Characterizing the responses of carbon dioxide, water, and energy exchange in Everglades peat and marl freshwater marshes to changes in hydroperiod

Jessica L. Schedlbauer[1], Steven F. Oberbauer[1], Evelyn E. Gaiser[1], Gregory Starr[2], and Jay Munyon[1]

[1]Department of Biological Sciences, Florida International University, Miami, FL, [2]Department of Biological Sciences, University of Alabama, Tuscaloosa, AL

Introduction

- Florida Everglades are highly productive, though oligotrophic
- Productivity is maintained by a tolerant emergent macrophyte, sawgrass (*Cladium jamaicense*), and abundant periphyton communities (Fig. 1)
- Periphyton NPP in the Everglades reported at some sites as 20,599 g C m^{-2} yr^{-1} (Ewe et al. 2006)

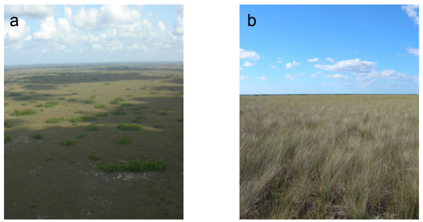

Figure 1. Long (a) and short (b) hydroperiod Everglades freshwater marsh

Hydroperiod is central in differentiating Everglades wetlands:

- **Long hydroperiod**: continuous water above the surface, peat soils, and low periphyton biomass
  - Everglades peat soils were formerly the world's largest single body of organic soils (Stephens and Johnson 1951)
  - Drainage and other agricultural activities have led to substantial loss of this organic carbon
- **Short hydroperiod**: 6 months or less with water above the surface, marl soils, and high periphyton biomass
  - Geochemical carbon fixation – large amounts of carbon are precipitated as calcium carbonate as CO_2 is reduced during photosynthesis: $CO_2 + H_2O \rightleftharpoons H_2CO_3 \rightleftharpoons HCO_3^- + H^+$
    $Ca^{2+} + 2HCO_3^- \rightleftharpoons CaCO_3 + CO_2 + H_2O$

- Everglades water levels vary seasonally and with water management (regulated quantity and timing of water delivery), but evaporative losses are not well characterized
- Historical slow sheet flow to be restored: Comprehensive Everglades Restoration Plan ($8 billion over 50 yrs)
- Everglades ecoregion is poorly represented by the current AmeriFlux network of eddy covariance sites (Hargrove et al. 2003)

Objective

- To determine the total CO_2 balance and the relative magnitudes of the biotic and abiotic CO_2 exchange processes in peat and marl forming wetlands of the Florida Everglades in response to changes in hydroperiod

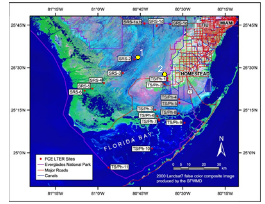

Figure 2. Location of study sites (yellow dots) in long (1) and short (2) hydroperiod Everglades marshes. Sites are co-located with existing sites in the Florida Coastal Everglades Long Term Ecological Research program (FCE-LTER).

Research Questions

1. What are the CO_2 balances of Everglades peat and marl forming wetlands?
2. What are the relative contributions of physiologically-based exchange and abiotic carbon precipitation to the net CO_2 flux?
3. What are the responses of CO_2 exchange processes to the dominant control, hydroperiod?
4. How does the contribution of macrophyte CO_2 flux vary with hydroperiod across the landscape?

Approach

Figure 3. Images of the short hydroperiod Taylor Slough site (located at LTER site TS/Ph 1b) with the eddy covariance and meteorological systems.

- **Eddy covariance & microclimatic measurements** will be made in long and short hydroperiod wetlands
- **Chamber measurements** will be used to determine plot-level CO_2 exchange and ecosystem dark respiration
- **Macrophyte/periphyton removal treatments** will be used to determine the contribution of these elements to net ecosystem exchange (NEE) and ecosystem respiration
- **Geochemical techniques** will be used to estimate net calcification & subsurface photosynthesis
- **Stable carbon isotope analysis** will be used to determine the contribution of ecosystem components to total ecosystem respiration
- **Process modeling** will be used to evaluate controls on fluxes and estimate landscape-scale macrophyte fluxes in response to changes in hydroperiod

Preliminary Data

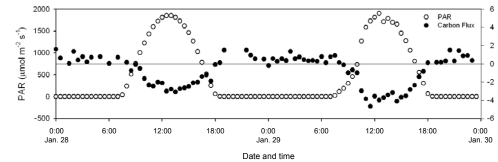

Figure 4. Daily time courses of photosynthetically active radiation (PAR) and carbon flux on January 28 and 29, 2008 at the short hydroperiod Taylor Slough site. Negative values for carbon flux indicate carbon uptake by the system.

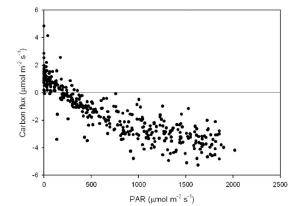

Figure 5. Relationship between photosynthetically active radiation (PAR) and carbon flux at the short hydroperiod Taylor Slough site. Data presented are from January 15 – 31, 2008. Negative values indicate carbon uptake.

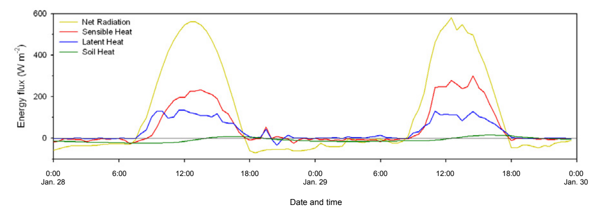

Figure 6. Daily time courses of net radiation (net short wave – net long wave radiation), sensible heat flux, latent heat flux, and soil heat flux on January 28 and 29, 2008 at the short hydroperiod Taylor Slough site.

Acknowledgements: Funding for this project is provided by NICCR grant No. 07-SC-NICCR-1059.

References:

Ewe, S.M.L., E.E. Gaiser, D.L. Childers, V.H. Rivera-Monroy, D. Iwaniec, and R.R. Twilley, 2006. Spatial and temporal patterns of aboveground net primary productivity (ANPP) in the Florida Coastal Everglades LTER (2001-2004). Hydrobiologia 569: 459-474.

W.W. Hargrove, F.M. Hoffman, and B.E. Law. 2003. New analysis reveals representativeness of AmeriFlux network. EOS Transactions 84:529-531.

Stephens, J.C. and L. Johnson. 1951. Subsidence of Peat Soils in the Everglades Region of Florida. United States Department of Agriculture Soil Conservation Service. 47 p.