Hydrologic Controls on Ecosystem Respiration in the Everglades Ridge-Slough Mosaic

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Introduction

The patterned topography characteristic of the ridge slough has undergone dramatic change associated with altered hydrology (Watts et al. 2010). Because this is a peat-forming region, the loss in topography is linked to changes in ecosystem productivity and respiration.

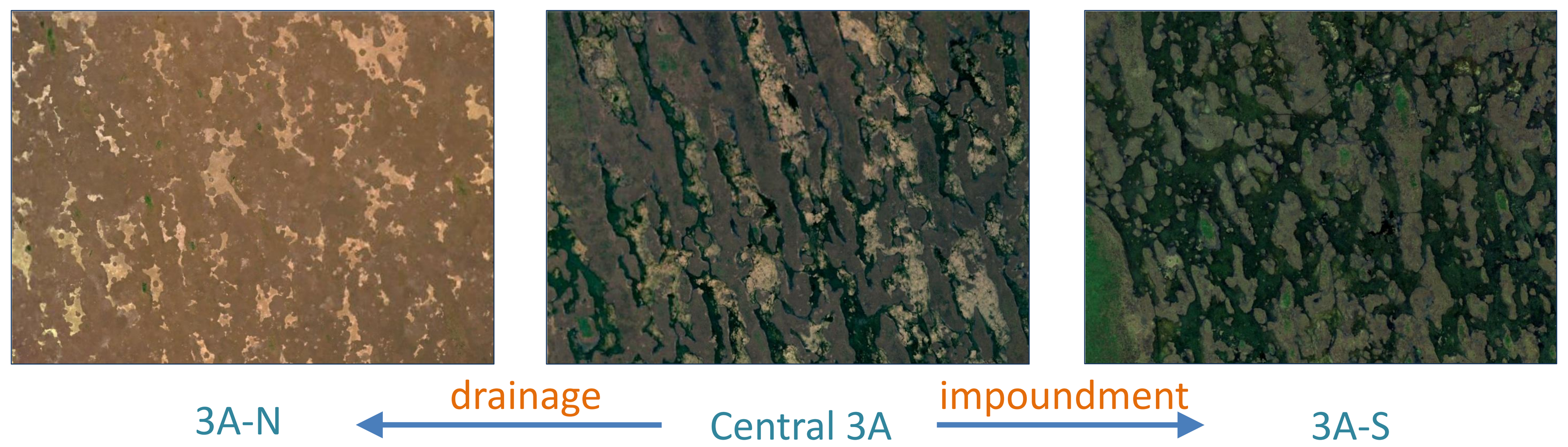

Figure 1. Hydrologic drainage and impoundment is linked to dramatic changes in the patterned ridge slough landscape. (Images from GoogleEarth, dimensions approximated 1km x 1.5km.) Ridges appear gray and sloughs are either dark grey/green or very light colored where periphyton is abundant.

The objective of this study is to determine what environmental variables control ecosystem respiration, and to examine the role hydrology (water depth, hydroperiod) plays in regulating ecosystem respiration.

Field Sampling

Dark ecosystem respiration, pH, water depth, vegetation species and cover, and soil/water temperature are measured at 64 sites spanning WCA 3A. The sites were arranged as 8 paired ridges and sloughs in 4 landscape blocks.

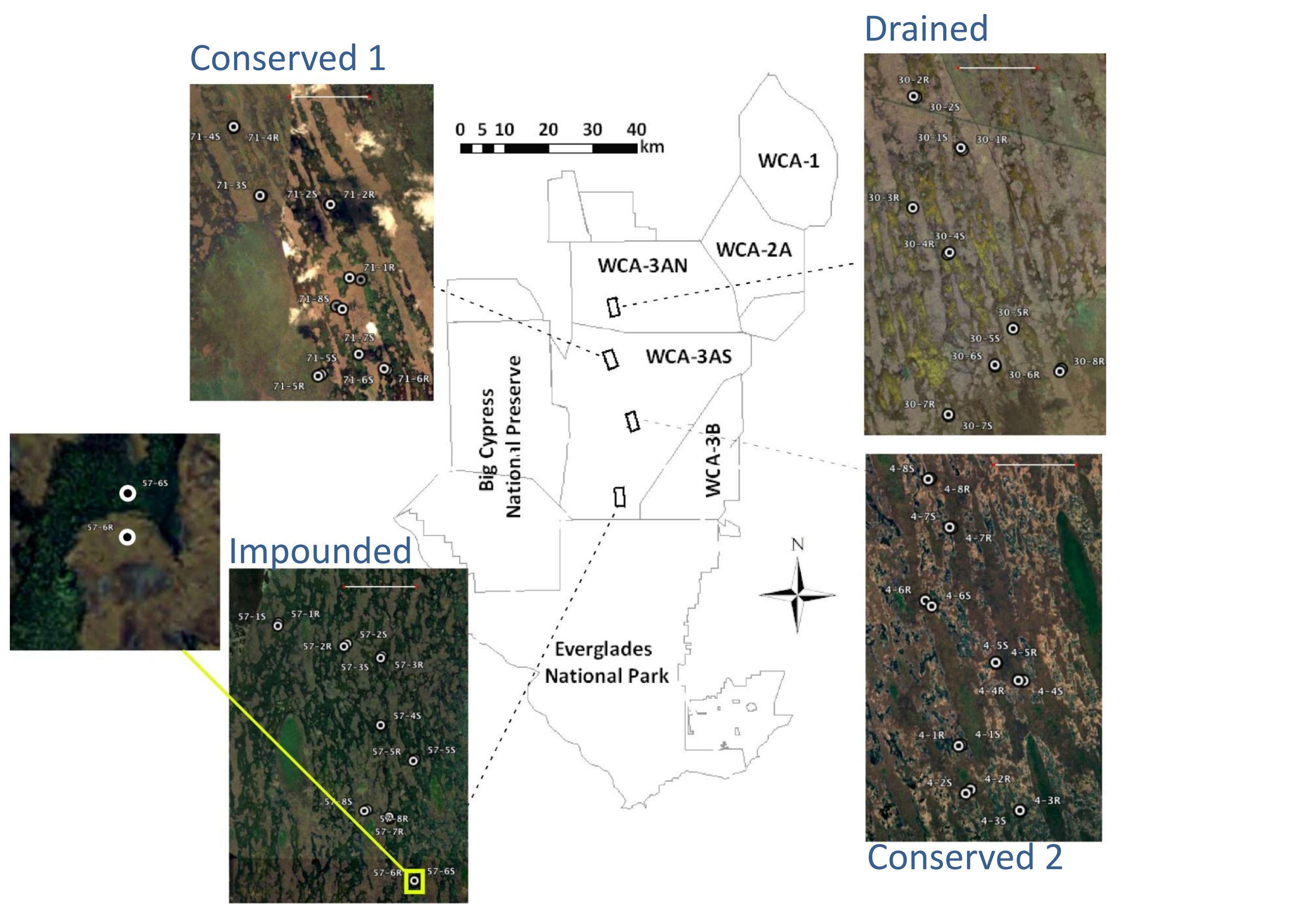

Figure 2. Locations of ecosystem respiration sites. Ecosystem parameters were measured at each site every 3 months during 2009. White bars in the photos indicate 1km distances.

Methods

Daily water levels for 2009 was obtained through the Everglades Depth Estimation Network (http://sofia.usgs.gove/Eden). Temperature was measured 10 cm below the surface. All available data is then put into nested models, with best- fit model selected by AIC. Coefficient parameterization was obtained using non-linear least squares method after Bates and Chambers (1988).

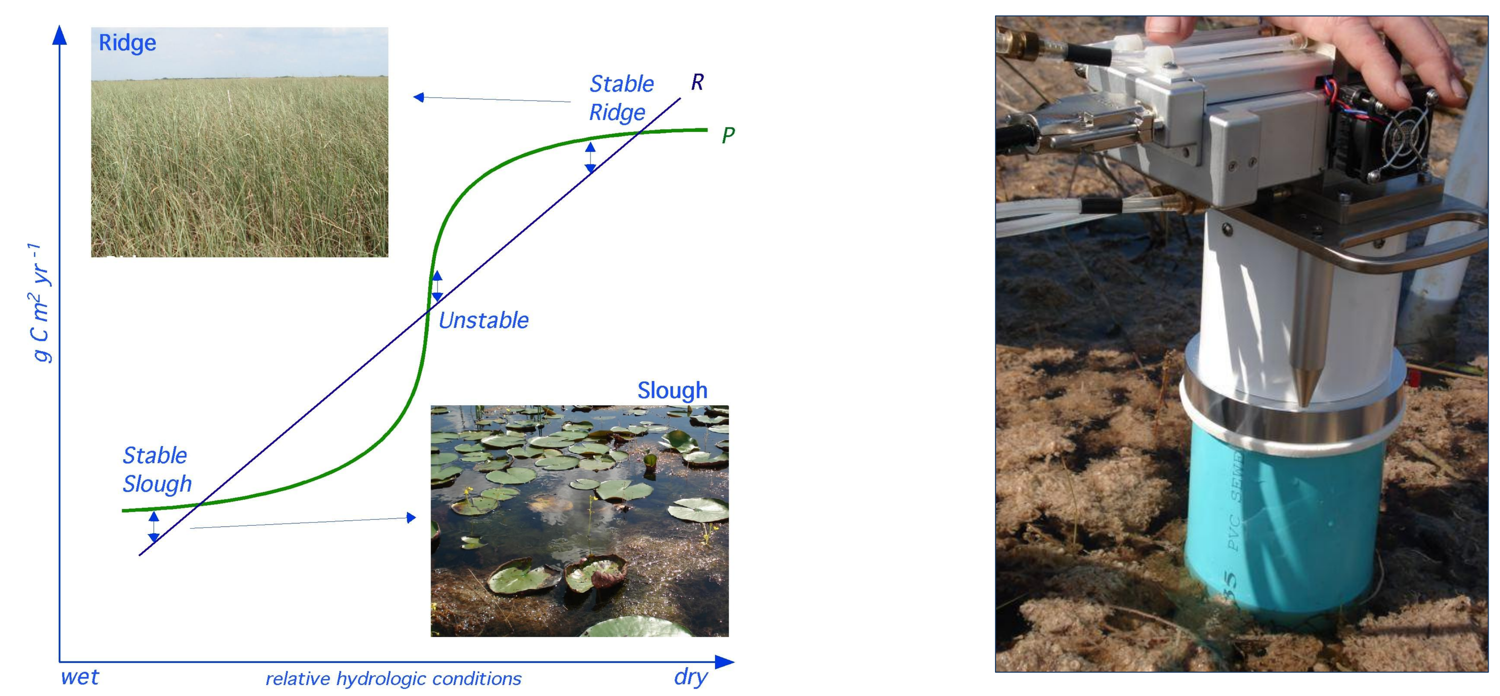

Figure 3. Theoretical diagram of productivity (P) and respiration (R) in the Everglades, which forms the basis for our hypotheses. The ultimate aim of this research is to discover the hydrologic parameter space for landscape peat accretion equilibria. Respiration rates were measured using a Li-6400 gas analyzer.

$$R_{eco}=Ke^{a(temp)}\ e^{b(water\ depth)}\ e^{c(temp*water\ depth)}$$

The model is designed after Knohl et al. (2008), with modifications including the soil moisture parameter altered for water table, and incorporates an interaction term between water table and soil/water temperature.

K = 37.83
a = -0.08
b = -0.04
c = 0.002

All terms are significant ($p<0.01$) and correlated (correlation among parameter estimates is 0.7 or higher.)

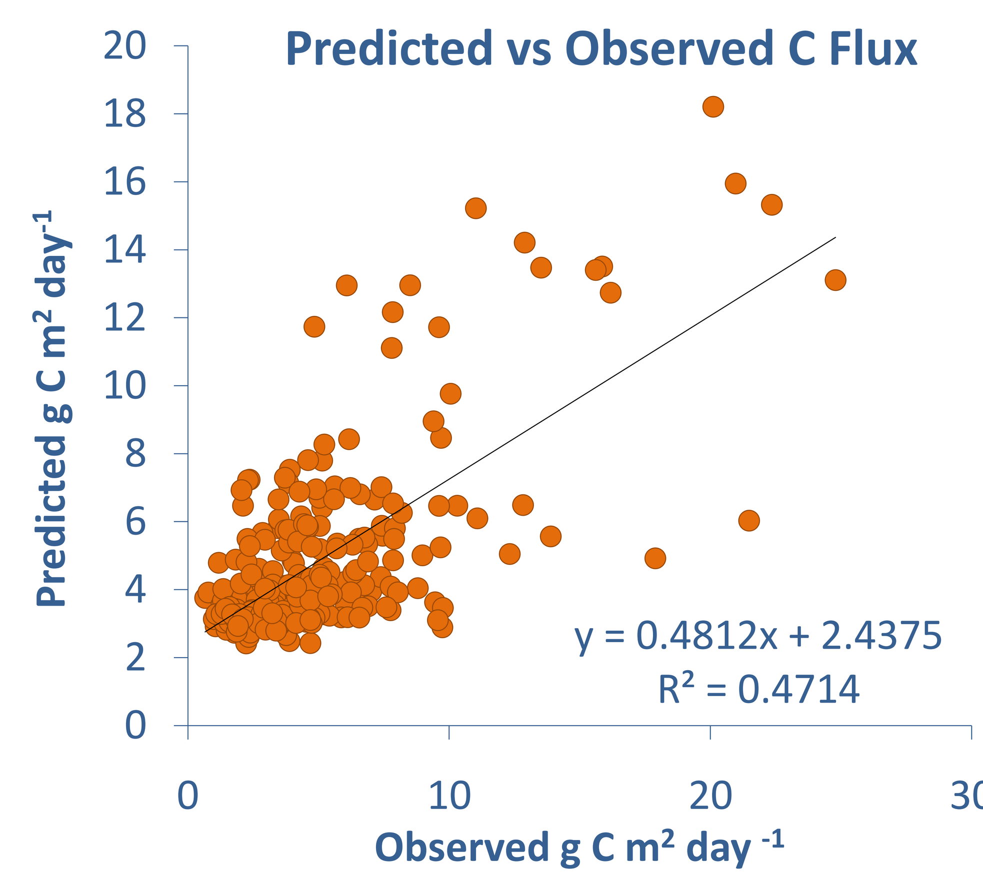

Figure 4. Predicted vs observed C fluxes.

Citations:

Watts, D.L., Cohen, M.J., Heffernan, J.B., Osborne, T.Z. 2010. Hydrologic modification and the loss of self-organized patterning in the ridge slough mosaic of the Everglades. Ecosystems. In Review.

Knohl, A., Søe, A.R.B., Kutsch, W. L., Göckede, M., Buchmann, N. 2008 Representative measurements of soil and ecosystem respiration in an old beech forest. Plant Soil 302: 189-202.

Bates, D.M. and Watts, D.G. 1988. Nonlinear Regression Analysis and Its Applications. Wiley.

Results

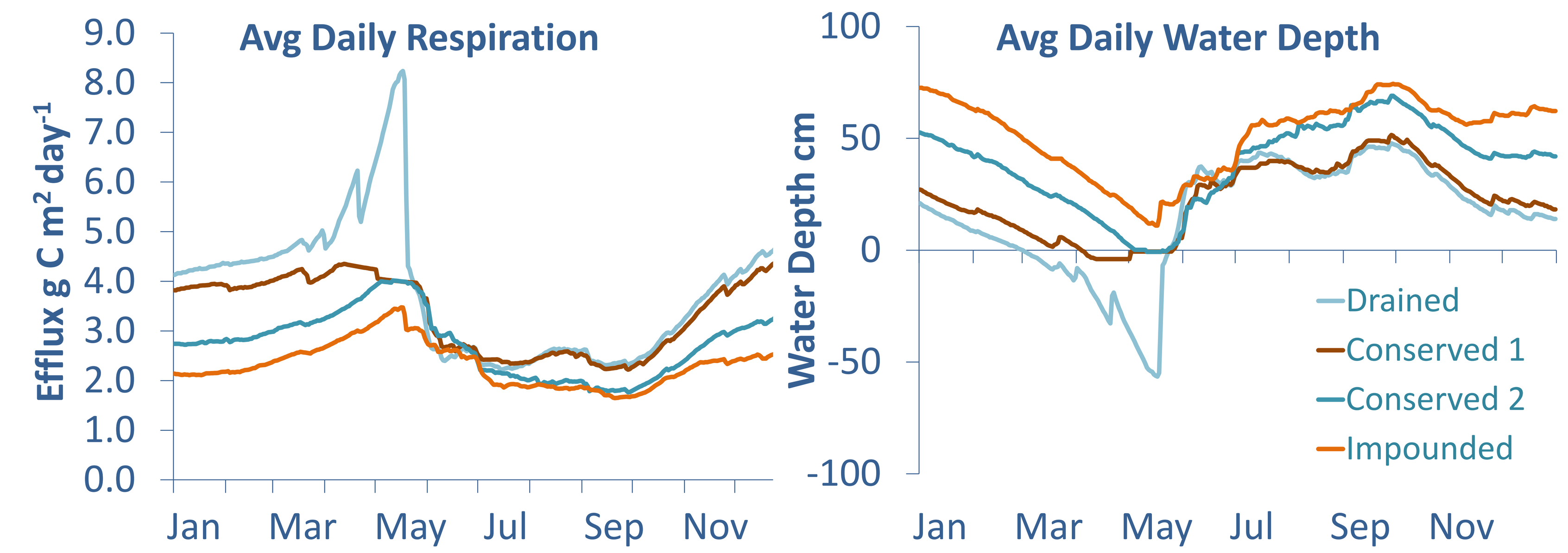

Figure 5. Average daily respiration (model output) and average daily water depth for each landscape block (averaged across sites). This highlights the importance of the deep draw downs in the Drained block on respiration. These plots also suggest that the Conserved 1 block is experiencing drier conditions and heightened respiration as compared to Conserved 2.

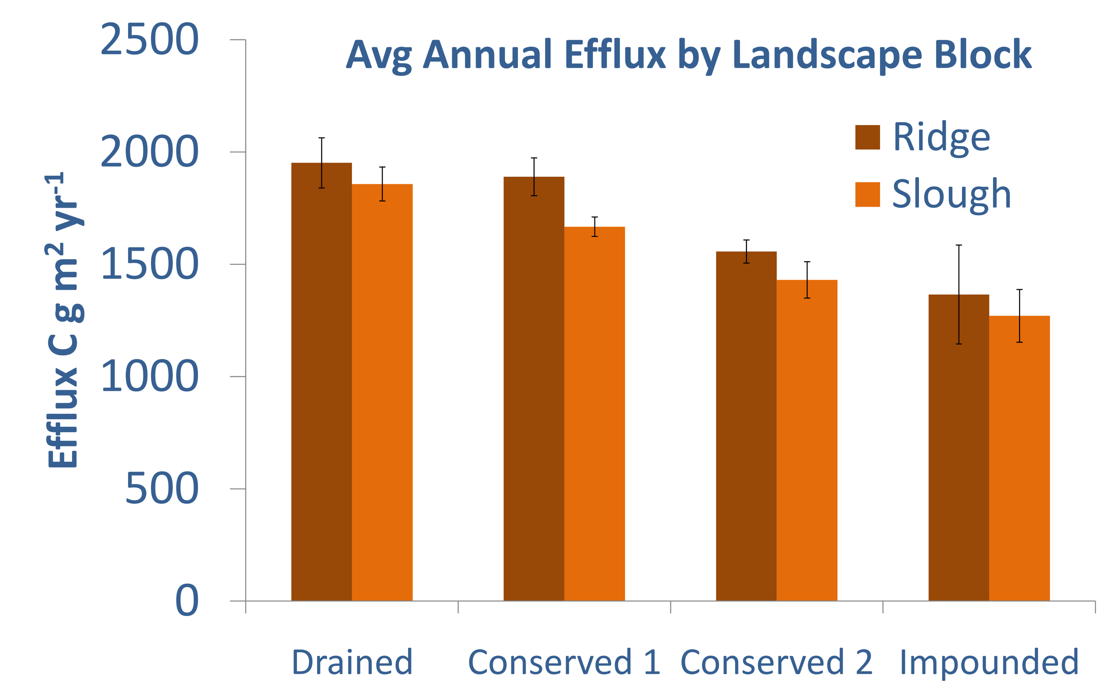

Figure 6. Modeled annual C respiration for all the sites. Our model may over-estimate ecosystem respiration.

Differences in respiration rates between ridges and sloughs are a result of elevation differences. The difference between communities is significant ($p<0.05$) for all but the Drained block, where elevation differences between communities is lost (Watts et al. 2010).

Conclusions

The unusual relationship between respiration and soil/water temperature of the raw data appears to be due to water depth controls on temperature (graph not shown).

Further model refinement will focus on capturing the variability in the data to increase the predictive power, as well as continued sampling.

Respiration rates are clearly strongly related to water depths, and the high respiration rates under deep draw-downs is likely a controlling component to the loss of ridge-slough changes measured by Watts et al. (2010).

The ultimate aim of this research is to build a model of both productivity and respiration, to discover under what hydrologic conditions a landscape peat accretion equilibrium rate is possible.

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