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 the University of California, Irvine'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 approximately $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 to better understand the ecological controls on wetland carbon, energy and water vapor exchange. The San Joaquin Marsh 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. Our UCWRC-funded research has three goals. (1) To understand the rates of and controls on marsh evapo-transpiration (E_t) and to determine whether wetlands have atypically high rates of evaporation. (2) To understand why wetland vegetation is capable of extraordinarily high rates of growth (Net Primary Production or NPP). (3) To understand why the marsh's E_t and NPP vary markedly from year to year.

Our research uses the eddy covariance technique to measure the exchanges of CO_2 (F_{CO2}) and water vapor (E_t) between the atmosphere and a few hectare patch of marsh. Measurements at the marsh indicate only moderate rates of E_t, which are broadly comparable to those of nearby grasslands, and very high rates of NPP, which are comparable to those of tropical forests. A longer-term look at the observations indicates that F_{CO2} and E_t fluctuated dramatically from year to year, with high photosynthetic uptake of CO_2 in summer 2000 and 2003, moderate uptake in 1999, low uptake in 2001, 2002, 2005 and 2006, and extremely low uptake in 2004. The midsummer rate of evapotranspiration also fluctuated dramatically, with high E_t in 2000 and 2003, moderate E_t in 1999, low E_t in 2001, 2002, 2005 and 2006, and negligible E_t in 2004. The interannual shifts in F_{CO2} and E_t were only partially a result of variation in flooding. While the extremely low rates of CO_2 uptake and evaporation observed in 2004 were a result of drainage to reduce mosquito habitat, the low rates

observed in 2001, 2002, 2005, and 2006 occurred despite the presence of ample water. We do not understand why the marsh's vegetation has varied dramatically from one year to the next.

In the last year, we started a series of field experiments to better understand why plant growth varies from year to year, and further investigated the use of remote-sensing to place the oscillations into a larger context. A continuous 20-year record of Landsat images for the marsh was assembled and calibrated. The images were then used to construct a 20-year record of the marsh's mid-summer Normalized Difference Vegetation Index (NDVI), a measure of vegetation density. The record of NDVI since 1999 shows excellent agreements with the simultaneous measurements of F_{CO2} and E_t at the marsh – years with high F_{CO2} and E_t also have a high NDVI.

Analysis of the longer time record of NDVI shows that the oscillations in marsh activity observed since 1999 occur throughout the Landsat time series. This analysis has provided evidence that the patterns observed since 1999 are not atypical for the San Joaquin Marsh. Moreover, a tool that will be used to determine whether other wetlands also show large year-to-year oscillations is under development. In the long term, our research will have practical implications for efforts to manage and restore wetlands, and possibly also for efforts to use wetlands for natural water treatment.

Publications

Goulden, M.L, Litvak, M.E., Miller, S.D. Factors That Control Typha Marsh Evapotranspiration. *Aquatic Botany*, in press.

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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