Nitrogen Dynamics and Metabolism

Work Order #3

Cohen Lab

March 10, 2017

Jenny Adler

Outline

- Task 2A: River Metabolism and Nutrient Uptake (Silver)
- Task 2B: **Nutrient Enrichment and Depletion Assays** (Alexander Springs)
- Task 2C: ***In Situ* SAV Growth** (Alexander Springs)

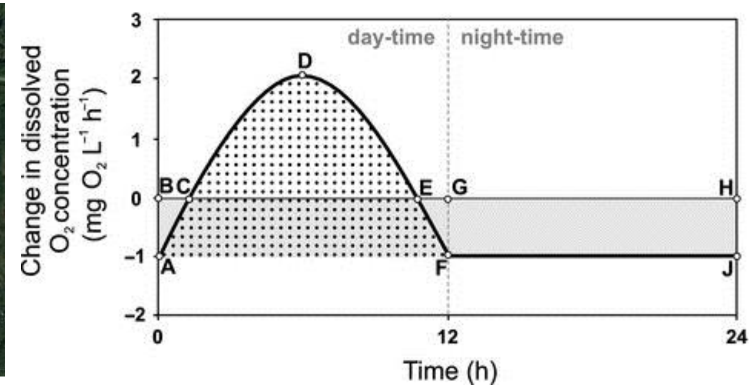
Task 2A

METABOLISM

(SILVER RIVER)

Long Term Continuous Metabolism

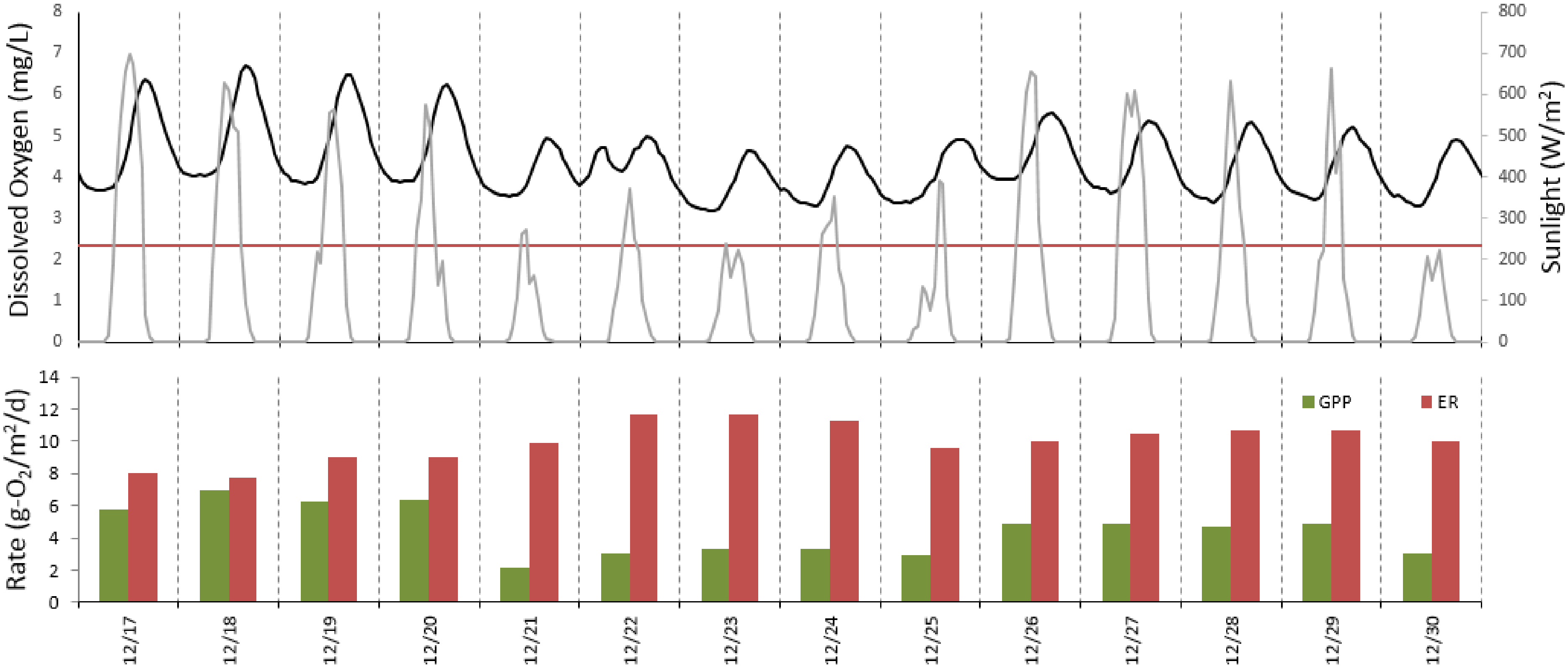
- Oxygen mass balance at the reach scale
  - Mammoth to SilverRiver-S5 (Dec, 2014 to present)
  - SilverRiver-S5 to SilverRiver-S1 (Nov 2015 to present)



- Primary production yields O_2, respiration uses O_2

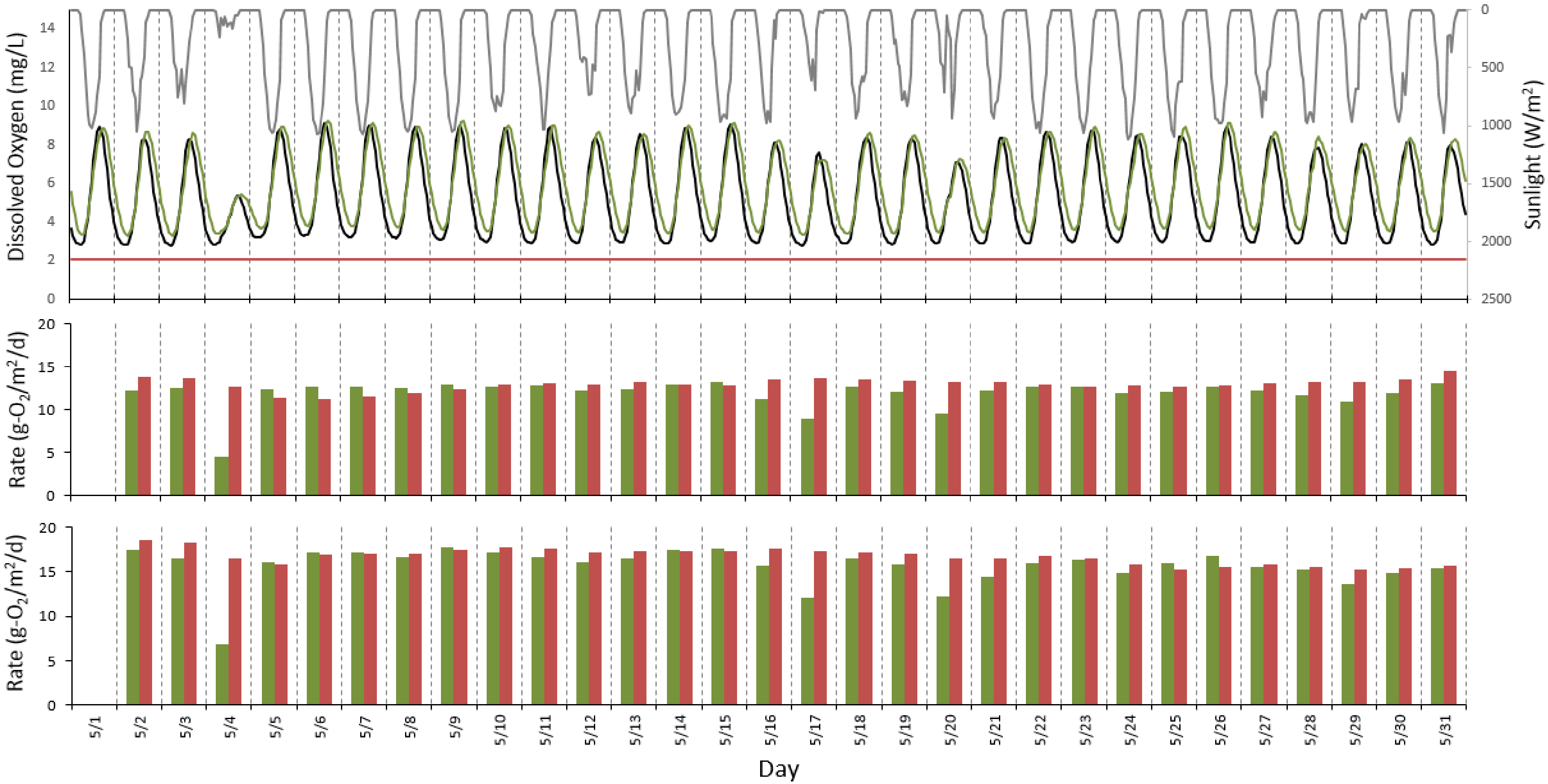
Example Period – Dec. 2014

- Upper River GPP ~ 0.5*ER (net heterotrophic)



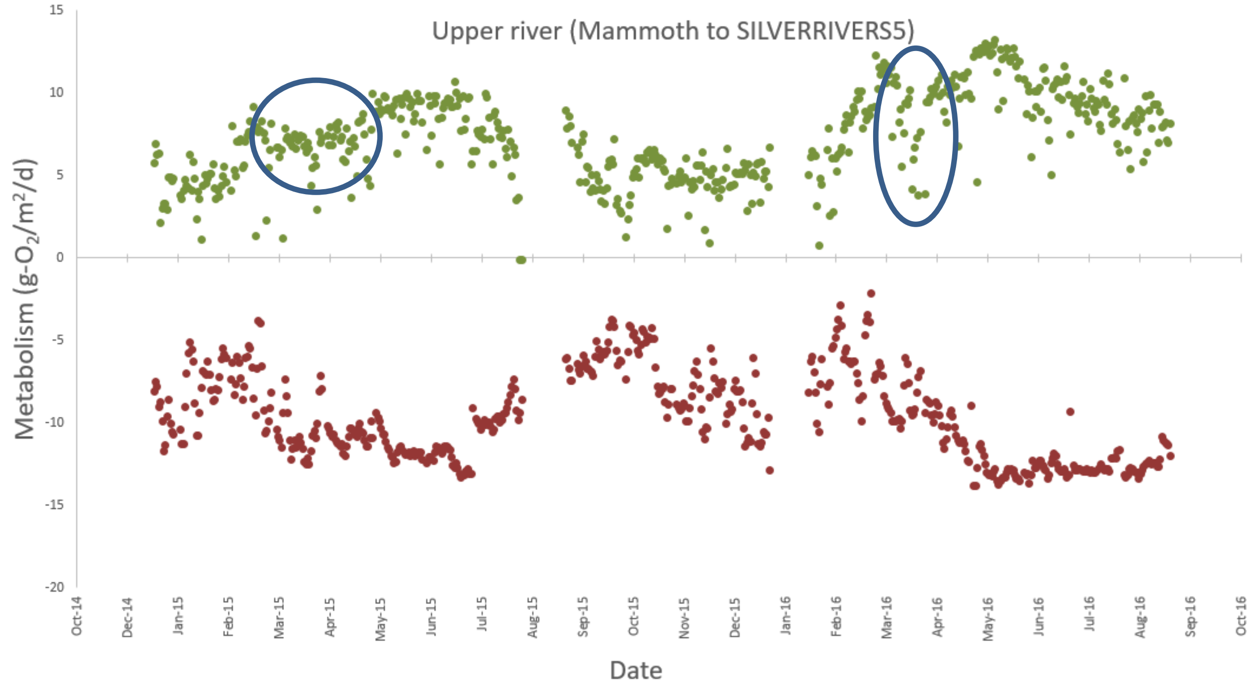
Example Period – May 2016

- $GPP_{upper} \sim 12.0$ g $O_2 m^{-2} d^{-1}$ $GPP_{lower} \sim 15.6$ g $O_2 m^{-2} d^{-1}$
- $ER_{upper} \sim 12.9$ g $O_2 m^{-2} d^{-1}$ $ER_{lower} \sim 16.7$ g $O_2 m^{-2} d^{-1}$



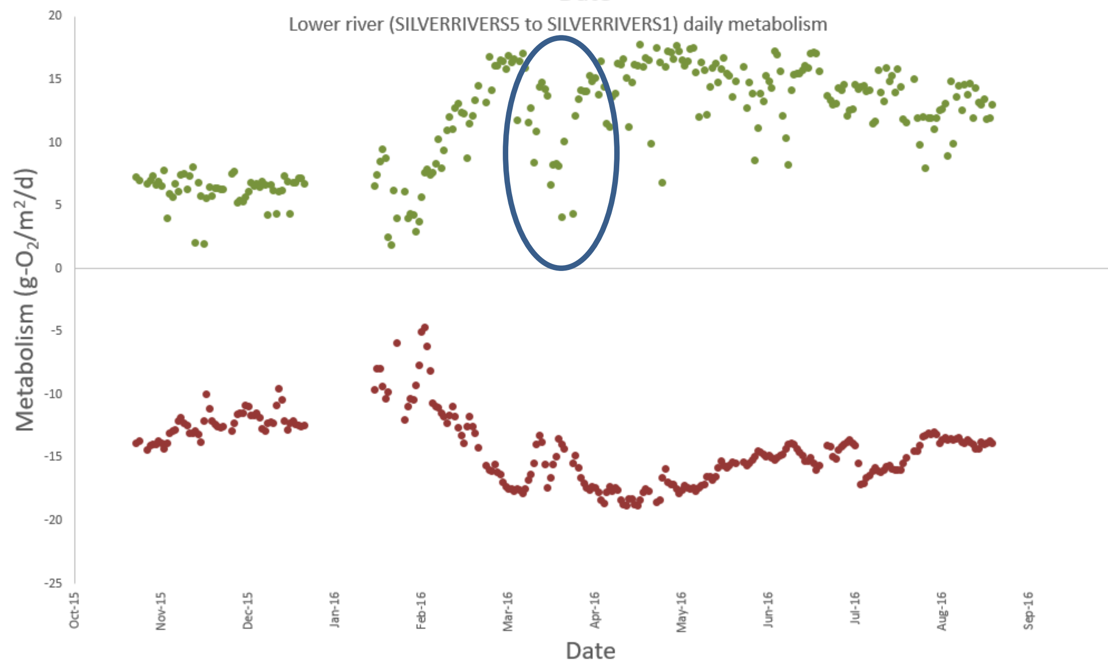
Upper River

- GPP ~ 7.4 g O_2 m^{-2} d^{-1}
  - 1000 g C m^{-2} yr^{-1}
- ER ~ 9.7 g O_2 m^{-2} d^{-1}
- P:R ~ 0.78
- GPP is predicatable
  - OpenLight (+) $p < 0.0001$
  - fDOM (-) $p < 0.0001$
  - $R^2 = 0.7$



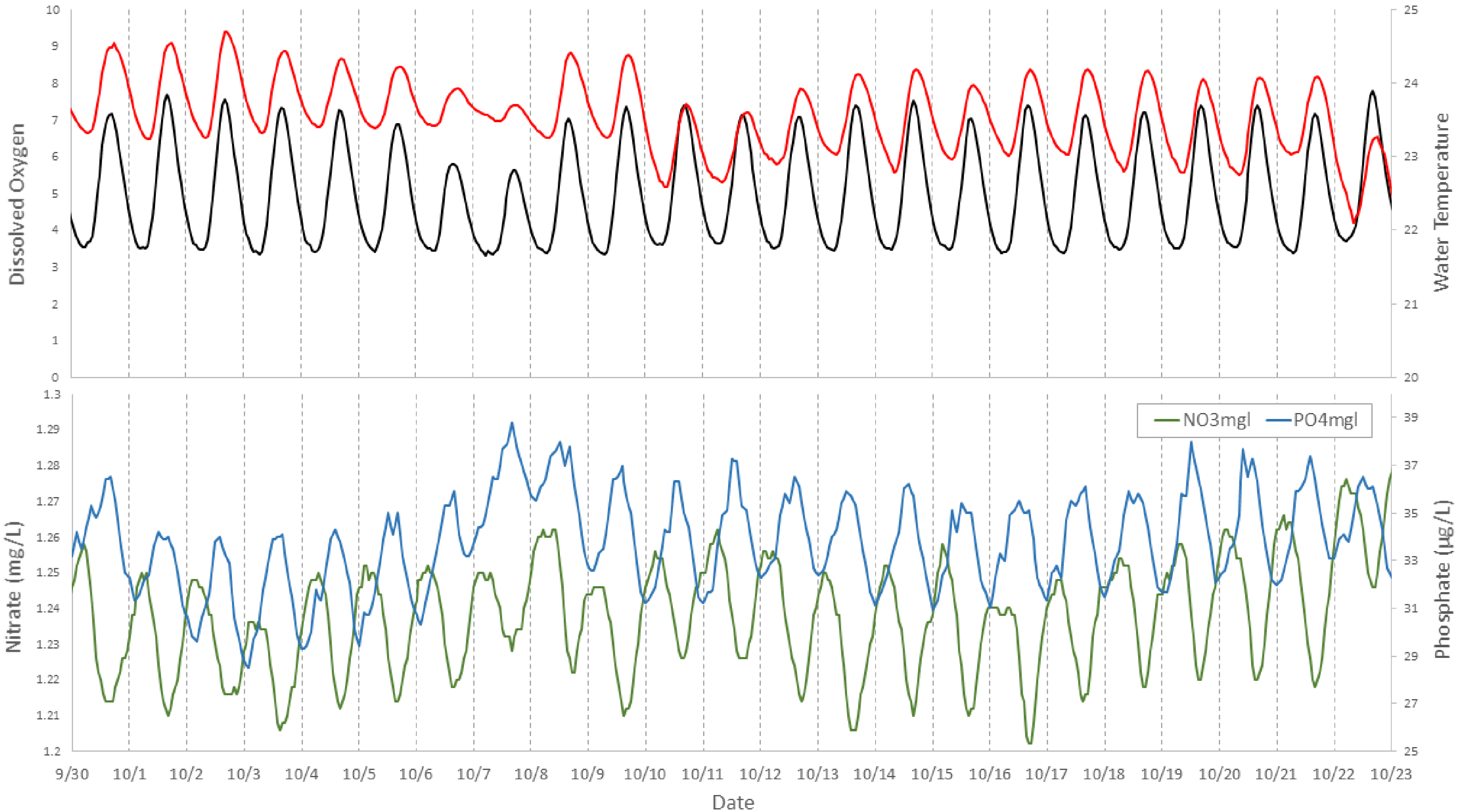
Lower River

- GPP ~ 11.6 g O_2 m^{-2} d^{-1}
  - 1500 g C m^{-2} yr^{-1}
- ER ~ 14.3 g O_2 m^{-2} d^{-1}
- P:R ~ 0.81



Coupled $[NO_3]$ and [SRP] Variation

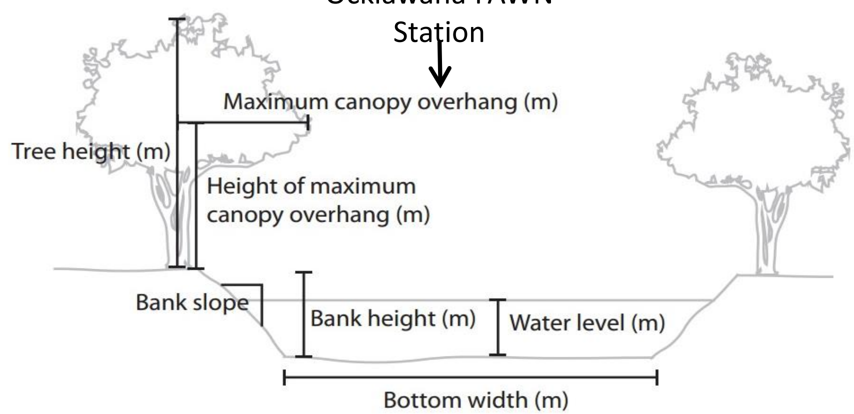
- NO_3 uptake during the day
- PO_4 uptake during the evening

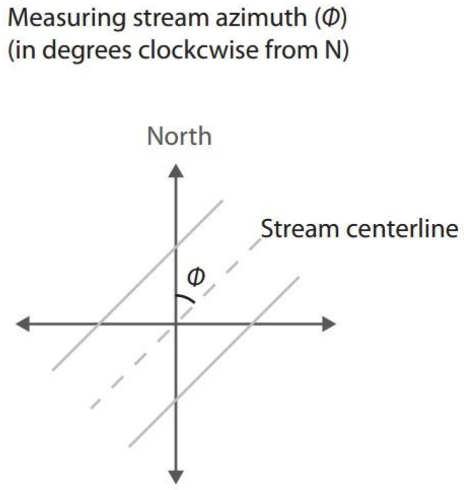


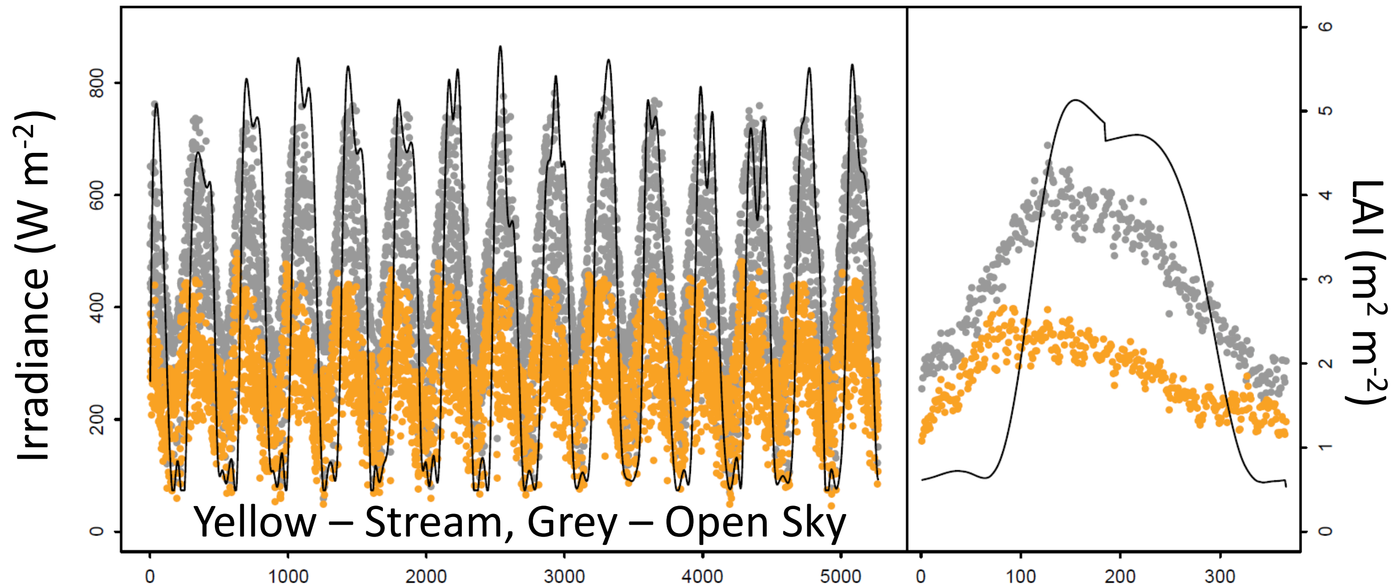
Light Model

MODIS LAI (250 m pixels, 4 day interval) adjusts open-sky irradiance

Solar Radiation
(w/m²)
Ocklawaha FAWN
Station







Task 2B

NUTRIENT ENRICHMENT ASSAY

(ALEXANDER SPRINGS CREEK)

Our Motivating Questions

(Task 2B)

- How does nutrient (N, P, Fe) enrichment affect system metabolism?
  - [overall growth response]
- How does nutrient enrichment (N, P, Fe) affect algal accumulation?
  - [algal growth response]
- How does nutrient depletion (N) affect growth and uptake?
  - [plant uptake kinetics]

How does nutrient (N, P, Fe) enrichment impact ecosystem metabolism?

[benthic boxes, act I]

Nutrient Enrichment/Depletion Assays

Benthic Boxes (Alexander)

CONTROL BOX	TREATMENT BOX 1	TREATMENT BOX 2	TREATMENT BOX 3

Conservative Tracer and Nutrient Additions

Ambient concentrations raised by:

20 mg/L for Cl (in all boxes)
2 mg/L for N
0.05 mg/L for P
0.05 mg/L for Fe

Treatments

N
P
Fe
N + P
N + Fe
P + Fe
N + P + Fe

Integrative Models of GPP and ER

- Effective for GPP (pseudo R^2 ~ 0.83) and ER (pseudo R^2 ~ 0.62)
- Informs interpretation of enrichment dosing

A: GPP	Est.	SE	t-value	p-value
Intercept (Fall)	-7.83	2.37	-3.30	0.004
Light	0.01	0.00	4.38	0.000
Depth	10.83	3.09	3.51	0.003
AFDM	0.04	0.02	2.19	0.044
Spring	3.08	0.90	3.43	0.003
Summer	-0.66	1.28	-0.52	0.611
Winter	1.69	1.06	1.59	0.132
Null Deviance	245.40			
Resid. Deviance	45.60			

B: ER	Est.	SE	t-value	p-value
Intercept	3.34	2.30	1.45	0.164
MeanGPP	0.40	0.17	2.38	0.029
Light	0.00	0.00	-1.13	0.273
Depth	4.15	3.18	1.31	0.208
AFDM	0.03	0.02	1.75	0.098
Null Deviance	126.60			
Resid. Deviance	48.20			

Nutrient Enrichment Effects (Alexander)

Significant temporal and spatial variation implies testing treatments using <u>**relative response**</u> (RR):

- Ratio of GPP in treatment vs. control

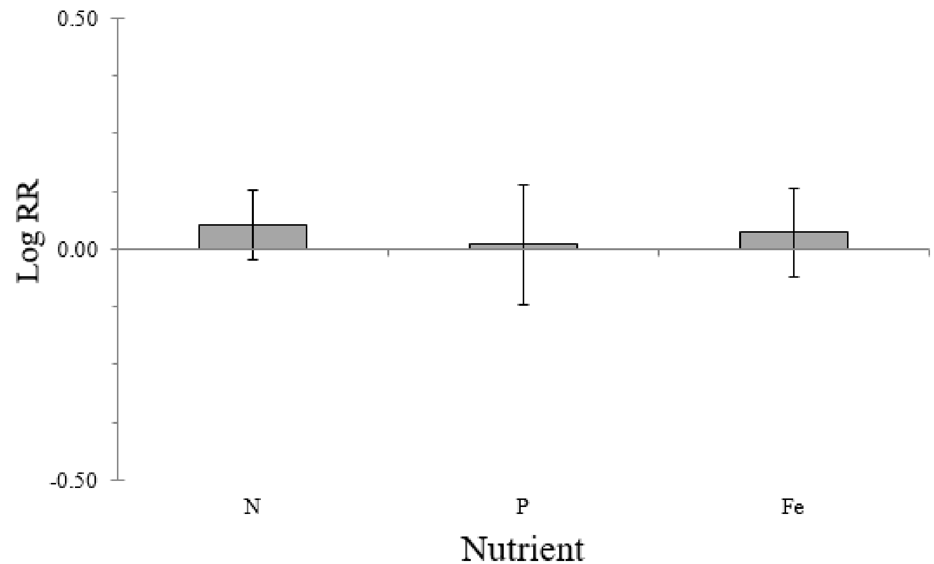
$$RR_{GPP} = \log\left(GPP_t : GPP_c\right)$$

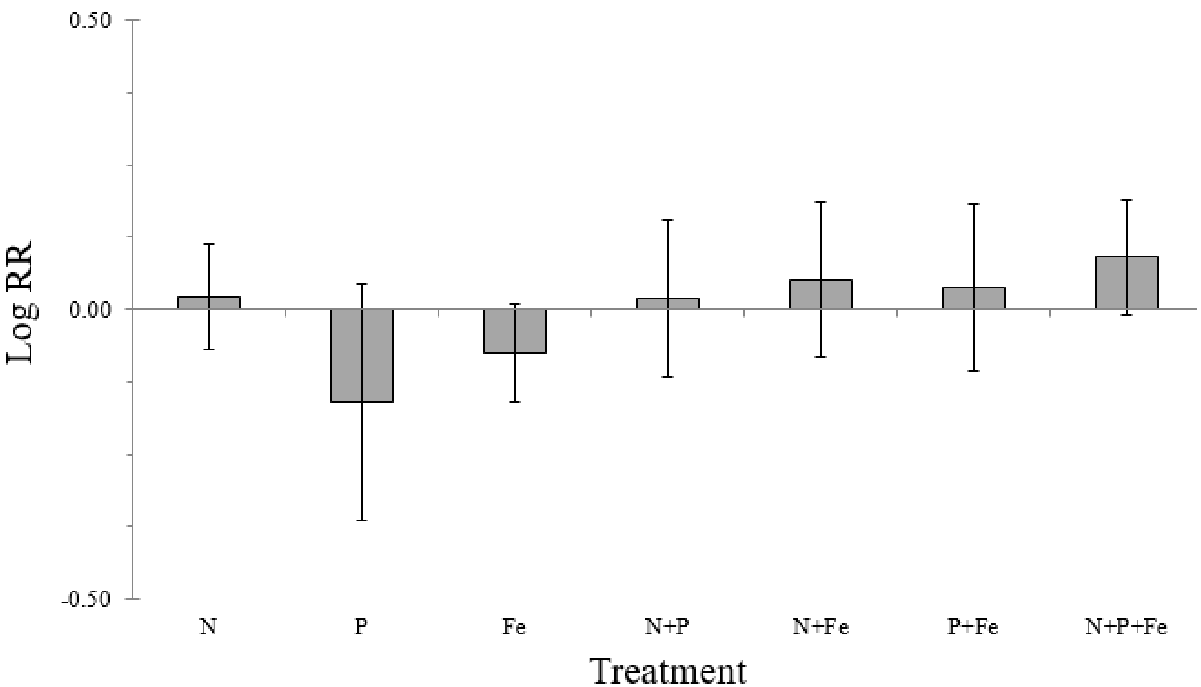
- Ratio of relative growth (GPP/B) in treatment vs. control

$$RR_{GPP:B} = \log\left(GPP_t/B_t : GPP_c/B_c\right)$$

GPP Response

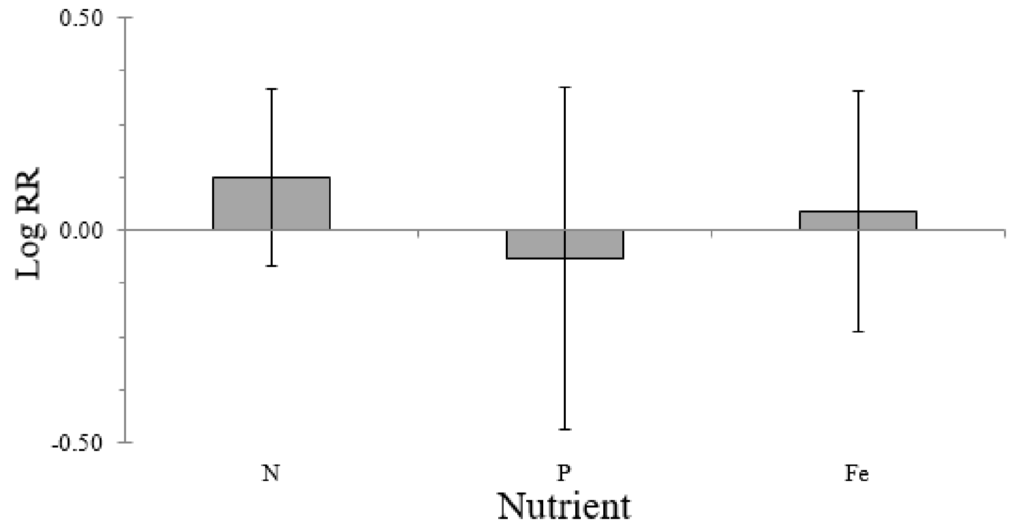
- No significant treatment effects
  - As treatments
  - As nutrient main effects only

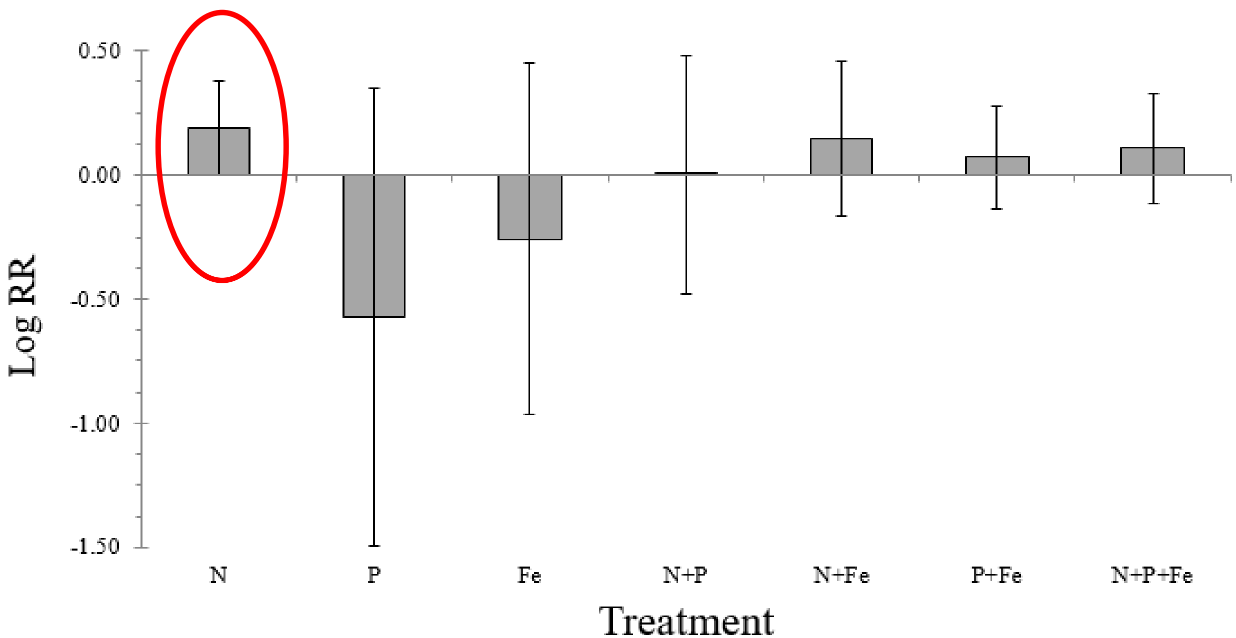




Relative Growth

- Weak N effect
  - p = 0.05
- No main effects
  - N effect disappears





Summary of GPP Response (Alexander)

- GPP is (expected to be) highly predictable
  - Light, Biomass, Depth Season target variables
- Nutrient enrichment had **<u>mostly no effect</u>**
  - No effects for GPP directly
  - Weak N effect for relative growth which disappears with other additions

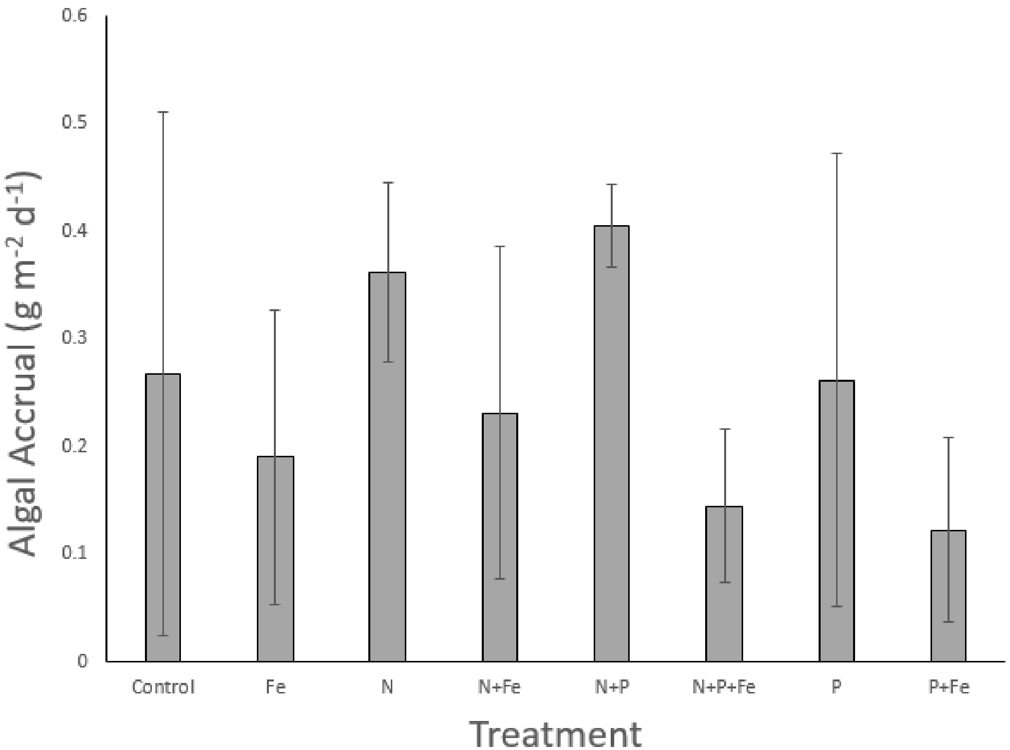
How does nutrient enrichment (N, P, Fe) affect algal accumulation?

[benthic boxes, act II]

Algal Tiles

- Unglazed ceramic tiles ($A = 144\ cm^2$)
- Hung in each box for week-long deployment
- Biomass accrual (dry weight)

Raw Algal Biomass Data



No clear enrichment effect without controlling for site variation (i.e., treatment relative to control)

Slightly higher algal accrual **overall** in Alexander (0.32 g m^{-2} d^{-1}) vs. Silver (0.25 g m^{-2} d^{-1}). *NB: Different seasons and light regimes.*

Preliminary model of algal growth suggests weak season effect, strong water depth effect, and weak SAV biomass effect (light effect not yet completed)

Nutrient Enrichment Effects

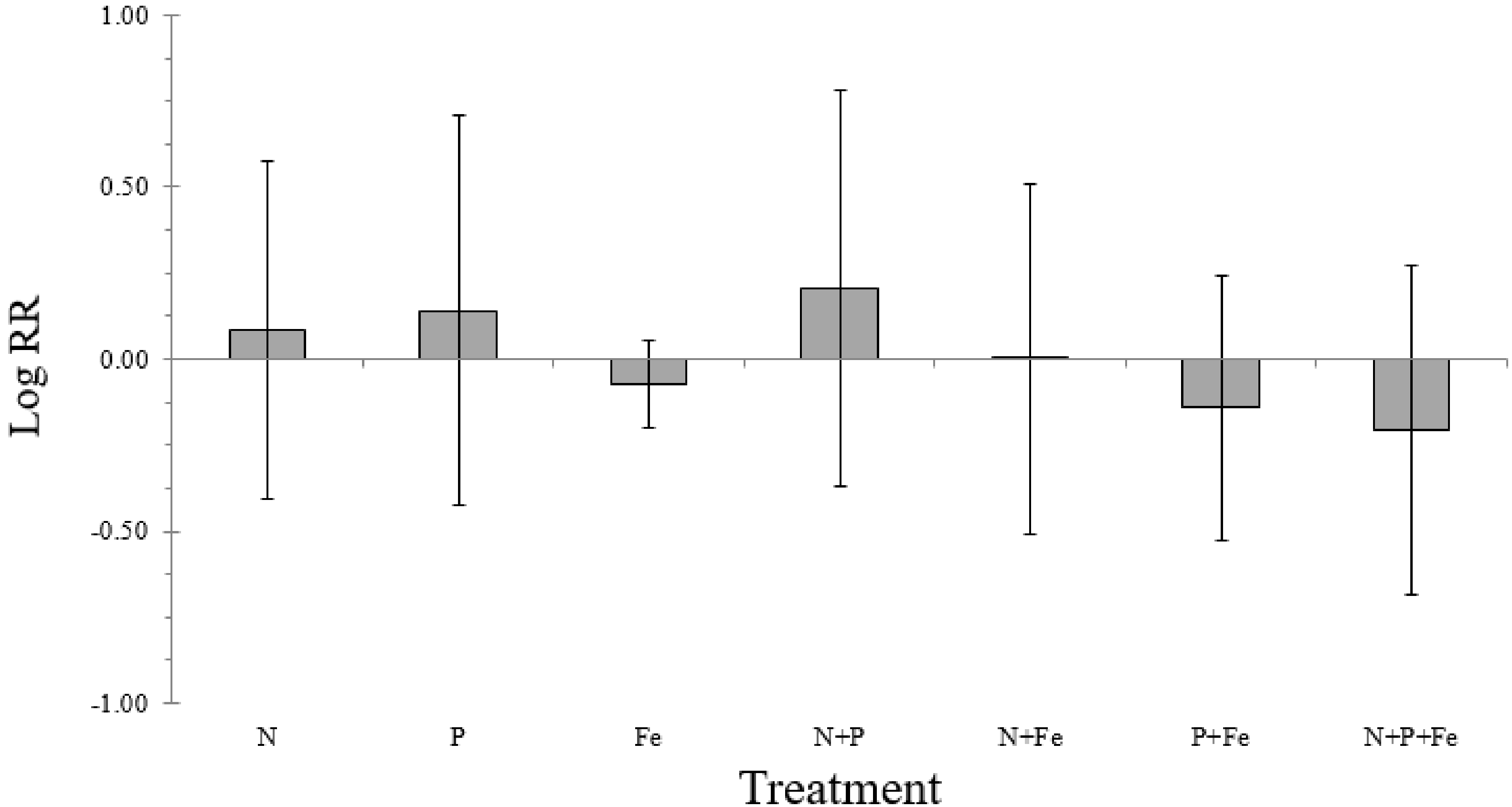
Significant temporal and spatial variation implies testing treatments using **relative response** (RR):

- Ratio of Algal Biomass in treatment vs. control

$$\mathbf{RR_{Algae} = log\ (Algae_t{:}Algae_c)}$$

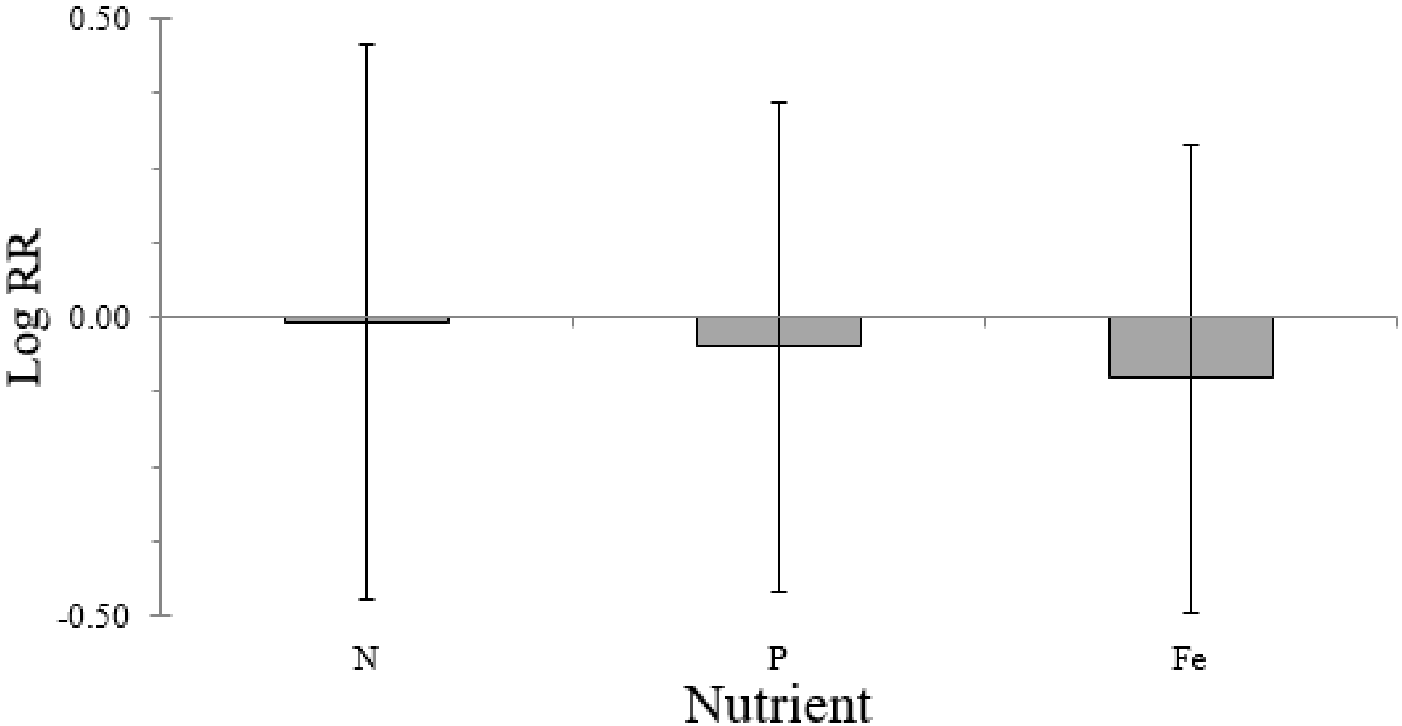
Treatment Effects - RR_{Algae}

- No statistically significant effects



Pairwise Enrichment

- No significant effects



Summary of Algal Response

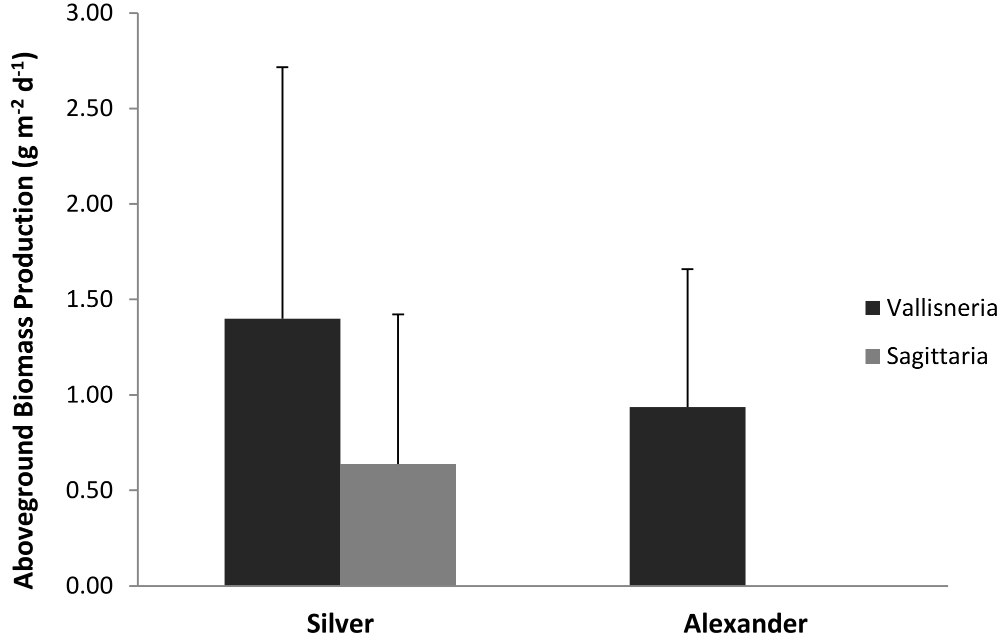
- Algal growth is somewhat predictable
  - Depth, season, SAV biomass, light (?)
- No significant treatment effects

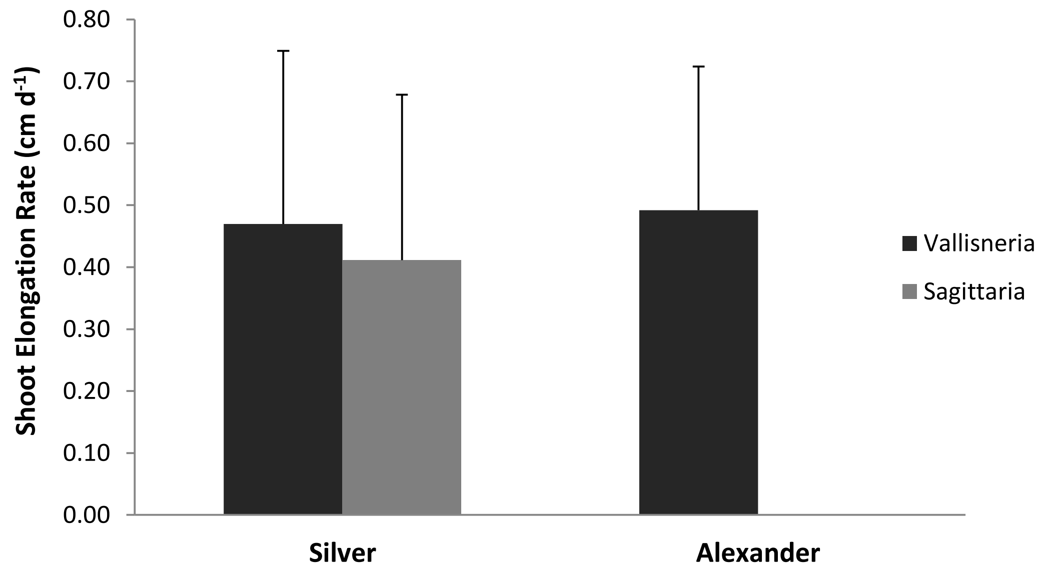
Task 2C

SUBMERGED VEGETATION GROWTH

(ALEXANDER SPRINGS CREEK)

SAV Growth Rates

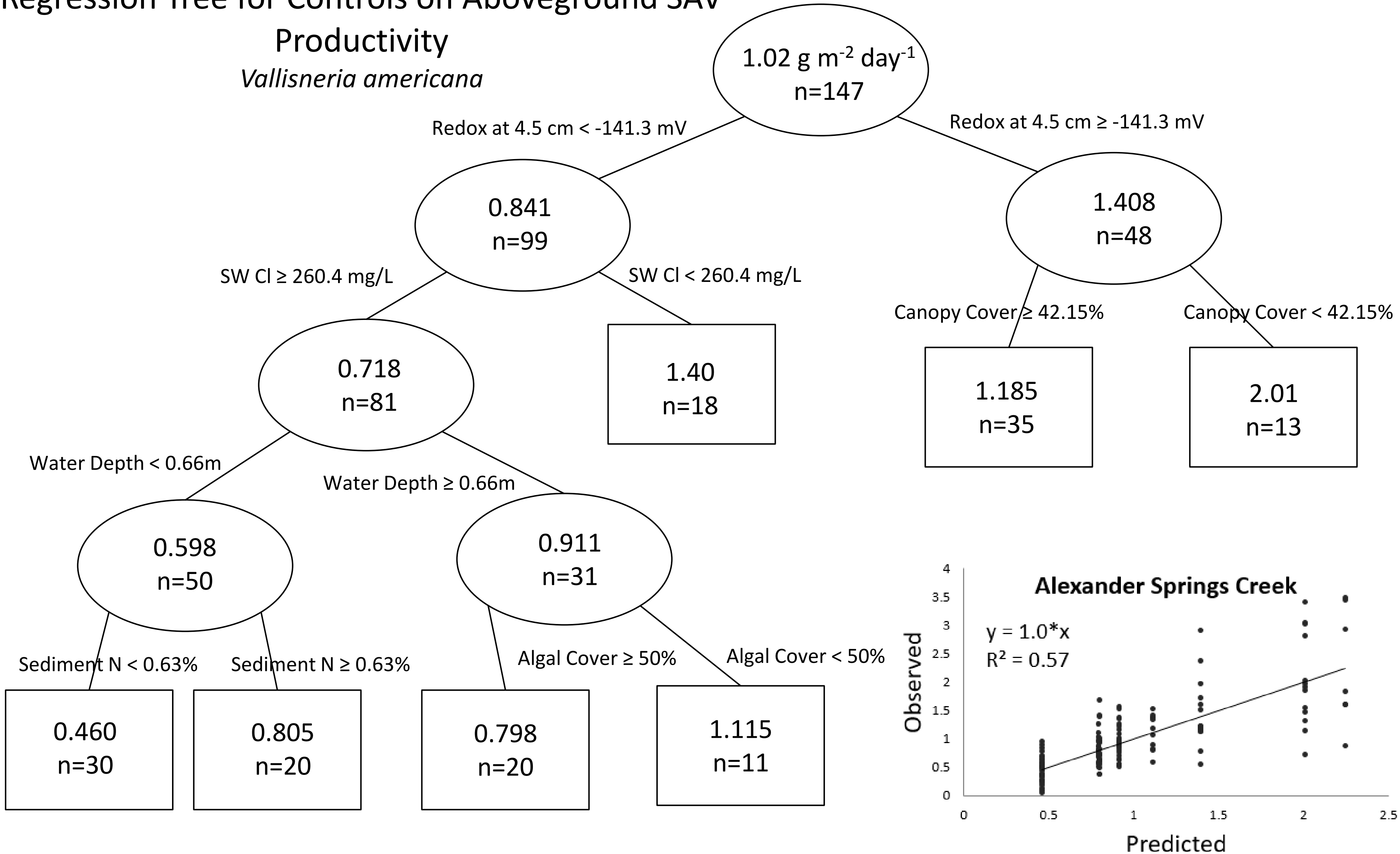




Alexander Springs Creek

Regression Tree for Controls on Aboveground SAV Productivity

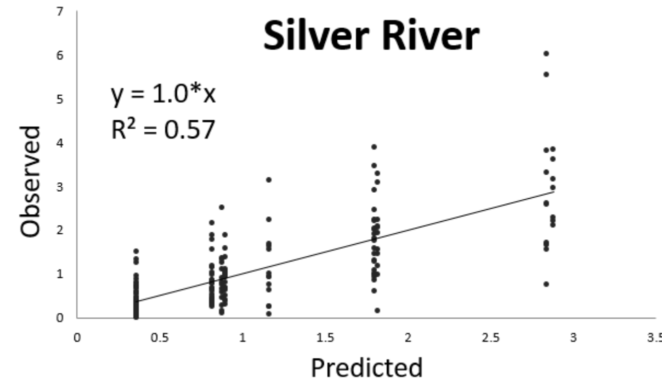
Vallisneria americana

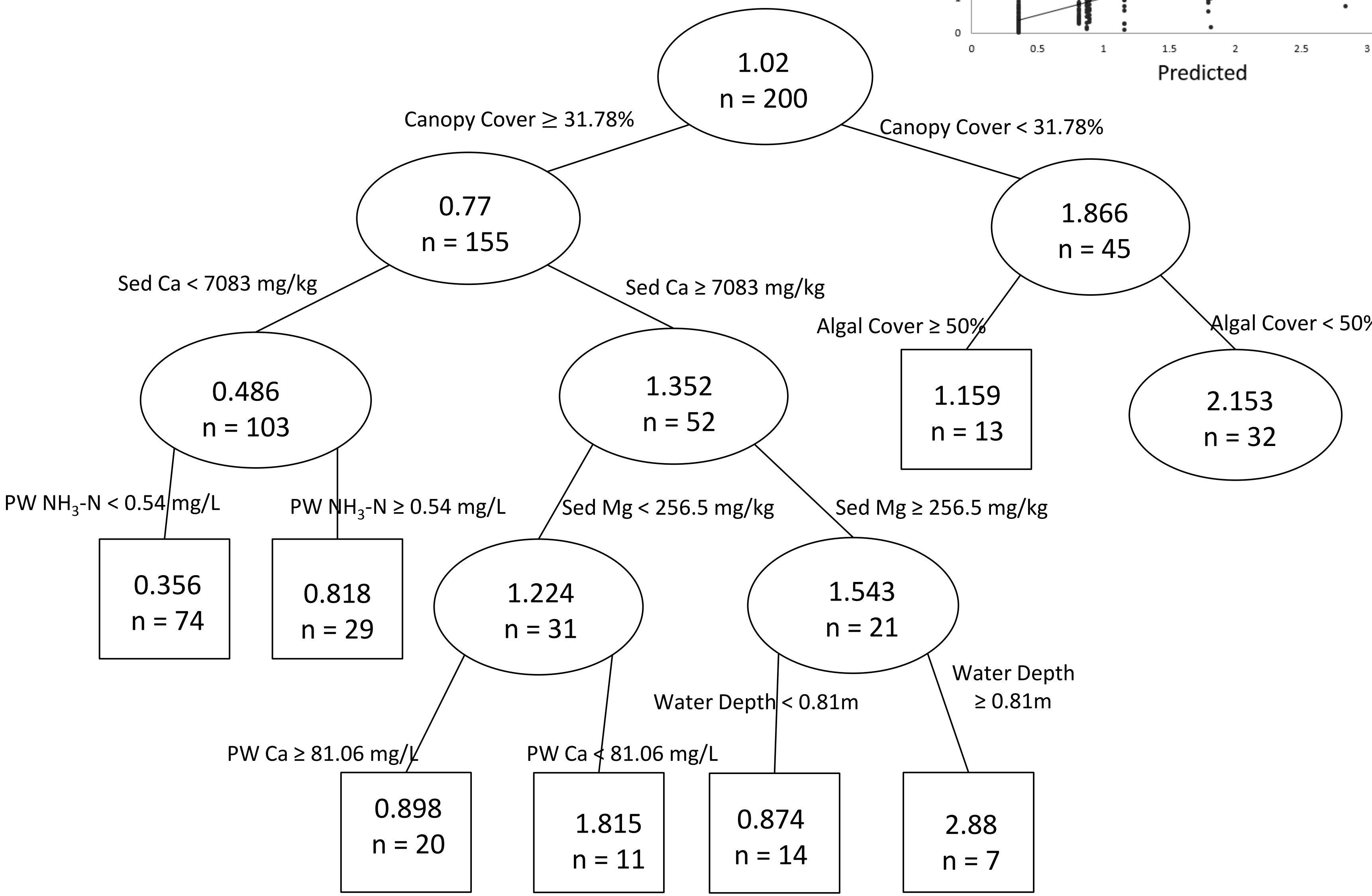


Silver River

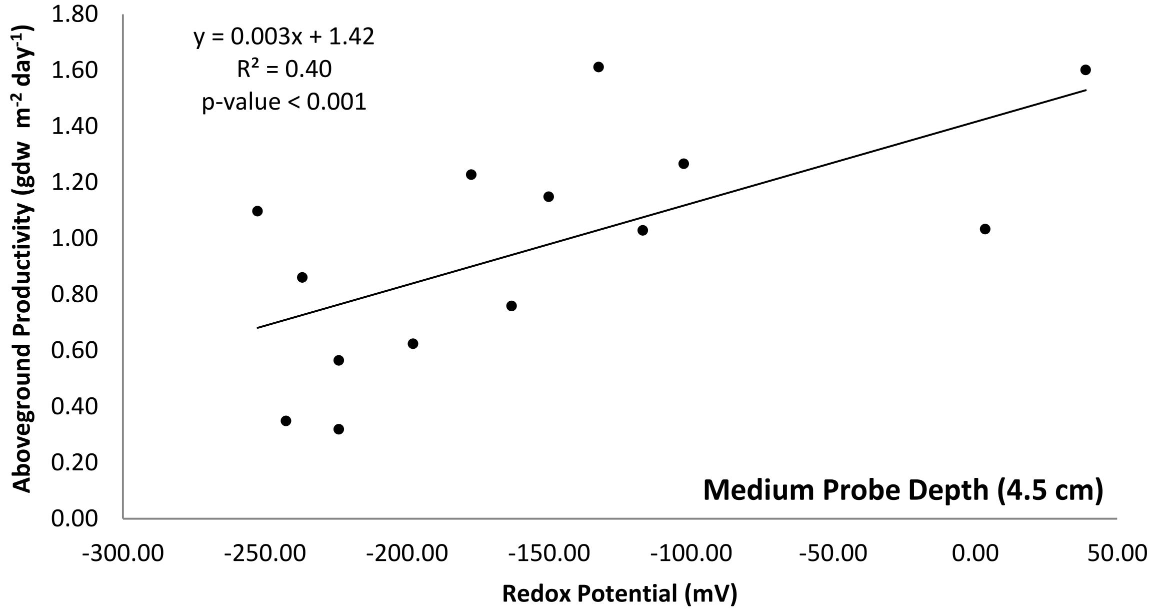
Regression Tree for Controls on Aboveground SAV Productivity

Vallisneria americana and Sagittaria kurziana





Redox Potential Controls SAV Growth Alexander Springs Creek



Summary - Task 2 Activities

- Ecosystem Metabolism
  - Higher in the lower river, responds to “dark days” on Silver River
  - P:R consistently < 1 (and this only counts aerobic respiration)
  - Effective benthic light model
- Nutrient Effects on Metabolism in Alexander (low N)
  - Metabolism varies substantially, and predictably
  - Nutrient enrichment had mostly no effect
    - Evidence of weak N stimulation
    - Disappears with other nutrient additions
- Nutrient Impacts on Algal Growth
  - Low rates of biomass accrual (0.31 g C m^{-2} d^{-1}) slightly higher than Silver
  - No significant treatment effects
- SAV Growth
  - Mean growth is the same in Silver and Alexander (no S. kurziana)
  - Models are effective at predicting SAV growth (R^2 ~ 0.6) but only **redox potential** (Alexander only, so far) is a compelling pairwise predictor

The Final Push

- **Task 2A**
  - Finalize rates for metabolism and nutrient retention, with April 1 data end date
  - Relate to climatic and canopy variables
- **Task 2B**
  - Synthesize metabolism predictions across Silver and Alexander control boxes
  - Synthesize nutrient enrichment effects across Silver and Alexander
  - Nutrient uptake dynamics
- **Task 2C**
  - Complete site redox measurements in Silver
  - Complete analysis of controls on SAV growth