Nutrient retention via vegetative uptake and sedimentation in created wetlands in subtropical Florida

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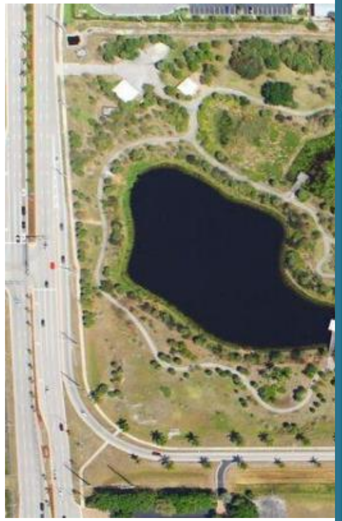
Wetlands as Pollution Treatment

- Domestic wastewater, agriculture runoff, urban stormwater runoff
- CWs avg. retention: 41% TN removal; 39% TP removal
  - Freedom Park 26% TN and 48% TP (Griffiths & Mitsch, 2017)

Freedom Park



Freedom Park preliminary goals

1. Ecological Goal— Maintain healthy functioning marsh zones to attract diverse wildlife and fish populations;
2. Water Quality Goal— Improve water quality received, treated, and discharged by the stormwater system with a goal of 80 percent reduction in phosphorus and 40 percent reduction in nitrogen concentrations;
3. Hydrologic Goal— Control water levels at an adequate elevation to sustain healthy, viable emergent vegetation and target a frequency of 75 percent yearly inundation; and
4. Recreational/Aesthetic Goal — Provide recreational opportunities for activities such as fishing, birdwatching, hiking with viewscapes of clean water free of floating algal mats and vistas of aesthetically pleasing plant communities.

Proposed issues to research

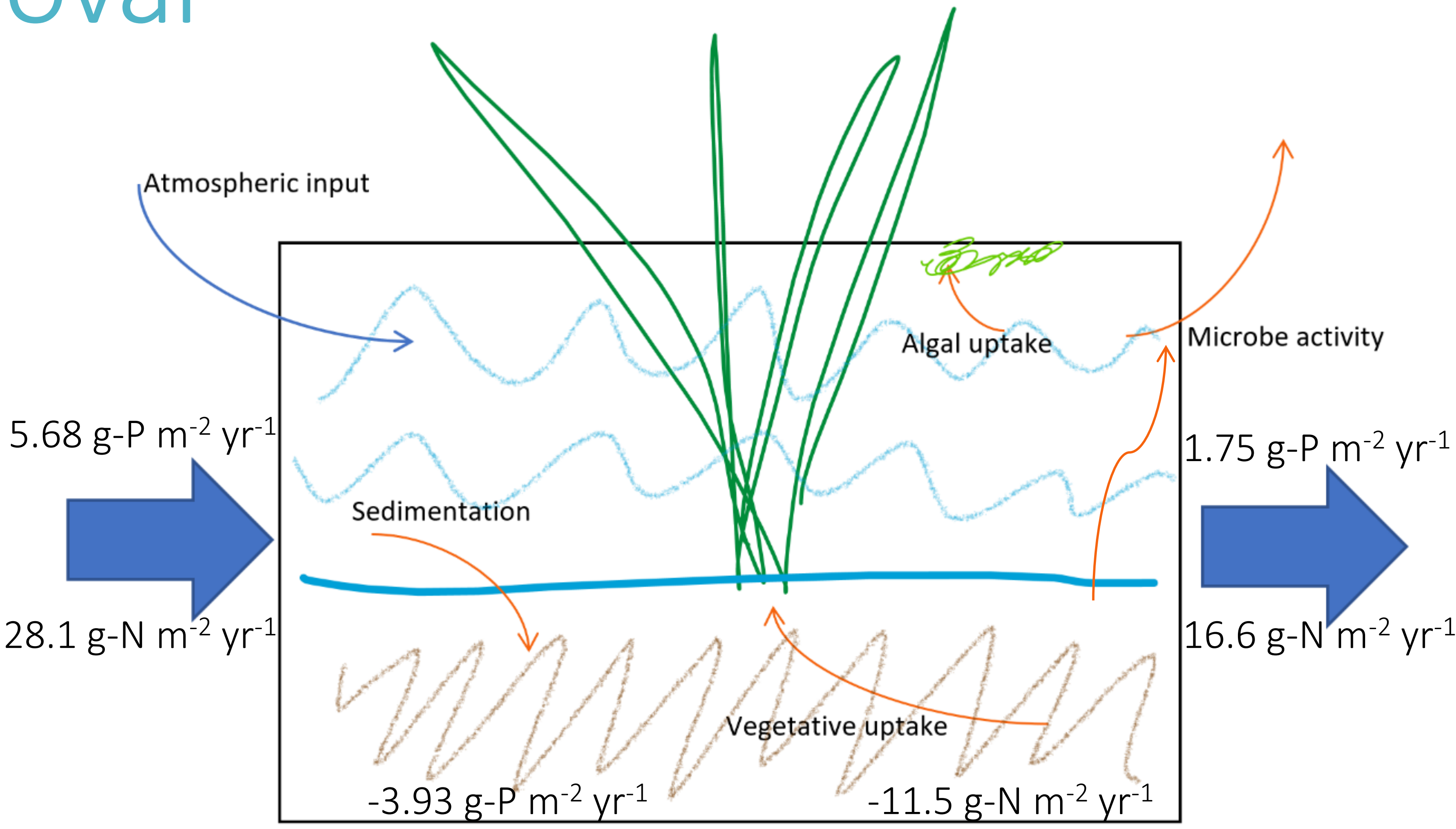
Issue 1: There is a fair amount of exotic vegetation invasion. The makeup of original planting scheme has changed significantly and the site managers need to decide if any sort of exotic control, harvesting, replanting, etc. is necessary.

Issue 2: Multi-year nutrient removal efficiency trends need to be determined and the relative importance of vegetation communities, hydrology, and sedimentation/ resuspension.

Issue 3: The overall sources and amounts of inflowing water need to be assessed as to their relative importance on water quality and magnitude and rate of exotic vegetation invasion (shallow water) or vegetation elimination (deep water).

Nutrient Removal

- Nitrogen retention:
  - Vegetative uptake
  - Sedimentation
  - **Microbial activity**
- Phosphorus retention:
  - **Sorption**
  - Plant/**algal uptake**
  - Sedimentation
  - Co-precipitation

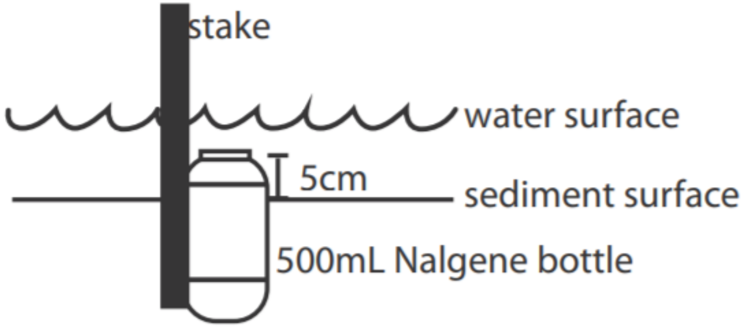


Griffiths & Mitsch, 2017

Sedimentation

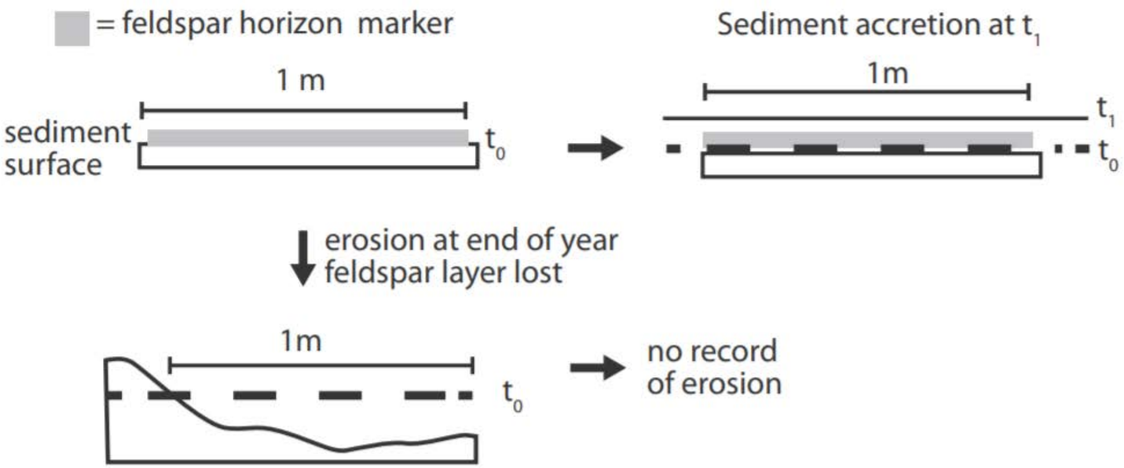
- Bottle sediment traps
  - May 20, 2016 – November 2018
- Horizon markers
  - November 20, 2017 – November 2018
  - “Calibrate” bottle trap method

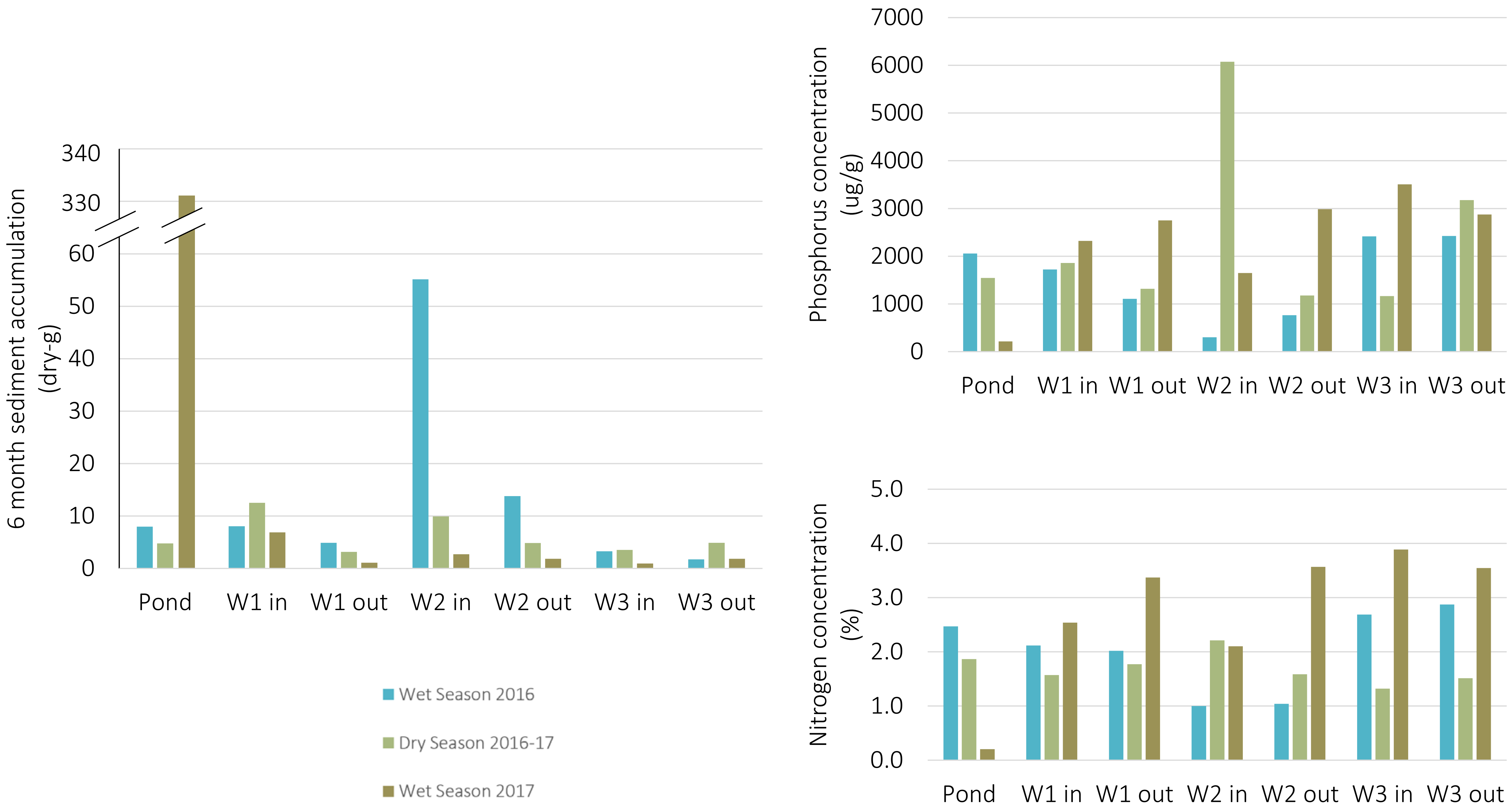
1) Gross Sedimentation—bottle sediment trap



Mitsch et al., 2014

2) Sediment Accretion—horizon markers

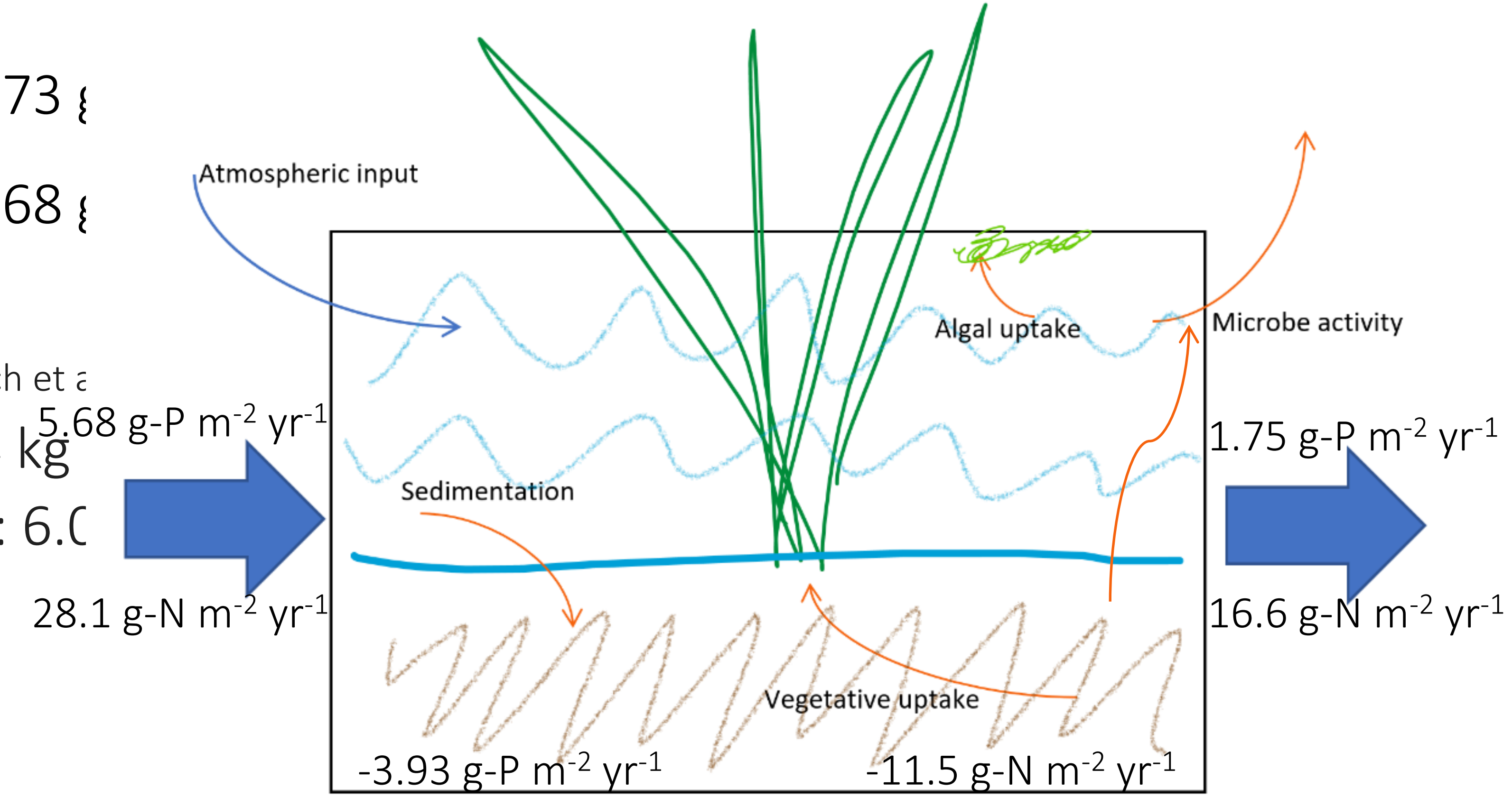



6 month sediment accumulation (dry-g)
340
330
60
50
40
30
20
10
0
Pond
W1 in
W1 out
W2 in
W2 out
W3 in
W3 out
Wet Season 2016
Dry Season 2016-17
Wet Season 2017
Phosphorus concentration (ug/g)
7000
6000
5000
4000
3000
2000
1000
0
Nitrogen concentration (%)
5.0
4.0
3.0
2.0
1.0
0.0

Sedimentation

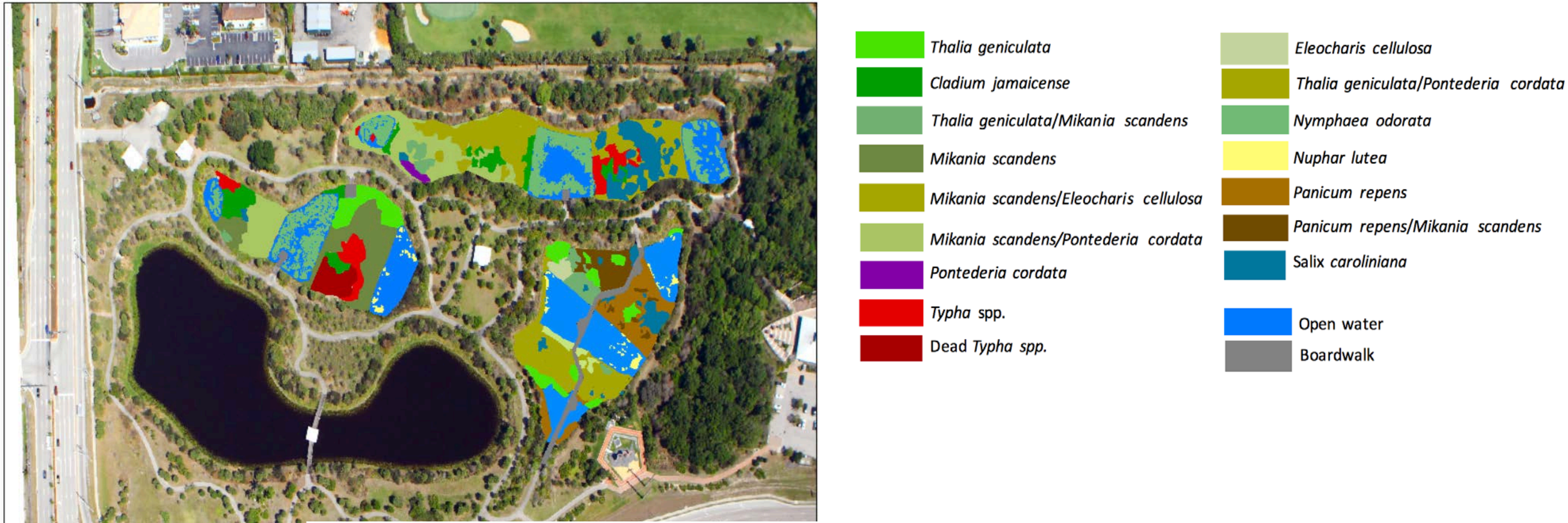
- ~~7.76 ± 2.46 g-P m^{-2} yr^{-1}~~ 0.73
- ~~81.74 ± 24.0 g-N m^{-2} yr^{-1}~~ 7.68

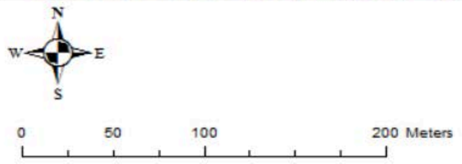
- Soil method comparison (Mitsch et a
  - Gross bottle method: 64 kg
  - Horizon marker method: 6.



Vegetation

- Biomass estimates in September and March
- Subsamples taken for nutrient analysis
- Aerial photography, GIS determination of vegetation communities

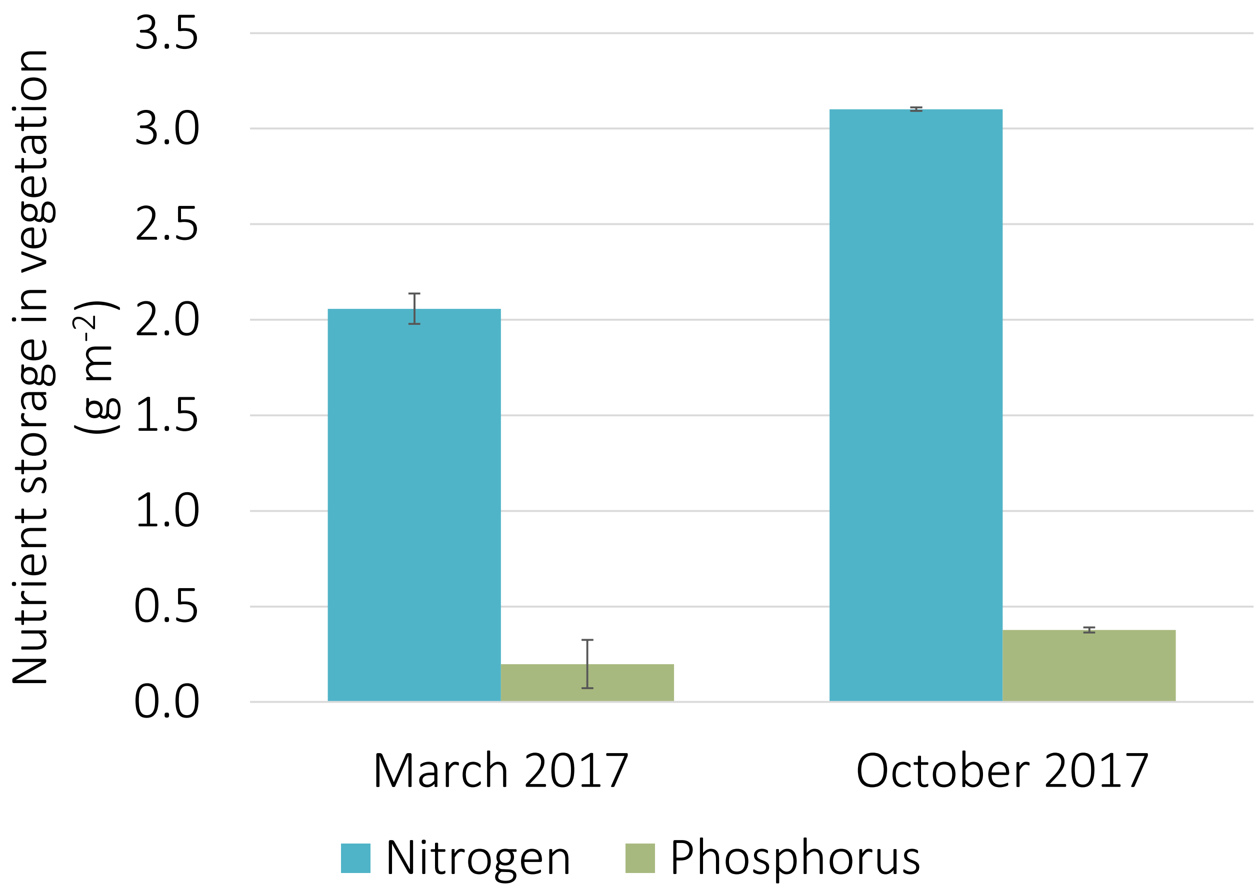




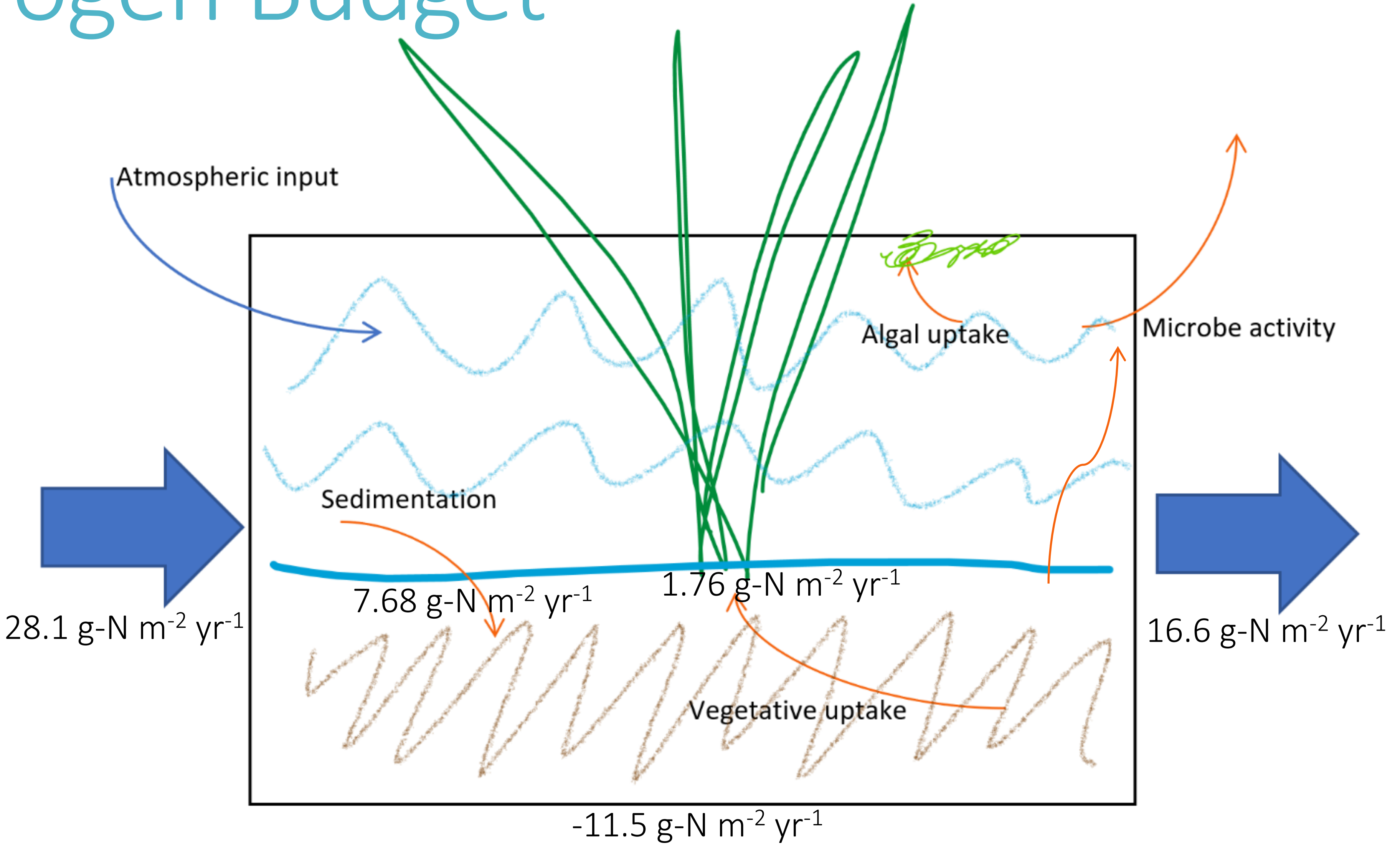
Species	Area (m²)	Dry weight (g/m²)	Total dry weight (g)	N (%)	P (ug/g)	N weight (g)	P weight (g)
Pontedaria	171.27	20.0	3425.39	2.345	2590	80.33	8.87
Torpedo grass	1917.86	60.0	115071.39	1.253	1323	1441.85	152.24
Carolina willow	1250.85	330.0	412782.01	2.114	1876	8726.21	774.38
Alligator flag	1677.45	190.0	318714.86	1.621	1737	5166.37	553.61
Typha	880.30	870.0	765859.22	1.194	1056	9144.36	808.75
Eleocharis	2458.33	30.0	73749.81	1.132	901.7	834.85	66.50
Climbing hempvine	5275.01	140.0	738501.29	2.1	3083	15508.53	2276.80
Sawgrass	1278.87	1170.0	1496280.57	0.995	497	14887.99	743.65

Vegetation

- Through the 2017 growing season
  - N change: +50.75%
  - P change: +89.90%
- 0.30 g-P m^{-2} yr^{-1}
- 1.76 g-N m^{-2} yr^{-1}



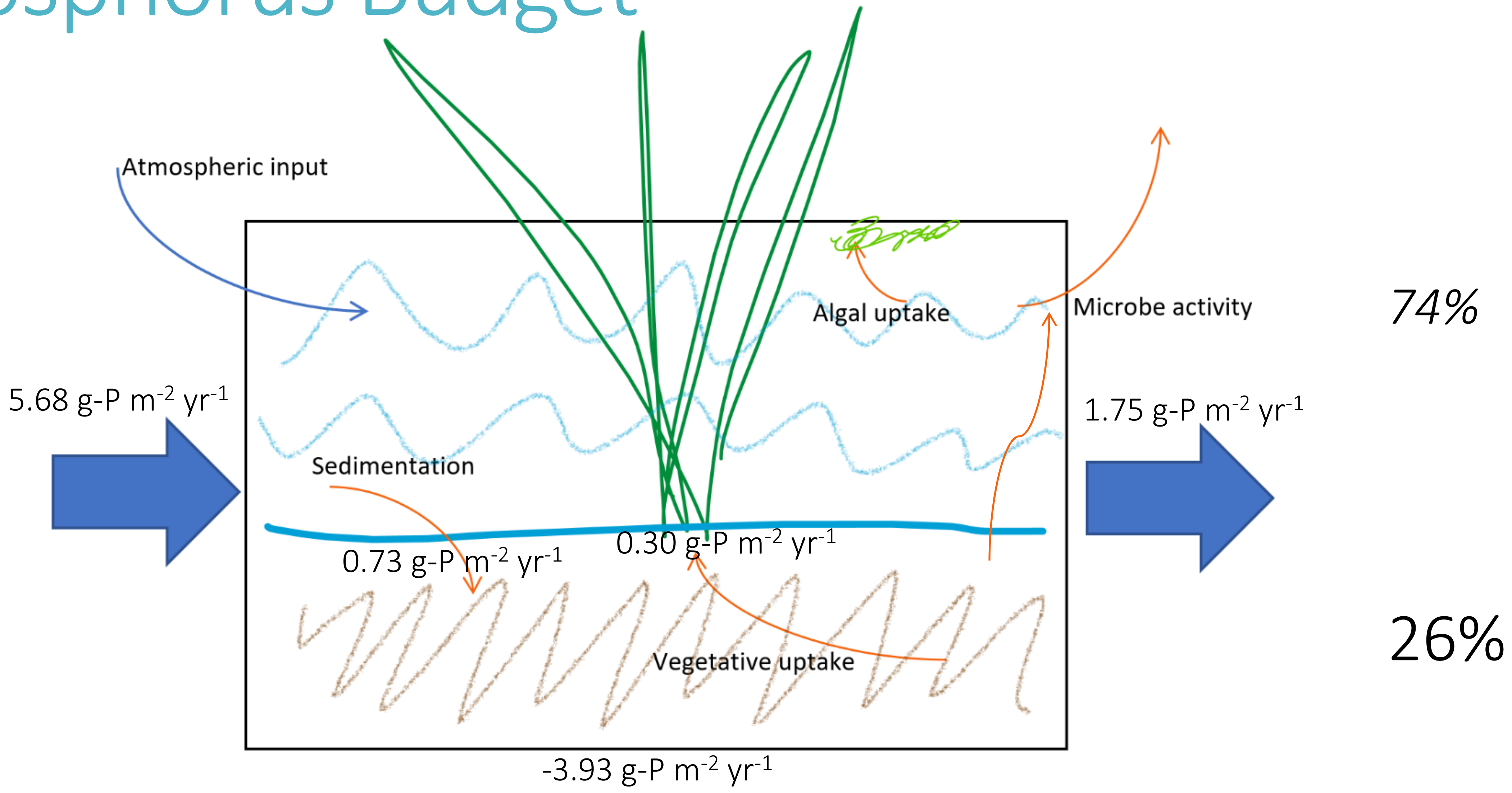
Nitrogen Budget



18%

82%

Phosphorus Budget



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Conclusions

- Nitrogen cycle dominated by sedimentation
    - Sustainable N retention: 10-40 g-N m^{-2} yr^{-1} (Mitsch et al., 2000)
    - Freedom Park retention: 11.5 g-N m^{-2} yr^{-1}
    - Focus on microbial activity and vegetative uptake = ↑ efficiency
- Phosphorus cycle dominated by algal uptake
    - Sustainable P retention: 0.5-5 g-P m^{-2} yr^{-1} (Mitsch et al., 2000)
    - Freedom Park retention: 3.93 g-P m^{-2} yr^{-1}
    - Focus on sedimentation = ↓ resuspension = ↑ sustainability
- Priorities need to be implicitly stated prior to creation and wetlands should be managed for those goals

Thank You!

Griffiths, L. N., & Mitsch, W. J. (2017). Removal of nutrients from urban stormwater runoff by storm-pulsed and seasonally pulsed created wetlands in the subtropics. *Ecological Engineering*, *108*, 414-424.

Mitsch, W.J., A.J. Horne, R.W. Nairn. (2000). Nitrogen and phosphorus retention in wetlands —Ecological approaches to solving excess nutrient problems. *Ecological Engineering 14,* 1-7.

Mitsch, W. J., Nedrich, S. M., Harter, S. K., Anderson, C., Nahlik, A. M., & Bernal, B. (2014). Sedimentation in created freshwater riverine wetlands: 15 years of succession and contrast of methods. *Ecological Engineering*, *72*, 25-34.

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