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CONTINUED STUDIES OF MANGROVE ECOSYSTEMS ON SAN SALVADOR ISLAND, BAHAMAS

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ABSTRACT

Mangrove ecosystems have been interpreted as demonstrating species zonation as a result of plant succession, geomorphology, physiological ecology, and population dynamics. There appears to be no consensus of scientific opinion explaining why zonation occurs and many exceptions to the "classical" pattern of zonation have been reported. On San Salvador Island, Bahamas, we have observed exceptions to this classical pattern of zonation. Reports in the literature hypothesize that a succession mechanism for zonation was not sequential replacement of species, but competition, modulated by nutrient pools, organic content of soil, temperature range, and salinity. To test the idea of nutrient pools, and/or salinity modulating zonation, since 1985, we have been conducting studies of soil nutrients and salinity from mangrove areas that exhibited zonation and non-zonation on San Salvador Island. Results of the initial studies did not support the hypothesis that nutrient pools modulate zonation. However, subsequent investigations did find some indication that salinity may be involved. More recently we have continued our analysis of these study sites and refined our salinity and soil analysis techniques for these mangrove soils. Our current results are consistent with our previous findings and support the idea that zonation may be due to salinity gradients.

INTRODUCTION

Kass and Stephens (1990) presented a preliminary study, conducted in 1986 and 1987, of mangrove swamp communities on San Salvador Island, Bahamas. In that study they reported exceptions to classical mangrove zonation on San Salvador. The results of the preliminary study, using both field and laboratory analysis techniques, did not support the idea that zonation, or lack thereof, was modulated by different concentrations of nutrient pools of ammonia, nitrate, or phosphate, as suggested by Johnstone (1983).

In 1988 and 1990, soils were again collected from the same soil sites investigated in 1986, and analyzed for ammonia, nitrate, and phosphate, in the laboratory at Elmira College, using Cornell Test Methods (Greweling and Peach, 1965). An analysis for potassium was added to this study. The same conclusions were supported from these results as were reported in the 1986 study. However, the results for potassium were not clear. While the 1988 analysis did not demonstrate differences in concentrations of potassium, the 1990 analysis indicated a difference in concentration of potassium at the sites studied.

In April of 1991, Kass and Stephens conducted additional field studies for soil nutrients at the Little Lake mangrove site on San Salvador Island, Bahamas (Fig. 1.) Concentrations of ammonia, nitrate, phosphate and potassium in the soils were analyzed. Additionally, the idea that zonation may be due to salinity gradients as suggested by Lugo and Snedaker (1974) was investigated in this 1991 study. Soil samples from all sites were also analyzed by laboratory methods.

MATERIALS AND METHODS

Field Analysis

Soil Nutrients

In 1991, soil samples were collected at 6 sites along the west shore of Little Lake, San Salvador Island, Bahamas (Fig. 1). Core samples were taken 50, 65, and 150 feet from

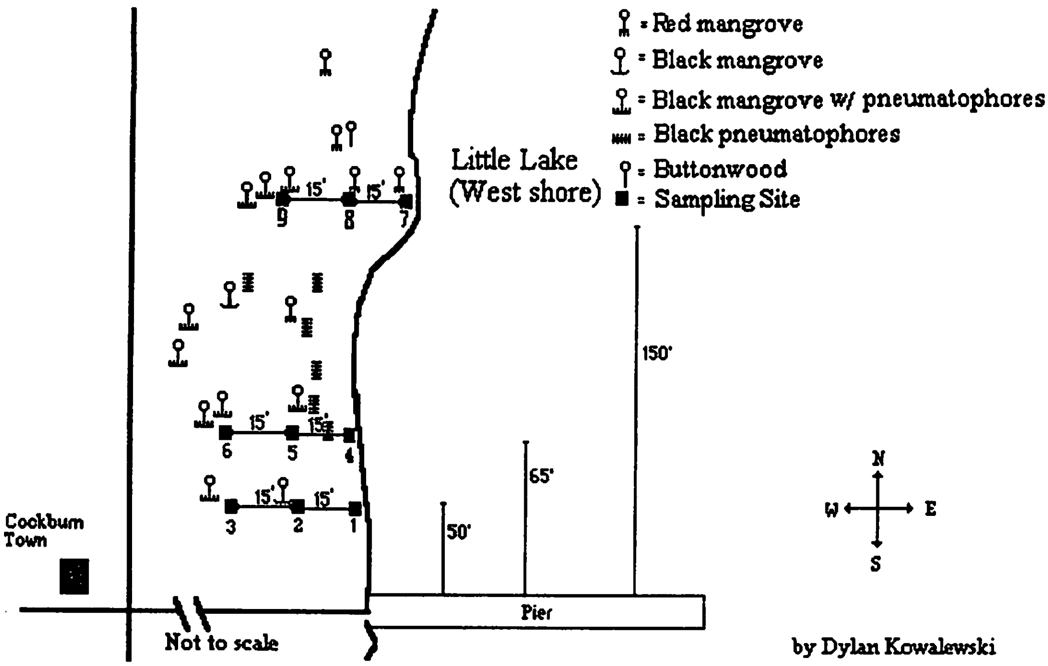

Figure 1. Mangrove site on west shore of Little Lake, San Salvador. Island, Bahamas.

the pier, along the shore, 15 feet from shore, and 30 feet from shore (Fig. 1). Each sample was placed into a zip loc bag and marked for identification. Instead of drying the soil on paper towels as was done in the previous study, the soil was dried in aluminum pie pans. This method was employed because it was suggested that nutrients may have been absorbed onto the paper towel during drying. Once the soil samples were dry they were analyzed using a Hach Soil Test Kit.

Salinity

Soils from the same sites were analyzed for total salinity using both a specific ion electrode and a Kernco Salinometer. Thirty grams of dry soil were suspended in 100 ml of deionized distilled water in a 500 ml nalgene bottle. The samples were swirled for 45 sec. and allowed to settle until the water was clear. The water was filtered through a piece of 9 cm Altstrom filter paper (grade 048-25). The filtered water was analyzed for total salinity.

LABORATORY ANALYSIS

The remaining soil from each sampling site was transferred to dry plastic zip loc bags and brought back to Elmira College. These samples were analyzed, during November 1991 - January 1992, at the Cornell University Nutrient Analysis Laboratory, employing the methods of McClenahan and Ferguson (1989) modified from Greweling and Peach (1965), and the Environmental Protection Agency (1979). Soils were analyzed for concentrations of ammonia, nitrate, phosphorous, and soluble salts. Analysis for ammonia was not detectable due to a color interference caused by excess calcium in these soils. The presence of potassium was not analyzed using these methods.

RESULTS

Mangrove Zonation

As reported previously (Kass and Stephens 1990), along the western shore of Little Lake, we observed Black Mangrove (*Avicennia germinans*) and Buttonwood (*Conocarpus erectus*) growing the same distance from shoreline, but generally not preceded by Red Mangroves (*Rhizophora mangle*) shoreward

(Fig. 1). In 1991, we observed a few Red Mangroves growing among these species. A line of Black Mangrove pneumatophores extends approximately 10 feet from the shore line (Figs. 1). Buttonwood and Black Mangrove grow in back of the line of pneumatophores. Behind these mixed species one finds an area of Black Mangroves and dense pneumatophores.

Soil Description

Soil samples taken along the shore were mostly sand and shells. Samples taken 15 feet from shore ranged from shells (closest to the pier) to shell and some organic matter (150 feet from the pier. Samples taken in dense pneumatophores (30 feet from shore) consisted of shell and organic matter.

Soil Nutrients

There were no obvious differences in the concentrations of ammonia (Table 1) or nitrate (Table 2) among the soil sites analyzed. The concentrations of phosphate (Table 3) do not seem to show a consistent trend. Concentrations of potassium (Table 4) appear to increase landward, and are highest in the areas of dense pneumatophores.

Salinity

It appears there is an increase in the salinity gradient as one moves from shore inland (Table 5). The lower value for sample site #3 may be due to the soil not being associated with dense pneumatophores.

Field Vs. Laboratory Analysis

The results obtained with the Hach field analysis kit were consistent with the soil analysis, for nitrate and phosphate, under laboratory conditions. We believe, therefore, that we can now conduct further field studies using the Hach analysis technique. Laboratory analysis for salinity was also consistent with field study techniques.

CONCLUSIONS

Our results do not support the idea that zonation is modulated by concentrations of ammonia, nitrate, or phosphate. The concentration of potassium in the soil,

Table 1. Soil Analysis of ammonia (NH_3)* from Little Lake San Salvador Island, Bahamas, 1991.

Locality	50' N of Pier	65' N of Pier	150' N of Pier
Along Shore	15, 17.5	19, 19	21, 24
15' from shore in front of Pneumatophores	10, 10	20, 20	25, 25
30' from shore in dense Pneumatophores	19, 19	20, 20	24, 30

*Analysis done using Hach Soil Test Kits; values in ppm.

Table 2. Soil Analysis of nitrate (NO_3^-) from Little Lake San Salvador Island, Bahamas, 1991.

Locality	50' N of Pier	65' N of Pier	150' N of Pier
Along Shore	(No detection) [<0.1]	(6.5) [<0.1]	(No detection) [<0.1]
15' from shore in front of Pneumatophores	(No detection) [0.1]	(No detection) [<0.1]	(8) [<0.1]
30' from shore in dense Pneumatophores	(16.5) [0.3]	(No detection) [<0.1]	(No detection) [0.1]

( ) Analysis done using Hach Soil Test Kits; values in ppm.

[ ] Analysis done using Cornell Test Methods (McClenahan and Ferguson 1989); values in ppm.

Table 3. Soil Analysis of phosphate (PO_4^{-3}) from Little Lake San Salvador Island, Bahamas, 1991.

Locality	50' N of Pier	65' N of Pier	150' N of Pier
Along Shore	(24) [0.2]	(64) [0.8]	(28) [0.4]
15' from shore in front of Pneumatophores	(80) [8.4]	(22) [0.7]	(26) [2.2]
30' from shore in dense Pneumatophores	(62) [5.1]	(30) [5.5]	(42) [4.8]

( ) Analysis done using Hach Soil Test Kits; values in ppm.

[ ] Analysis done using Cornell Test Methods (McClenahan and Ferguson 1989); values in ppm.

Table 4. Soil Analysis of potassium (K)* from Little Lake San Salvador Island, Bahamas, 1991.

Locality	50' N of Pier	65' N of Pier	150' N of Pier
Along Shore	50	128	150
15' from shore in front of Pneumatophores	50	25	100
30' from shore in dense Pneumatophores	85	240	355

* Analysis done using Hach Soil Test Kits; values in ppm.

Table 5. Determination of Soil Salinity from Little Lake San Salvador Island, Bahamas, 1991.

Locality	50' N of Pier			65' N of Pier			150' N of Pier		
	g/l	%	umhos/cm	g/l	%	umhos/cm	g/l	%	umhos/cm
Along Shore	5	0.5	5300	6	0.6	10400	9.0	0.7	12200
15' from shore in front of Pneumatophores	2.5	0.2	900	2.5	0.3	2600	3.9	0.4	4600
30' from shore in dense Pneumatophores	3.6	0.3	3500	37	3.5	35600	32	2.5	38800

g/l - determined by specific ion electrode
% - average of 3 replicates determined with a Salinometer
umhos/cm - determined at Cornell Nutrient Analysis Laboratory measuring electrical conductivity

however, appears to increase in the areas supporting the greatest density of Black Mangroves. The highest concentration of salt is also apparent in soil among the dense pneumatophores of the Black Mangroves growing farthest from the shoreline. These results for salinity are consistent with the ideas of Watson (1928, as reported by Snedaker, 1982), who suggested tidal patterns affecting inundation and drainage are also a primary factor in zonation of mangrove species in Malaysia. In 1974, Lugo and Snedaker extended this concept to include salinity of inundating water. Since the inland lakes of San Salvador are tidal and hypersaline, it is possible that the distribution of mangroves growing along these lakes is due to tidal inundation and is modulated by evaporation. The lack of Red Mangroves at the highest salinity support the idea that Black Mangroves have a better capacity to survive in such areas. Tiwari *et al.* (1979) reported that Black mangroves are known to live in soils of 90% salinity. Additionally, as reported by Snedaker (1982), zonation may be due to a physiological response to tide maintained gradients, and each species may have definable tolerances and optima under specific conditions. Recent reports in the literature seem to support this idea (Burchett *et al.*, 1989; Gordon, 1988; Pezeshski, DeLaune, and Partick, 1990; Smith 1988). Furthermore, a species that can grow in an environment with a higher concentration of potassium may be consistent with our understanding of the potassium modulated membrane ATPase on cell membranes, a requirement for ion exchange (Salisbury and Ross, 1992).

REFERENCES CITED

Burchett, M.D., C. J. Clark, C. D. Field, and A. Pulkownik. 1989. Growth and respiration in mangrove species at a range of salinities. Physiol. Plant. 75: 299-303.

EPA. 1979. Methods for Chemical Analysis of Water and Wastes. U.S. EPA Environmental Monitoring and Support Laboratory, Publication EPA-600/4-79-020.

Gordon, D. M. 1988. Disturbance to mangroves in tropical-arid western Australia: Hypersalinity and restricted tidal exchange as factors leading to mortality. J. Arid Env. 15: 117-145.

Johnstone, I. M. 1983. Succession in zoned mangrove communities: Where is the climax? Chapter 15 in Biolgy and ecology of mangroves, ed. H. J. Teas. Tasks for Vegetation Science 8. Dr. W. Junk Pub. The Hague.

Kass. L. B. and L. J. Stephens. 1990. The trees of the mangrove swamp community of San Salvador Island, Bahamas and their "succession" patterns. In Proceedings of the Third Symposium on the Marine and Terrestrial Botany of the Bahamas, R. Smith ed. Bahamian Field Station. San Salvador, Bahamas. pp 53-65.

Lugo, A. E., and S. C. Snedaker. 1974. The ecology of mangroves. Ann. Rev. Ecol. Syst. 5: 39-64.

McClenahan, M. C. and G. Ferguson. 1989. Methods for Soil, Plant, and Water Analysis. Cornell University Nutrient Analysis Laboratory. Ithaca, N. Y.

Pezeshki, S. R., R. D. DeLaune, and W. H. Partick. 1990. Differential response of selected mangroves to soil, flooding and salinity: Gas exchange and biomass partitioning. Can. J. For. Res. 20(7): 869-874.

Salsibury, F. B. and C. W. Ross. 1992. Plant Physiology 4th ed. Wadsworth Pub. Co. Belmont CA.

Smith, Thomas J. III. 1988. Differential distribution between subspecies of the mangrove *Cerops tagal*. Competitive interactions among a salinity gradient. Aqu. Bot. 32: 79-89.

Snedaker, Samuel C. 1982. Mangrove species zonation: Why? Chapt 1 in Contributions to the ecology of halophytes, eds. D. N. Sen and K. S. Rajpurohit. Task for vegetation Science 2. Dr. W. Junk Pub. The Hague.

Tiwari et al. 1979. State of the Art Report on Mangrove Ecosystems. Government of India, New Delhi.