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

Lauren N. Griffiths¹,² and William J. Mitsch²,¹

¹ School of Geoscience, University of South Florida, Tampa, FL 33620
² Everglades Wetland Research Park, Florida Gulf Coast University, Naples, FL 34112
Wetlands as Pollution Treatment

• Domestic wastewater, agriculture runoff, urban stormwater runoff

• CWs avg. retention: 41% TN removal; 39% TP removal
  o 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.
Issues studied:

**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:**
  - Plant/*algal uptake*
  - Sedimentation
  - Co-precipitation

5.68 g-P m⁻² yr⁻¹
28.1 g-N m⁻² yr⁻¹
-3.93 g-P m⁻² yr⁻¹
-11.5 g-N m⁻² yr⁻¹

1.75 g-P m⁻² yr⁻¹
16.6 g-N m⁻² yr⁻¹

Griffiths & Mitsch, 2017
Sedimentation

• Bottle sediment traps
  o May 20, 2016 – December 6, 2018
• Horizon markers
  o November 20, 2017 – December 6, 2018
  o “Calibrate” bottle trap method

1) Gross Sedimentation—bottle sediment trap

Mitsch et al., 2014
Sedimentation

- \( 7.41 \pm 1.67 \text{ g-P m}^{-2} \text{ yr}^{-1} \) 1.96 g-P m\(^{-2}\) yr\(^{-1}\)
- \( 76.6 \pm 15.7 \text{ g-N m}^{-2} \text{ yr}^{-1} \) 20.3 g-N m\(^{-2}\) yr\(^{-1}\)

- Horizon marker “calibration”

- Additional nitrogen input
  \( \rightarrow \) Atmospheric deposition?
Vegetation

• Biomass estimates in September and March
• Subsamples taken for nutrient analysis
• Aerial photography, GIS determination of vegetation communities
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<th>Species</th>
<th>Area (m²)</th>
<th>Dry weight (g/m²)</th>
<th>Total dry weight (g)</th>
<th>N (%)</th>
<th>P (ug/g)</th>
<th>N weight (g)</th>
<th>P weight (g)</th>
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March 2017
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

Atmospheric input
up to 10.6 g-N m\(^{-2}\) yr\(^{-1}\)

-28.1 g-N m\(^{-2}\) yr\(^{-1}\)
+16.6 g-N m\(^{-2}\) yr\(^{-1}\)

-11.5 g-N m\(^{-2}\) yr\(^{-1}\) + ???

20.3 g-N m\(^{-2}\) yr\(^{-1}\)
1.76 g-N m\(^{-2}\) yr\(^{-1}\)

Sedimentation

Algal uptake

Microbe activity

28.1 g-N m\(^{-2}\) yr\(^{-1}\)
16.6 g-N m\(^{-2}\) yr\(^{-1}\)

Vegetative uptake

up to 10.6 g-N m\(^{-2}\) yr\(^{-1}\)
Phosphorus Budget

5.68 g-P m\(^{-2}\) yr\(^{-1}\)

1.96 g-P m\(^{-2}\) yr\(^{-1}\)

0.30 g-P m\(^{-2}\) yr\(^{-1}\)

1.75 g-P m\(^{-2}\) yr\(^{-1}\)

-3.93 g-P m\(^{-2}\) yr\(^{-1}\)

Atmospheric input

Algal uptake

Microbe activity

Vegetative uptake

Sedimentation

43%

57%
**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.
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Conclusions

• Nitrogen cycle dominated by sedimentation
  o Sustainable N retention: 10-40 g-N m⁻² yr⁻¹ (Mitsch et al., 2000)
  o Freedom Park retention: 11.5 g-N m⁻² yr⁻¹
  o Focus on microbial activity and vegetative uptake = ↑ efficiency

• Phosphorus cycle dominated by algal uptake
  o Sustainable P retention: 0.5-5 g-P m⁻² yr⁻¹ (Mitsch et al., 2000)
  o Freedom Park retention: 3.93 g-P m⁻² yr⁻¹
  o Focus on sedimentation = ↓ resuspension = ↑ sustainability

• Priorities need to be implicitly stated prior to creation and wetlands should be managed for those goals
Thank You!


