The Effects of Excessive Nutrients in Vernal Pools

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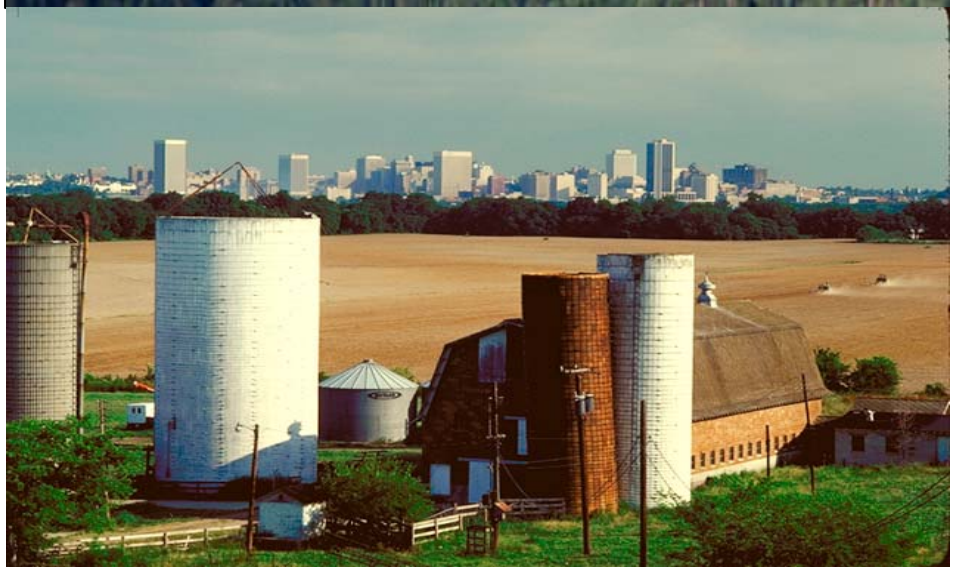
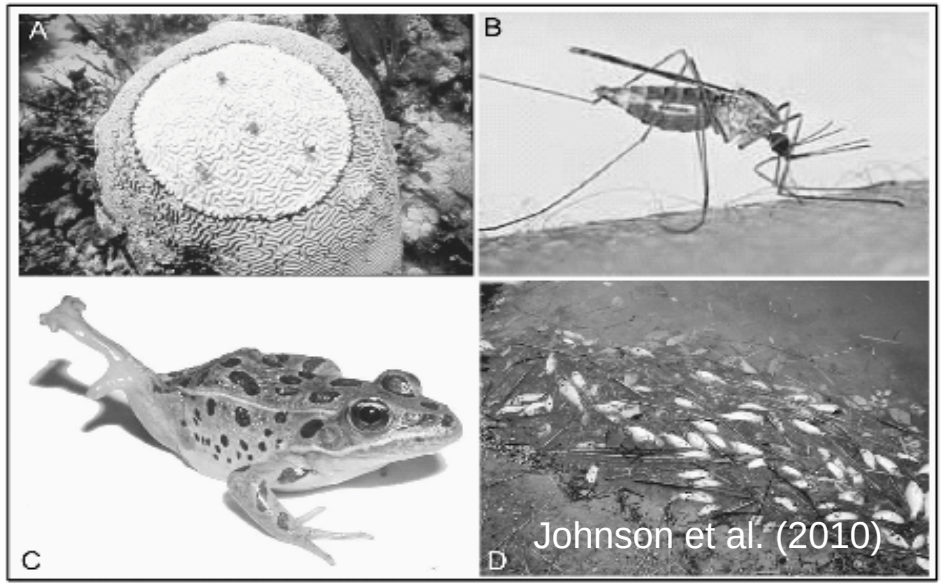
Eutrophication

- Excessive nitrogen and phosphorus
- Urban and agricultural development
- Threat to terrestrial and aquatic ecosystems worldwide



Eutrophication

- Ecosystem changes
  (Carpenter et al. 1998; Smith & Schindler 2009)
  - Reduces ecosystem function
  - Increase disease
  - Changes community composition and structure
  - Reduces biodiversity

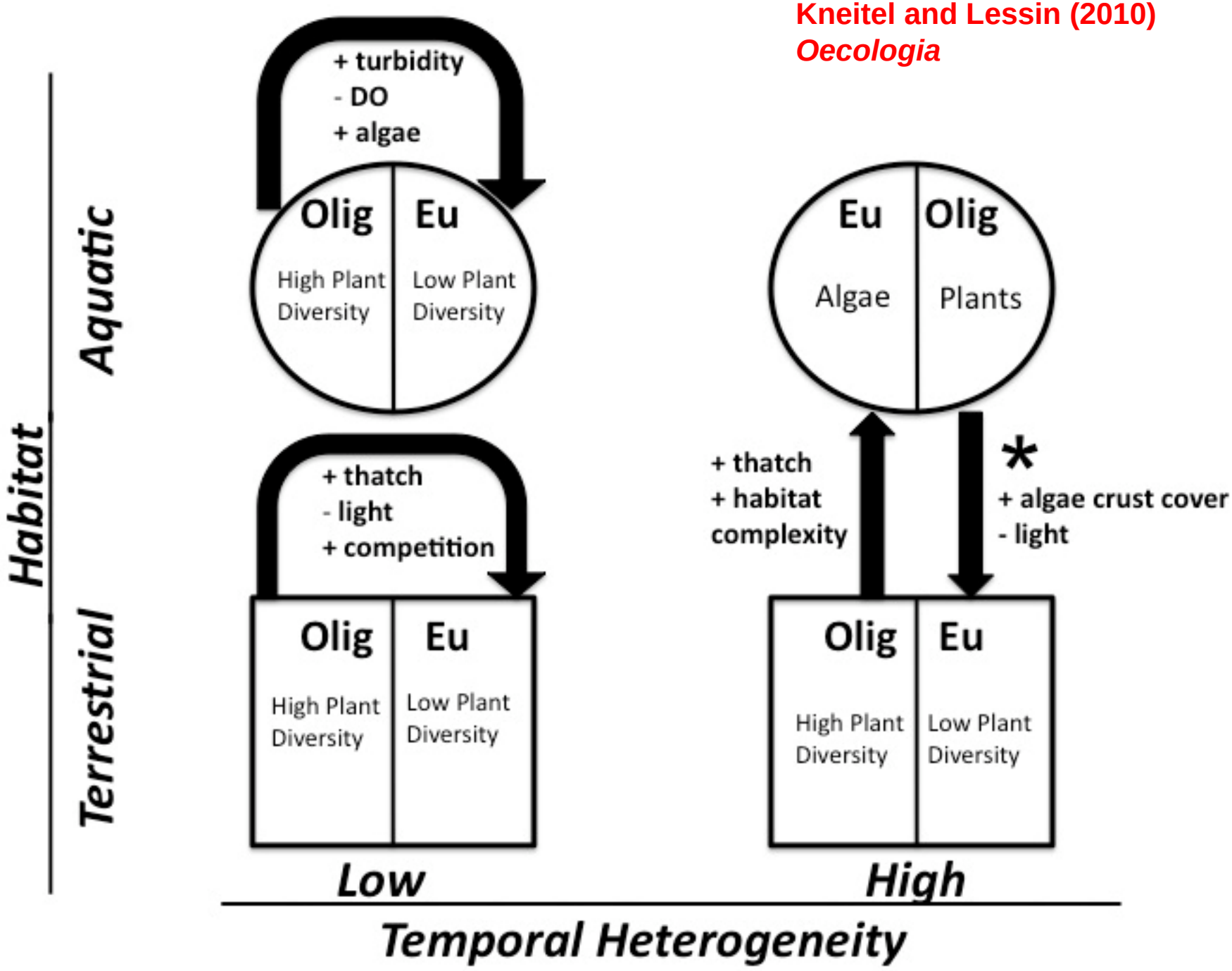


Johnson et al. (2010)

Eutrophication in Shallow Lakes and Ponds

Low nutrients ***High nutrients***

Kneitel and Lessin (2010)
Oecologia



California Vernal Pools

- Seasonal ponds (wetlands)
- High diversity & endemism
  - >60 endemic plants and invertebrates
- Many endangered:
  - Aquatic vertebrates and invertebrates (~7)
  - Terrestrial plants (~12)

California Vernal Pools

- High habitat loss (~90%)
- Embedded in urban and agricultural matrix

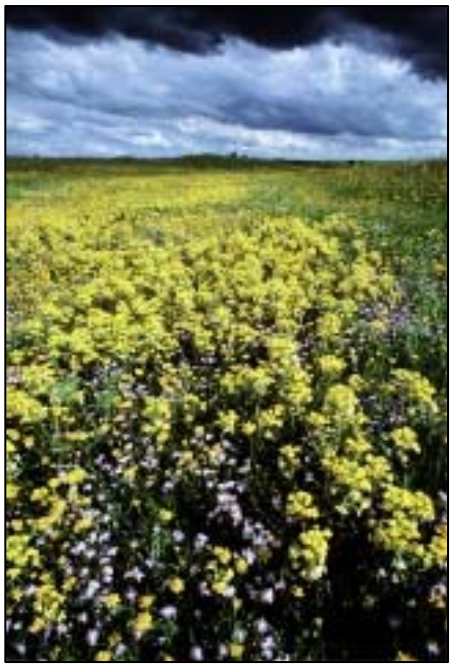
Ecosystem Phases: Vernal Pools

Winter

Aquatic Phase

-Soils saturate

-Standing water

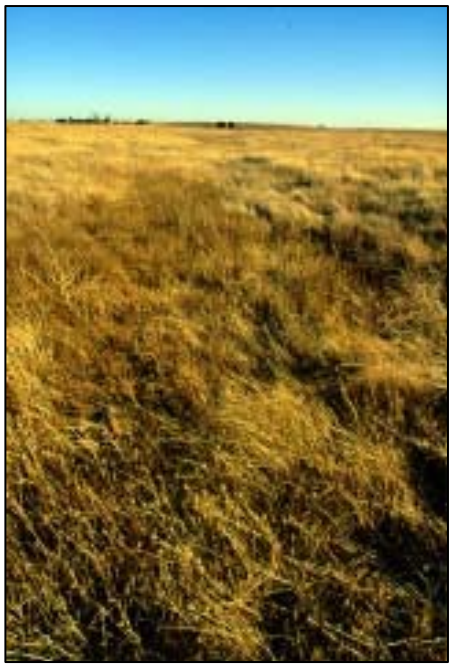


Spring

Flower Phase

-Soil moist

-Drying phase



Summer/Fall

Dry Phase

-Soils dry

Eutrophication effects across phases?

Winter

Aquatic Phase

-Soils saturate

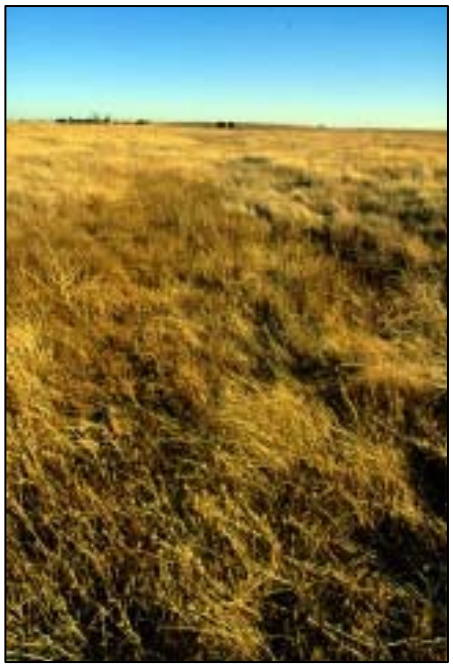
-Standing water

Spring

Flower Phase

-Soil moist

-Drying phase

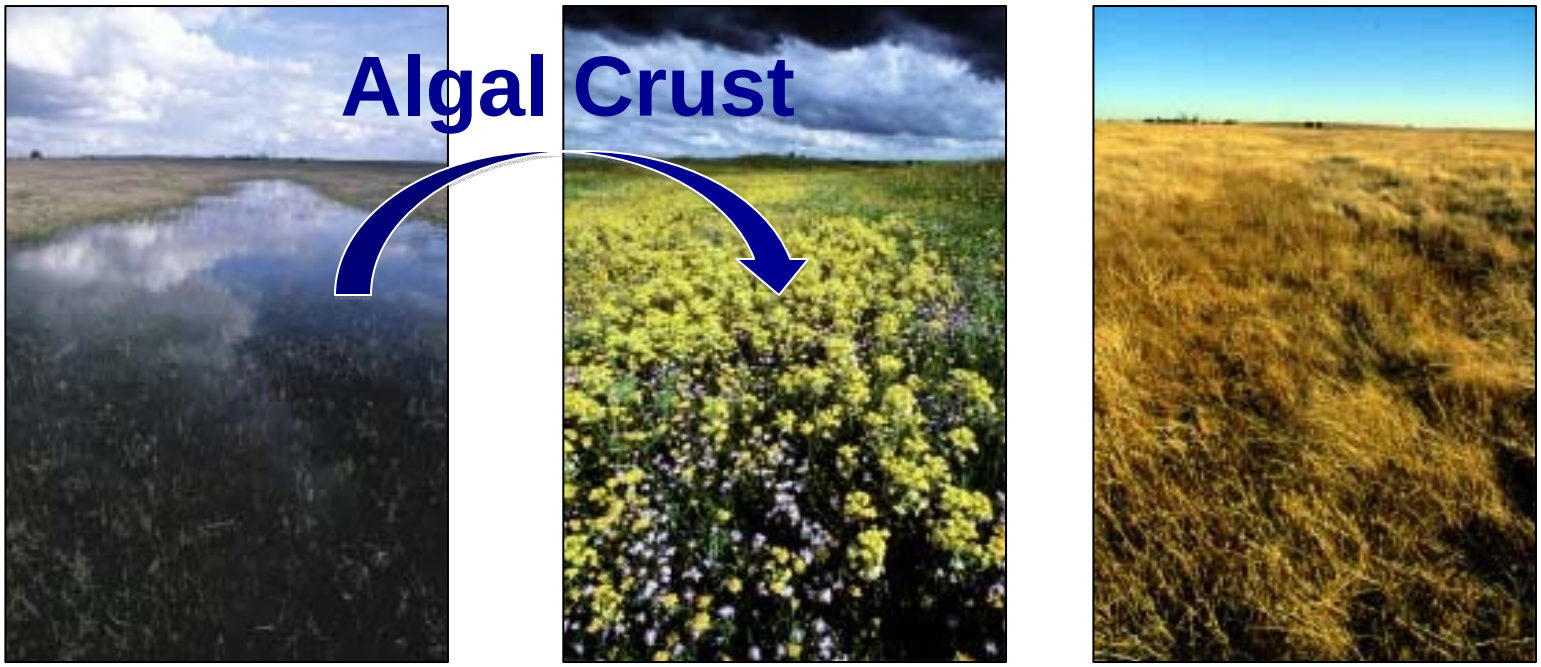


Summer/Fall

Dry Phase

-Soils dry

Eutrophication effects across phases?

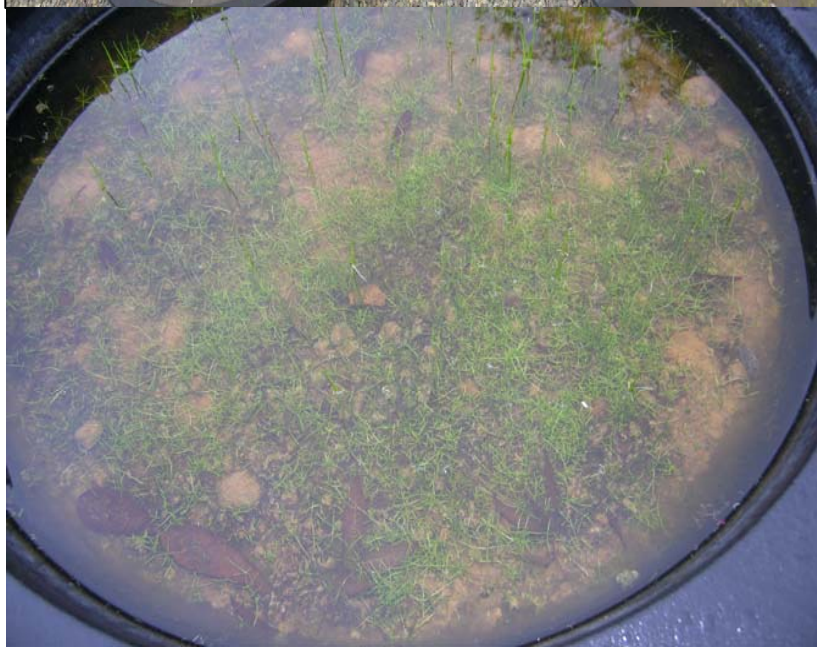


Algae & Inverts

Plant Diversity

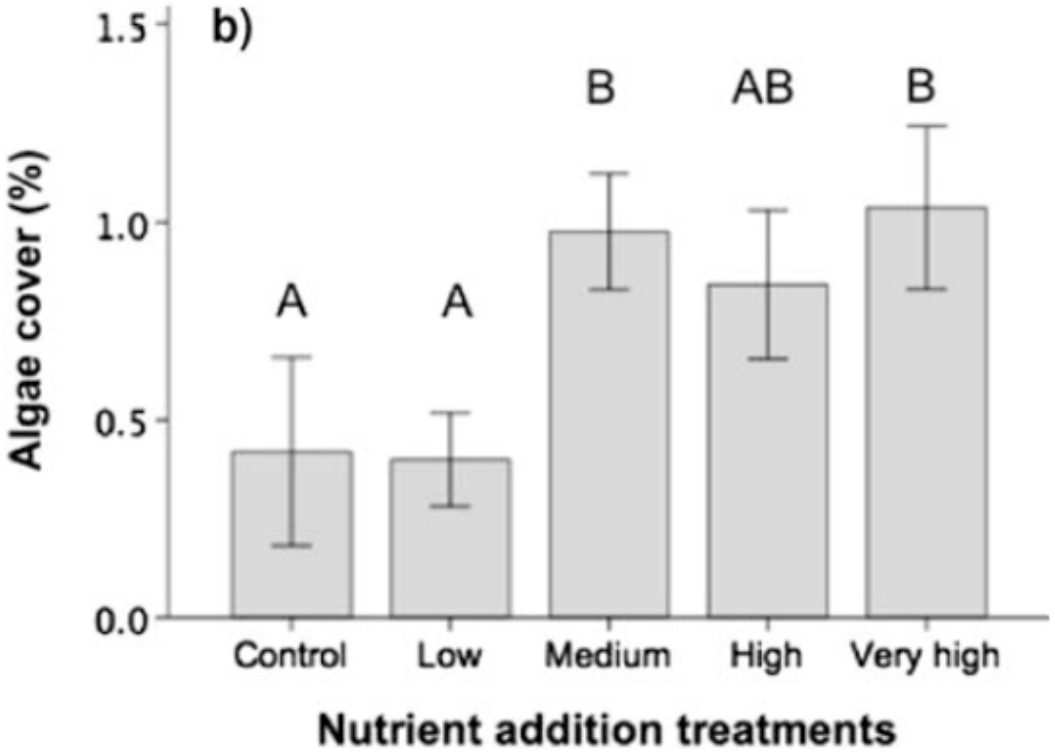
Eutrophication Experiment

- Soil-lined mesocosms
- ***N and P solution*** **(Carrie Lessin)**
- Dependent variables:
  - Algal crust cover
  - Plant percent cover and richness



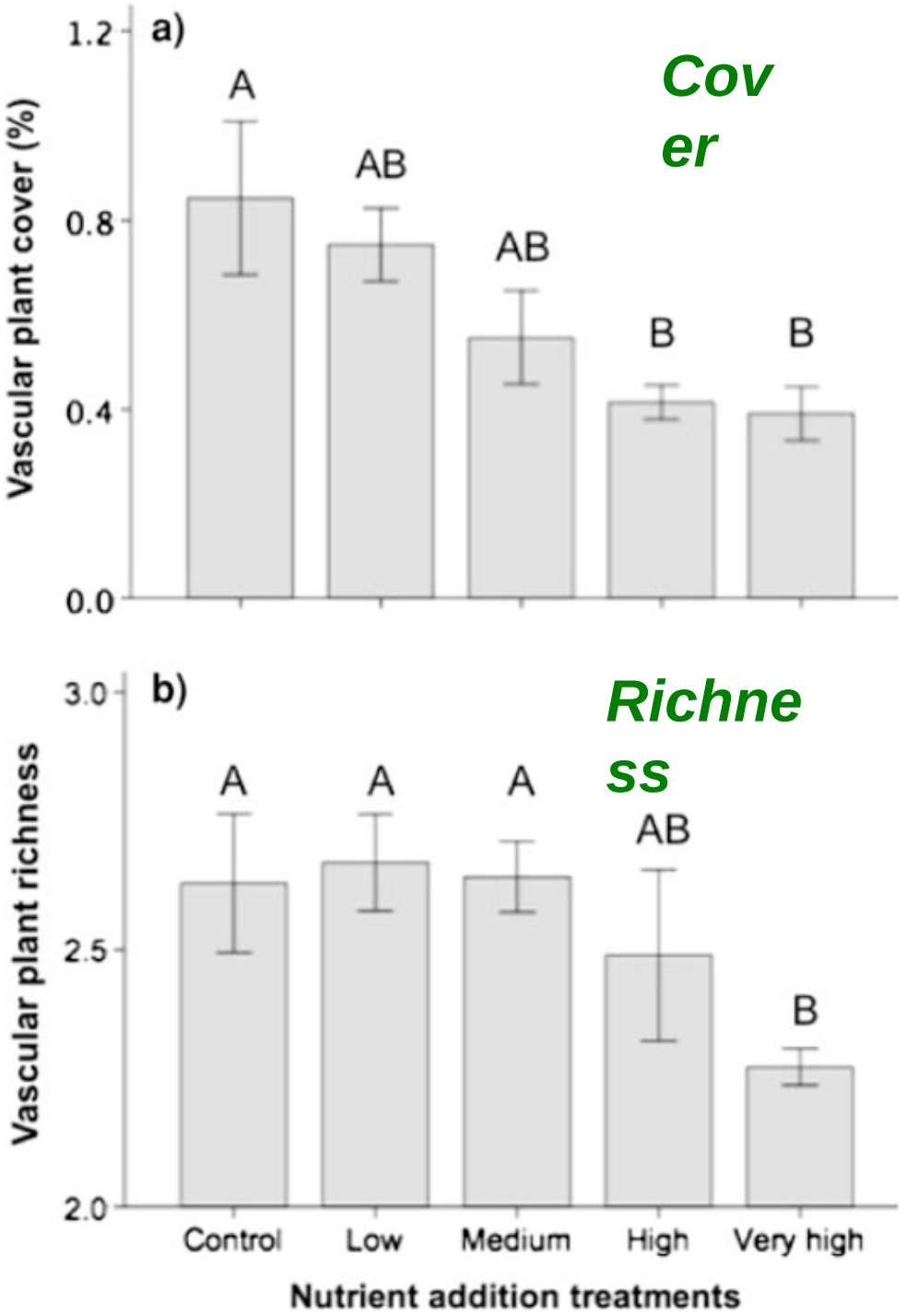
Kneitel and Lessin (2010)
Oecologia

Results: Aquatic



Kneitel and Lessin (2010)
Oecologia

Results: Terrestrial

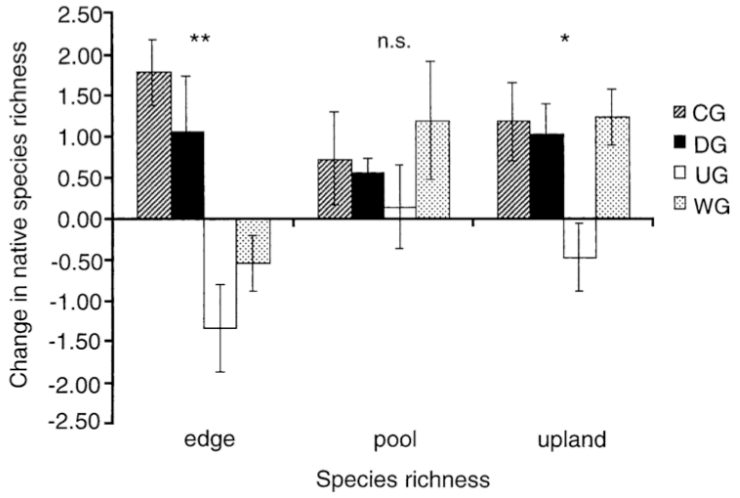


Grazing

- More than half of the world's land
- More than 85% of publicly-owned lands in the western US
- Common on grasslands in vernal pool habitat

Grazing

- Direct effects on the edges of vernal pools (Marty 2005)

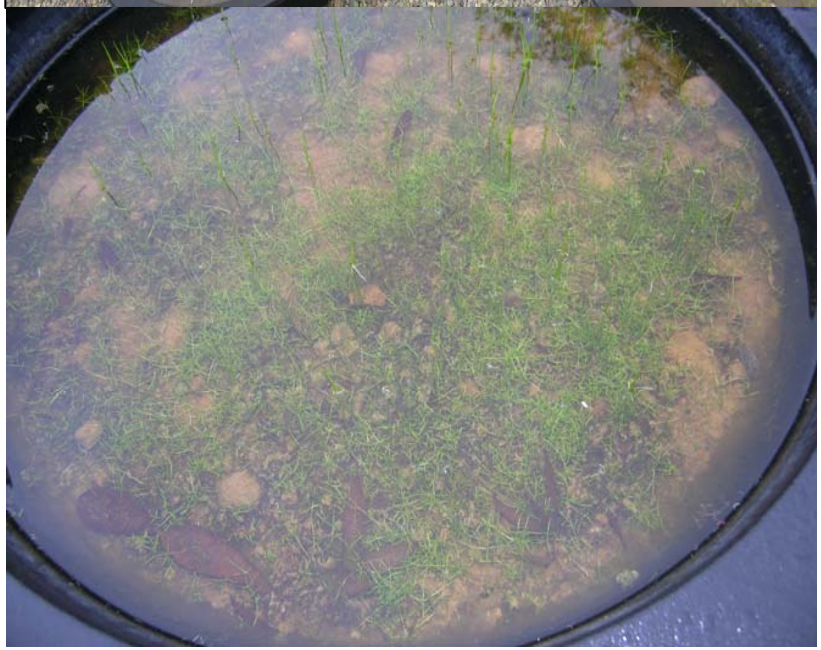


- Indirect effects of copious waste?

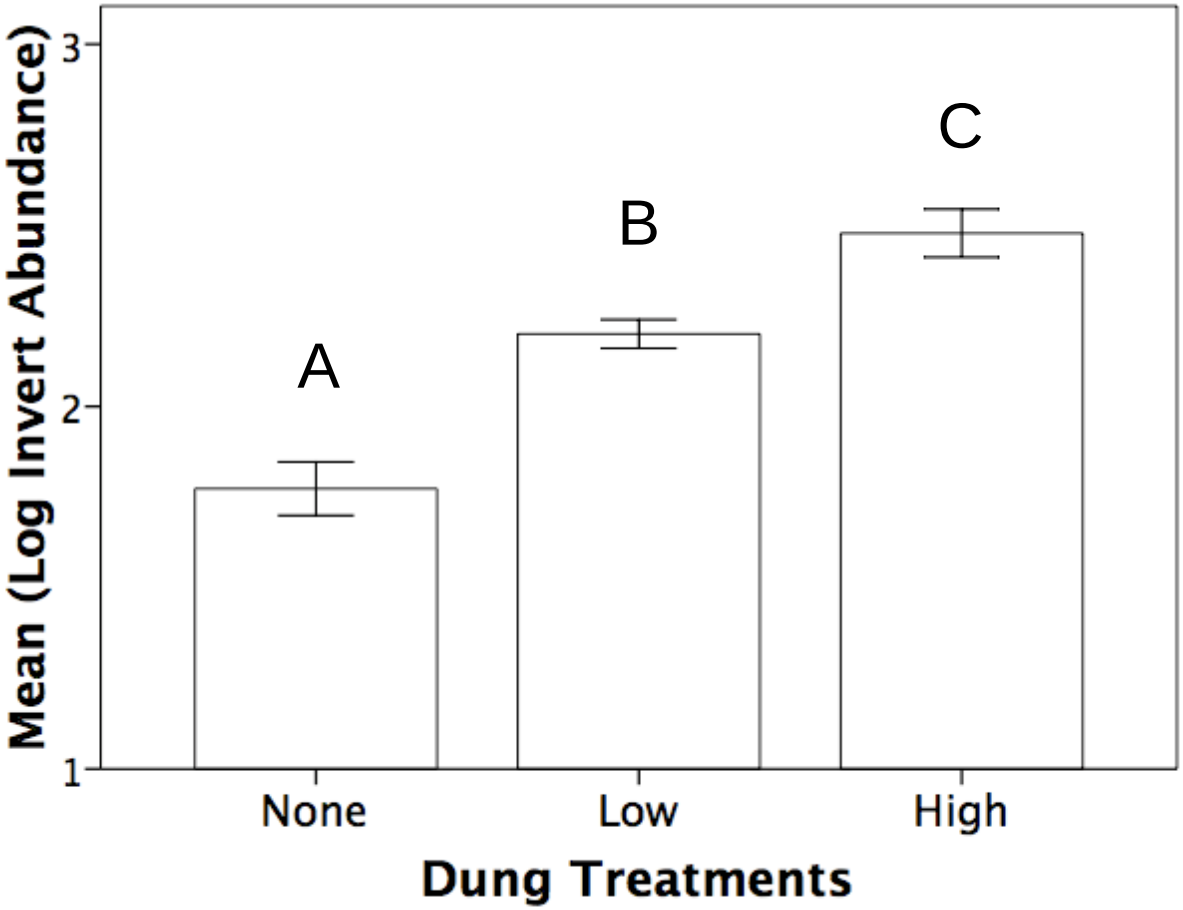
Cattle Waste Experiment

- Soil-lined mesocosms
- ***Cow Dung and Urine***
- Dependent variables:
  - Invertebrate density, Algal crust cover
  - Plant percent cover and richness

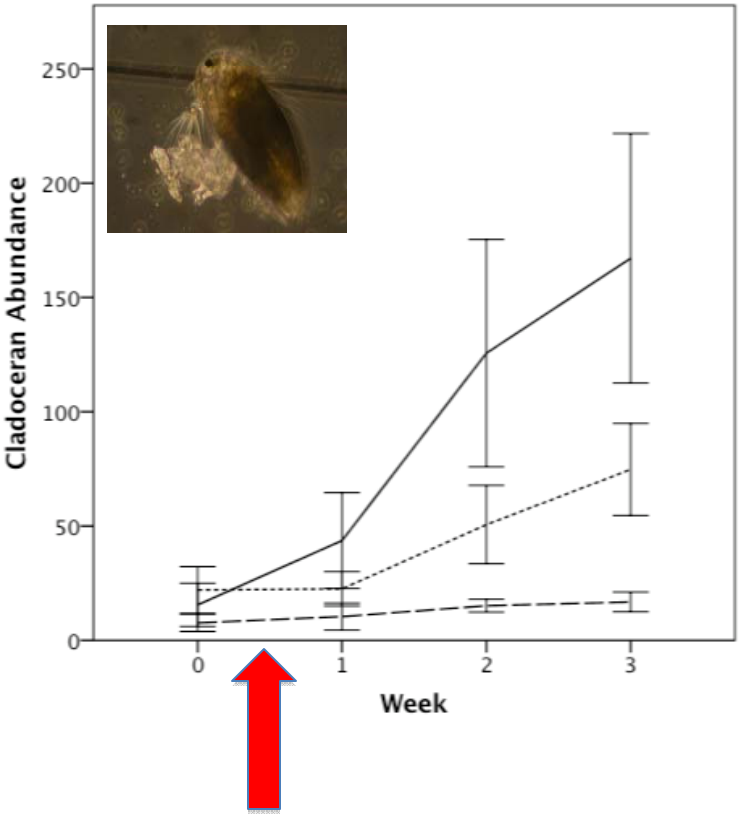
Croel and Kneitel, in review

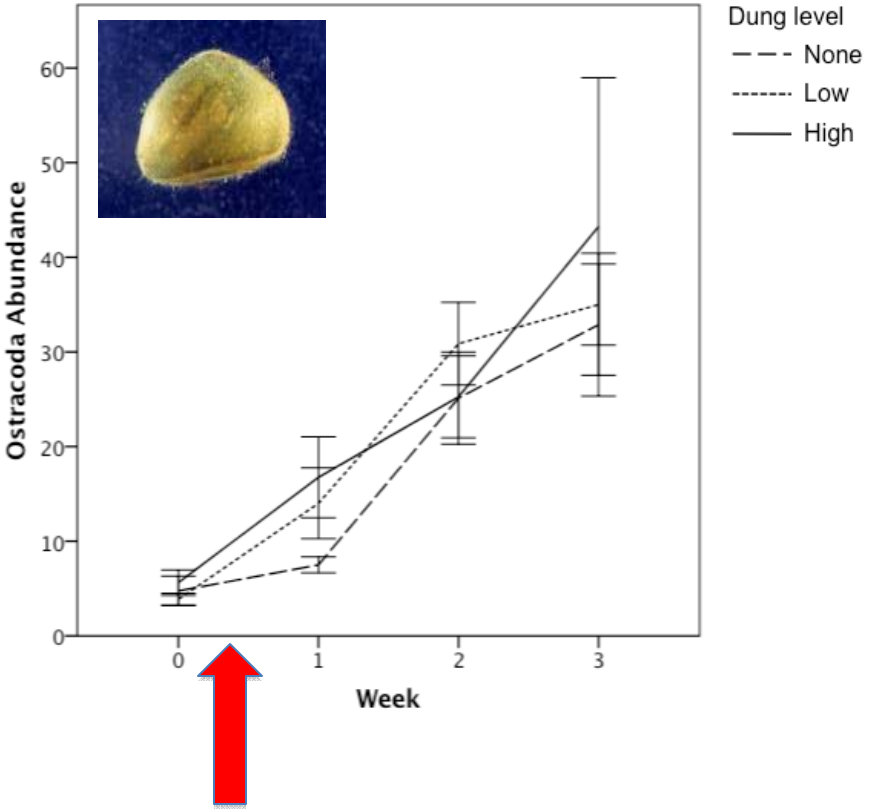


Results: Aquatic

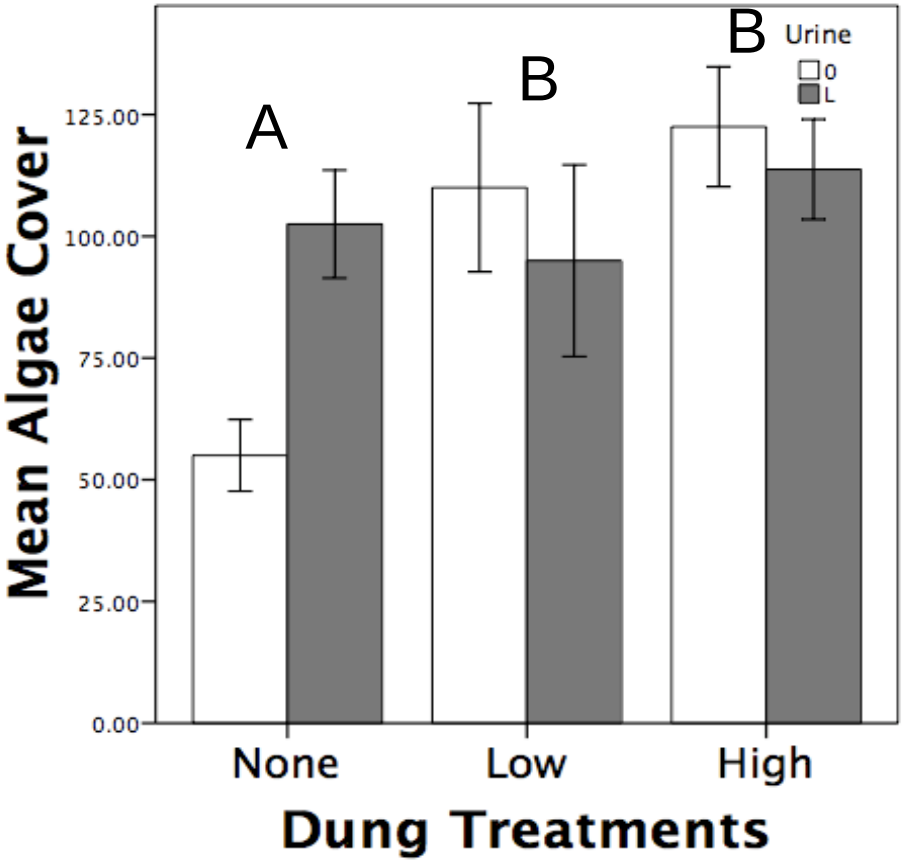


Results: Aquatic

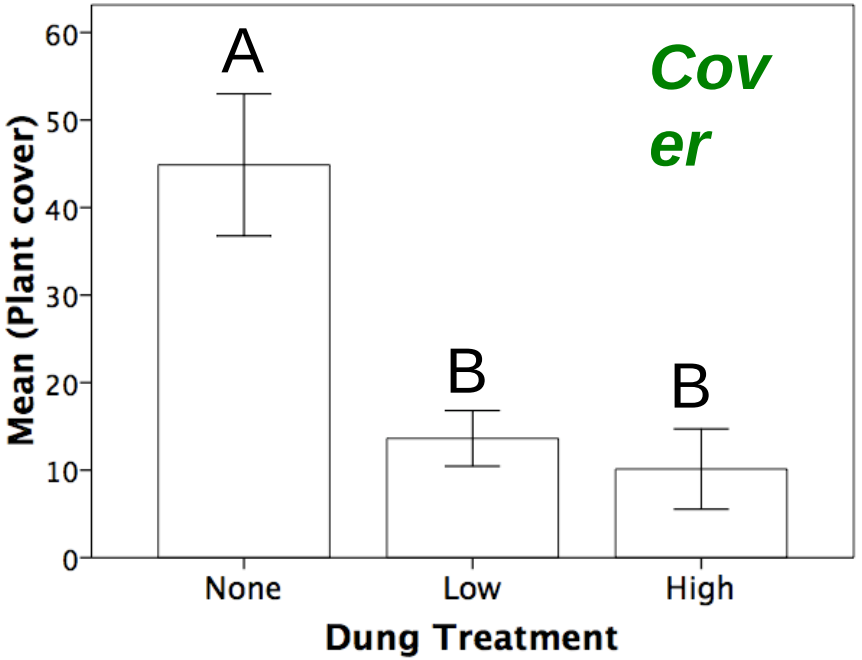


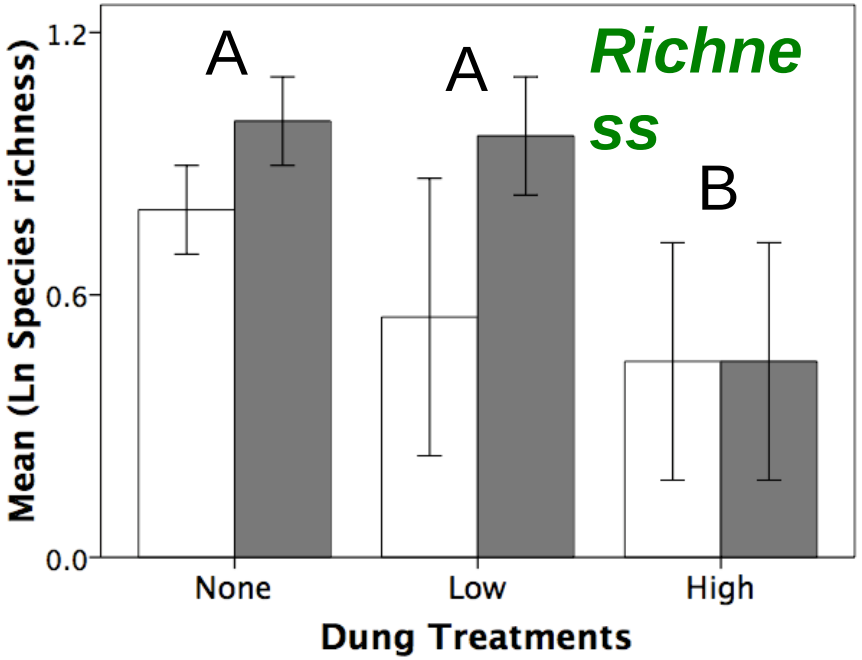


Results: Aquatic



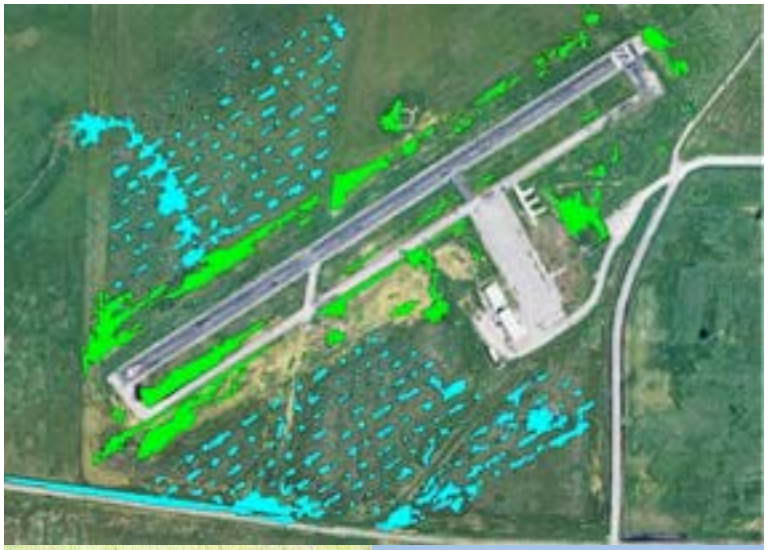
Results: Plants



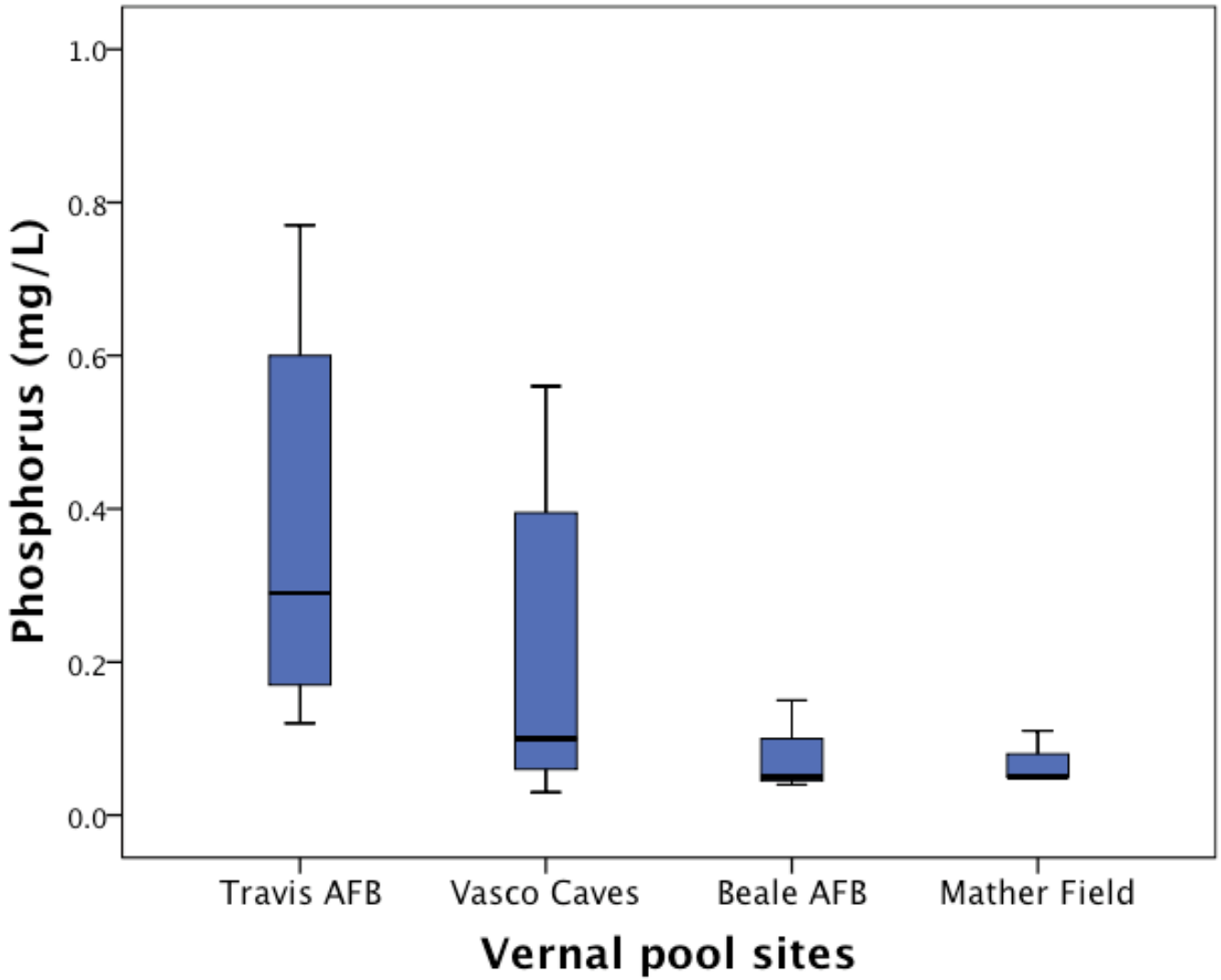


Do these patterns occur outside a bucket?

- Travis Air Force Base
  - 256 constructed pools
  - >10 year restoration study (Collinge)
- Measured aquatic and terrestrial community

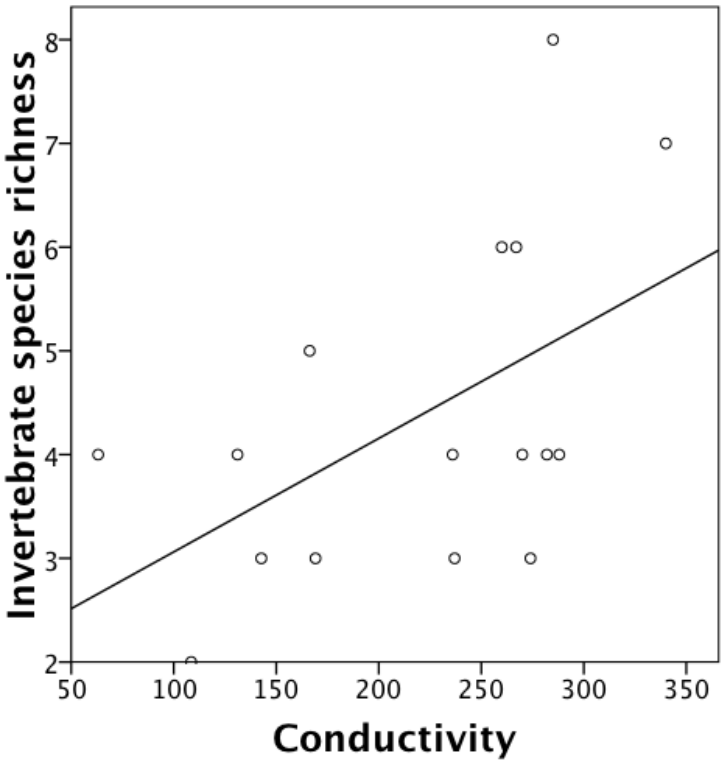


Variation in Phosphorus

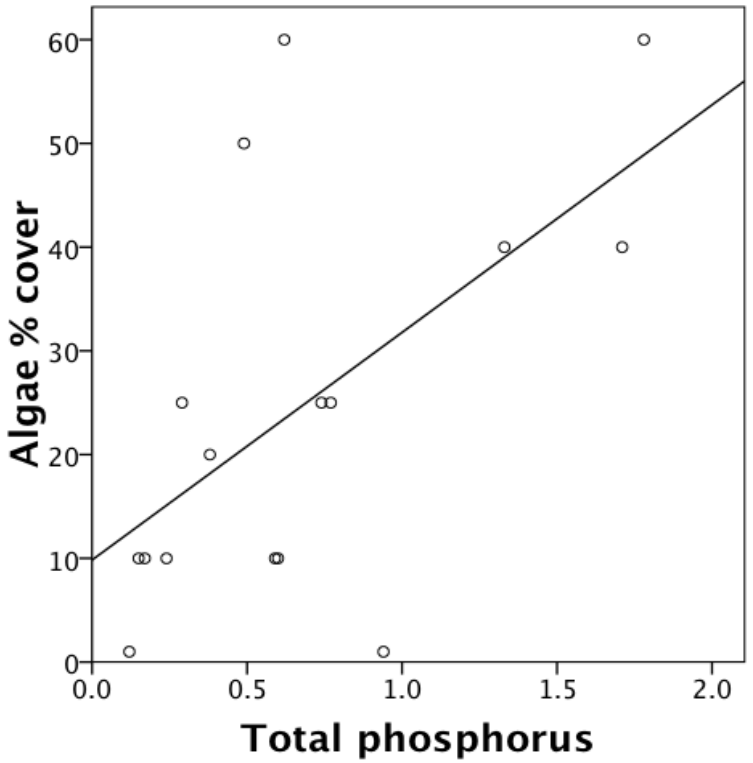


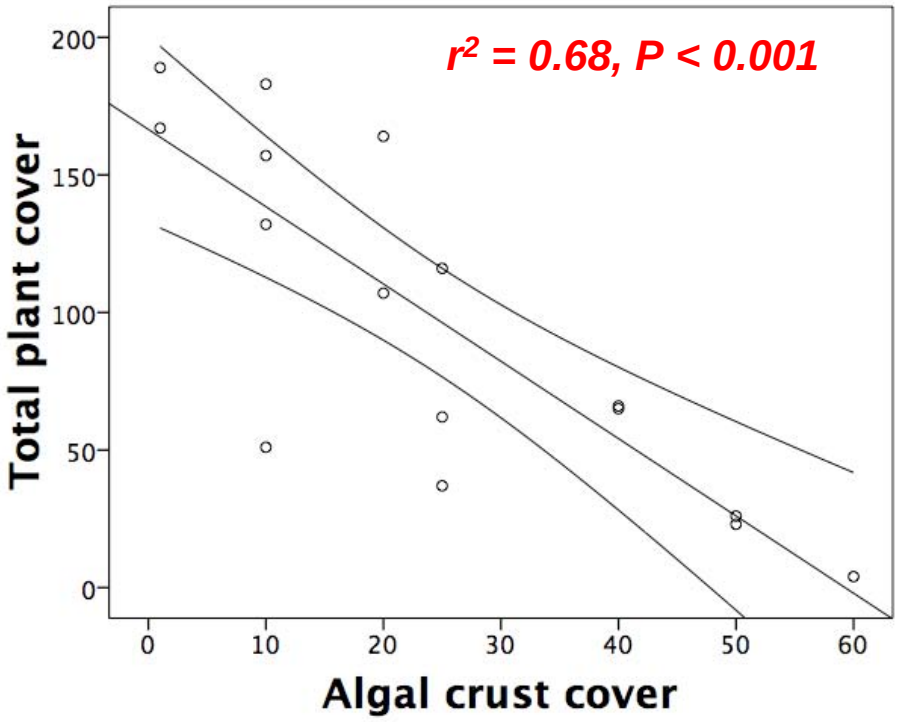
Aquatic Results

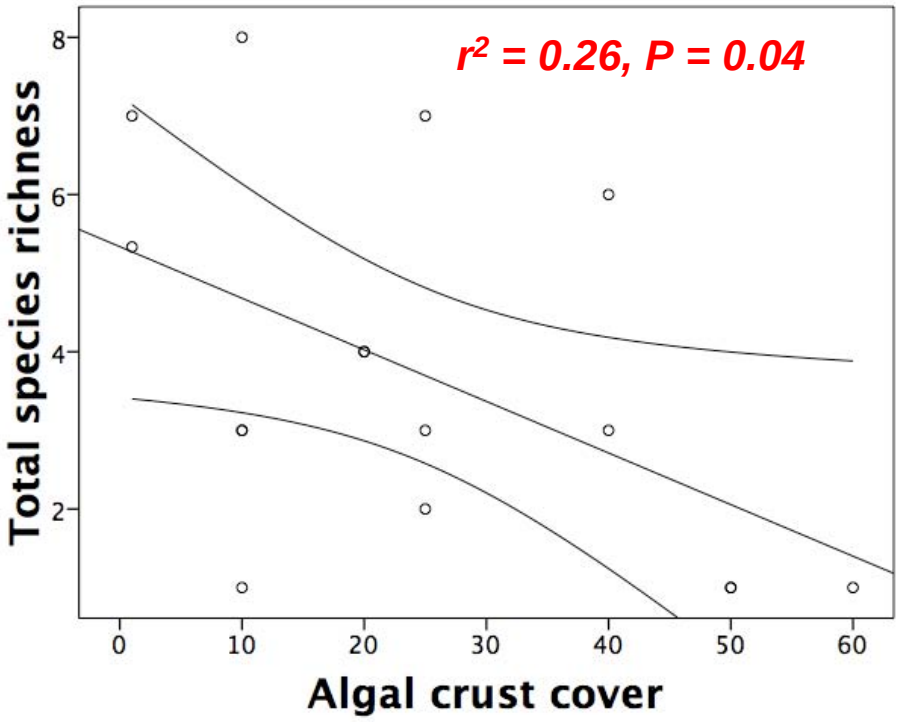
$R^2 = 0.28$, $P = 0.035$

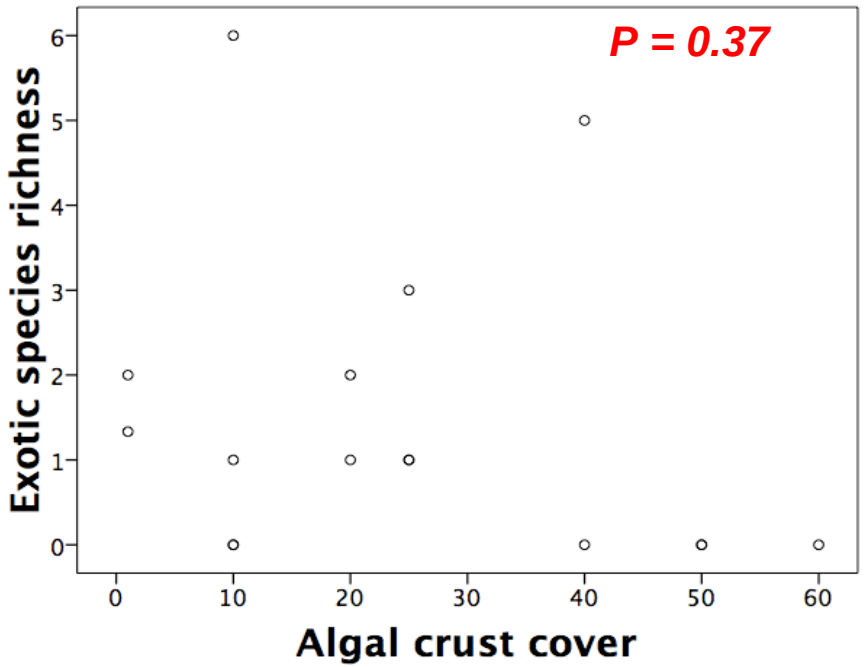


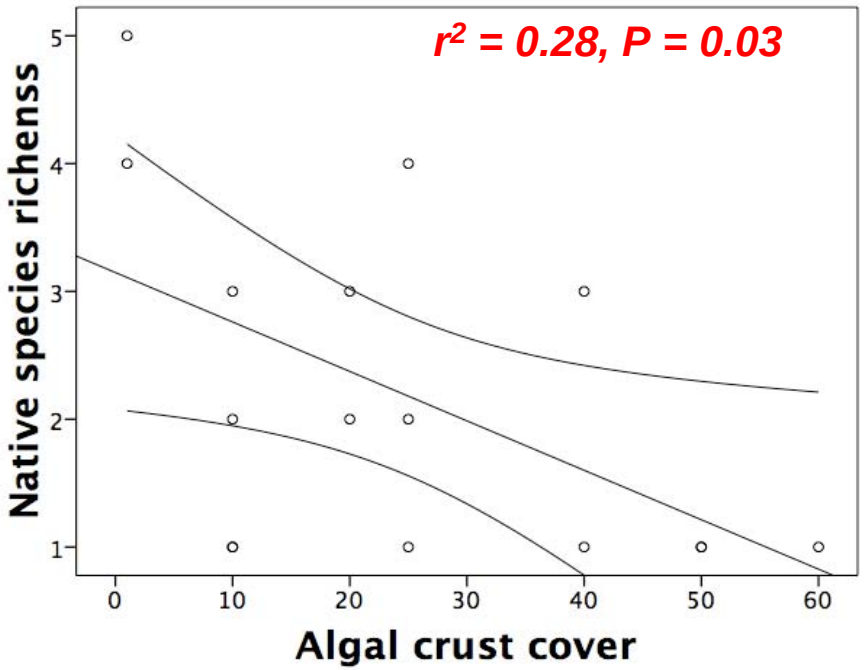
$R^2 = 0.34$, $P = 0.018$

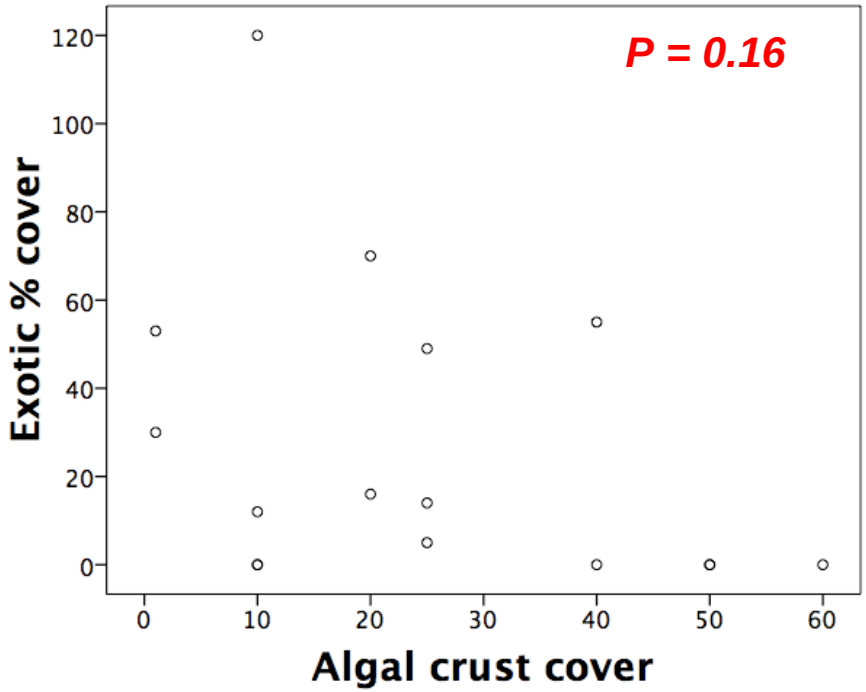


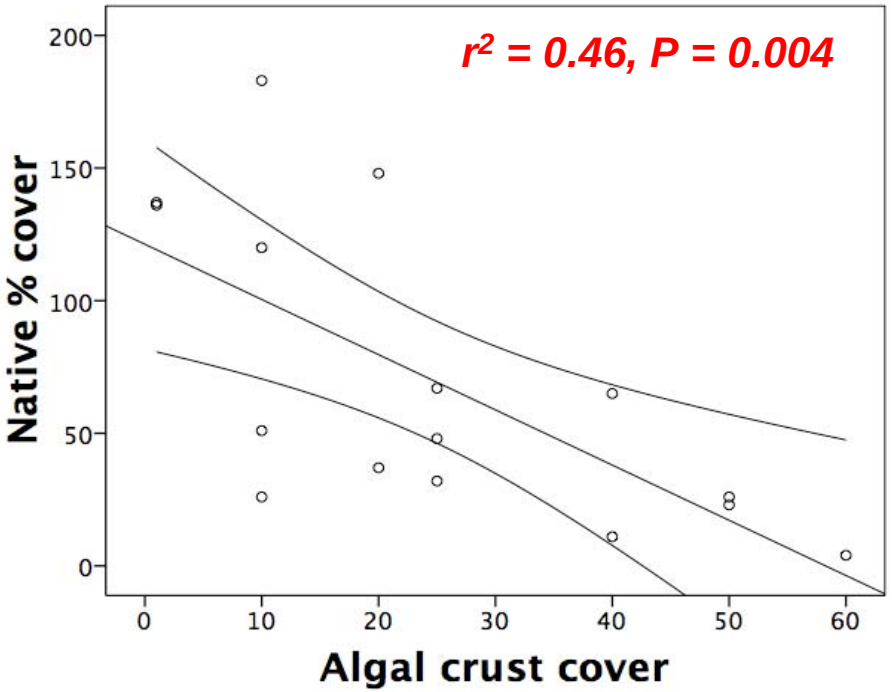

$r^2 = 0.68, P < 0.001$
Total plant cover
200
150
100
50
0
0
10
20
30
40
50
60
Algal crust cover


$r^2 = 0.26, P = 0.04$
Total species richness
8
6
4
2
0
10
20
30
40
50
60
Algal crust cover


P = 0.37
Exotic species richness
Algal crust cover
0
1
2
3
4
5
6
0
10
20
30
40
50
60

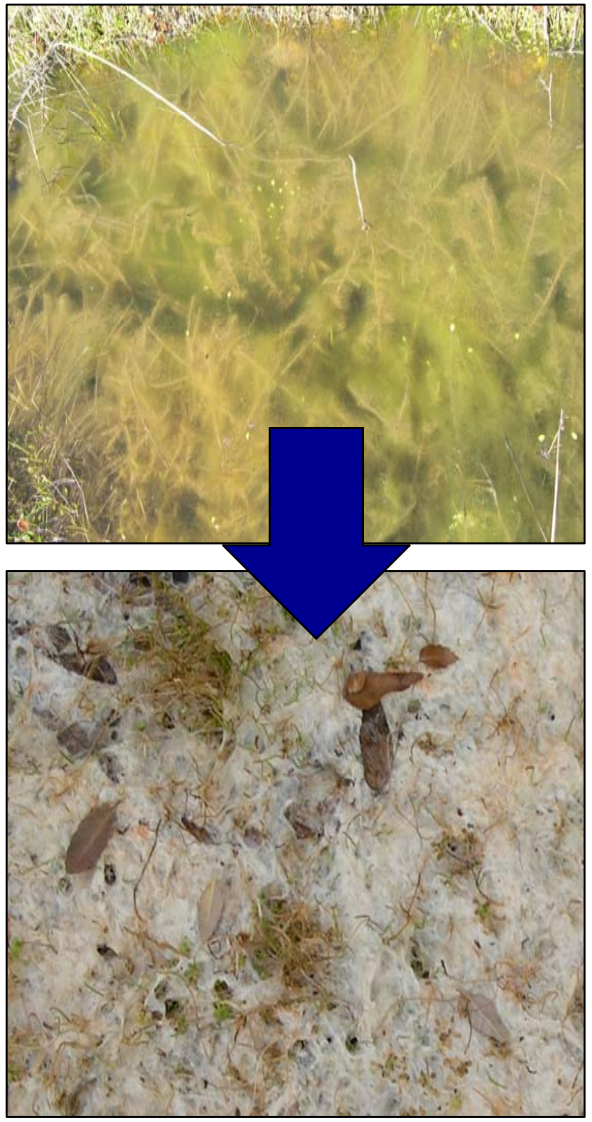

r2 = 0.28, P = 0.03
Native species richenss
Algal crust cover
1
2
3
4
5
0
10
20
30
40
50
60


P = 0.16
Exotic % cover
Algal crust cover
0
20
40
60
80
100
120
0
10
20
30
40
50
60


r2 = 0.46, P = 0.004
Native % cover
Algal crust cover
0
50
100
150
200
0
10
20
30
40
50
60

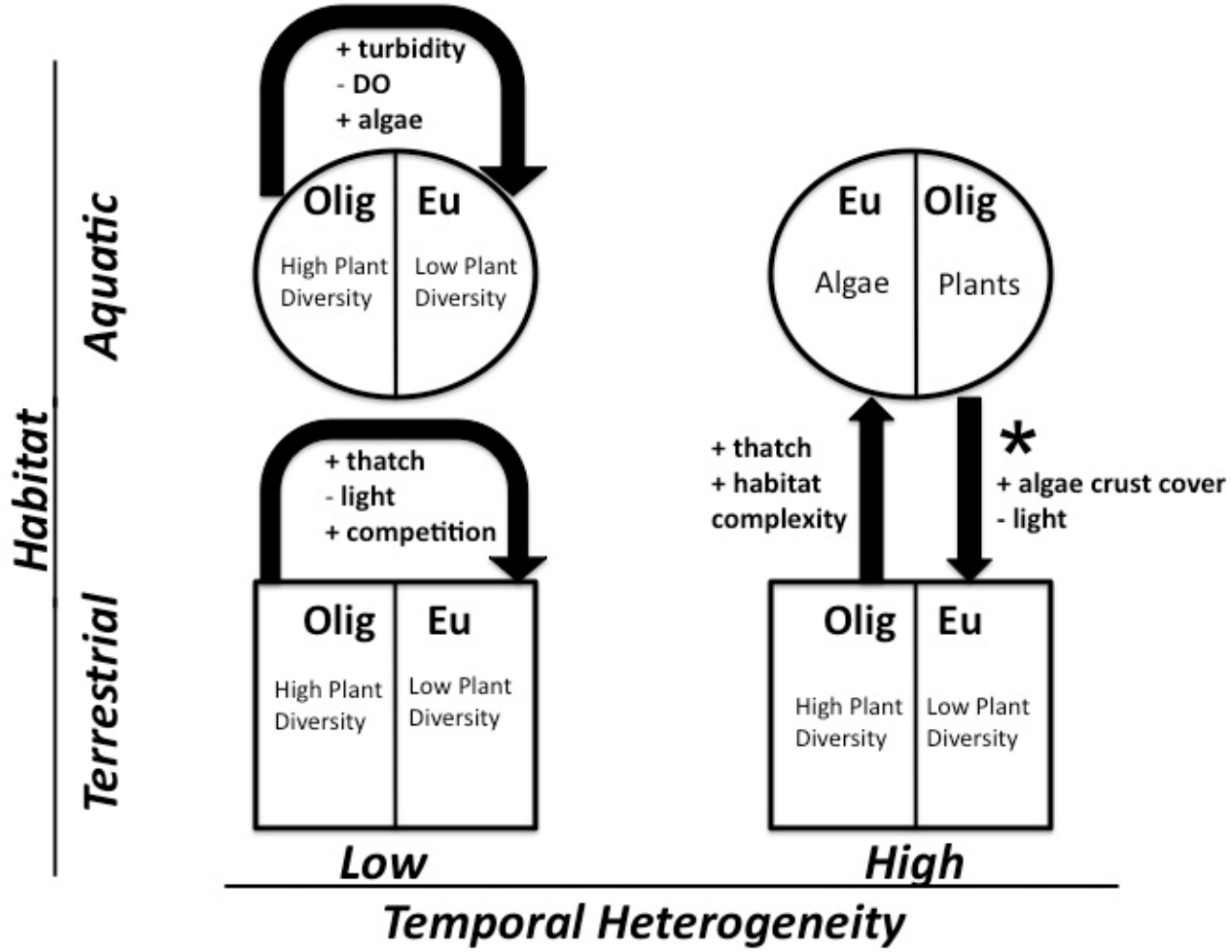
Conclusions

- **Consistent with previous theoretical and empirical studies**
- **Nutrient inputs cause shifts in California vernal pools (mesocosms and field)**
- **Shifts in “aquatic phase” affect “terrestrial phase” species diversity and cover**



"Moreover, we require a much better understanding of the significant but as yet poorly understood interactions that occur between nutrient enrichment and key physical, chemical and biological characteristics of receiving waters."

Smith and Schindler (2009) *TREE*



Conservation Implications

Urban/Agriculture Nitrogen & Phosphorus

Acknowledgements

- Funding:
  - NSF to SKC
  - CSUS
  - CSUS-NSM SURE Research Grants
  - CSUS- Biological Sciences
- CSUS:
  - Carrie Lessin
  - Mike Memeo
  - Mike Baad
  - William Hamilton
  - Don Agostinelli
- Justin Cutler (USFWS)