



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.

Both scientists and the public recognize the importance of wetlands. 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. Searches of the scientific literature indicate a lack of research on the biogeochemical and hydrological cycles of California Tule Marshes. The disconnect is obvious: scientists and the public recognize wetlands as critically important, 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 (SJFM) to better understand the ecological controls on wetland carbon, energy and water vapor exchange. The SJFM is an 82-ha *Typha latifolia* and *Scirpus californicus* remnant of a large historical wetland. The marsh is located on the UCI campus, allowing easy access and facilitating undergraduate and graduate student training. The main goal of our UCWRC-funded research is to understand the biophysical and environmental controls on carbon, energy, and water vapor exchanges at the SJFM.

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 1999-2008 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 CO₂ 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). 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 carbon uptake is often associated with year-to-year variation in LAI, with greater CO₂ uptake during years with more leaves.

The SJFM is a highly productive ecosystem that is characterized by a large accumulation of litter. We hypothesize 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 CO₂ uptake (Net Ecosystem CO₂ 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. 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.

Publications

Rocha, A.V. (2008) The importance of intrinsic controls in driving interannual NEP variability. Ph.D. Dissertation. UC Irvine. Department of Earth Systems Science.

Rocha, A.V., D.L. Potts, and M.L. Goulden (2008), Standing litter as a driver of interannual CO₂ exchange variability in a freshwater marsh, JGR-Biogeosciences, In Press.

Rocha, A.V., and M.L. Goulden (2008), Why is marsh productivity so high? New insights from eddy covariance and biomass measurements in a Typha marsh, Agricultural and Forest Meteorology, In Press.

Rocha, A.V., and M.L. Goulden (2008), Large interannual CO₂ and energy exchange variability in a freshwater marsh under consistent environmental conditions, JGR Biogeosciences, In Press.

Goulden, M.L., M.C. Litvak, and S.D. Miller (2007), Factors controlling marsh evapotranspiration, Aquatic Botany, 58, 97-106.

Professional Presentations

Adrian V Rocha and Michael L Goulden, Spatio-temporal variability in vegetation indices in a freshwater marsh and its implications for CO₂ exchange. American Geophysical Union, Fall 2006, San Francisco.

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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