Hypothesis testing of mangrove community development: a microcosm design to test hydropod-nutrient interactions

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3. PATTERNS OF MANGROVE DEVELOPMENT IN FCE LTER

Mangroves are excellent communities to test the interactions of resource and regulator gradients to explain succession patterns in the intertidal zone. Because of the relative simplicity in species composition in the Neotropics, mangroves offer an opportunity to test the limitation of the resource-based hypothesis by regulator gradients to define succession of coastal wetlands. An individual-based model designed to simulate patterns of mangrove forest development (FORMAN: Chen and Twilley 1988) used salinity (regulator gradient) and phosphorus soil concentrations (resource gradient) to predict tree growth (Fig. 3). Each of the three mangrove species demonstrates optimum growth along specific combinations of these two gradients as indicated by the response curves in Figure 1.

Field observations of mangrove development by Chen and Twilley (1988) along the Shark River estuary of the FCE LTER (Fig. 2) suggest that resource gradients are responsible for changes in structure and function of mangrove forest stands. Shifts in the composition in rooted (Rhizophora mangle) and white (Laguncularia racemosa) mangroves represent community development since Hurricane Donna in 1964 (Fig. 3). Regulator gradients of salinity and sulfide do not explain the variation in community structure and productivity (biomass); while reduced concentrations of total phosphorus coincide with increased productivity and increased presence of R. mangle.

The FORMAN model was used to simulate the effects of changes in resource gradient to explain processes controlling community development along the Shark River estuary (Fig. 4). Original simulations with just phosphorus concentration did not account for the reduction of while mangroves-between SRS and SRS-5. An additional change in recruitment was needed to get the model fit as shown in Figure 4. The hypothesis in this simulation (Chen and Twilley 1988) was that increased hydropod in the upper Shark River estuary reduced the establishment of white mangroves in this region of the estuary.

The FORMAN model assumes linear effects accounted by hydropod regulators, salinity and nutrient availability; whereas non-linear responses may be more accurate to characterize mangrove forest growth. The lack of experimental data precluded running the FORMAN model to test the hydropod effect on mangrove forest dynamics. To predict spatial and temporal patterns of the forests it is critical to develop experimental designs that quantify the interactive effects of resource and regulator gradients on species-specific growth and establishment.

1. MICRO COSM SETUP

Our microcosm setup is composed of tidal platforms (Fig. 5) that can be divided into different hydroperiods each. These platforms consist of basins and (deep) tanks situated on top of a 190 L-reservoir (Fig. 5). Water is distributed to each individual bucket. Tidal amplitude is controlled independently in each bucket by two concentric pipes that drain water back to the reservoir and to allow flushing. For a hydroperiod of permanent flooding no drainage occurs, and the buckets remain permanently flooded. Timers control inundation frequency on a duration on a semidurnal period. The tidal system is set up in a 1.8 ha greenhouse located at the Center for Ecology on an Environmental Technology, University of Louisiana at Lafayette. Air temperatures in the greenhouse are maintained above 26 C and within 2 C of the high summer temperatures. Light within the greenhouse is 53% of the ambient solar energy.

5. PREDICTIONS

Using this experimental setup we will test the hypothesis that the patterns of mangrove structure observed in the Shark River estuary by Chen and Twilley (1998) are largely the result of species specific responses to levels of nutrients and hydroperiod as indicated in the following predictions.

P1. Net productivity (NPP) of L. racemosa will be higher than R. mangle growing at high phosphorus concentration (5 g P m-2 d-1; N/P ratio = 100) under both tidal and permanently flooded hydropod.

P2. NPP of R. mangle will be higher than L. racemosa at low phosphorus concentration (0.5 P m-2 d-1; N/P ratio = 100) under both tidal and permanently flooded hydropod.

P3. L. racemosa at low phosphorus concentration (0.5 P m-2 d-1; N/P ratio = 100) and permanently flooded hydropod will show more than additive effects on the reduction of NPP.

P4. Root shoot ratio of both species at low phosphorus concentration (0.5 P m-2 d-1; N/P ratio = 100) will be higher than the root mean under high phosphorus concentration (5 g P m-2 d-1; 0.5 P m-2 d-1).

P5. Root shoot ratio of both species will be higher under tidal hydropod than permanently flooded hydropod under both nutrient gradients.

To test our predictions we are using two levels of hydroperiod (tidal range of 30 cm and permanently flooded) and two levels of soil fertility (5 g P m-2 d-1 and 0.5 P m-2 d-1).

1. REFERENCES


Fig. 1. Simulated development of mangrove forests after 100 years along gradients of soil relative nutrient availability (RNA) and salinity by the FORMAN model for Rhizophora mangle (top), Avicennia germari (middle), and Laguncularia racemosa (bottom). (From Chen and Twilley 1998).

Fig. 2. Location of study sites along SRS in FCE (From Chen and Twilley 1999).

Fig. 3. Forest structure by species (left) and changes of soil carbon (C), nitrogen (N), and phosphorus (P) in mangrove forests along the SRS in FCE. C, N, and P data are mean of three sampling dates (S).

Fig. 4. Comparison of field and simulation data (FORMAN model: Chen and Twilley 1988) for species composition in LTER along SRS in FCE. Field data from Chen and Twilley (1999).

Fig. 5. Components of a tidal individual platform. Dotted lines between the splitter and the buckets represents tubing. Lines in the buckets are PVC pipes.