Partitioning root zone and deep sediment dynamics using paired surface elevation tables in Everglades National Park, Florida, USA.

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Introduction

Surface elevation tables (SETs) are used worldwide in a variety of coastal wetland environments to measure long term soil elevation change. Long term measurements are important in order to determine if the system is able to keep pace with sea level rise (Childers et al. 1993). Soil elevation change is a combination of several processes that occur within the soil profile (Whelan et al. 2005). These processes include sedimentation, erosion, compaction, and groundwater discharge/recharge (Cahoon et al. 2011). By using a paired shallow and deep SET design, shallow root zone and deep sediment profile change dynamics can be determined (Whelan et al. 2005, see Figure 1).

Hydrology can influence sedimentation both directly and indirectly. Local hydrology controls the oxidative state of the soil thereby regulating the process of root growth and decomposition and organic matter accumulation (Cahoon et al. 2011, Mitsch and Gosselink 2007). Sediment deposition, erosion and sediment compression are processes directly influenced by the hydrologic conditions of each site (Cahoon et al. 2011, Whelan et al. 2005). Groundwater levels regulate the shrink-swell response of the soil profile.

Long term monitoring of wetland elevation change is important to evaluate the health and vulnerability of coastal wetlands. The Comprehensive Everglades Restoration Plan (CERP) has included wetland surface elevation as a Performance Measure for monitoring restoration success (Recover 2009).

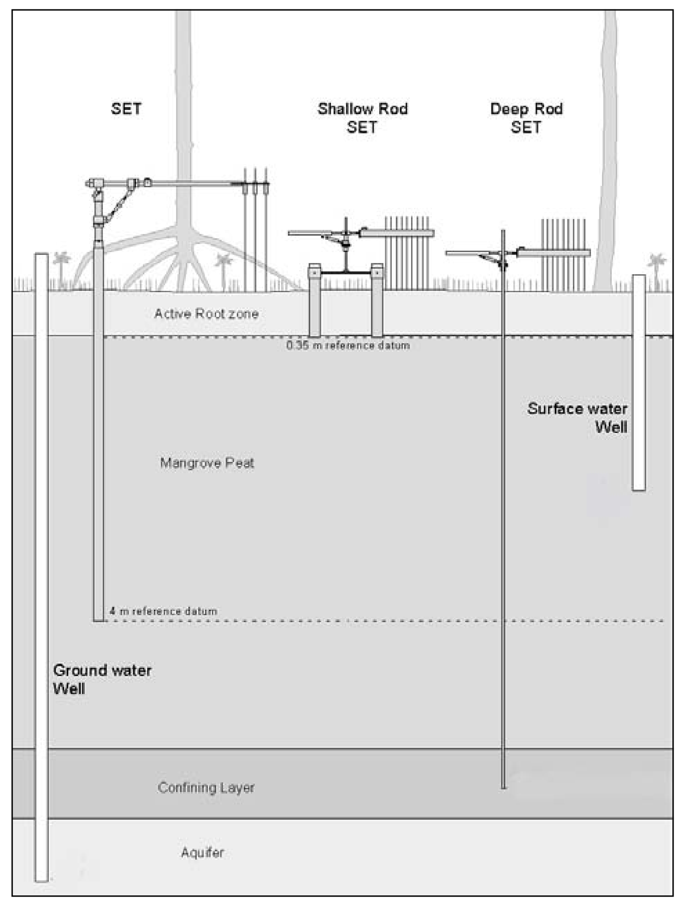

Figure 1. Soil profile and the types of SETs used to measure elevation change. Adapted from Cahoon et al. 2002.

Methods

Twenty four paired shallow and deep rod SETs were installed at eight sites along downstream-upstream transects on the Shark and Lostmans Rivers, on the southwest coast of Everglades National Park (ENP). Each SET pair was installed adjacent to preexisting hydrologic stations (Figures 2, 3 and 4). Each hydrologic station contains an automated groundwater gage recorder and surface water recorder. Elevation change was measured quarterly for five years (2006-2011).

A linear regression was calculated for each site with elevation change of the deep SETs as the dependent variable and groundwater level change as the independent variable. Regression was also run on the relationship between elevation change of the shallow SETs and surface water level change for the downstream sites (SH3 and LO3).

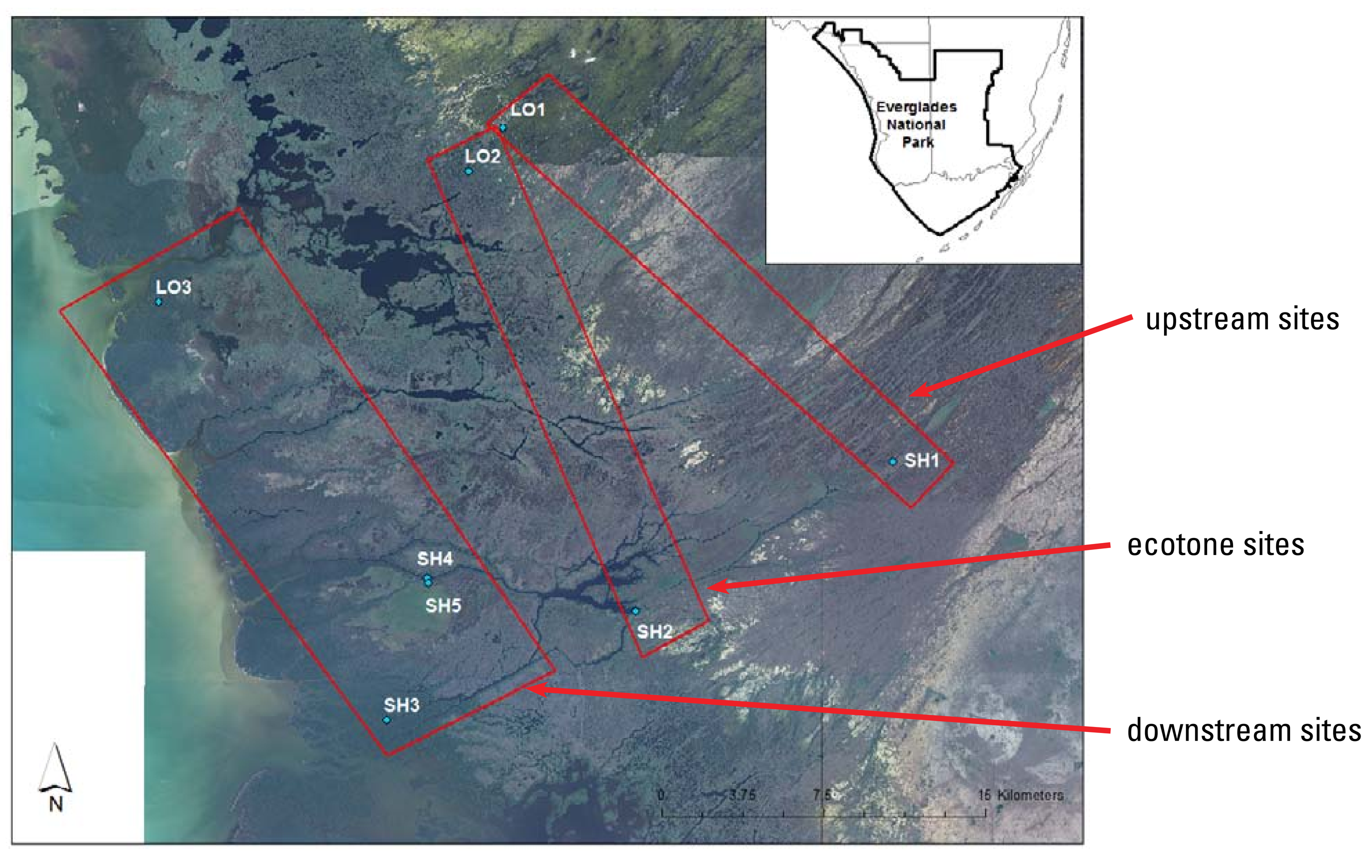

Figure 2. Map of study sites along southwest coast of Everglades National Park.

Figure 3. Photo of upstream site SH1 showing hydro station, SETs and the marsh environment.

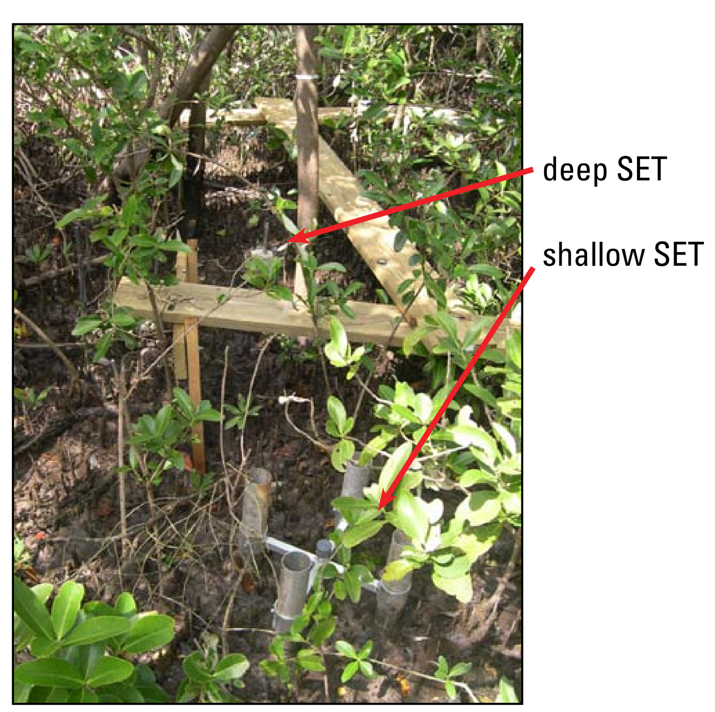

Figure 4. SETs located in a mangrove forest at downstream site, LO3.

Results

Linear Regression

Significant results were found for LO2, SH1, SH3, SH4 ($p < 0.05$) and SH5 ($0.05 < p < 0.1$) (Table 1).

At upstream (LO1 and SH1) and ecotone sites (LO2 and SH2) the daily rate of change (DRC) of soil elevation is explained by a negative relationship with DRC of groundwater levels (Table 1, Figure 5).

The relationship at downstream sites (LO3, SH3, SH4 and SH5) is positively related to the DRC of groundwater levels (Table 1, Figure 6).

No significant results were found for surface water levels and shallow elevation at the downstream sites (Table 2).

Table 1. Results from linear regression for daily rate of change (DRC) of surface elevation (dependent variable) and DRC of groundwater levels (independent variable) for each site.

Site	Slope	Intercept	F	df	R^2	p value
LO1	-0.009	-0.004	0.832	1,10	0.077	0.383
LO2	-0.035	-0.015	15.086	1,14	0.519	0.002
LO3	0.010	-0.001	0.359	1,8	0.043	0.566
SH1	-0.037	-0.005	5.324	1,12	0.307	0.040
SH2	-0.005	-0.011	0.255	1,12	0.021	0.623
SH3	0.029	0.006	21.722	1,16	0.576	0.000
SH4	0.025	-0.008	27.827	1,11	0.717	0.000
SH5	0.028	-0.049	3.910	1,16	0.196	0.065

Table 2. Results from linear regression for daily rate of change (DRC) of surface elevation (dependent variable) and DRC of surface water levels (independent variable) for the downstream sites.

Site	Slope	Intercept	F	df	R^2	p value
LO3-shallow	0.001	0.007	0.250	1,13	0.019	0.626
SH3-shallow	0.005	0.010	2.666	1,16	0.143	0.122

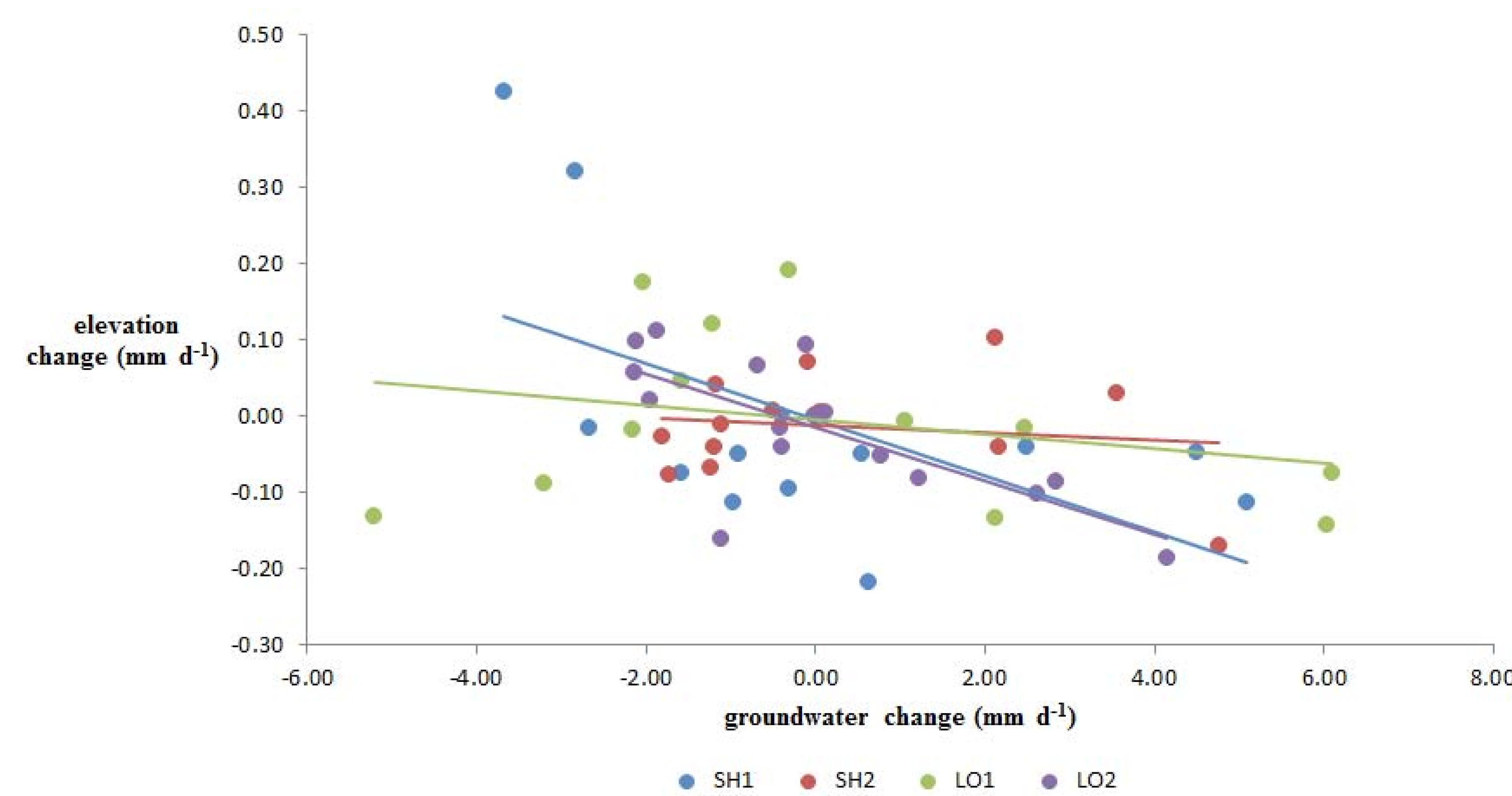

Figure 5. Groundwater level change and surface elevation change for upstream and ecotone sites. Color of regression lines correspond to color of symbol. Note the negative slope for all sites.

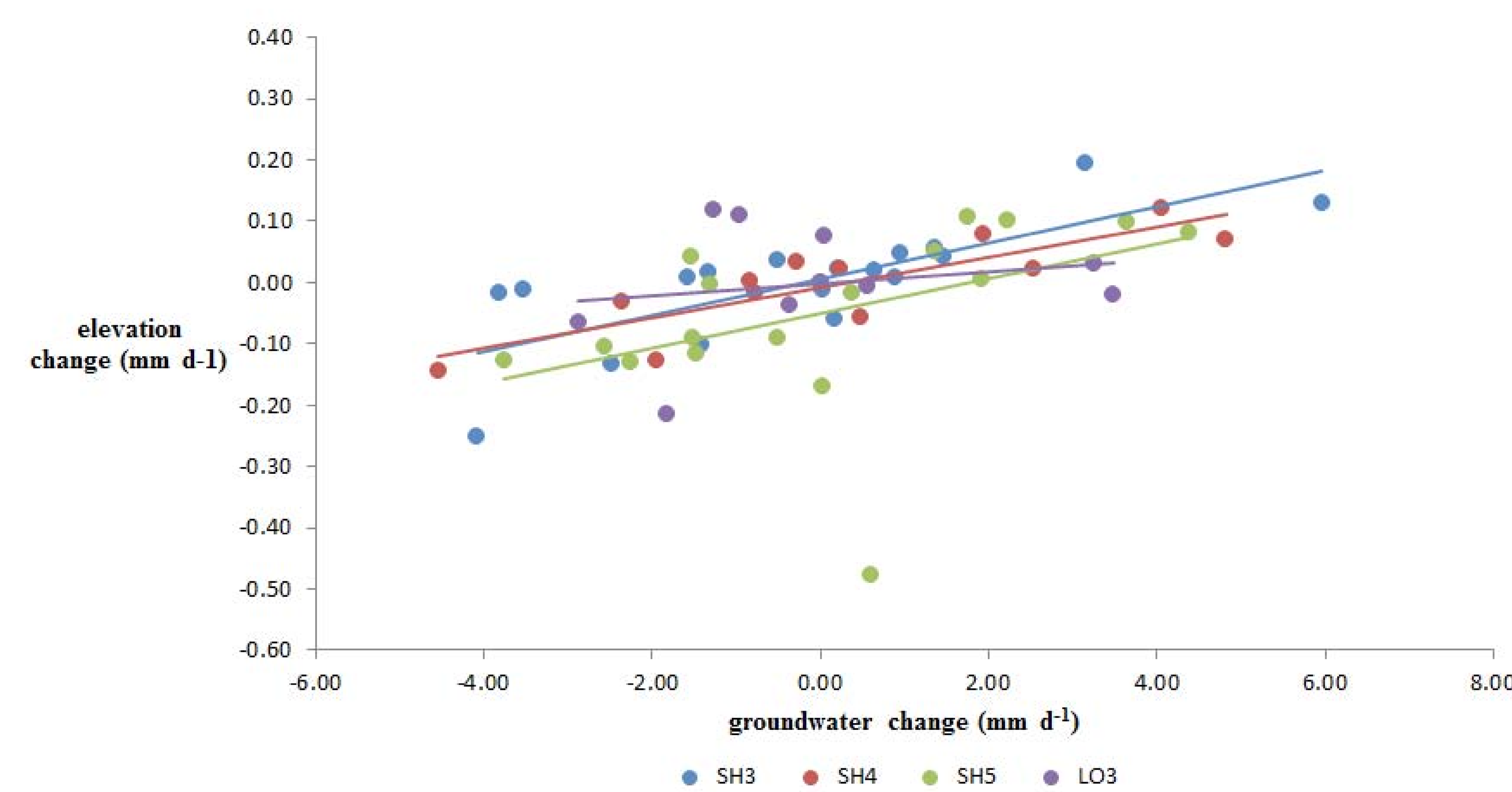

Figure 6. Groundwater level change and surface elevation change for downstream sites. Color of regression lines correspond to color of symbol. Note the positive slope for all sites.

Discussion

Wetlands in the coastal Everglades are faced with impacts from global climate change such as, sea level rise, altered precipitation and temperature, in addition to impacts from CERP. CERP will add freshwater to the system. How will this alter wetlands productivity, including the belowground production that leads to peat formation and buildup? Another important question is how the increased surface water levels from CERP will impact groundwater levels.

Our results clearly show a relationship between groundwater levels and sediment surface elevation at a number of sites in the coastal Everglades. More importantly, we have shown that the relationship changes depending on location in the flow-way. At upstream locations the relationship is negative, with decreasing water levels leading to increases in sediment surface elevation. This may be because particulate material suspended in the water column settles and becomes cohesive. At downstream, mangrove forest sites, the relationship is positive. As groundwater levels increase, sediment surface elevation increases. This observation was first reported by Whelan et al. (2005) from a single location. We have now corroborated this observation and extended the finding to other locations in the mangrove zone.

The response of elevation change to groundwater across the landscape is important because it represents a regional effect and not a local one. This is an important concept for restoration projects and predicting long term stability of wetlands in the face of sea level rise.

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Further Information

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