CHARACTERISTICS OF LIGHTNING GAPS IN THE MANGROVE FORESTS OF EVERGLADES NATIONAL PARK.

Kevin R. T. Whelan[1] and Thomas J. Smith III[2]

[1] Student Career Experience Program

[1,2] U. S. Geological Survey
Center for Water and Restoration Studies.
C/o Biological Sciences, OE 167,
University Park
Florida International University
Miami, Florida, 33199. 305-348-6047.
whelank@fiu.edu
tom_j_smith@usgs.gov

Photo 1: Aerial view of a recently created lightning gap. Shark River area.

ABSTRACT

Florida has the highest level of cloud to ground lightning strikes in the United States. Consequently, gap formation in the mangroves due to lightning strikes is a common disturbance phenomenon. We investigated some basic characteristics of lightning gaps in the mangroves of Southwest Florida. The 39 lightning gaps censused were comprised of mixed species and age classes of mangroves. The mean canopy gap area was 212 m^2 and the extended gap size was 299 m^2. Gaps were slightly elliptical in shape with an average eccentricity of 1.28. However, there was no evidence of wind extensions to the gaps. Gap size was partially explained (33%) by surrounding tree height. In a subset of six gaps of differing age we have found that coarse woody debris is generally higher than the surrounding forest. We propose to develop a relative aging formula based on this relationship. Our investigation of sediment parameters of these same gaps has found that there is no difference in soil bulk density; however, the soil cohesiveness in the gaps is lower than the closed canopy forest. We additionally found differences in the mean abundance of crab burrows depending on gap successional status.

Keywords: Lightning strike, gaps, extended gap area, mangroves

INTRODUCTION

Lightning gaps have been identified as a common disturbance in mangroves throughout the world, including Papua New Guinea (Paijmans and Rollet 1977), Malaysia (Anderson 1964), Panama (Smith 1992), Florida (Odum et al. 1982, Smith et al. 1994), and the Dominican Republic (Sherman et al. 2000). Lightning created canopy gaps are abundant in the mangrove forests of Florida (Photo 1, 2, 3). An average 5,000 cloud to ground strikes occur annually in Florida, the highest level found in the United States. The dynamics of Florida mangrove systems may result from the interactions of small-scale lightning gaps, large-scale hurricane disturbances and sea level rise. In addition to these ecosystem forcing functions are the modifications due to the Greater Everglades Restoration effort. This effort will greatly influence hydrological flow through much of the 100,000 ha of mangroves in South Florida. Clearly, to understand how the mangrove ecosystems may change in response to restoration it is important to determine how these mangrove ecosystems respond to small- and large-scale disturbance along with sea level rise. To understand lightning gaps in mangroves it is imperative to determine some basic characteristics of these types of gaps. This is only the second time lightning created gaps in the mangrove ecosystem have been extensively studied.

The goal of this project is to characterize the role of lightning generated gaps within South Florida mangrove ecosystems. This is being accomplished by: following short-term changes in community level and environmental processes; evaluating community characteristics in a time series of gaps along a known salinity gradient; and appraising the regional impact of mangrove gap dynamics. Here we present findings of 39 gaps from the general region for canopy and expanded gap size and direction of orientation. Additionally, we present initial findings of habitat characteristics for six gaps of differing successional age located in the lower Shark River Region.

OBJECTIVES

- •Determine basic gap characteristics.
  - •Compare canopy gap area and extended gap area.
  - •Size distribution, gap orientation.
  - •Relationship of gap area to surrounding forest height.
- •Investigate differences due to gap age.
  - •Relate relative gap aging based to the amount of coarse woody debris amount.
  - •Determine sediment parameters:
- •Sediment compaction, sediment shear strength, and bulk density.
- •Crab abundance.

METHODS

•Gap area was based on an elliptical approximation techniques (area = $\pi LW/4$) Three estimations (visual longest axis, cardinal and primary intercardinal compass directions).

•Height measurements of 8 trees that surrounded the gap (using a clinometer).

•Coarse woody debris transect surveys (following the methods of Allen 2000).

•Crab counts of Eight 1 m^2 plots per gap (3 new, 5 closing, and 3 forest sites).

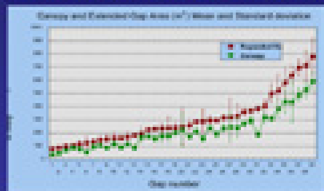

Figure 1 Comparison of canopy and extended gap area for 39 gaps.

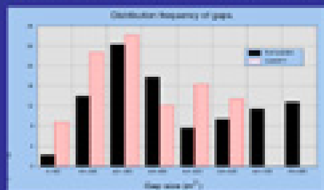

Figure 2 Size distribution of gap area.

Figure 3 Expanded gap size versus surrounding tree height.

Figure 4 Relative aging of gaps.

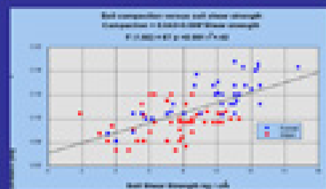

Figure 5 Soil compaction versus soil shear strength.

Figure 6 Abundance of crab burrows by gap successional status.

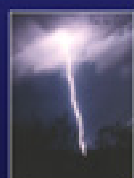

Photo 3: Aerial view of newly created lightning gaps and older gaps.

Photo 2: Clearly visible, elliptic patch of dead standing trees. Shark River area.

STUDY AREA

RESULTS

•There is little difference in canopy and extended gap area. Gap size varies from 37 m^2 to 779 m^2. Most gaps occur in the 201-300 m^2 (28%) with an average canopy gap area of 212 m^2 and an extended gap area 299 m^2 (Figure 1 + 2).

•Gap size was partially explained (33%) by surrounding tree height (large gaps tend to be in forests of larger trees (Figure 3)).

•We have developed a relative aging of gaps based on the ratio of the coarse woody debris of the gap (16.7 to 192 tons ha^{-1}) compared to the average of coarse woody debris amount for the study island (82.82 tons ha^{-1}). There is a linear relationship between relative gap age and the amount of coarse woody debris present. (Older gaps had a greater amount of woody debris compared to younger aged gaps (Figure 4)).

•We assessed sediment parameters for six gaps of different successional age and found that compaction is significantly lower in gaps (0.094 kg/cm^2) and higher in the surrounding closed canopy forest (0.124 kg/cm^2). The same was true for sediment shear strength (gap mean = 7.4 kg/cm^2 and forest mean = 8.8 kg/cm^2). Shear strength and soil compaction taken together indicates soil cohesiveness. There is a linear relationship between these parameters and our data supports this linear relationship. Consistently, gap samples were grouped towards lower end of this relationship (Figure 5).

•There was no difference in sediment bulk density between gaps and the surrounding forest (gap mean = .18 forest mean = .20 student t = -0.67 $p > 0.50$).

•The total abundance of fiddler crab burrows decrease as gaps recover. This occurs due to a reduction in the number of small burrows present in closing gaps (Figure 6 - MANOVA main effect gap status Rao R=17.7 df=8 df2 = 100 $p<0.01$).

CONCLUSION

Lightning created gaps in south Florida are approximately 299 m^2 with a directional bias of the longest axis in the 60-90 degree direction. The surrounding forest height affects the size of the lightning gap created. The lightning gaps are elliptical in shape (1.28 eccentricity). These are on average smaller but of similar shape to other lightning created gaps in the mangroves reported by Sherman et al. 2000. We have proposed a possible relative aging technique based on the amount of coarse woody debris in a gap compared to average coarse woody debris in the surrounding forest. In the further we will use historical aerial photographs to age a subset of gaps and using this ratio of CWD will develop an equation for relative aging. It appears that roots within the lightning created gaps die as a consequence of above ground tree mortality and possibly from the lightning itself. Root death causes the physical properties of the sediment to differ from the surrounding forest type. We found that sediment compaction and shear strength is significantly lower in gaps than surrounding forest. Additionally, soil cohesiveness is lower in the gaps, however, there was no difference in sediment bulk density between gaps and the surrounding forest. Additionally, there are differences in the size distribution of crab burrows which may be related to these soil parameters. There are plans to extend this type of investigation of lightning gaps to the mid-stream and upstream areas of the Shark River Region. In this way we will investigate the effect of salinity on the recovery process.

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CITATIONS
Anderson, J.A.R. 1964. Some observations on climatic damage in peat swamp forests in Sarawak. Commonwealth Forestry Review. 43: 145-158.
Allen, J. A., K. C. Ewel, B. D. Keeland, T. Tara & T.J.Smith III. 2000. Downed wood in Micronesian mangrove forests. Wetlands. Vol. 20, No 1, pp. 169-176.
Odum, W.E., McIvor, C.C. & Smith, T.J., 1982. The mangroves of South Florida: a community profile. FWS/OBS-81/24. Fish and Wildlife Service. Washington, DC.
Paijmans, K. & Rollet, B. 1977. The mangroves of Galley Reach, Papua New Guinea. Forest Ecology and Management. 1:119-140.
Runkle, J.R. 1981. Gap regeneration in some old-growth forests of the eastern United States. Ecology. 62(4): 1041-1051.
Sherman, R.E., Fahey, J.T. & Battles, J.J., 2000. Small-scale disturbance and regeneration dynamics in a neotropical mangrove forest. Journal of Ecology. 88:165-178.
Smith, T. J. III. 1987. Seed predation in relation to tree dominance and distribution in mangrove forest. Ecology. 68, 266 – 273.
Smith T.J. III, 1992. Forest structure. Tropical Mangrove Ecosystems (ed A.I.Robertson & D.M. Alongi), pp 101-136. American Geophysical Union
Smith, T.J. III, Robblee, M.B., Wanless, H.R. & Doyle, T.W. 1994. Mangroves, hurricanes and lightning strikes. Bioscience. 44:256-262.