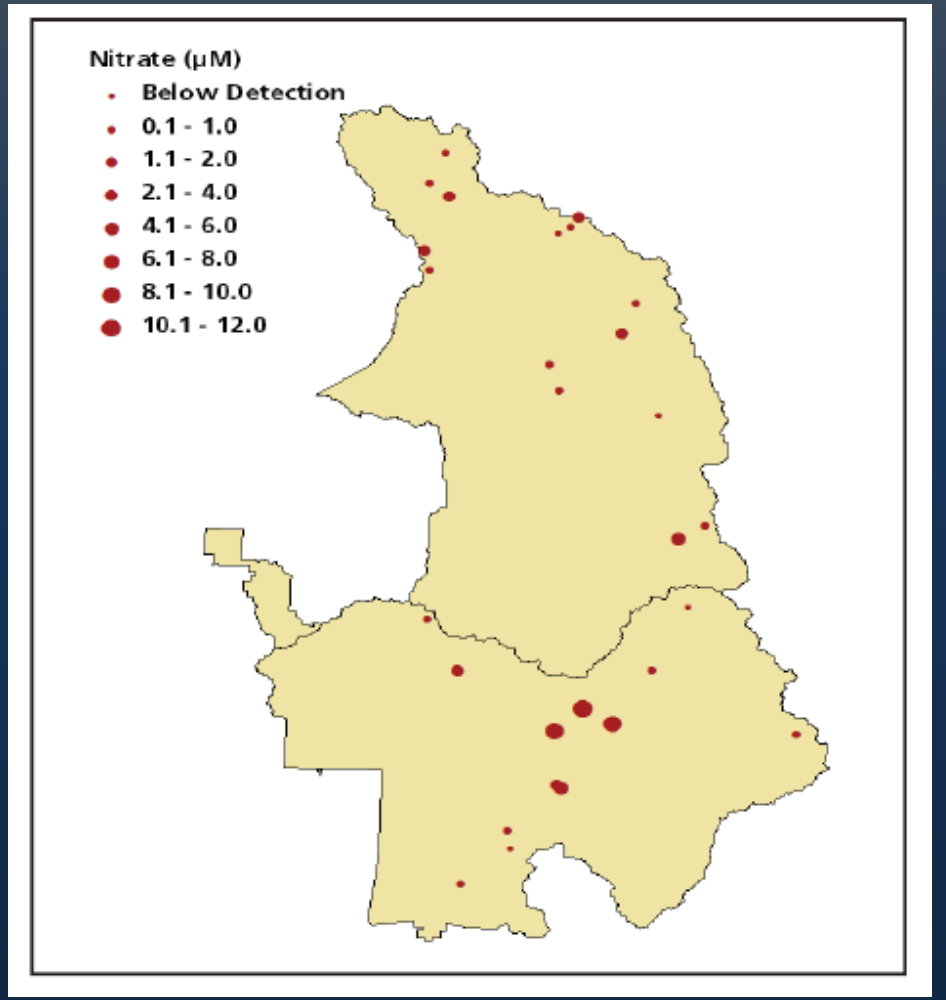
Experiment	Month	10% Dose µM	50% Dose µM	90% Dose µM
Moat - limnocorrals	July	0.44 (0.60)	1.1 (0.67)	2.6 (2.2)
Moat - limnocorrals	September	0.89 (3.9)	4.0 (7.5)	18 (28)
Moat - cubies	September	0.23 (0.44)	0.67 (0.69)	2.0 (0.17)
Emerald - cubies	September	0.32 (0.34)	1.2 (0.84)	4.7 (6.3)

Application of Criteria

Yosemite



Sequoia & Kings Canyon



Criteria Example

*****Preliminary Criteria Estimates*****

10, 50, and 90% dose estimates for nitrate and % Park lakes exceeding dose estimates

	10% Dose µM N	% Exceeded	50% Dose µM N	% Exceeded	90% Dose µM N	% Exceeded
High	0.89	28 (7.6)	4.0	18 (7.0)	18	0
Low	0.33	37 (8.0)	1.0	29 (7.6)	3.1	21 (7.6)

- High estimates: Moat Sept (limnocorrals)
- Low estimates: Moat July (limnocorrals), Moat Sept (cubies), Emerald Sept (cubies)

Summary

1. I have developed preliminary nutrient criteria for N and applied to monitoring data
2. Results suggest dose response models are a viable approach to developing nutrient criteria. However, the estimates would benefit from more experiments and increased sample size as phytoplankton response is highly variable.
3. Next steps: Apply refined criteria to existing synoptic surveys:
    - Western Lakes Survey 1985 (Eilers et al. 1989)
    - Western Lakes resurvey 1999 (Clow et al. 2002)
    - National Park Service monitoring data: 2008 – 2011
4. Look at changes in criteria exceedence and shifts in nutrient limitation over-time
5. Spatial analyses to determine variables that help explain nutrient affected lakes.

Questions…

Photo: Rich Thiel