Past and Present Tree Island Elevation Responses to Hydrology – Everglades Project

Project Overview and Background:

In forested wetland environments, the processes of primary production, nutrient cycling and root decomposition are key factors that promote soil accretion and overall system stability (Wetzel et al., 2005; Cahoon et al., 2006; D'Alpos et al., 2007). Thus, to evaluate how soil accretion and elevation change are affected under different hydrological conditions it requires detailed information on both aboveground and belowground processes. Furthermore, measurements of litterfall production and tree growth across varying hydrologic conditions are critical in resolving how aboveground production and nutrient cycling vary with hydrology (Barbour et al., 1987) and how these processes are linked to tree island health. Though rarely measured (e.g., Powell and Day, 1991; Megonigal et al, 1997; Grier et al, 1981), root production and turnover can contribute as much as half of the carbon cycled annually in forests (Vogt et al., 1998) and therefore cannot be ignored to better understand the mechanisms associated to soil formation and accretion (Baker et al., 2001; Cahoon et al., 2006). Research under this component will address three hypotheses: (a) differences in hydrologic regimes are primary explanatory variables of belowground dynamics (b) trees in nutrient poor environments will allocate more biomass to the belowground component, and (c) variation in above and belowground processes, together, may alter accretion and elevation.

To gain a longer-term perspective, however, paleoecological studies will provide evidence of the nature and sequence of environmental conditions conducive to tree island formation and resilience (Stone et al., 2002). For instance, recent studies carried out on fixed and strand tree islands point to the importance of drought cycles on tree island initiation and development over the last two millennia (Willard et al., 2006). Results from paleoecological studies indicate that tree islands formed under natural environmental change triggered by regional to global-scale climatic events, such as El Niño and the Little Ice Age (Willard et al., 2006). However, less well known is how resilient existing tree islands are under managed hydrologic conditions characterized by drainage, impoundment, and slower moving water (Willard et al. 2002). Based on a preliminary study conducted from Tree Island 3AS3 in August 2006 (Smoak and Gore 2007), 210Pb-dated profiles of 13C and 15N show the 1950s was a period of major changes in the tree island and slough habitat, the timing of these changes coincident with the transition from drainage to impoundment in southern WCA-3A. In addition to quantifying responses of tree island vegetation and soil accretion to past and future hydrologic changes, paleoecological information will also enable researchers to consider legacies of past hydrologic and ecological conditions as a context for understanding in situ rates of production and decomposition, soil chemistry, and elevation changes observed at these islands. Thus, understanding the development and resilience of tree islands through both paleoecological and in situ approaches is critical to prevent, and possibly reverse, the reduction of tree islands since the 1950s, presumably the result of water management practices that influence tree island hydroperiods (Sklar and van der Valk, 2002).

Management and Restoration Objectives:

The first set of objectives of this research includes (1) determining the spatial pattern and variability of litterfall; (2) defining the effects of water level variability on long-term patterns of litterfall production, phosphorus sequestration and nitrogen cycling; and (3) determining soil/peat accretion rates in relation to current water management practices and future predicted hydrologic restoration goals. Objectives 1 - 3 will provide a means to assess the ecological processes linked to tree island health and soil formation. Similarly these objectives will help to define where tree islands are more (or less) vulnerable to drowning and loss due to reduced productivity, lower rates of accretion, or greater sensitivity to water level variability. The second set of objectives utilize a paleoecological approach to (4) quantify vegetation changes in tree islands over the past 100-200 years and (5) determine the hydrological conditions conducive to tree island formation, development, and maintenance. Objectives 4 and 5 will provide the pre-drainage variation in community types and soil development, essentially restoration targets for tree island health. These objectives complement the first three by providing a longer-term data set documenting tree island responses to hydrologic variation that occurred over several decades to centuries. Combined, accomplishing these objectives will provide Water Management District with ecological and hydrological information that is suitable to maintaining or promoting tree island communities under different hydrological conditions.

Methodological Approach:

To understand short-term and long-term processes in tree islands, researchers will employ a combination of in situ measurements of ecosystem functions (e.g., production, decomposition, accretion) and paleoecological analyses (e.g., soil profiles of plant and animal fossils). Together, these data provide researchers with a mechanistic understanding of the tree island responses to hydrology. Importantly, this combination addresses both short-term responses (season to yearly, via monitoring) and long-term responses (decades to centuries, via paleoecology analyses), matching the timescales relevant to the pace of adaptive management and restoration activities. Paleoecological research at tree island sites will be used to develop independent proxies of hydroperiod using fossil animal material (Smoak and Gore, 2007) and of vegetation changes using plant-derived material (Saunders et al., 2006; Willard et al., 2006). These data will help confirm and interpret the hypotheses relating tree island vegetation changes to local and regional hydrologic conditions and resolve how these systems may respond, positively or negatively, to future restoration measures. The combined paleo-inferred changes in vegetation, hydrology and soil accretion will be compared with hydrologic records (i.e., water stage data), with historic hydrology hindcasted by the South Florida Water Management Model Version 3.5, and with paleo-climate data that captures regional precipitation over the past several centuries (Willard et al., 2006).

Application of Results:

In the Everglades, where inorganic sediment input is scarce, belowground peat production is the primary process that control soil accretion. Thus, understanding how current hydrological conditions are affecting aboveground and belowground processes on tree islands are key factors to better mange the system to promote soil formation and accretion. The key to successful management and restoration of tree islands relies on our understanding of the processes that control elevation change (i.e., peat accumulation and organic matter decomposition) in relation to past and future hydrologic regimes (i.e., flow rates, depths, and hydroperiods). Estimation of both aboveground and belowground processes and fine-root production in particular, will help to determine the processes that lead to soil formation and elevation sustainability. Such processes represent the primary sources of energy and nutrient flow through forested systems; particularly for those systems that are subject to periodic disturbances that increase the frequency and extent of fine root turnover. In addition, quantifying long-term changes historically, through paleoecological analyses, will help to understand how tree islands may respond to restoration measures. Importantly, these analyses will resolve the degree to which restoring the original ridge and slough landscape can also maintain productive and stable tree island communities.