The Forgotten Tropical Ecosystem

Aided by the mass media, environmental groups and their celebrity endorsers have rallied public support for campaigns to end the destruction of two beautiful tropical ecosystems, the rainforests and the coral reefs. Likely due to the aesthetic sensory overload that these biomes deliver, "Save the Rainforest" and "Save the Reefs" movements enjoy substantial social prominence, and their logos are seen everywhere from tee-shirts to Ben-and-Jerry's ice-cream flavors. Meanwhile tropical mangrove forests, perhaps because their most abundant animal species are mud-dwelling crabs and the dominant plant-life consists of stubby trees, receive little attention, although the level of habitat degradation they experience is analogous to other tropical ecosystems. Virtually unnoticed by the public, approximately 35% of mangrove stands have been deforested since 1960. Already plant and animal communities have felt the direct consequences, and undoubtedly humans will soon.

Mangroves refer to the shrub-like trees of the *Rhizophoraceae* family that uniquely inhabit the tropical zone between the latitudes of 25° N and 30°S, where they grow on the narrow coastal fringes between estuaries and the sea. By virtue of their location, large portions of their trunk and buttress-like aboveground root systems are daily submerged in water for the hours of high tide. These areas also serve as mixing grounds for river and ocean water, and subsequently the nutrients and organisms derived from the two ecosystems that are picked up and carried by these currents. This unique and nutrient-rich habitat has evolved to form a highly productive and extensive ecosystem which is estimated to cover 18 million hectares of the globe (Bowen et al. 2001).

Scientists have classified 3 functional zones in every mangrove stand, which are each characterized by a different variety of mangrove. Fringe mangroves occupy tidal zones and therefore grow in full strength salt-water and daily receive the full brunt of the tides. Riverine mangroves grow along river banks and are flooded by freshwater and ocean currents. Basin mangroves grow behind the other zones and are less subject to tidal inundation. Because of this high water turnover mangrove forests teem with rich supplies of both land and sea-derived nutrients. Elevated levels of soil matrix aeration also arise due to constant mixing of river and sea currents. Several studies show that this aeration process results in the formation of a sponge-like soil complex which traps large quantities of sediment and nutrients. It follows that mangrove forests effectively intercept land-derived nutrients and pollutants and suspend them in the soil matrix, thereby preventing these compounds from reaching the ocean before being processed by nutrient-fixing bacteria. This cycle gives rise to a variety of different services, including high levels of nutrient processing and providing food for resident species. The services that mangroves provide are essential for preserving the integrity and biodiversity of this dynamic habitat. The diverse fauna that inhabit mangrove forests include: many fish and shellfish taxa, hundreds of species of birds, all sizes of reptiles, snakes, and even tigers (India) and manatees (Florida) (Bowen et al. 2001).

In addition to supporting resident animal species, mangrove forests also provide several invaluable services to neighboring ecosystems. The spongy soil matrix and thick mesh-like root systems of mangrove trees also prevent the tides from eroding the coastline. Furthermore, their mere presence impedes destructive floodwaters from approaching inland areas. Mangroves also serve as buffers against the powerful winds of tropical storms, thereby sheltering inland ecosystems and coastal developments. As previously mentioned, mangrove forests absorb large quantities of bio-hazardous compounds from land sources that seep into rivers through groundwater runoff, thereby preventing these compounds from damaging nearby marine ecosystems like seagrass beds and coral reefs. In addition, the viability of these delicate marine ecosystems may actually be dependent on mangrove forests' high productivity (Bowen et al. 2001).

In their study of the link between mangrove forests and coral reef systems in the Caribbean, ecologist Peter Mumby and his colleagues discovered that large quantities of processed (i.e. digestible) organic material in the form of nutritive detritus are exported by mangrove forests via returning tides. Currents carry this detritus to local seagrass beds and coral reefs, where consumers have come to depend on their availability in order to feed. Mumby supports the hypothesis that coral reefs depend on the functionality of nearby mangrove forests by two key observations. First, per unit of biomass, mangrove forests have productivity levels similar to that of rainforests. Unlike rainforests, however, throughout the entire year mangrove forests maintain very low levels of leaf litter. Much of this detritus, Mumby determined, is washed out into the ocean, along with large amounts of nutrients. The second observation that supports the dependence hypothesis is that among the ten largest reefs in the Mesoamerican Coral Reef System (extending from Mexico to Belize) Mumby's team observed that the reefs that were the largest and had the highest levels of biodiversity and productivity were those with the strongest links to coastal mangrove forests. The strength of the link between the two communities was determined by the reef's proximity to the mangrove stand and the level of nutrient and organismal exchange between the two habitats (Arias-Gonzalez et al. 2004)

However, despite the numerous benefits that functional mangrove forests provide and the evident inter-connectedness between mangroves and neighboring biomes, the deforestation of mangrove forests for land development and aquaculture (i.e. fish and shrimp farms) reasons has steadily **increased** over the last forty years. Ecologists currently estimate that global mangrove forest cover has decreased by 35% since 1960. Their destruction poses real dangers to both human and non-humans alike. The interruption of food webs due to habitat destruction has already caused the local extinctions of several fish and crustacean species. Furthermore, research suggests mangrove deforestation is likely to affect the functionality of dependent reef ecosystems. Coasts become vulnerable to sediment washout and increased levels of shore erosion. Large scale eutrophication in coastal marine environments where substantial areas of mangrove coverage have been cleared has already occurred, as levels of nutrient and land contaminant inputs increase, and loads of unfiltered chemicals are exported into the ocean, provoking harmful algal blooms which leave large anoxic dead zones in their wakes. The potential negative impact to human societies is great, as land developments and coastal cities are left exposed to receding shore lines, flooding, and the violent winds of tropical storms (Kaly 1998).

Unfortunately, restoring devastated mangrove forests has proven difficult. Mangrove-based ecosystems are structurally complex, and have evolved over millennia around specific geographic components. For this reason, once a mangrove forest is cleared, restoring previous tidal patterns is difficult. This makes recreating and sustaining the salinity conditions to which previous mangroves and animal communities had acclimated also difficult. Finally, after a mangrove stand has been cleared for some time, the make-up of the soil (fundamental to ecosystem functionality) is irreparably altered. Presently, little work has been done to restore deforested mangrove stands. The majority of proposals to do so require the development of advanced biotechnologies. These efforts will undoubtedly go beyond the planting of several trees and may include: the reshaping of coastlines, chemical treatments to the soil, and purposeful reintroduction (in stages) of certain animal species (Farnsworth 1997).

Because of the obvious difficulties that mangrove forest restoration poses, conservation efforts are clearly the best option. If we want to save coral reefs (and coastal cities), we should invest in saving the mangroves.

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