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Late Holocene Ecological Development of the Graeme Hall Swamp, Barbados, West Indies

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ABSTRACT.—Understanding coastal evolution and recent sea level changes are important for small island states. A 2.25m core of wetland sediments lifted from the Graeme Hall Swamp in Barbados provides a 1,400 year record of sedimentological and vegetation change. Mineral and organic matter that are coincident with the development of a red mangrove community overtop basal carbonaceous sands. Despite its coastal location, geomorphological features preclude of chronology with sea level change.

KEYWORDS.—Mangroves, sea level change, coastal geomorphology, fossil pollen, radiocarbon dates, sublittoral molluscs

Studies from Caribbean sites (Ramcharan 2004; Digerfeldt and Hendry 1987; Feller et al. 1990) show that mangrove wetland formation began about 6,000 years ago when the rate of post-glacial sea level rise slowed. Red mangrove (*Rhizophora mangle* L.) communities growing in low energy coastal environments, that have substantial freshwater/marine hydraulic gradients, produce large amounts of organic matter that accumulate in situ to form peat. Because the mangrove habitat also accumulates mineralogic and biogenic sediments that are transported on tidal and fluvial flows, it can indicate local marine and terrestrial influences. Since red mangrove communities usually occupy the upper half of the tidal range, the presence of fossil mangrove pollen in the sediments has been used to indicate Holocene sea levels (Ellison 1986; Kaplan 2003; Ramcharan 2004). Ellison (1986) further showed that the sequential deposition of mangrove peat is a useful proxy indicator of sea level rise.

Barbados (13°10'N, 59°30'W) is a low carbonate island with a limestone cap that is fissured and fractured from uplift and erosion. Carbonate reef deposits off the island's southeast coast provided evidence of post-glacial sea level rise (Fairbanks 1989). However, the late-Holocene record (the past 6,000 years) is not well documented. The Graeme Hall swamp (Fig. 1), is a mangrove/herbaceous marsh community that occupies a 35 ha sinkhole on the island's south coast and supports the only existing *Rhizophora mangle* community in Barbados. That mangroves occur in Barbados is intriguing because the island supports no rivers, it is located east of the major Caribbean Sea currents that could transport mangrove propagules, and it is distant from possible provenance sources in South America. This paper describes the chronological development of the wetland and suggests the possible role of changing sea levels.

A 2.25 m long sediment core was lifted from the wetland with a Dachnowsky-type corer. Samples for fossil pollen analysis were prepared according to Cwynar et al. (1973), while thermal analysis of sediments follows Dean (1974). Fossil pollen identifications were based on Roubik and Moreno (1991) and checked against the pollen reference collection at the Royal Ontario Museum, Toronto, Canada. Radiocarbon dating was done at the Geology Department of Brock University, St. Catharines, Ontario, Canada, and calibration followed Stuiver and Reimer (1993). Loss-on-ignition (LOI) and fossil pollen diagrams were drawn using CANPLOT (Campbell and McAndrews 1992).

The sediments comprise basal biogenic sand (coral, algal and mollusc shell fragments) over-topped by peat and organic muds (Fig. 2a). Basal sand suggests a bay at the location while organic matter indicates an expansive plant community. High silicate amounts indicate land-based erosion. A reduction in carbonate sediments at 190

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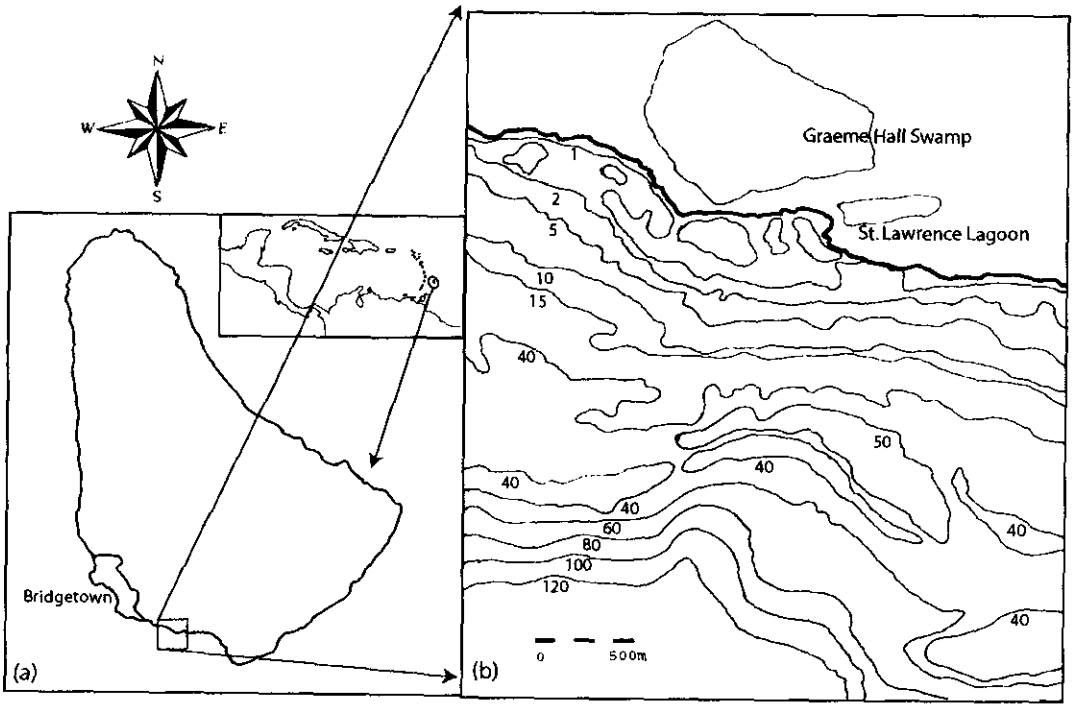

FIG. 1. *Map showing the coastal physiography and location of the Graeme Hall swamp in the south coast of* Barbados.

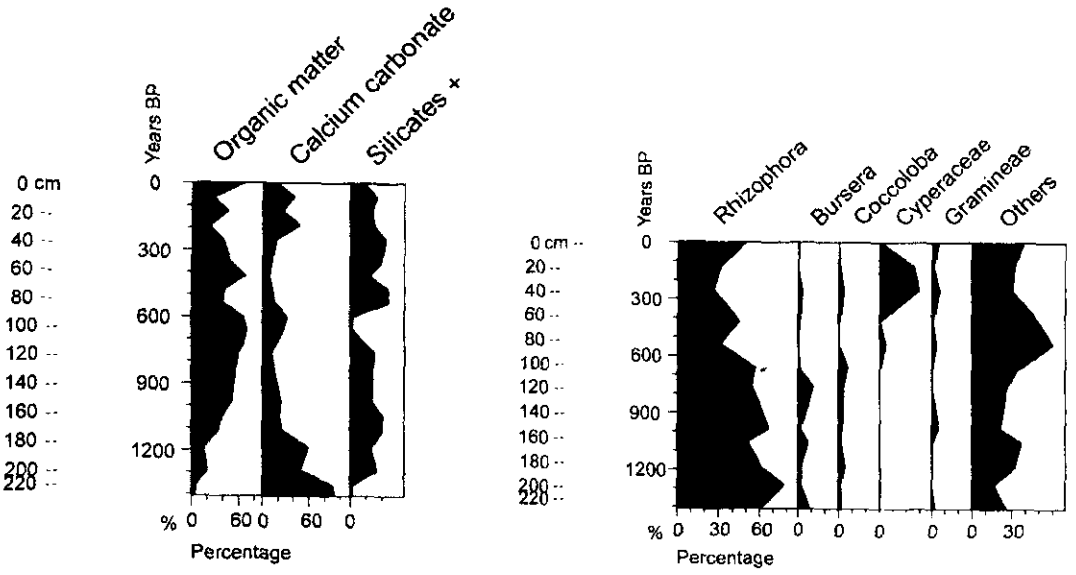

FIG. 2. A. (left) Loss on Ignition diagram showing the percentage occurrence of organic matter, carbonates and silicates in the sediments. The depth scale (Y-axis) is accompanied by an interpolated chronology. B (right) Percentage distribution of key fossil pollen taxa in the sediments. The depth scale (Y-axis) is accompanied by an interpolated chronology.

cm and a corresponding rise in silicates suggest restriction of the marine influence and synchronous sediment retention in the bay, while the increase in carbonates at 90-100 cm suggests wave over-topping under storm conditions. Increased calcium concentrations associated with high silicate values in the upper core segments, suggest deposition from land-based sources due to agriculture.

Two radiocarbon dates (Table 1) based on mollusc shells and wetland peat provides a chronology of wetland and vegetation development over the past 1,300 years. Fossil pollen analysis of the sediments (Fig. 2b) shows red mangrove dominating the record from earliest times. Initially, mangrove pollen counts were low, suggesting that the community was a fringing mangrove (van der Hammen 1963); the higher pollen counts and peat deposition that is present later confirm a stronger, though not dominant, *Rhizophora* presence. Other species in the record include birch gum (*Bursera simaruba*), sea grape (*Coccoloba uvifera*), and several Cyperaceae. Several other species remain unidentified, suggesting diversity in the local flora. Three pollen zones are recognized. Zone 1 (1,300-700 years B.P.) comprises *Rhizophora* associated with *Bursera*, *Coccoloba* and other coastal plants. A low absolute count of *Rhizophora* pollen in this zone suggests early colonization of the site by a fringe mangrove community in a littoral environment. Zone 2 (700-400 years B.P.) shows increasing species diversity that is associated with a decline in *Rhizophora* and the reduced presence of *Bursera* and *Coccoloba*. A sharp increase in carbonates between 600 and 700 years B.P. suggests a storm event that would have damaged the tree communities and allowed a weedy flora to establish. Zone 3 (the past 400 years) is represented by an increase in Cyperaceae, possibly a result of land clearing after settlement. The increase in *Rhizophora* pollen in the uppermost level of the core is likely due to current land management activities that are focused on maintaining the mangrove communities that now occupy the wetland.

From the basal sands, 11 species of molluscs from 9 families were collected. Several species are habitat specific and are commonly found on rocky shore/sublittoral (*Cerithium* sp., *Batillaria minima*, and *Bulla striata*), soft bottom (*Anodonta alba*, *Tagelus divisus*), and brackishwater (*Neritina virginea*) habitats. The absence of marine molluscs from the upper levels of the core suggests a rapid change from the initial marine conditions that existed at the site, and the establishment of less saline conditions that affected them adversely.

Since red mangroves occupy the upper half of the tidal range, the presence of fossil *Rhizophora* pollen has been used to indicate Holocene sea levels (Ellison 1986; Ramcharan 2004; Kaplan 2003). This relationship between mangroves and sea levels assumes hydraulic connectivity between the wetland and the coastal nearshore. However, as a facultative halophyte, *Rhizophora* can exploit a range of salinity and hydraulic conditions and so can indicate sea level only under restricted conditions. The early reduction in marine influence at Graeme Hall suggests that hydraulic connectivity was impaired and compromises the use of these radiocarbon dates to determine sea level state.

A localized depression in the coral cap facilitated the formation of a marine embayment that initially supported a marine molluscan epifauna and a fringing red mangrove community that expanded as the marine influence diminished. Land-based sediments and authocthonous peat accumulated at the site and facilitated

TABLE 1. Calculated and calibrated radiocarbon dates of Graeme Hall Swamp sediments, Barbados.

Sample depth (cm)	Material type	Calculated ^{14}C date (BP)	Calibrated ^{14}C date (BP)	Laboratory number	Sedimentation rate (mm/yr)
104-114	Peat	833 ± 75	690 ± 75	BGS 2397	1.9 mm/yr
225	Mollusc shells	1,409 ± 40	1,300 ± 40	BGS 2395	

mangrove expansion and created habitats for other coastal plants. The increase in fossil Cyperaceae pollen suggests de-watering of the wetland, possibly for agriculture. Since unrestricted tidal flows identify sea level position, *Rhizophora* communities indicate sea level selectively.

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Monitoring Efforts Yield New Plant Records For Mona Island, Puerto Rico, A Tropical Dry Forest Wonderland

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Abstract.—Intensive ecological monitoring on Mona Island, Puerto Rico, yielded seven new floristic records for the island. We report for the first time the following flowering plants: *Chamaescyse ophthalmica* (Pers.) D. G. Burch, *Flueggea acidoton* (L.) G. L. Webster (both Euphorbiaceae), *Heteropogon contortus* (L.) P. Beauv. ex Roem. & Schult. (Poaceae), *Neptunia plena* (L.) Benth. (Fabaceae), *Piriqueta*

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