Understanding the Spatial and Temporal Patterns of Wetland Evapotranspiration and Primary Production

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Both scientists and the public recognize the importance of wetlands, but understanding of the ecological processes that control the functioning of California wetlands is lacking. We are working at UCI's San Joaquin Freshwater Marsh to understand the ecological controls on wetland carbon, energy and water vapor exchange, and to explain why the marsh's vegetation varies dramatically from one year to the next.

The importance of wetlands is recognized by both scientists and the public, but understanding of the ecological processes that control the functioning of California wetlands is lacking. Economists estimate a hectare of wetland provides ~$14,000 in goods and services a year; the citizens of California have demonstrated support for wetland protection by voting for bond measures. At the same time, the biological, chemical and physical processes that control the carbon, nutrient and water cycles of California wetlands remain poorly understood. We are working at UCI's San Joaquin Freshwater Marsh (SJFM) to better understand the biophysical and environmental controls on wetland carbon, energy and water vapor exchange. Located on the UCI campus, the SJFM is an 82-ha *Typha latifolia* and *Scirpus californicus* remnant of a large historical wetland.

Observations of the SJFM's carbon, energy, and water vapor exchange since 1999 demonstrate that these processes are highly variable from year to year. The observed interannual variability in carbon exchange from 1999-2003 was much greater than has been reported for other ecosystem types, such as tropical forests. The interannual variability at the SJFM is remarkable for two reasons: (1) the year-to-year shifts in carbon storage occurred despite similar environmental conditions between years and (2) the maximum rates of carbon uptake (Gross Ecosystem CO_2 Exchange, or GEE) were poorly correlated with ground based measures of green leaf area (Leaf Area Index, or LAI), but well correlated with remotely sensed surface greenness indices (the Enhanced Vegetation Index, or EVI; Figure 1). These results diverge markedly from previous ecological studies, which have demonstrated that: (1) year-to-year variation in carbon uptake is usually attributable to year-to-year variation in weather, and (2) year-to-year variation in

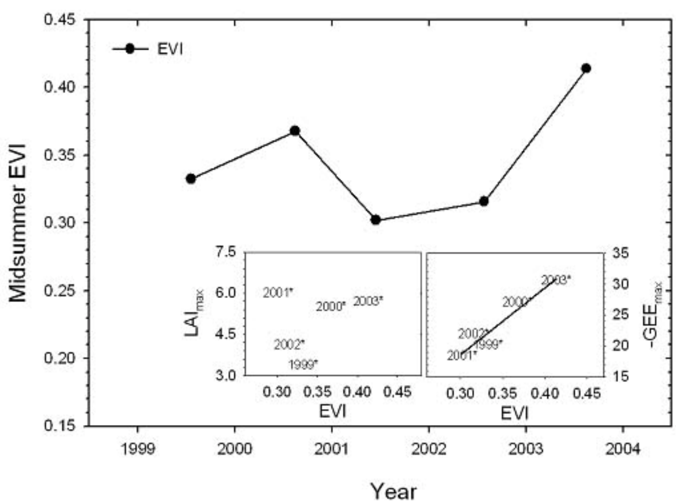

Figure 1. Midsummer Enhanced Vegetation Index (EVI) from 1999-2003. Relationship between green leaf area (LAI) and EVI (left inset plot) and relationship between EVI and maximum gross carbon uptake (GEE) (right inset plot). Symbols in inset plots are representative years.

carbon uptake is often associated with year-to-year variation in LAI, with greater CO_2 uptake during years with more leaves.

The SJFM is a highly productive ecosystem characterized by a large accumulation of litter. We hypothesized that standing litter from the previous year decouples the normal relationship between GEE and LAI by shading the green leaves and decreasing both GEE and EVI. We tested this hypothesis using small-scale manipulations of litter and measurements of EVI and chamber based CO_2 uptake (Net Ecosystem CO_2 Exchange, or NEE). EVI and chamber based NEE were measured after adding or reducing standing litter. Experimental manipulations supported our hypothesis by demonstrating that litter can confound the relationship between green leaf area, EVI, and NEE (Figure 2). Standing litter reduced EVI and NEE under constant green leaf area, resulting in poor relationships between green leaf area, EVI and NEE. Standing litter decreased NEE and EVI by 15 to 50%, which indicated that standing litter has a significant impact on the SJFM's carbon, energy, and water vapor exchange. Our work has implications for wetland restoration and wetland biogeochemical cycling and indicates that the link between productivity and carbon storage in freshwater systems is complex.

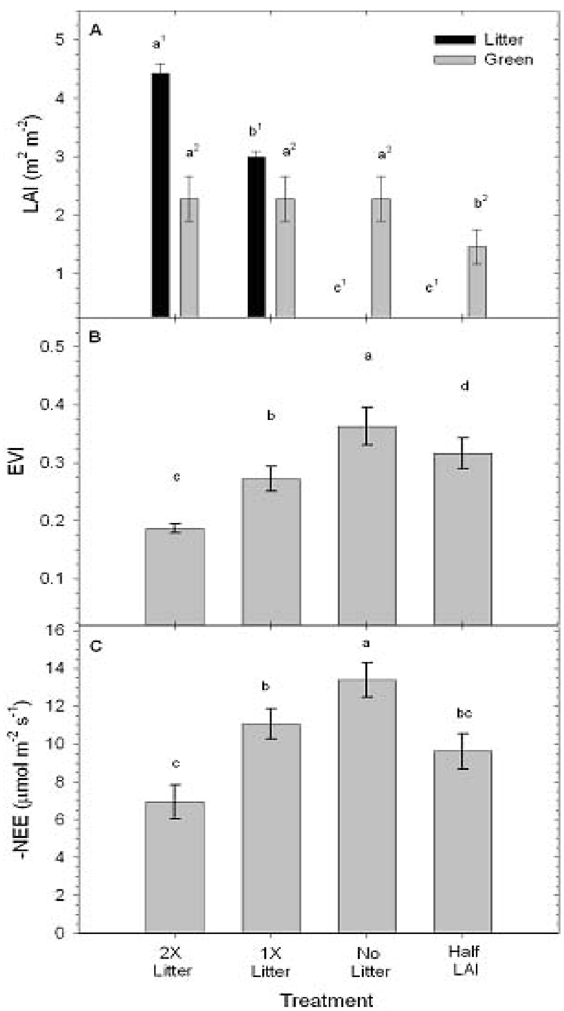

Figure 2. Average green leaf (Gray Bars) and litter (Dark Bars) area index [A], Enhanced Vegetation Index (EVI) [B], and Net Ecosystem Exchange of CO_2 (-NEE) [C] for each treatment. Error bars represent standard errors and different letters indicate significant differences at the 95% confidence level.

Publications

Goulden, M.L, M.E. Litvak, and S.D. Miller. Factors that control Typha marsh evapotranspiration. Aquatic Botany 86 (2007) 97–106.

Professional Presentations

Adrian V. Rocha and M.L. Goulden, Spatiotemporal variability in vegetation indices in a freshwater marsh and its implications for CO_2 exchange. American Geophysical Union, Fall 2006, San Francisco, CA.

Collaborative Efforts

Clara Tinoco from the Universidad Nacional Autónoma de México worked on the San Joaquin Marsh project while on sabbatical.

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