



Review and synthesis

Mangroves and people: Lessons from a history of use and abuse in four Latin American countries



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ABSTRACT

From native pre-Columbian subsistence economies to the modern global economy, mangroves have played an important role providing goods and services to human societies for millennia. More than 90% of the world's mangroves are located in developing countries, where rates of destruction are increasing rapidly and on large scales. In order to design effective conservation strategies, it is critical to understand the natural dynamics and anthropogenic drivers of these coastal wetland habitats. We use retrospective techniques to reconstruct mangrove forest history in the Eastern Tropical Pacific. We examine available, present day estimates of mangrove area and evaluate the representation of mangroves in the protected area systems of Costa Rica, Panama, Colombia and Ecuador, evaluating existing policies regarding mangroves. Archaeozoological evidence shows that mangroves were exploited for many thousands of years by pre-Columbian societies. Post-conquest deforestation prevailed during the next 400 years. Since 1990, despite increasingly positive attitudes towards mangroves and their inclusion in protected areas and conservation policies, mangrove cover has continued to decline due to expanding human activities (agriculture, aquaculture, coastal development), even in the presence of laws prohibiting their removal. Here we provide an historical ecology baseline of mangroves in the Eastern Tropical Pacific, from which to view current trends and map future trajectories. Given the myriad negative consequences of mangrove loss recorded worldwide, and the strong ecological connectivity of the region, developing effective strategies for mangrove management at an appropriate scale will be paramount to protect coastal livelihoods and biodiversity.

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1. Introduction

Largely restricted to tropical and subtropical latitudes, mangroves are the only vascular flowering trees that can live in the confluence of land, freshwater, and ocean (Hogarth, 2007). This involves adapting to fluctuating environmental conditions such as changes in salinity, regular soil inundation, shifting sediments, and in-water low oxygen concentrations (Kathiresan and Bingham, 2001). As such, mangroves display a large set of morphological and ecophysiological adaptations to help them survive in these dynamic habitats. Among these adaptations are (1) the exclusion of salt by roots, (2) rapid canopy growth, (3) viviparous embryos, (4) tidally dispersed propagules, (5) exposed roots that breathe above ground, (6) highly vascularized wood, (7) efficient nutrient retention, and (8) salt-excreting leaves (Alongi, 2002; Duke, 2011).

Despite being considered a rare forest type because of their small global extent (less than 1% of tropical and subtropical forests worldwide), mangroves provide a wide range of ecosystem services and direct uses including coastal protection, fuel (charcoal, firewood), food (fruit, leaves, associated vertebrates and invertebrates), and construction material (Hogarth, 2007). Even though the ecological importance of mangroves has come to be widely recognized, reports of the Food and Agriculture Organization show a widespread decline of mangrove area, with losses over 20% of total global coverage (36,000 km²) between 1980 and 2005 alone (FAO, 2007a). It has been claimed that estimated rates of mangrove loss are three to five times greater than the overall loss rates calculated for other forests and coral reefs on a global scale (Valiela et al., 2001). In light of the current degradation rate of marine ecosystems, intensifying anthropogenic impacts, and climate change, protected areas emerge as an essential strategy for conservation. More than 90% of the world's mangroves are located in developing countries, where rates of destruction are rapidly increasing (Duke et al., 2007).

In order to design more effective conservation strategies, it is critical to understand long-term anthropogenic effects as well as the natural dynamics of this marine-coastal habitat in space and time. Study of forests' past dynamics represents a fundamental insight (Dahdouh-Guebas and Koedam, 2008). Pre-Columbian societies represent more than 95% of the history of mangrove/human interaction in the neotropics. Historical ecology techniques derived from social sciences, such as exploration of documentary archives and archaeological investigations, can provide valuable information and complement other direct survey methods (e.g. remote sensing) applied to understand current processes and map possible future trajectories (Dahdouh-Guebas and Koedam, 2008).

The Eastern Tropical Pacific (ETP), is a distinct marine ecoregion encompassing continental shore between southern Baja California to northern Peru including oceanic island groups such as Cocos, Malpelo, and Galápagos oceanic islands (Spalding et al., 2007). However, within this broader region, the Pacific waters of Panama, Costa Rica, Colombia and Ecuador (Fig. 1) share particular conservation significance by containing a cluster of World Heritage Sites (Edgar et al., 2011). This area, termed in this study as the ETP, is an important biogeographical region in terms of marine resource productivity and biodiversity, supporting a range of rich fisheries and exhibiting many endemic species (Fiedler and Talley, 2006). In this paper we use retrospective techniques to reconstruct mangrove forest history in ETP countries, with the aim of understanding the historical reasons behind mangrove deforestation in the region. Additionally, we review available estimates of mangrove area from recent years and evaluate the representation of mangroves in the marine protected areas of four countries, examining existing policies regarding mangrove conservation. The historical timeline of ETP mangrove forests and their current protection status that we

present improves our understanding of the relationship dynamics between mangroves and humans, and provides a regional information baseline from which governments can build improved management strategies.

2. An historical timeline of mangrove decline

2.1. Evolution of perceptions & attitudes towards mangroves

Mangroves' ability to thrive in salt water has attracted substantial scientific attention and academic curiosity, especially among botanists (Walters et al., 2008). However, since our understanding of the services provided by mangroves, as a coastal habitat has been scant and defective until recently, attitudes towards mangroves as an ecosystem have been ambivalent (Lugo and Snedaker, 1974).

As far as we know, the first descriptions of mangroves by ancient literate observers were made in the year 325 BCE by Nearchus, the Greek Admiral of Alexander the Great's fleet. In the 'Chronicles of Nearchus' he described mangroves in the Red Sea, the Persian Gulf, and the Indus Delta (Bowman, 1917). Twenty years later in 305 BCE Theophrastus, a pupil of Aristotle, also referred to mangroves in his 'Enquiry into Plants' (Schneider, 2011): "But there are plants in the sea, which they call 'bay' and 'olive' [...]. On the islands which get covered by the tide they say that great trees grow, as big as planes or the tallest poplars..." (Hort, 1916). On the American continent, the first Spanish chronicler to describe mangroves from a botanical standpoint was Gonzalo Fernández de Oviedo in his 'General and Natural History of the Indies' in 1531, placing emphasis on their usage by indigenous communities: "Mangrove is one of the best trees in these lands, and it is common in these islands (Greater Antilles) and in Tierra Firme (mostly the Isthmus of Panama). Its wood is one of the best ones around for building shelves, poles, posts for houses, fences, window frames, and doors and other small things...the bark of these mangroves is singularly good for tanning cow leather in a short time" (de Oviedo y Valdés 1535).

Literature about mangroves between the 17th and 20th centuries focused mainly on describing mangrove morphology, habitat, distribution, species diversity, taxonomy, and systematics (Bowman, 1917). From around 1900 onwards, studies that highlighted the ecological role of mangroves (mostly regarding their functions of sediment consolidation and shoreline maintenance) emerged to join earlier descriptive literature (Lugo and Snedaker, 1974). The second half of the 20th century signalled the first public initiatives for mangrove conservation following work that highlighted their economic value for Florida fisheries due to their role in food web enrichment (Lugo and Snedaker, 1974). Thus, the history of society's perceptions towards mangrove systems has evolved only recently from being considered as a barren wasteland of unhealthy soils, to being complex ecosystems upon which humans depend. The following sections explore the decline of mangrove forests in the ETP region.

2.2. Early pre-Columbian societies

As the 16th century quote from Oviedo (above) implies, mangroves played a crucial role in the way of life for many coastal societies, and are closely linked with human culture. In India, the Solomon Islands and Kenya, mangroves have been regarded as sacred spaces where special rites take place, temples are erected, and trees worshipped (Kathiresan and Bingham, 2001). In Latin America, the importance of these habitats to indigenous cultures is evident from zooarchaeological data, which supports cultural anthropological inferences about prehistoric subsistence and

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