Effects of Hydrology on Red Mangrove Recruits

Introduction

Coastal wetlands along the Gulf of Mexico have been experiencing significant shifts in hydrology and salinity levels over the past century as a result of changes in sea level and freshwater drainage patterns. Local land management in coastal zones has also impacted the hydrologic regimes of salt marshes and mangrove areas. Parks and refuges in south Florida that contain mangrove forests have, in some cases, been ditched or impounded to control mosquito outbreaks and to foster wildlife use. And while mangroves dominate the subtropical coastlines of Florida and thrive in saltwater environments, little is known about how they respond to changes in hydrology under managed or variable tidal conditions. USGS researchers designed a study to evaluate the basic hydrological requirements of mangroves so that their health and survival may be more effectively managed in controlled impoundments and restored wetlands.

Mangroves are commonly found in the intertidal zone (between low and high tides) in a rather broad spectrum of hydrologic settings. Because they thrive at the interface of land and sea, mangroves are subject to changes in freshwater flow (flow rate, nutrients, pollutants) and to marine influences (sea-level rise, salinity). Salinity has long been recognized as a controlling factor that determines the health and distribution of mangrove forests. Field and experimental observations indicate that most mangrove species achieve their highest growth potential under brackish conditions (modest salinity) between 10 and 20 parts per thousand (ppt). Yet, if provided with available propagules, successful regeneration, and limited competition from other plants, then mangroves can survive and thrive in freshwater systems as well.

Because little is known about the growth and survival patterns of mangrove species relative to changing hydrology, USGS scientists conducted greenhouse and field experiments to determine how flooded or drained patterns of hydrology would influence growth of the red mangrove, *Rhizophora mangle* (fig. 1). Red mangrove propagules (recruits) of select sizes and genotypes (i.e., genetically similar groups) were planted both in greenhouses and in the field. Seedling growth was monitored in both studies on a quarterly basis for over a year; measurements included shoot growth, seedling height, and a final harvest of plant biomass.

Fig. 1. Tom Doyle, a USGS scientist, measured seedling height and diameter of red mangroves to determine differences in growth rates as a result of hydrologic conditions.

Greenhouse Experiment

A greenhouse study mimicked both impounded and tidal hydrology for mangrove recruits planted in deep pots of sand and peat (fig. 2). Hydrologic treatments included permanent flooding and tidal cycling. All study treatments followed the same automated and simultaneous tidal schedule, a daily ebb and flow of 6-hour durations. Water treatments included freshwater (<0.01 ppt salinity) and brackish conditions (15 ppt).

Fig. 2. In the greenhouse study, red mangrove seedlings were arranged in tanks and received hydrologic treatments of varying salt and fertilizer concentrations.

Results

Differences between salinity and hydrological treatments in this experiment were insignificant and otherwise masked by plant response to substrates and nutrients. These experimental findings suggest that both substrate and nutrient quality play a much greater role than the factors of hydrology and salinity in determining mangrove growth and form (i.e., secondary branching).

Field Trials

Field trials were conducted in coastal waters and impoundments of Ding Darling National Wildlife Refuge on Sanibel Island, Florida (fig. 3). Site locations included a protected bay under continuous tidal influence and two controlled impoundments, one of which remained at a static level while the other was allowed to flush with tides 3 months after initial planting. Unlike the greenhouse experiment, all potted recruits were in an organic peat substrate.

Fig. 3. In the field experiments, fixed and floating nurseries of planted red mangrove seedlings were monitored for plant growth and survival in controlled impoundments and open bay sites.

Potted recruits of red mangrove were planted into both fixed and floating nursery structures designed to mimic tidal and static water levels above and below mean tide. The floating nurseries served as an experimental control because the water level remained the same in both tidal and impounded waters. Fixed structures were set to mean tide height so that potted plants were either flooded at high tides or drained at low tides, depending on the actual tides themselves. Floating nurseries, on the other hand, maintained steady water level and soil saturation conditions by moving up and down with the changing tide or fluctuations in impoundment water levels.

Results

Red mangrove recruits exposed to tidal fluctuation experienced greater growth than those confined to static water levels. In the first 3 months, there were no significant differences between the impounded, fixed sets and all floating groups, including the tidal site. Thereafter, however, recruits subjected to tidal fluctuations (i.e., the impoundment opened to tidal influence and the fixed site in the bay) showed positive growth.

Whether in the open impoundment or the uncontrolled bay site, red mangrove recruits subjected to tidal exchange exhibited growth elongation significantly greater than the closed impoundment. In addition, there were no significant differences in growth start or success among genotypes or propagules of varied initial sizes. Although susceptibility to insect attack and dieback was greater in the elevated soil group, plant survival was not significantly affected by hydrologic treatment. These findings suggest that hydroperiod—the rate and level of tidal exchange—plays a much more important role in determining mangrove growth and success than previously documented.

Conclusion

These field and greenhouse experiments show that salinity may have less effect on mangrove growth and development than hydrologic conditions and substrate quality, particularly in freshwater and brackish zones. The lack of plant response to hydrology in the greenhouse study may be attributed to the regular inundation cycle that essentially kept soils saturated. These experiments also provide a framework to isolate causal relationships within a multifactorial design under both controlled and field conditions.

The hydrology and salinity experiments conducted by the U.S. Geological Survey have provided insight into the degree that hydrologic fluctuations and substrate quality augment mangrove growth and survival. This empirical evidence will be used to upgrade MANGRO, an existing mangrove forest simulation model. The refinement of MANGRO, in turn, will help private, State, and Federal land managers assess how large-scale water management projects and restoration alternatives may affect mangrove habitat and distribution in south Florida.

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