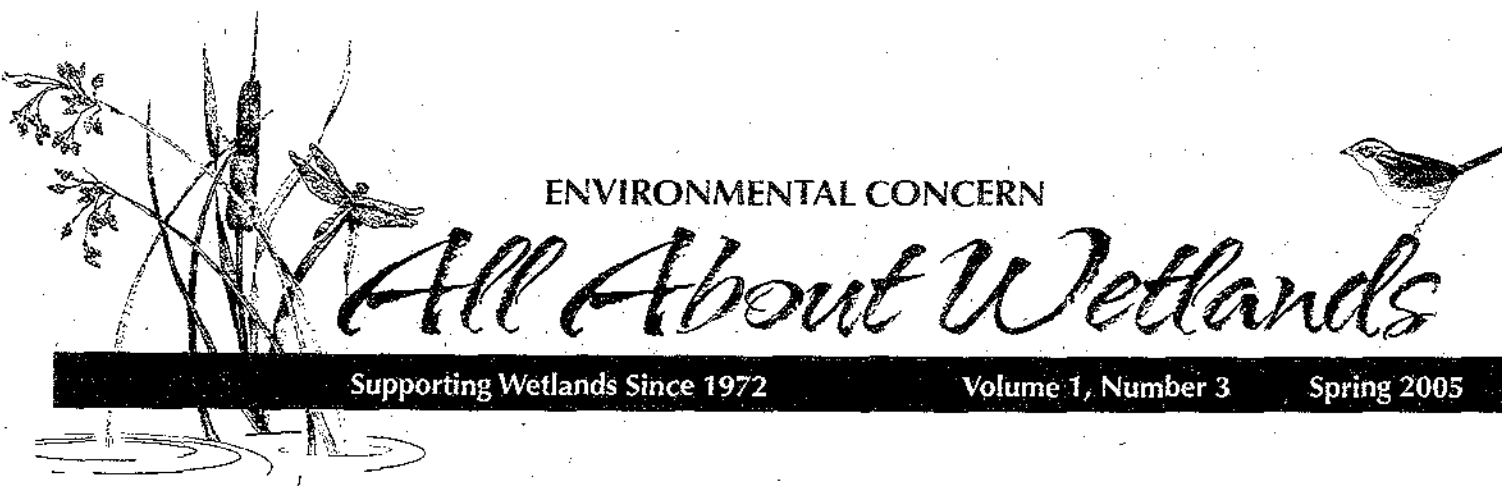


Mangroves, Hurricanes and Tsunamis

By Roy R. Lewis III

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INTRODUCTION

Mangrove forests are ecologically important coastal ecosystems (Lugo and Snedaker 1974) composed of one or more of the 69 species of plants called mangroves (Duke 1992). Mangroves are frequently inundated by the tides and thus have special physiological adaptations to deal with salt in their tissues. They are however, not obligate halophytes that require salt to grow, but instead facultative halophytes that prosper in competition with other plant species that cannot tolerate salt water inundation. Figure 1 shows the interior of a typical mangrove forest dominated by the red mangrove (*Rhizophora mangle*) near Key West, Florida. The well developed prop roots and drop roots facilitate establishment and survival of this species in frequently flooded coastal and estuarine areas. These and similar adaptations within their root systems provide support in soft mud sediments and transport oxygen from the atmosphere to their roots which are largely in anaerobic sediments. Most also have floating seeds that are produced annually in large numbers and float to new sites for colonization.

These ecosystems currently cover 56,575 mi² (146,530 km²) of the tropical shorelines of the world (FAO 2003). This represents a decline from 76,450 mi² (198,000 km²) of mangroves in 1980, and 60,860 mi² (157,630 km²) in 1990 (FAO 2003). Overall it is estimated that the historical cover of mangroves worldwide has been reduced by 50% (Ong 1995). These losses are largely attributed to dredging and filling to create human development projects in coastal areas like ports, industrial sites, home sites and aquaculture ponds (Saenger 2002). This numerical loss is translated into a functional loss.

The ecological benefits of mangroves include stabilizing shorelines, reducing wave and wind energy against shorelines (including tsunamis) and thus protecting inland structures (Mazda et al. 1997), supporting coastal fisheries for fish and shellfish through direct and indirect food support and provisions for habitat, and support of wildlife populations including a number of wading birds and sea birds (Lewis et al. 1985). Mangrove forests also support timber production for construction materials and supply some special chemicals for industry, and medicinal products for local use (Saenger 2002).

IMPACT OF TSUNAMIS

The December 26th tsunami has brought to the public's attention the role mangroves play in reducing storm

surge associated with hurricanes and tsunamis. Following this disaster, there have been various reports of certain areas being protected from damage by a "greenbelt" of mangroves. The Matang community in Kedah state, Malaysia, has one of the largest and best managed mangrove forests in the area and was "untouched" by the tsunami according to a report in the Bangkok Post (February 12, 2005). Such a report contrasts starkly with the images coming out of Banda Aceh, Aceh Province, northern Sumatra, Indonesia where vast areas of mangroves have been removed for development. The Global Environmental Centre in Malaysia has prepared a preliminary report on the damage from the tsunami (Parish and Lee 2005), and reports that:

"Banda Aceh is built on the mainland as well as a series of low-lying islands in the delta of the Krueng Aceh River. The area originally would have been covered with mangrove forest but most of the forest was cleared during the development of the town. To the west of the town along the coast a large area of mangroves was cleared in the last 30 years or so and converted to fish and prawn ponds. A number of patches or small islands of mangroves remain in the branches of the delta and



Figure 1 - a mangrove forest dominated by the red mangrove (*Rhizophora mangle*) near Key West, Florida. (Photo by Roy R. Lewis III, 2004)



among the fish ponds...Following the tsunami almost all of the buildings in the town are obliterated and all the fish/shrimp ponds have been destroyed...Remnants of the mangroves are still visible – but it is not possible to tell if the trees are still alive as the leaves seem to have turned brown.”

The Jakarta Post reported on January 19, 2005, that approximately 100,000 acres (40,000 ha) of mangroves had been damaged in Aceh Province and that the Indonesian Ministry of Forestry was starting a five year, \$21.6 million mangrove rehabilitation program. The intent was to build a 3.5-5 kilometer buffer area of mangroves and fish farms between the coast and major towns and cities to protect them during future cyclones and tsunamis. Despite the known benefits of mangroves, there are already reports in the Southeast Asian media are documenting lax enforcement of rules against rebuilding on the coast and a return to large scale tourism directly on the beaches.

DOCUMENTED IMPACTS OF HURRICANES

In reducing the damaging effects of a storm or a surge, however, the mangroves themselves take the brunt of the energy, suffering damage. Previous research on hurricane damage to mangroves includes Cahoon and Hensel (2002) for hurricane Mitch that struck Honduras and adjacent areas in October 1998, McCoy et al. (1996) for hurricane Andrew on the southwestern coast of Florida which came ashore in August, 1992, and Craighead and Gilbert (1962) who described impacts from hurricane Donna that hit southwest Florida in September 1960. The basic conclusion reached by all these authors is that depending on the strength of the hurricane and the duration of its impacts on a given mangrove forest, impacts may be severe and long-lasting, or short-lived and primarily effecting the size of mangroves and species composition within a mangrove forest (Figure 2).

Mangroves, depending on the species, have the ability to resprout from broken stems and even the trunk of a tree that has lost its canopy. As noted by Tomlinson (1986), “complete regeneration of the crown is possible...after trunk damage or decapitation...from “resting” or “reserve” buds on the persistent trunk portion (epicormic branches or stump sprouts).” This ability, however, is limited or absent in the genus *Rhizophora* pictured in Figure 1. It is however present in the other two genera present in Florida, *Laguncularia* and *Avicennia*. Thus the result of an acute impact that removes by breakage the upper half of the forest structure can result in a shift in the dominant species cover from *Rhizophora* to *Laguncularia* and *Avicennia*. In fact this is what is reported by Cahoon and Hensel (2002) for some specific areas in Honduras damaged by hurricane Mitch. In addition to breakage of tree trunks, 6-40

inches (15-100 cm) of sediment were deposited in certain mangrove areas due to river transport and deposition during the high rainfall period associated with the hurricane. Forests receiving less than 6 inches (15 cm) of sediment deposition suffered no mortality. Those that received 20-40 inches (50-100 cm) of sediment showed extensive mortality, but Cahoon and Hensel (2002) report “strong signs of forest regeneration” even in these areas and note that the added sediment will raise the ground level elevation of the regenerating forest and thus make them less vulnerable to the potential impacts of sea level rise. This is an unexpected long-term benefit of episodic events like hurricanes.

An example of severe and long-lasting effects of a hurricane on mangroves is the island of Guanaja, one of the Bay Islands of Honduras. Extreme winds and flooding produced 97% mortality of the mangroves and regeneration has not occurred. In situations such as this, the resulting absence of root growth in highly organic peat soils has resulted in the collapse of the soils due to oxidation, and an actual lowering of the ground elevation formerly occupied by mangroves (Cahoon and Hensel 2002). As noted by Lewis (in press), mangrove forests around the world are limited in their range of elevations of the soil surface upon which they can grow. In fact, a failure to understand this fact has led to large scale failures in attempts at mangrove restoration when plantings were attempted on mud flats situated at a tidal elevation too low to support mangroves (Lewis 2000, Lewis in press). Areas of damage from hurricane Mitch may therefore be topographically too low for successful restoration by simply planting mangroves in areas where natural seedling recruitment is absent due to a lack of enough live trees in the vicinity to produce a viable and abundant seed crop. This lack of natural seeds is referred to as “propagule limitation” by Lewis (in press).



Figure 2 - Mangrove forest damaged by hurricane Charley near the City of Punta Gorda in early September 2004. (Photo by Roy R. Lewis III, 2004)



Illustration of Prop Roots and Drop Roots: These roots reach from stems and branches down into the soil below.

As noted by Cahoon and Hensel (2002), such areas may never be suitable for mangroves again, and may therefore convert to shallow open water habitats. True restoration of such areas would require the placement of enough sediment to raise the elevations into the proper zone to support mangroves, and perhaps planting of mangroves if propagule limitation still existed. This would be a very expensive engineering challenge, as it would likely require dredging of sediments and their placement in former mangrove areas. Similar intended and unintended mangrove forest creation and restoration has occurred in the United States with the creation of dredged material islands (spoil islands) associated with harbor dredging projects in Florida (Lewis and Dunstan 1974, Lewis 1982, Lewis 1990), but is unlikely to be an affordable option in third world countries.

MANGROVE RESTORATION

If mangrove restoration is identified as a necessary action following severe impact by hurricanes or tsunamis, the most cost effective restoration option is the identification of areas of existing or former mangroves that may have become isolated from tidal flow due to dike construction or blockage of natural tidal streams within mangrove forests by storm or tsunami wave deposition of sediments. The opening of these areas is referred to as hydrologic restoration and is much less expensive per acre than any attempt to raise ground surface elevations when used at the appropriate sites (Turner and Lewis 1997, Brockmeyer

et al. 1997, Lewis in press), and much more successful than simply planting mangroves, which often fails due to inappropriate site selection (Lewis in press). In many parts of the world shrimp aquaculture ponds have been constructed in mangrove forests, and later abandoned due to disease outbreaks (Stevenson et al. 1999). It is estimated that as many as 625,000 acres (250,000 ha) of abandoned ponds may be awaiting restoration back to mangroves (Lewis in press). Some of these are in the same countries hit by hurricane Mitch, and the December 26th tsunami, and rather than expand the use of aquaculture ponds and destroy more mangroves, as has been recommended as an economic incentive to these storm and tsunami damaged areas, cost effective hydrologic restoration of abandoned or damaged aquaculture ponds should be considered.

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