

THE VEGETATED LITTORAL: MANGROVES AND SALT MARSHES

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Summary

The mangrove and salt marsh ecosystems are dominant coastal ecosystems, the former in the tropics and subtropics (and even extending into the temperate areas) and the latter mainly in the temperate region of the earth. These two ecosystems are characterized by terrestrial plants (halophytes) that have the necessary adaptations to live in soft, often anaerobic substrates that are subjected to varying degrees of tidal inundation and salinities up to full strength seawater. Apart from being very productive, these ecosystems play important roles in coastal protection, supporting their own and adjacent coastal fisheries, and providing timber and a host of other natural products. They constitute an estimated 2% of the earth's land surface and can be considered rare. They are also highly threatened, with an estimated loss of at least 50% since the middle of the twentieth century (which places these ecosystems under the "headed for extinction" category of the International Union for the Conservation of Nature and Natural Resources).

This article is about the two groups of plants that colonize the main part of the intertidal range. It is about their structure, function, state of health, and sustainable management (i.e. conservation).

The mangrove and salt marsh ecosystems are two of the world's most critical life-support systems, situated between the land and the sea. These ecosystems are ephemeral in terms of their location in that they move in response to changes in sea level. The fact that mangrove and salt marsh plants have existed for millions of years, through numerous glacial and interglacial periods, shows that these ecosystems are well adapted to global climate changes. Since *Homo sapiens* is a very recent inhabitant of Earth, their impact was not noticeable in the last shift from glacial to the present interglacial but their ability to change the environment, as demonstrated in the past couple of hundred years, has been profound. It is thus a moot point whether these two ecosystems can adequately respond to global changes brought on by *Homo sapiens*. Equally important is to consider what actions should be taken to minimize damage to these two ecosystems.

There are enough reasons why we should conserve our rare and useful mangrove and salt marsh ecosystems, yet they (especially mangroves because most of them occur in developing countries) are still being destroyed at a rate that places them in the endangered category. There is still a lot of science to be done but time has almost run out. It is time to apply the precautionary principle.

1. Introduction

The littoral or intertidal zone defines the interface between land and sea. This is a zone of land that is intermittently inundated to varying degrees by tidal waters. This is also generally known as the coastline and coasts may be divided by the nature of their substrate, from rocks (the rocky shore ecosystem) to sandy (the sandy beach ecosystem) to mud. The upper reaches of beaches are often vegetated (strand vegetation) but most of this often-narrow strip of vegetation is beyond the reach of all but exceptionally high tides. In the muddy coasts, vegetation almost invariably establishes, especially where there is a supply of freshwater from rivers or subterranean sources. In such situations,

either mangrove (in the tropics, sub-tropics, and into the temperate where there are no ground frosts) or salt marsh ecosystems establish. These two ecosystems are characterized by terrestrial plants (halophytes) with the necessary adaptations to live in soft, often anaerobic substrates that are subjected to varying degrees of tidal inundation and salinities up to full strength seawater. Seagrasses are often also found in the infra-littoral but these are not considered here because they are more marine plants, usually found completely submerged (but having a certain tolerance to exposure). At the supra-littoral upper shore, truly terrestrial plants are also present. Also sometimes found in this supra-littoral zone (in places with a marked seasonal rainfall distribution or where evaporation usually exceeds precipitation, so that salt pans are formed) are a group of plants that can tolerate hypersaline (saltier than seawater) conditions. Under this definition, plants like *Salicornia*, *Chenopodium*, *Sesuvium*, *Limonium*, *Atriplex*, *Samolus repens*, *Suaeda monoica*, and *Ameria* would, strictly, not be considered as salt marsh plants; this group is not considered here.

The mangrove and salt marsh ecosystems are dominant coastal ecosystems, the former in the tropics and subtropics (and even extending into the temperate areas) and the latter mainly in the temperate region. Apart from being very productive, these ecosystems play important roles in coastal protection, supporting their own and adjacent coastal fisheries, and providing timber and a host of other natural products. They constitute an estimated 2% of the earth's land surface and can be considered rare. They are also highly threatened, with an estimated loss of at least 50% in the second half of the twentieth century (which places these ecosystems under the "headed for extinction" category of the International Union for the Conservation of Nature and Natural Resources).

This article is about the two groups of plants (mangrove and salt marsh) that colonize the main part of the intertidal range. It is about the structure, function, state of health, and sustainable management of the mangrove and salt marsh ecosystems.

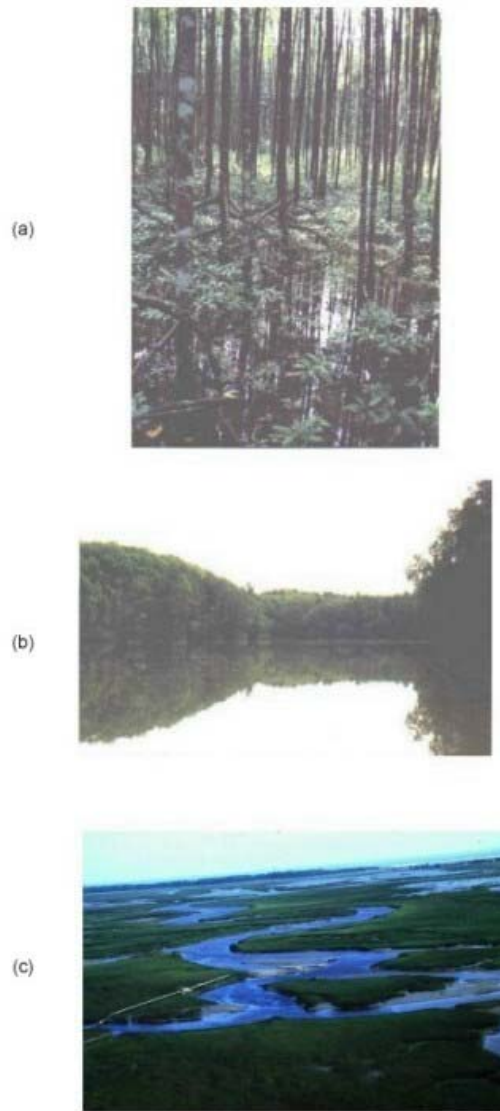


Figure 1. Mangroves in Mattang forest, Malaysia—(a) forest view; (b) river view—and (c) the *Spartina* salt marsh at North Inlet, South Carolina, USA

The mangrove and salt marsh ecosystems are two of the world's most critical life-support systems, situated between the land and the sea. These ecosystems are ephemeral in terms of their location, in that they move in response to changes in sea level. The fact that mangrove and salt marsh plants have existed for millions of years, through numerous glacial and interglacial periods, shows that these ecosystems are well adapted to global climate changes. Since *Homo sapiens* is a very recent inhabitant of Earth, their impact was not noticeable in the last shift from glacial to the present interglacial but their ability to change the environment, especially in the past couple of hundred years, has been profound. It is thus a moot point whether these two ecosystems can adequately respond to global changes brought on by *Homo sapiens*. Equally important is to consider what actions should be taken to minimize damage to these two ecosystems.

Where development along the coasts have occurred, the back of mangroves and salt marshes have usually been converted to alternate uses (e.g. agriculture or industrial

land) and should there be an increase in sea level there will be nowhere for mangroves and salt marshes to move to. The chances are infinitely better should the sea level fall, because there are very few areas where the seaward side of mangroves and salt marshes have been developed. The present likely scenario is for the sea level to rise (predicted as a consequence of increases in atmospheric carbon dioxide as a result of fossil fuel burning by *Homo sapiens*). So, based on present forecasts, many mangroves and salt marshes may drown as a result of the predicted sea-level rise. It must be pointed out that whilst it is true that the concentration of atmospheric carbon dioxide has risen alarmingly since the industrial revolution, it is not completely certain that this has resulted in global warming, which in turn would cause sea levels to rise. Some important feedback mechanisms are not clearly understood. Although there may be signals, these are still not completely clear-cut. There is also evidence that the present interglacial peaked a few thousand years ago and that the trend for sea-level rise reversed. On the stable Sunda Shelf, for instance, sea level has fallen some three to five meters in the last 4000 years. The jury is still out on this question.

There are enough reasons why we should conserve our rare and useful mangrove and salt marsh ecosystems, yet they (especially mangroves, because most of them occur in developing countries) are still being destroyed at a rate that places them in the endangered category. There is still a lot of science to be done but time has almost run out. It is time to apply the precautionary principle.

Granted, it is not easy for developing countries with mushrooming population numbers to conserve for posterity when it is uncertain where the next meal is coming from, but not all developing countries are in such dire straits. Also, much of the destruction and degradation is not so much a result of need as of greed (the mangrove woodchips/ rayon industry, for example). The problem is the low value that has been placed on mangroves and salt marshes and our flawed economic system in its consideration (or lack thereof) of ecological values. There is a need for a paradigm shift, and towards this there is an urgent need for ecologists to work very much more closely with economists—not merely to put values on goods and services but to evolve an ecologic-economic system that is more socially just and that will result in the sustainable use of ecosystems. This is indeed the challenge of the new millennium; if it is not met, humankind may not survive to see the next.

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Biographical Sketches

Professors J.E. Ong and W.K. Gong are ecologists with the Centre for Marine and Coastal Studies of Universiti Sains Malaysia. Between them they have muddled for half a century in the mangrove ecosystem. The long-term objective of their studies is to attempt to close the carbon and nutrient (nitrogen and phosphorus) budgets of a mangrove ecosystem. In the process, they hope to acquire knowledge on the functioning of this very complex and crucial tropical ecosystem. They collaborate closely with a multidisciplinary group of scientists in the ASEAN region (e.g. SARCS/WOTRO/LOICZ Integrated Biogeo-chemical and Socio-economic Modelling and ASEAN-Australia Cooperative Programme on Living Coastal Resources) as well as those from leading institutions in Australia, Japan, the U.K., and the USA.