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Tidal Influence on Mangrove Community Structure and Recovery Post-Hurricane Disturbance: Revisiting Hurricane Charley (2004) Effects on Sanibel-Captiva, Fl.

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Introduction

Mangroves have the ability to buffer hurricane effects such as severe winds, storm surge and heavy erosion (Sadd et. al., 1999). Because of their critical role in protecting the shoreline, maintaining ecosystem functions, and providing habitat, mangrove community recovery post-hurricane disturbance is a key concern to tropical and subtropical coastlines.

One concern in naturally disturbed ecosystems is whether added anthropogenic stress can act synergistically and result in a system conversion (Everham and Brokaw, 1996).

Hurricane Charley (2004) provided an opportunity to study mangrove recovery. Initial results from Milbrandt et. al. (2006) indicated significantly lower seedling densities in tidally restricted locations following Hurricane Charley. This study expands on those results by measuring the seedling densities and litterfall three years post Hurricane Charley.

The goal of this study is to determine whether tidal influence has an effect on mangrove recovery and if wind intensity has a lasting effect on hurricane-disturbed mangrove communities.

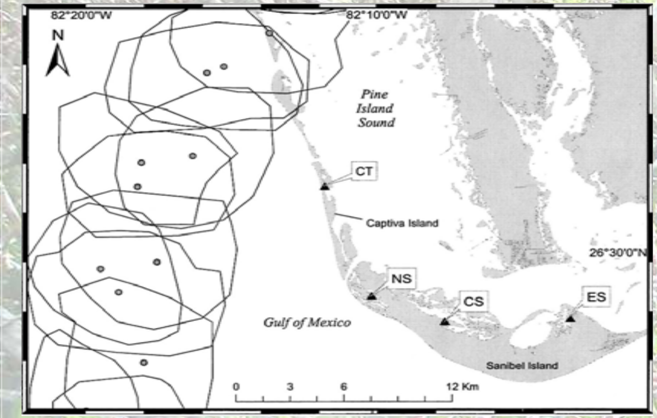

Figure 1. Hurricane Charley (2004) eye-wall and site regions (Milbrandt et. al., 2006) on a decreasing wind intensity gradient [Captiva (CT), North Sanibel (NS), Central Sanibel (CS) and East Sanibel (ES)].

Methods

The study site consists of four regions that experienced a decreasing wind intensity (Fig. 1). Each region consists of a tidally restricted and unrestricted location representing tidal influence (Milbrandt et. al., 2006).

Seedling densities were measured in 2007 within 1 m^2 quadrats (Photo 1). One permanent quadrat and eight replicate quadrats were measured within each plot. Quadrats were established at a random bearing and distance from the center of each plot.

Litter fall was collected 5 times per plot from spring 2007 to spring 2008, which falls within the monthly (Twilley et. al., 1986) and quarterly (Ellison and Simmons, 2003) sampling procedures for mangrove litter fall collection. One litter trap was placed at random distances and bearings within each plot . The litter boxes were underlain with a 2 mm mesh screening with an area of 0.25 m^2 (Twilley et al., 1986) attached to wooden posts approximately 1 m above ground (Photo 2). Within the first week of collection the litter was separated by species into leaf material, stem, reproductive, and miscellaneous parts, then dried at 70°C for 72h (Twilley et al., 1986).

Photo 1. (Above) Seedling density quadrat.

Photo 2. (Right) Litter trap.

Results

- Significantly lower seedling densities were observed in tidally restricted locations (10.17 seedlings m^{-2}) when compared to tidally unrestricted locations (31.93 seedlings m^{-2}) (Fig. 2) (M-W test, $p<0.0001$).
- Significantly lower seedling densities were observed in regions of higher wind intensity (Captiva, 6.31 seedlings m^{-2} < North Sanibel, 9.08 seedlings m^{-2} < Central Sanibel, 29.94 seedlings m^{-2} < East Sanibel, 42.85 seedlings m^{-2}) (Fig. 3) (K-W test, $p<0.0001$) .

- Significantly lower litter fall was observed in tidally restricted locations (0.1669 $g \cdot m^{-2} \cdot d^{-1}$) when compared to tidally unrestricted locations (0.6563 $g \cdot m^{-2} \cdot d^{-1}$) (Fig. 4) (2-way ANOVA, p=0.005).
- Significantly lower litter fall was observed in regions of higher wind intensity (Captiva, 0.0872 $g \cdot m^{-2} \cdot d^{-1}$ < North Sanibel, 0.3729 $g \cdot m^{-2} \cdot d^{-1}$ < Central Sanibel, 0.5709 $g \cdot m^{-2} \cdot d^{-1}$ < East Sanibel, 0.6283 $g \cdot m^{-2} \cdot d^{-1}$) (Fig. 5) (2-way ANOVA, p=0.046) .

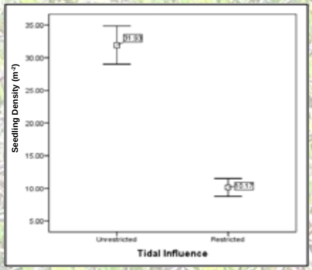

Figure 2. Mean (1±SE) seedling densities of restricted and unrestricted locations combined for all regions.

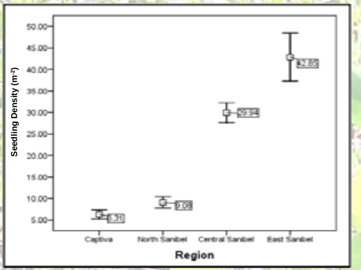

Figure 3. Mean (1±SE) seedling densities per region of restricted and unrestricted locations. X-axis represents increased distance from the hurricane eye-wall and decreased wind intensity.

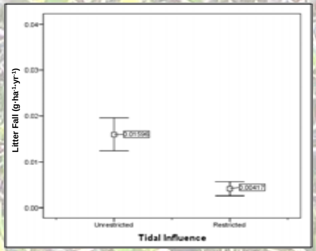

Figure 4. Mean (1±SE) DW of litter fall of restricted and unrestricted locations combined for all regions.

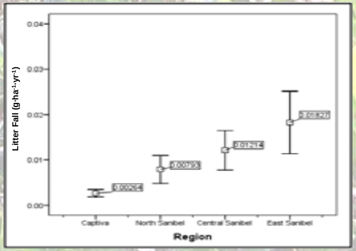

Figure 5. Mean (1±SE) DW of litter fall per region of restricted and unrestricted locations. X-axis represents increased distance from hurricane eye-wall and decreased wind intensity.

Discussion

These results support the initial Milbrandt et. al. (2006) post hurricane recovery study. Both mangrove seedling densities and litter fall were significantly higher in tidally unrestricted locations. Three years following Hurricane Charley, mangrove seedling densities and litter fall reflect the decreasing hurricane wind intensity gradient, increased production with less intense disturbance.

Mangrove communities exist in areas prone to tropical storms and hurricanes. Understanding the mangrove recovery process to hurricane disturbance allows us to prevent additional anthropogenic stress from hindering the natural recovery process of these vital ecosystems.

The alteration of local hydrology impedes the availability of natural ecosystem recovery. Mangrove management and restoration efforts should consider tidal influence, seedling availability, and potential disturbances that would negatively impact a vulnerable system. Responses to multiple disturbances must be considered for future research and ecosystem management.

These results provide insight into the mangrove recovery process and are useful in both restoration and land use planning, which are essential to sustainable management practices of barrier island systems.

Acknowledgments

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