Acta Oecologica 63 (2015) 82–90

Contents lists available at ScienceDirect

Acta Oecologica

journal homepage: www.elsevier.com/locate/actoec

Recent advances in understanding Colombian mangroves

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ARTICLE INFO

Article history:
Received 28 February 2013
Received in revised form
21 November 2014
Accepted 12 January 2015
Available online 22 January 2015

Keywords:
Mangroves
Dynamics
Palynology
Coastal ecosystems
Colombia

ABSTRACT

Throughout the last 15 years, researchers at the National University of Colombia at Medellin have studied Colombian mangroves. Remote sensing, pollen analysis of superficial and deep sediments, Holocene coastal vegetation dynamics, sediment dating using ^{14}C and ^{210}Pb, sampling in temporary plots, sampling in temporary and permanent plots, and other techniques have been applied to elucidate long- and short-term mangrove community dynamics. The studied root fouling community is structured by several regulatory mechanisms; habitat heterogeneity increases species richness and abundance. Fringe mangroves were related to Ca concentration in the soil and the increased dominance of *Laguncularia racemosa* and other nonmangrove tree species, while the riverine mangroves were associated with Mg concentration and the dominance of *Rhizophora mangle*. The seedling and mangrove tree distributions are determined by a complex gradient of natural and anthropogenic disturbances. Mangrove pollen from surface sediments and the existing vegetation and geomorphology are close interrelated. Plant pollen of mangrove and salt marsh reflects environmental and disturbance conditions, and also reveals forest types. Forest dynamics in both coasts and their sensitivity of to anthropogenic processes are well documented in the Late Quaternary fossil record. Our studies of short and long term allow us to predict the dynamics of mangroves under different scenarios of climate change and anthropogenic stress factors that are operating in Colombian coasts. Future research arises from these results on mangrove forests dynamics, sea-level rise at a fine scale using palynology, conservation biology, and carbon dynamics.

1. Introduction

Mangrove trees grow along subtropical and tropical coasts, where they fulfill several valuable socioecological and economic services (Alongi, 2009). Mangrove forests are a valuable economic resource as important breeding grounds and nursery sites for various animal species, including offshore fish populations (Barbier, 2000; Nagelkerken et al., 2008). They stabilize coastal lands and offer protection against storms, tsunamis, and sea-level rise (e.g., Dahdouh-Guebas et al., 2005; Mukherjee et al., 2010). More than 90% of the world's mangroves are located in developing countries (Duke et al., 2007), where impoverished human populations depend on their resources for subsistence (Walters et al., 2008). In this context, a group of researchers at the National University of Colombia studied different aspects related to the goods and services of mangroves in Colombia.

Colombia is the only South American country with coastlines on the Pacific Ocean (1200 km) and the Caribbean Sea (>1800 km). Precipitation and tidal patterns vary between these coasts. There are two dry seasons each year along the Caribbean coast, where the average rainfall does not exceed 2500 mm year^{-1}. There is a rainfall gradient from the northeast to the western Caribbean, including the islands of San Andrés, Providencia, and Santa Catalina (Fig. 1) (Álvarez-León and Polanía, 1996; Lacerda et al., 2001). In contrast, heavy rains (>3000 mm year^{-1}) predominate the Pacific coast throughout the year, where the mean tidal range is about 3 m. These conditions guarantee nearly continuous strips of mangroves along the Pacific coast, whereas in the Caribbean, narrow strips of forests are linked to freshwater sources (Zamora et al., 2013).

Such patterns of rainfall, tides, and local geomorphology produce mangrove stands with different structures and species compositions. Mangrove species that comprise the canopy of Caribbean mangroves are *Rhizophora mangle* L. (red mangrove), *Avicennia germinans* (L.) L. (black mangrove), *Laguncularia racemosa* (L.) C.F. Gaertn. (white mangrove), *Conocarpus erectus* L., *Pelliciera rhizophorae* Planch. & Triana, and the fern *Acrostichum aureum* L. Colombian Pacific mangroves are built of *Rhizophora racemosa* G. Mey., the putative hybrid *Rhizophora harrisonii* Leechm. (*cf* Cerón-

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http://dx.doi.org/10.1016/j.actao.2015.01.001
1146-609X/

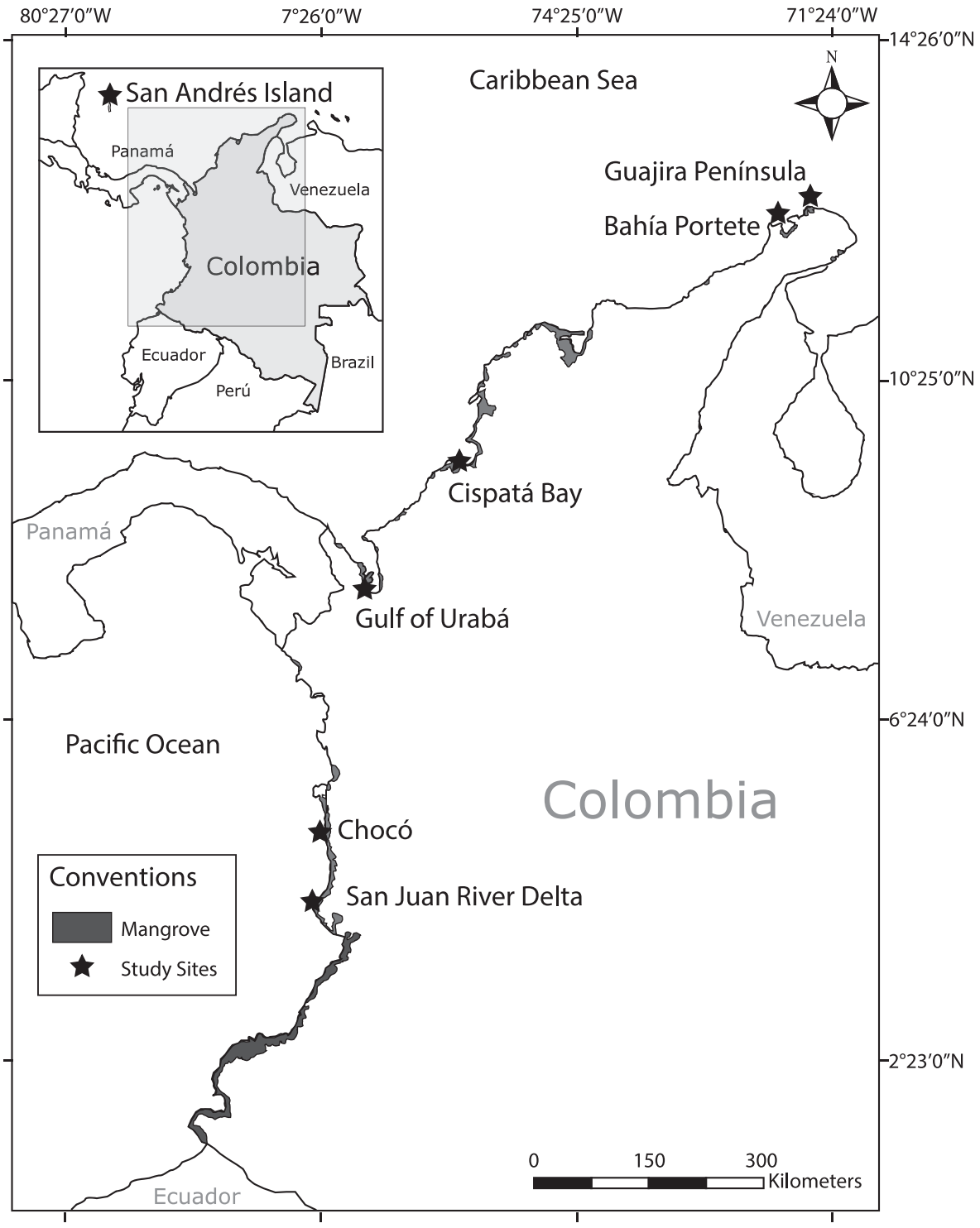

Fig. 1. Map of the distribution of mangroves and the study sites in Columbia.

Souza et al., 2010), and *Mora megistosperma* (Pittier) Britton & Rose. Mangrove stands south of the San Juan River are more developed than those of the northern coast (Sánchez-Páez et al., 2000; Lacerda et al., 2001).

Our sites are found throughout the Caribbean: San Andrés Island in the west, the Gulf of Urabá at the southern limit, Guajira Peninsula in the driest northeastern part, and Cispatá Bay on the central Colombian coast. The Caribbean Current flows from east to west past San Andrés Island and the Old Providence Archipelago, and then detours to the southwest at the Nicaraguan Rise to form a counterclockwise eddy in the southwestern Caribbean (Geister and Díaz, 1997). In the archipelago, sediment-laden runoff from the Central American continent fails to affect the transparency and salinity of its ocean waters. There have been few thorough investigations of our sites compared to the Ciénaga Grande de Santa Marta, the largest extent of mangrove forests in the Colombian