# Establishment and Examination of a Long-term Mangrove Forest Dynamic Plot in Estero Bay, Florida

Edwin M. Everham III, Brian Bovard, Oscar Maradiaga, Jenny Morris, Megan King, Gillian Stocking, Hannah Lafrenz

Department of Ecology and Environmental Studies, The Water School, Florida Gulf Coast University, Fort Myers, FL 33965

## 1. Background

- Mangroves are literally at the frontline of climate change stress, impacted by both sea level rise and more intense hurricanes. In addition, they are critical green infrastructure for protecting human development in a climate-changing world.
- In 2017, a 1-ha long-term monitoring plot was established within a fringe mangrove system in the Imperial River Preserve, Bonita Springs, Florida and a smaller plot was initiated on Big Hickory Island (Figure 1), with the intention of developing a baseline for understanding the impacts of sea level rise and hurricane disturbance events.
- Hurricane Ian impacted the sites in September 2022, flooding the system with >3 m of storm surge.
- In these two posters we report on the results of our initial and on-going forest surveys, including hurricane impacts, survival, litterfall, and canopy structure.

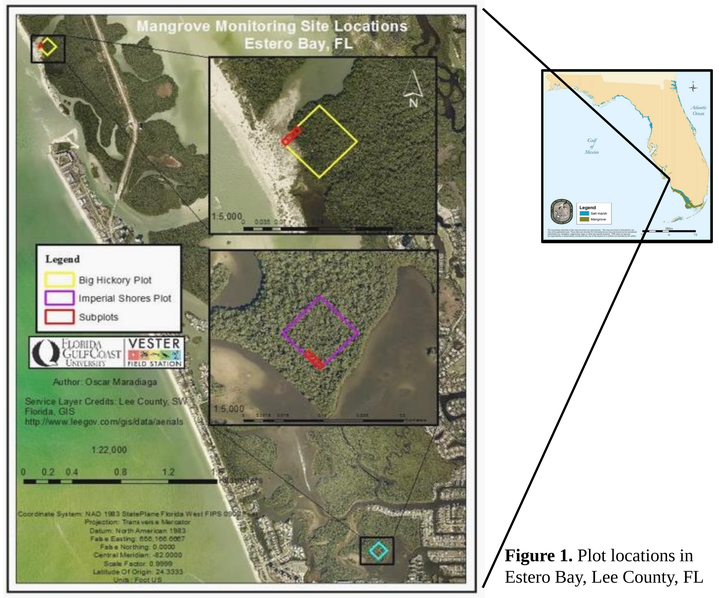


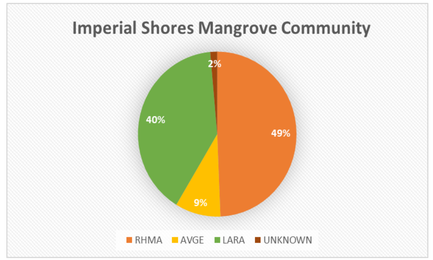

**Figure 1.** Plot locations in Estero Bay, Lee County, FL

## 2. Methods

- Our plots were intended to following the protocol for Man in the Biosphere Biodiversity plots.
- The 1-hectare plot is organized into 100 - 10 m by 10 m quadrats. In each we identified, mapped, measured, and tagged all mangrove stems > 4cm dbh. In addition, litterfall data was collected (Figure 4), and an additional transect – following the direction of storm surge - was established to examine deposition (Figure 3).
- Initial plot establishment only included the first 30 % (30 quadrats)of the plot before Hurricane Ian. Following the hurricane, we resampled that portion of the plot and added an additional 21 quadrats randomly selected from the rest of the plot – giving us data from just over 0.5 ha.
- Post-hurricane assessment included determination of mortality, non-lethal structural damage, and defoliation.
- Pre-hurricane sampling included nested 1 $m^2$ seedling plots. These were sampled following Ian and additional plots were established along the storm surge transect.

## 3. Results

- This mangrove system is a mixture of smaller *Rhizophora mangle* and *Laguncularia racemosa*, with a remnant population of older *Avicennia germinans*
- The initial survey indicated overall mortality of 29%, but delayed mortality occurred while the hurricane damage assessment was occurring (Figure 3), resulting in an underestimate of the final impact.
- Qualitative and quantitative observations at this site indicated delayed and spatially dependent stress and mortality in the mangroves.
- Sediment deposition on the western end of the transect was 9.4 cm deep and demonstrated a decline to 0 cm of deposit 80 m into the forest (Figure 3).
- Linear regression analyses revealed organic content at 5 cm below the soil surface was negatively related to sediment deposition depth ($p=0.0003$, $r^2=0.82$). *Rhizophora mangle* mortality was linearly related to the depth of sediment deposition ($p=0.0001$, $r^2=0.96$). *Laguncularia racemosa* mortality demonstrated a strong exponential-shaped relationship with sediment deposition depth with 100% mortality in areas with even the smallest amounts of deposition.
- Litterfall data was collected between the two storms. These data show seasonal differences, and a delayed elevated deposition following Hurricane Irma (Figure 4).
- Post-Ian seedlings response is dominated by red mangroves, but many of these were established per hurricane. The white mangrove seedling establishment appeared to be all hurricane response (Figure 5).



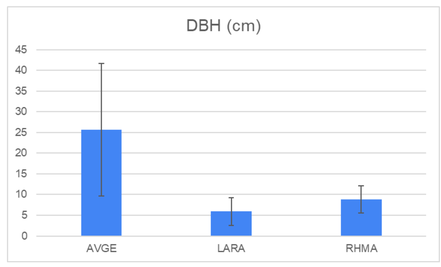




**Figure 2.** Community structure. This plot is dominated by red mangroves, with a large number of small white mangroves and a small number of large black mangroves.

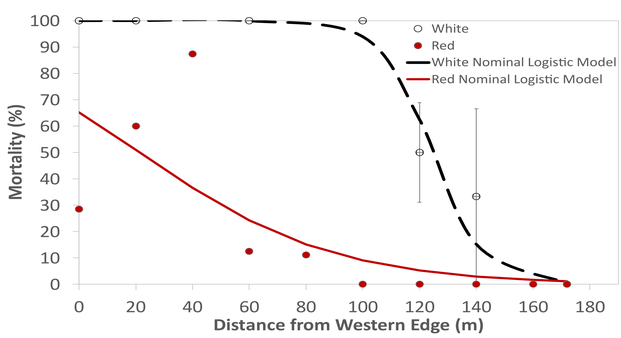



**Figure 3.** Mortality of both red and white mangroves was higher at the western edge of the plot where hurricane sediment deposits were greatest and decreased towards the eastern edge and is almost non-existent 100m into the plot where no evidence of deposition was present. The white mangroves were impacted more severely than the red mangroves. Salinity levels across this gradient were similar to previous years, and well within the tolerance limits of mangroves.

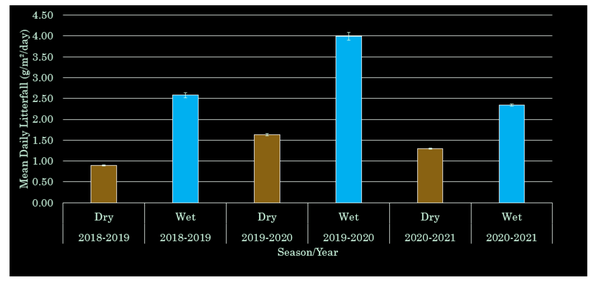



**Figure 4.** Litterfall data illustrate seasonal difference, but also elevated deposition delayed after Hurricane Irma. We believe these dynamics are partly tied to delayed mortality and delayed coarse wood debris fall.

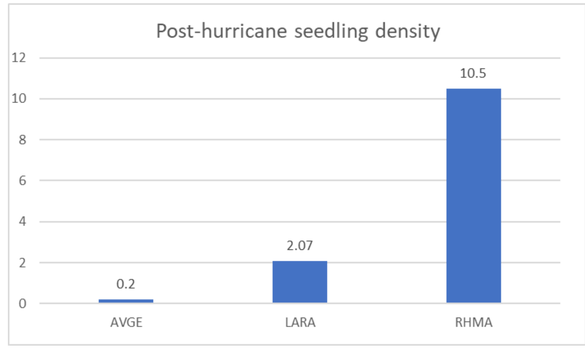



**Figure 5.** Post-Ian seedlings densities are dominated by red mangroves – though seedlings were established before the storm.

## 4. Discussion and Conclusions

- Our long-term mangrove study plot demonstrates a complex community, possibly as legacies of sea level rise and previous disturbances, rather than the predicted species zonation by elevation.
- Our engagement of the systems between Irma and Ian, and then at a high frequency for an extended period after Ian, allowed us to experience and document the delayed mortality related to fine particle sediment deposition on portions of the study plot.
- The pattern of elevated mortality through time highlights the importance of timing of post-hurricane damage assessment and the need for long-term monitoring.
- However, our ability to establish and monitor large plots is resource limited. Working in mangrove systems following disturbance is challenging and those challenges will increase as the Florida climate warms. The integration and ground-truthing of technology-mediated data collection and remote sensing facilitates larger-scale questions about disturbance and recovery.
- Next steps in the plot include: resampling the earliest quadrats to better quantify the delayed mortality; continuing to track seedling dynamics; and initiate a leaf monitoring project to quantify leaf life-span for better understanding of post-disturbance litterfall dynamics.

## 5. Acknowledgements

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