Short Term Dynamics of Vegetation Change Across a Mangrove-Marsh Ecotone in the South-west Coastal Everglades: Storms, Sea-level, Fire and Freeze

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Abstract

The position of the mangrove – marsh ecotone (MME) is known to have changed through time at several locations in coastal Everglades and Florida Keys. Based upon aerial photographs of the region, we know that this ecotone has migrated significantly. In 1927 the MME was approximately 100m from the river bank. By 1994, the MME was 350m from the river bank, an inland shift of approximately 250m, a distance readily measurable on the photographs. We established a transect across this MME which spans a distance of >350m, running from a tall mangrove forest at the river's bank (*Rhizophora mangle*, *Laguncularia racemosa*, and *Avicennia germinans*) into a sawgrass (*Cladium jamaicense*) dominated plain (figure 1). Our physical data indicate that this transect, located on a large coastal island, and is disconnected from upstream hydrologic signals. The transition of an area from mangrove to marsh, or vise versa, will depend on the response of the local hydrological conditions to changes in sea-level and climate at the synoptic scale (Smith 1997). Thus we feel that the movement of this ecotone over the past 70 years is related to a rise in sea-level.

Introduction

- The diagram of our MME study area is shown in figure 2. Associated with each site are permanent plots for measuring changes in mangrove forest canopy and in the abundance of seedlings along with porewater wells at 30cm and 60cm depths.
- The river's edge is dominated by tall mangrove forests, particularly *Rhizophora mangle* and *Laguncularia racemosa*. Moderate amounts of *Rhabdadenia biflora, Acrostichum aureum*, and *Tillandsia usneoides* are also found in this area of the transect.
- Both *Rhizophora* and *Avicennia* disappear from the inland areas of the transect, leaving *Laguncularia* as the only mangrove species where the forest gives way to a marsh dominated by *Cladium jamaicense*. *Schinus terebinthifolius* appears as you approach the inland MME.
- Along the inland MME, *Laguncularia* display multi-stemmed architecture which results from its ability to retain reserve meristems. The differential recovery is dependent upon the locations of reserve buds on the trunk. This pattern of damage along ecotones has also been reported in other habitats (Olmstead, Dunevitz, and Platt 1993).
- Causes of short term mortality (figure 3) due to storms is common near the river's edge and into the interior forest. While freeze and fire are the major mortality factors at the MME.

Methodology

- Vegetation plots are circular with their radius dependent upon stem density. Two plot locations per site were chosen randomly and permanently marked. All tree stems occurring within the plot were permanently tagged, species, measured for diameter at breast height (dbh), compass bearing, distance from the center stake recorded and condition codes assessed. Survey dates are as follows: **Site 1-** 1994, 1997, 1998, 1999, 2000, 2002. **Sites 2-7-** 1997, 1999, 2000, 2002. **Site 8-** 1997, 1998, 1999, 2000, and 2002.
- We examined mangrove seedling dynamics by establishing eight one m^2 plots at each site and permanently staked them in each corner with _ inch PVC. Seedlings were classified as non-established or established. Propagules are considered non-established if no rooting has taken place, or if rooted, only cotyledons are present. Established propagules are firmly rooted into the substrate and have two true lamina expanded. Non-established propagules are counted and established seedlings are tagged with lightweight aluminum tags, species, lamina count and height (cm) recorded. *Schinus terebinthifolius* seedlings are also followed. Other species occurring within the plots are noted. Percent coverage of forest canopy and/or *Cladium* (also culm count) recorded. Survey dates are as follows: Nov 1997, Feb 1999, Dec 1999, Oct 2000, and Dec 2001 (Jan, Apr 2002).
- Beginning in the coastal marsh, a 90m belt transect was established terminating in mangrove forest. Nine contiguous 10 X 10 plots were created and two 5 X 5 subplots chosen from each. All tree stems occurring within the plot was permanently tagged, species, measured for dbh, compass bearing, distance from the center stake recorded and condition codes assessed. Established in March 2001.
- Sediment porewater salinity has been measured at two depths (30 & 60cm) at each of the five sites along the transect. Three wells are sampled at each depth. Sampling was done weekly the first year (1997) then bi-weekly there after.
- Porewater for nutrient analyses was collected at each of the porewater sampling sites. Soil porewater was sampled at depths of 0cm, 30cm, and 60cm. River water and water from two shallow groundwater wells were also sampled. Sampling was conducted twice during summer 2002 (July, August) and once during winter 2003 (January).

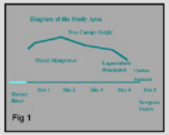
Fig 1

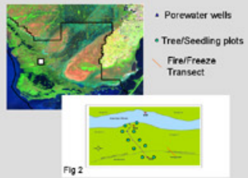

Fig 2

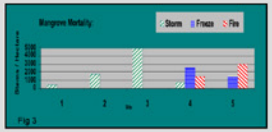

Fig 3

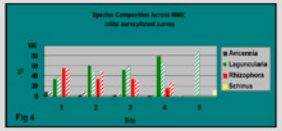

Fig 4

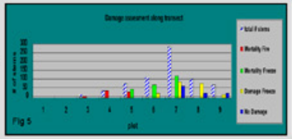

Fig 5

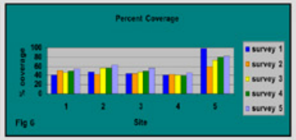

Fig 6

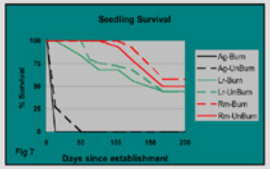

Fig 7

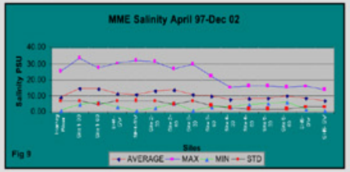

Fig 9

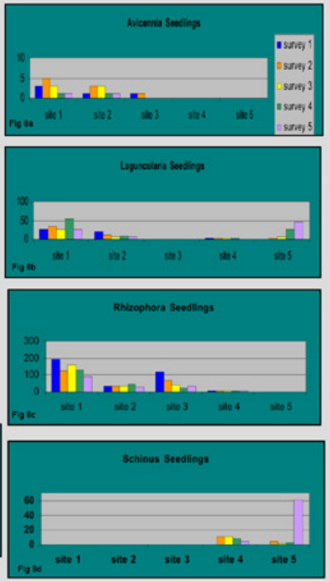

Fig 8a, Fig 8b, Fig 8c, Fig 8d

Figures 8 a-d Total # established seedlings

Results and Discussion

- *Rhizophora mangle* has increased in some plots with no significant change in others (figure 4). *Avicennia germinans* abundance continues to be low with very little change. *Laguncularia racemosa* produces the most variable results. The tree plots at site 5 were established in response to the freeze of 1997 in which all stems were freeze killed. The following year, virtually all of the freeze dead stems produced basal sprouts producing considerable regeneration of above ground biomass. The freeze of January 2001 produced similar results. It is interesting to note that at site 3, *Laguncularia* tree abundance has been steady, yet very few non-established and no established *Laguncularia* seedlings are found here (figs 3, 8b).
- *Laguncularia* seedlings are the most common non-established and *Rhizophora* the most common established seedling (fig 8c). *Avicennia* continues to be almost absent in either phase (fig 8a). High initial survey numbers are due to multiple cohorts being tagged. Successive seedling recruitment captures individual cohorts. Porewater salinity and percent vegetation coverage do not completely explain seedling patterns along the MME (figs 8a-d, 6, 9). At survey 5, high numbers of both *Laguncularia* and *Schinus terebinthifolius* recruitment may be due to temporal variation of sampling (fig 8b, 8d). Site 5 was not sampled until Apr 2002 in which more established seedlings were present. If sampled in Dec 2002, the established seedlings may have been captured in a non-established phase. In addition, *Schinus* fruit tends to ripen significantly between Nov and Feb (Nelson 1994). Therefore, conditions were probably more favorable for the presence of established seedlings due to the sampling being conducted at the end of the dry season, rather than the beginning.
- In terms of fire impacts, the preliminary results from our seedling transplant experiment are interesting (fig 7). We hypothesized that seedlings transplanted into a recently burned sawgrass marsh would have higher survival rates than ones planted under an unburned sawgrass canopy. For all three species of mangroves, however, the reverse was true. Individuals in the unburned marsh had greater survival. The largest effect was among species. *Avicennia*, in both burned and unburned marshes, died rapidly, whereas 45% or more of both *Laguncularia* and *Rhizophora* survived for at least 200 days.
- Stems that were burned show no signs of recovery (fig 5). In contrast, many stems that were killed by freeze have shown substantial recovery and regrowth by the production of basal sprouts. This recovery after freeze damage is consistent with other vegetation plots we have in this MME and with results reported by Olmstead et al.
- The variability in porewater salinity along our MME transect is partially tidal but mainly due to the seasonal effects of precipitation and evaporation. The most significant overall salinity difference is found between sites 3 and 4 (fig 9). This area is the noticeable transition between mangrove and marsh where *Cladium jamaicense*, *Laguncularia, Conocarpus erectus*, and numerous epiphytic species dominate the flora. In addition, this is the area where *Schinus* establishment is taking place.
- Preliminary soil porewater nutrient data indicate increased levels of nitrogen (N) and carbon (C) at site 3 and increased turbidity and ammonia (NH_3) at site 5. The winter samples indicated lower concentrations of most nutrients and greatest nutrient concentrations were found within the upper root zone, 30cm. Ratios of C:N:P indicate wide variability with C in great excess of N and P. Future data collection is needed to strengthen validity of inferred patterns and allow correlations between salinity and nutrient content.
- We have been sampling for a relatively short timeframe and have measured a lot of dynamic activity along this transect. Mangrove-marsh ecotones at more upstream sites in the Everglades ecosystemwill be useful locations in which to monitor the effects of increasing freshwater inflow.

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