

Managing Mangroves for Resilience to Climate Change

Global climate change is one of the greatest challenges that humans will face in this century. Although geological records show climatic changes throughout history, the present rate of global warming threatens the survival of entire ecosystems. Among the most at-risk ecosystems are mangroves, which are especially vulnerable to sea-level rise. By understanding which mangrove stands are able to survive sea-level rise and other changes, natural resource managers can identify and protect refuges that self-seed and act as sources for seeding of future mangrove communities.

Potential Impacts of Climate Change

Global climate change, specifically changes in temperature, CO₂, precipitation, hurricanes and storms, and sea level, combined with anthropogenic threats will threaten the resilience of mangroves. The impacts of climate change on mangroves will be summarized briefly below, although sea-level rise will be emphasized because it is projected to be the greatest climate change threat to mangroves. It is important to note that climate change impacts on mangroves will not occur in isolation; the response of mangroves to climate change will be a result of these impacts acting synergistically.

Effects of changes in temperature

Since 1880, the Earth has warmed 0.6-0.8° C and it is projected to warm 2-6° C by 2100 mostly due to human activity. While mangroves are not expected to be adversely impacted by the projected increases in sea temperature, increases in air temperature may cause serious impacts. Temperatures above 35°C have led to thermal stress affecting mangrove root structures and establishment of mangrove seedlings. At leaf temperatures of 38-40°C, almost no photosynthesis occurs. Some scientists have suggested that mangroves will move pole-ward with increasing air temperatures

Effects of changes in CO₂

Atmospheric CO₂ has increased from 280 parts per million by volume (ppmv) in the year 1880 to nearly 370 ppmv in the year 2000. Increased levels of CO₂ will affect mangroves in either good or bad ways. High levels of CO₂ are expected to enhance photosynthesis and mangrove growth rates, whereas increased temperature and CO₂ lead to the degradation of coral reefs caused by mass bleaching and impaired growth. Damage to coral reefs may adversely impact mangrove systems that depend on the reefs to provide shelter from wave action.

Effects of changes in precipitation

Precipitation rates are predicted to increase by about 25 percent by 2050 in response to global warming. However, at regional scales, this increase will be unevenly distributed with either increases or decreases projected in different areas. Decreased precipitation results in a decrease in mangrove productivity, growth, and seedling survival, and may change species composition favoring more salt tolerant species. Decreased precipitation is also likely to result in a decrease in mangrove area, decrease in diversity, and projected loss of the landward zone to unvegetated hyper saline flats. Increased precipitation may increase mangrove area, diversity of mangrove zones, and mangrove growth rates in some species.

Effects of changes in hurricanes and storms

According to some recent researches, tropical storms will increase in frequency and/or intensity due to climate change, posing an additional threat to mangroves. Large storm impacts have resulted in mass mortality in 10 Caribbean mangrove forests in the last 50 years. Major storms

can also lead to a change in community structure based on a differential response to damage from the storm. It is suggested that species proportions may shift because they have different rates of regeneration. Furthermore, flooding, caused by increased precipitation, storms, or relative sea-level rise may result in decreased productivity, photosynthesis, and survival of mangroves.

Effects of changes in sea level

During the 21st century, mean sea-level projections range from 0.09 to 0.88 m. Sea-level rise is the greatest climate change challenge that mangrove ecosystems will face. Geological records indicate that previous sea-level fluctuations have created both crises and opportunities for mangrove communities, and they have survived or expanded in several refuges. Mangroves can adapt to sea-level rise if it occurs slowly enough, if adequate expansion space exists, and if other environmental conditions are met.

Understanding the impact of sea-level rise on mangrove ecosystems must take into account factors that affect the ecological balance of that ecosystem, such as the substrata type, coastal processes, local tectonics, availability of freshwater and sediment, and salinity of soil and groundwater. Tidal range and sediment supply are two critical indicators of mangrove response to sea-level rise. Mangrove communities in macro-tidal, sediment rich areas (e.g., mangrove communities in northern Australia) may be better able to survive sea-level rise than those in micro-tidal sediment starved areas (e.g., mangroves in Caribbean islands).

Carbonate settings are often associated with coral atolls and islands, where landward migration to escape the effects of sea-level rise is not possible and sediments are often limited; thus mangrove communities in carbonate islands are considered extremely vulnerable to sea-level rise.

It is important to note that although access to sediment is critical for mangroves to survive sea-level rise, too much sediment (e.g. resulting from poor agricultural practices) can bury their pneumatophores and kill mangroves

Ten Strategies Managers Can Apply to Promote Resilience

While there is little that protected area managers can do to control large-scale threats like sea-level rise, there are at least ten strategies managers can apply that collectively hold promise to increase the viability of mangroves by enhancing their resilience.

1. Spread risk by identifying and protecting representative mangrove habitats

To effectively spread the risk of losing mangroves to sea-level rise, managers should identify and protect representative species and habitats, replicates of these, and sources of seed to ensure replenishment following disasters.

2. Identify and protect critical areas that are naturally positioned to survive climate change

Managers should protect communities that have demonstrated resilience to climate stressors and/or are naturally positioned to survive global threats. For mangrove ecosystems, local conditions like the presence of sediment-rich, macro-tidal environments, and the availability of freshwater to compensate for increased salinity, will aid mangrove survival and increase their resilience to sea-level rise. These areas should be incorporated into protected area design or otherwise incorporated into integrated coastal management programs.

3. Manage human stresses on mangroves

Over half of mangrove areas are located within 25 km of urban centers inhabited by 100,000 or more people. Close proximity to urban areas poses threats like pollution, dyking, channelization, unregulated felling, conversion to aquaculture or agriculture, and other forms of coastal development. Therefore, not only should managers mitigate existing anthropogenic threats, but

they should also plan for these threats to grow with the increasing impacts of climate change on coastal communities.

4. Establish greenbelts and buffer zones to allow for mangrove migration in response to sea-level rise, and to reduce impacts from adjacent land-use practices

Mangrove greenbelts can provide significant coastal protection from erosion and should be established along erosion-prone coastlines and riverbanks and in areas which experience significant damage from typhoons, tidal surges, cyclones, and geomorphic erosion. Greenbelts should be a minimum of 100 m, but preferably up to 500 m or 1 km at the open coast and 30-50 m along riverbanks and lagoons, and >10 m on islands, creeks, and channels. In the Red River Delta in Vietnam, engineers estimate that an earthen sea dyke with rock facing will last about five years before it requires repair from wave damage, whereas the same sea dyke with a 100 m wide protective mangrove belt will last up to 50 years. It is also important to establish buffer zones bordering the seaward and landward margins of protected mangrove areas to provide a transition between human settlements with intensively used land and water areas and the protected area.

5. Restore degraded critical areas that have high survival prospects

Mangrove areas that are currently degraded but that meet resilience criteria should be restored. Restoration of these areas may help create sustainable livelihoods for local communities and may also reduce the pressure on neighboring mangrove areas. Additionally, data suggest that there is a direct correlation between planting a variety of species to reforest an area and having diverse mangrove restoration objectives. Multi-species systems of mangroves seem to have greater ecological resilience and can better benefit local communities

6. Maintain connectivity between mangroves and associated systems

Connectivity between mangrove systems and upland water catchments should be maintained to ensure an adequate supply of sediment and freshwater. Healthy mangroves should be selected wherever they are connected through currents to areas that may succumb to sea-level rise or to areas that would be suitable new areas for colonization following sea-level rise. If well protected, mangroves benefit adjacent ecosystems by filtering sediments and pollutants, providing nursery habitats, stabilizing sediments, thus improving the water quality for sea grasses, corals, and fish communities.

7. Establish baseline data and monitor the response of mangroves to climate change

Because of the limited number of pristine mangrove forests and the increasing level of threat, establishing baseline data for mangroves is urgent and essential. Data should include a range of variables including: tree stand structure, tree abundance, species richness, and diversity; invertebrate abundance, richness, and diversity; primary production (biomass and litter), nutrient export; hydrologic patterns (Ellison 2000); and rates of sedimentation and relative sea-level rise. Human threats and existing management should also be assessed. Baseline data can be used to develop vulnerability assessments that determine how areas will likely be affected by projected climate change.

Changes in near shore chemistry (CO₂ levels and salinity), hydrography (sea level, currents, vertical mixing, storms and waves), and temperature should be monitored over long time scales to determine climate changes and possible climate trends.

8. Implement adaptive strategies to compensate for changes in species ranges and environmental conditions

If mangrove conservation strategies are to be successful in protecting species and habitats, they will need to adapt to the changing climate conditions. The ability to predict the location of future habitat sites, and build these potential sites into protected area design and adaptation, will be a crucial element of long-term planning to ensure sustainable protected areas in the face of global change. Flexible strategies and boundaries should be established and tracked to allow for adaptive management.

9. Develop alternative livelihoods for mangrove-dependent communities as a means to reduce mangrove destruction

Encouraging local communities to develop alternative livelihoods that are less destructive than over-harvesting of mangroves or conversion to fish or shrimp ponds is a crucial step to mitigate mangrove deforestation. Examples of alternative livelihoods include charcoal production from coconut shells instead of from mangroves as well as traditional honey harvesting in mangroves. In Vietnam, seaweed farming has been proposed as an income generating alternative to mangrove destruction. Alternative livelihood options and diverse income opportunities allow communities to be flexible to adapt to social, political, and economic changes.

10. Build partnerships with a variety of stakeholders to generate the necessary finances and support to respond to the impacts of climate change

The tremendous challenges of global climate change require creative solutions and collaboration. Strong leadership is necessary to help mobilize support at local, regional, and global levels. Building global, regional, and local partnerships among industries (agriculture, tourism, water resource management) and conservation and infrastructure development can help alleviate the financial burdens of responding to large-scale threats like climate change.

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