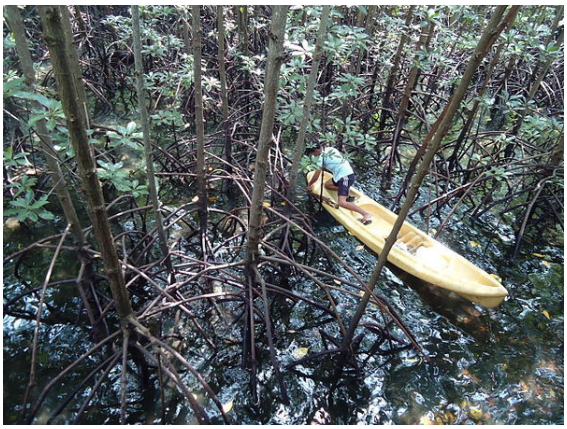
Mangrove

Mangroves in Malaysia

Mangroves in Cambodia.



A mangrove forest in Palawan, Philippines.

Pneumatophores penetrate the sand surrounding a mangrove tree.

Mangroves are various large and extensive types of trees up to medium height and shrubs that grow in saline coastal sediment habitats in the tropics and subtropics—mainly between latitudes 25° N and 25° S. The remaining mangrove forest areas of the world in 2000 was 53,190 square miles (137,760 km^2) spanning 118 countries and territories.[1][2]

The word is used in at least three senses: (1) most broadly to refer to the habitat and entire plant assemblage or **mangal**,[3] for which the terms **mangrove forest biome**, **mangrove swamp** and **mangrove forest** are also used, (2) to refer to all trees and large shrubs in the mangrove swamp, and (3) narrowly to refer to the mangrove family of plants, the Rhizophoraceae, or even more specifically just to mangrove trees of the genus *Rhizophora*.

The mangrove biome, or mangal, is a distinct saline woodland or shrubland habitat characterized by depositional coastal environments, where fine sediments (often with high organic content) collect in areas protected from high-energy wave action. The saline conditions tolerated by various mangrove species range from brackish water, through pure seawater (30 to 40 ppt (parts per thousand)), to water concentrated by evaporation to over twice the salinity of ocean seawater (up to 90 ppt).[4][5]

1 Etymology

The term "mangrove" comes to English from Spanish (perhaps by way of Portuguese), and is likely to originate from Guarani. It was earlier “mangrow” (from Portuguese *mangue* or Spanish *mangle*), but this word was corrupted via folk etymology influence of the word "grove".

2 Ecology

The world's mangrove forests in 2000.

Mangrove swamps are found in tropical and subtropical tidal areas. Areas where mangal occurs include estuaries and marine shorelines.[5]

The intertidal existence to which these trees are adapted represents the major limitation to the number of species able to thrive in their habitat. High tide brings in salt water, and when the tide recedes, solar evaporation of the seawater in the soil leads to further increases in salinity. The return of tide can flush out these soils, bringing them back to salinity levels comparable to that of seawater.

At low tide, organisms are also exposed to increases in temperature and desiccation, and are then cooled and flooded by the tide. Thus, for a plant to survive in this environment, it must tolerate broad ranges of salinity, temperature, and moisture, as well as a number of other key environmental factors — thus only a select few species make up the mangrove tree community.

About 110 species are considered "mangroves", in the sense of being a tree that grows in such a saline swamp,[5] though only a few are from the mangrove plant genus, *Rhizophora*. However, a given mangrove swamp typically features only a small number of tree species. It is not uncommon for a mangrove forest in the Caribbean to feature only three or four tree species. For comparison, the tropical rainforest biome contains thousands of tree species, but this is not to say mangrove forests lack diversity. Though the trees themselves are few in species, the ecosystem these trees create provides a home for a great variety of other organisms.

Mangrove plants require a number of physiological adaptations to overcome the problems of anoxia, high salinity and frequent tidal inundation. Each species has its own solutions to these problems; this may be the primary reason why, on some shorelines, mangrove tree species show distinct zonation. Small environmental variations within a mangal may lead to greatly differing methods for coping with the environment. Therefore, the mix of species is partly determined by the tolerances of individual species to physical conditions, such as tidal inundation and salinity, but may also be influenced by other factors, such as predation of plant seedlings by crabs.

Once established, mangrove roots provide an oyster habitat and slow water flow, thereby enhancing sediment deposition in areas where it is already occurring. The fine, anoxic sediments under mangroves act as sinks for a variety of heavy (trace) metals which colloidal particles in the sediments have scavenged from the water. Mangrove removal disturbs these underlying sediments, often creating problems of trace metal contamination of seawater and biota.

Mangrove swamps protect coastal areas from erosion, storm surge (especially during hurricanes), and tsunamis.[6][7] The mangroves' massive root systems are efficient at dissipating wave energy.[8] Likewise, they slow down tidal water enough so its sediment is deposited as the tide comes in, leaving all except fine particles when the tide ebbs.[9] In this way, mangroves build their own environments.[6] Because of the uniqueness of mangrove ecosystems and the protection against erosion they provide, they are often the object of conservation programs, including national biodiversity action plans.[7]

However, mangrove swamps' protective value is sometimes overstated. Wave energy is typically low in areas where mangroves grow,[10] so their effect on erosion can only be measured over long periods.[8] Their capacity to limit high-energy wave erosion is limited to events such as storm surges and tsunamis.[11] Erosion often occurs on the outer sides of bends in river channels that wind through mangroves, while new stands of mangroves are appearing on the inner sides where sediment is accruing.

The unique ecosystem found in the intricate mesh of mangrove roots offers a quiet marine region for young organisms.[12] In areas where roots are permanently submerged, the organisms they host include algae, barnacles, oysters, sponges, and bryozoans, which all require a hard surface for anchoring while they filter feed. Shrimps and mud lobsters use the muddy bottoms as their home.[13] Mangrove crabs munch on the mangrove leaves, adding nutritients to the mangal muds for other bottom feeders.[14] In at least some cases, export of carbon fixed in mangroves is important in coastal food webs.

Mangrove plantations in Vietnam, Thailand, the Philippines and India host several commercially important species of fishes and crustaceans. Despite restoration efforts, developers and others have removed over half of the world's mangroves in recent times.

Mangrove forests can decay into peat deposits because of fungal and bacterial processes as well as by the action of termites. It becomes peat in good geochemical, sedimentary and tectonic conditions.[15] The nature of these deposits depends on the environment and the types of mangrove involved. In Puerto Rico the red (Rhizophora mangle), white (Laguncularia racemosa) and black (Avicennia germinans) mangroves occupy different ecological niches and have slightly different chemical compositions so the carbon content varies between the species as well between the different tissues of the plant e.g. leaf matter vs roots.[15]

In Puerto Rico there is a clear succession of these three trees from the lower elevations which are dominated by red mangroves to farther inland with a higher concen-

tration of white mangroves.[15] Mangrove forests are an important part of the cycling and storage of carbon in tropical coastal ecosystems.[15] Using this it is possible to attempt to reconstruct the environment and investigate changes to the coastal ecosystem for thousands of years by using sediment cores.[16] However, an additional complication is the imported marine organic matter that also gets deposited in the sediment due to tidal flushing of mangrove forests.[15]

In order to understand peat formation by mangroves, it is important to understand the conditions they grew in, and how they decayed. Termites are an important part of this decay, and so an understanding of their action on the organic matter is crucial to the chemical stabilization of mangrove peats.[15]

3 Biology

Of the recognized 110 mangrove species, only about 54 species in 20 genera from 16 families constitute the "true mangroves", species that occur almost exclusively in mangrove habitats.[3] Demonstrating convergent evolution, many of these species found similar solutions to the tropical conditions of variable salinity, tidal range (inundation), anaerobic soils and intense sunlight. Plant biodiversity is generally low in a given mangal.[5] The greatest biodiversity occurs in the mangal of New Guinea, Indonesia and Malaysia.[17]

3.1 Adaptations to low oxygen

A red mangrove, Rhizophora mangle.

Red mangroves, which can survive in the most inundated areas, prop themselves above the water level with stilt roots and can then absorb air through pores in their bark (lenticels). Black mangroves live on higher ground and make many pneumatophores (specialised root-like structures which stick up out of the soil like straws for breathing) which are also covered in lenticels.

Above and below water view at the edge of the mangal.

These "breathing tubes" typically reach heights of up to 30 cm, and in some species, over 3 m. The four types of pneumatophores are stilt or prop type, snorkel or peg type, knee type, and ribbon or plank type. Knee and ribbon types may be combined with buttress roots at the base of the tree. The roots also contain wide aerenchyma to facilitate transport within the plants.

3.2 Limiting salt intake

Salt crystals formed on grey mangrove leaf.

Red mangroves exclude salt by having significantly im-

permeable roots which are highly suberised, acting as an ultrafiltration mechanism to exclude sodium salts from the rest of the plant. Analysis of water inside mangroves has shown 90% to 97% of salt has been excluded at the roots. In a frequently cited concept that has become known as the "sacrificial leaf", salt which does accumulate in the shoot then concentrates in old leaves, which the plant then sheds. However, recent research suggests the older, yellowing leaves have no more measurable salt content than the other, greener leaves.[18] Red mangroves can also store salt in cell vacuoles. As seen in the picture on the right, white (or grey) mangroves can secrete salts directly; they have two salt glands at each leaf base (correlating with their name—they are covered in white salt crystals).

Red mangrove seeds germinate while still on the parent tree.

3.3 Limiting water loss

Because of the limited fresh water available in salty intertidal soils, mangroves limit the amount of water they lose through their leaves. They can restrict the opening of their stomata (pores on the leaf surfaces, which exchange carbon dioxide gas and water vapour during photosynthesis). They also vary the orientation of their leaves to avoid the harsh midday sun and so reduce evaporation from the leaves. Anthony Calfo, a noted aquarium author, observed anecdotally a red mangrove in captivity only grows if its leaves are misted with fresh water several times a week, simulating the frequent tropical rainstorms.[19]

3.4 Nutrient uptake

Because the soil is perpetually waterlogged, little free oxygen is available. Anaerobic bacteria liberate nitrogen gas, soluble iron, inorganic phosphates, sulfides, and methane, which make the soil much less nutritious. Pneumatophores (aerial roots) allow mangroves to absorb gases directly from the atmosphere, and other nutrients such as iron, from the inhospitable soil. Mangroves store gases directly inside the roots, processing them even when the roots are submerged during high tide.

3.5 Increasing survival of offspring

In this harsh environment, mangroves have evolved a special mechanism to help their offspring survive. Mangrove seeds are buoyant and are therefore suited to water dispersal. Unlike most plants, whose seeds germinate in soil, many mangroves (e.g. red mangrove) are viviparous, whose seeds germinate while still attached to the parent tree. Once germinated, the seedling grows either within the fruit (e.g. *Aegialitis*, *Avicennia* and *Aegiceras*), or out through the fruit (e.g. *Rhizophora*, *Ceriops*, *Bruguiera* and *Nypa*) to form a propagule (a ready-to-go seedling) which can produce its own food via photosynthesis.

The mature propagule then drops into the water, which can transport it great distances. Propagules can survive desiccation and remain dormant for over a year before arriving in a suitable environment. Once a propagule is ready to root, its density changes so the elongated shape now floats vertically rather than horizontally. In this position, it is more likely to lodge in the mud and root. If it does not root, it can alter its density and drift again in search of more favorable conditions.

4 Taxonomy and evolution

The following listing (modified from Tomlinson, 1986) gives the number of species of mangroves in each listed plant genus and family. Mangrove environments in the Eastern Hemisphere harbor six times as many species of trees and shrubs as do mangroves in the New World. Genetic divergence of mangrove lineages from terrestrial relatives, in combination with fossil evidence, suggests mangrove diversity is limited by evolutionary transition into the stressful marine environment, and the number of mangrove lineages has increased steadily over the Tertiary with little global extinction.[20]

4.1 Major components

4.2 Minor components

5 Geographical regions

Main article: Mangrove tree distribution
Further information: List of mangrove ecoregions

Mangroves can be found in over 118 countries and territories in the tropical and subtropical regions of the world. The largest percentage of mangroves is found between the 5° N and 5° S latitudes.[21] Approximately 75% of world's mangroves are found in just 15 countries.[21] Asia has the

largest amount (42%) of the world's mangroves, followed by Africa (21%), North/Central America (15%), Oceania (12%) and South America (11%).[21]

5.1 Africa

There are important mangrove swamps in Kenya, Tanzania, République Démocratique du Congo (RDC) and Madagascar, with the latter even admixing at the coastal verge with dry deciduous forests.

Nigeria has Africa's largest mangrove concentration, spanning 36,000 km^2. Oil spills and leaks have destroyed many in the last 50 years, damaging the local fishing economy and water quality.[22]

Along the coast of the Red Sea, both on the Egyptian side and in the Gulf of Aqaba, mangroves composed primarily of *Avicennia marina* and *Rhizophora mucronata*[23] grow in about 28 stands that cover about 525 hectares. Almost all Egyptian mangrove stands are now protected.

5.2 Americas

Mangroves live in many parts of the tropical and subtropical coastal zones of North, South and Central America.

5.2.1 Continental United States

Because of their sensitivity to subfreezing temperatures, mangroves in the continental United States are very limited to the Florida peninsula (see Florida mangroves) and some isolated growths[24] of black mangrove (*Avicennia germinans*) at the southmost coast of Louisiana[25] and South Texas.[26]

5.2.2 Central America and Caribbean

Mangroves occur on the Pacific and Caribbean coasts of Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, and Panama. Significant mangals include the Marismas Nacionales-San Blas mangroves in Mexico. Mangroves can also be found in many of the Antilles including Puerto Rico, Cuba, and Hispaniola,[27] as well as other islands in the West Indies such as the Bahamas.

Belize The nation of Belize has the highest overall percentage of forest cover of any of the Central American countries.[28] In terms of Belize's mangrove cover—which assumes the form not only of mangrove 'forest', but also of scrubs and savannas, among others[29]—a 2010 satellite-based study of Belize's mangroves by the World Wildlife Fund (WWF) and the Water Center for the Humid Tropics of Latin America and the Caribbean found, in 2010, mangroves covered some 184,548 acres (74,684 hectares) or 3.4% of Belize's territory.[30]

The same area in Honduras shown from 1987 (bottom) to 1999 and the corresponding removal of mangrove swamps for shrimp farming.

In 1980, by contrast, mangrove cover stood at 188,417 acres (76,250 hectares)—also 3.4% of Belize's territory, although based on the work of mangrove researcher Simon Zisman,[31] Belize's mangrove cover in 1980 was estimated to represent 98.7% of the precolonial extent of those ecosystems. Belize's mangrove cover in 2010 was thus estimated to represent 96.7% of the precolonial cover.[30] Assessing changes in Belize's mangrove cover over a 30-year period was possible because of Belize's participation in the Regional Visualization and Monitoring System, a regional observatory jointly implemented by CATHALAC, RCMRD, ICIMOD, NASA, USAID, and other partners.[32]

5.2.3 South America

Brazil contains approximately 26,000 km^2 of mangals, 15% of the world's total.

Ecuador has substantial remaining mangrove forests in the provinces of El Oro, Guayas, Manabi and Esmeraldas with limited forest remaining in Santa Elena.[33] The northern portion of Esmeraldas province has a large pristine mangrove forest that is preserved as the Reserva Ecológica Cayapas-Mataje (REMACAN) and is an original Ramsar site.[34] This forest is the most preserved within Ecuador and likely the most pristine forest along the Pacific Coast of the Americas.[35]

The only other major mangrove holding in Esmeraldas

is in-and-around the community of Muisne and the Rio Muisne Estuary Swampland Wildlife Refuges.[36] The mangroves in-and-around the estuaries of Muisne have decreased in area from 3222 ha in 1971 to 1065 ha as of 2005, during this time commercial shrimp aquaculture has become the dominant land-cover within this estuary environment.[37]

On the border of Esmeraldas province and Manabí province is a formerly large area of mangrove within Cojimies Estuary. The mangroves in this estuary are some of the most degraded in Ecuador with only 19% of 1971 mangrove area remaining as of 1998, although mangrove has recovered since this date.[35] Within Manabí the major mangrove holding estuary is the Chone estuary situated near the city of Bahía de Caráquez. Again, Chone has undergone substantial mangrove deforestation since the advent of commercial aquaculture in Ecuador.[37] Although mangrove loss appears to have halted in this estuary and mangrove regrowth driven by local fisherman is now occurring.[38]

Peru has a very small region of mangrove located in the north-west of the country on the Ecuadorian Border.[39]

Venezuela's northern Caribbean island, Margarita, possesses mangrove forests in the Parque nacional Laguna de La Restinga. Venezuela has 4% of the world's mangroves, with an extension of 6735 km^2.[40]

Colombia possesses large mangrove forests on both its Caribbean and Pacific coasts.

The Mangrove forests of Suriname have a height of 20-25 m and are found mainly in the coastal area. There are six types of mangroves, namely two types of parwa or black mangroves, three types of red mangroves (mangro) and a small mangrove species (white mangrove, akira or tjila).[41]

5.3 Asia

5.3.1 Indomalaya ecozone

A view of the Pichavaram (Tamil Nadu, South India) mangrove forest from the viewing tower.

Mangroves occur on Asia's south coast, throughout the Indian subcontinent, in all Southeast Asian countries, and on islands in the Indian Ocean, Arabian Sea, Bay of Bengal, South China Sea and the Pacific.

The mangal is particularly prevalent in the deltas of large Asian rivers. The Sundarbans is the largest mangrove forest in the world, located in the Ganges River delta in Bangladesh and West Bengal, India.

The Pichavaram mangroves in Tamil Nadu is India's largest mangrove forest and the second largest in the world, The Bhitarkanika Mangroves Forest of Odisha, by the Bay of Bengal, is India's second largest mangrove forest. Other major mangals occur on the Andaman and Nicobar Islands and the Gulf of Kutch in Gujarat.[42]

Mangroves occur in certain muddy swampy islands of the Maldives.[43]

On the Malayan Peninsula mangroves cover an estimated 1,089.7 square kilometres (420.7 sq mi), while most of the remaining 5,320 square kilometres (2,054 sq mi) mangroves in Malaysia are on the island of Borneo.[44]

In Vietnam, mangrove forests grow along the southern coast, including two forests: the Can Gio Mangrove Forest biosphere reserve and the U Minh mangrove forest in the sea and coastal region of Kiên Giang, Cà Mau and Bạc Liêu provinces.

The mangrove forests of Kompong Sammaki in Cambodia are of major ecological and cultural importance, as the human population relies heavily on the crabs and fish that live in the roots.

The three most important mangrove forests of Taiwan are: Tamsui River in Taipei, Jhonggang River in Miaoli and the Sihcao Wetlands in Tainan. According to research, four types of mangrove exist in Taiwan. Some places have been developed as scenic areas, such as the log raft routes in Sihcao.

Indonesia In the Indonesian Archipelago, mangroves occur around much of Sumatra, Borneo, Sulawesi, and the surrounding islands, while further north, they are found along the coast of the Malay Peninsula. Indonesia has around 9.36 million hectares of mangrove forests, but 48% is categorized as 'moderately damaged' and 23% as 'badly damaged'.[45]

- A cluster of mangroves on the banks of the Vellikeel River in Kannur
- The 'green tunnel' of mangrove in Sihcao, Tainan, Taiwan
- A mangrove of the genus *Sonneratia*, showing abundant pneumatophores growing on the landward margin of the reef flat on Yap
- The location and relative density of mangroves in Southeast Asia and Australasia

Pakistan Pakistani mangroves are located mainly along the delta of the Indus River (the Indus River Delta-Arabian Sea mangroves ecoregion). Major mangrove forests are found on the coastline of the provinces of

Sindh and Balochistan. In Karachi, land reclamation projects have led to the cutting down of mangrove forests for commercial and urban development. On 22 June 2013, 750,000 mangrove saplings were planted at Kharo Chan, Thatta, in a little over 12 hours. This is the highest number of saplings planted within a day.[46]

5.3.2 Middle East

Oman, near Muscat, supports large areas of mangroves, in particular at Shinas, Qurm Park and Mahout Island. In Arabic, mangrove trees are known as *qurm*, thus the mangrove area in Oman is known as Qurm Park. A small mangrove area is present in the Kingdom of Bahrain. Mangroves are also present extensively in neighboring Yemen.[47]

Iranian mangrove forests occur between 25°11′N to 27°52′N. These forests exist in the north part of the Persian Gulf and Sea of Oman, along three maritime provinces in the south of Iran. These provinces, respectively, from southwest to southeast of Iran, include Bushehr, Hormozgan, and Sistan and Balouchestan.

Mangrove is also widely seen in Tarut Island, east of Qatif in Saudi Arabia. In addition, large forest of mangrove surround the coast to the south of Qatif (Siahat Beach). Nonetheless, because of sea land re-claiming the mangrove is being cut down which makes lots of sea fish losses their natural habitats.

The mangrove forests that cover thousands of hectares of land along the UAE shoreline form an integral part of its coastal ecosystem. The Environment Agency – Abu Dhabi (EAD) is currently working on rehabilitation, conservation and protection of mangrove forests in seven key sites in Abu Dhabi including: Saadiyat Island, Jubail Island, Marawah Marine Biosphere Reserve (which also comprises famous Bu Tinah Island), Bu Syayeef Protected Area, Ras Gharab, the Eastern Corniche and Ras Ghanada.

5.3.3 India

The Mangrove tidal forests are found in the areas of coasts influenced by tides. Mud and silt get accumulated on such coasts. Dense Mangroves are common varieties with roots of plants submerged under water. The deltas of Ganga, the Mahanadi, the Krishna, the Godavari, and the Kaveri are covered by such vegetation.

In the **Ganga-Bramhaputra** delta, Sundri trees are found, which provide durable hard timber. Palm, Coconut, keora, agar, also grow in some parts of the delta. Royal Bengal Tiger is the famous animal in these forests. Turtles Crocodiles, Gharials and Snakes are also found in these forests.

Sunderbans

5.3.4 Bangladesh

The Sundarbans is the largest single block of tidal halophytic mangrove forest in the world.[1] The Sundarbans is a UNESCO World Heritage Site covering parts of Khulna Division of Bangladesh.

The Sundarbans National Park is a National Park, Tiger Reserve, and a Biosphere Reserve. It is in the Sundarbans delta in the Indian state of West Bengal. This region is covered by mangrove forests. It is one of the largest reserves for the Bengal tiger. Sundarbans mangrove forest is the largest in the world, and covers areas of India and Bangladesh for more than 80 kilometers in forming Sundarbans National Park, declared a World Heritage Site by Unesco. A third of this area is covered by water and marshes, as well Sundarbans since 1966 has been considered a sanctuary for wildlife because it is estimated that there live about 400 Royal Bengal Tigers and more than 30,000 deer in this area. The forest lies at the feet of the Ganges and is spread across areas of Bangladesh and West Bengal, India, forming the seaward fringe of the delta. The seasonally-flooded Sundarbans freshwater swamp forests lie inland from the mangrove forests. The forest covers 10,000 km2 of which about 6,000 are in Bangladesh. It became inscribed as a UNESCO world heritage site in 1997, but while the Bangladeshi and Indian portions constitute the same continuous ecotope, these are separately listed in the UNESCO world heritage

list as the Sundarbans and Sundarbans National Park, respectively. The Sundarbans is intersected by a complex network of tidal waterways, mudflats and small islands of salt-tolerant mangrove forests. The area is known for the eponymous Royal Bengal Tiger (Panthera tigris tigris), as well as numerous fauna including species of birds, spotted deer, crocodiles and snakes. Sundarbans was designated a Ramsar site on May 21, 1992. The fertile soils of the delta have been subject to intensive human use for centuries, and the ecoregion has been mostly converted to intensive agriculture, with few enclaves of forest remaining. The remaining forests, together with the Sundarbans mangroves, are important habitat for the endangered tiger. Additionally, the Sundarbans serves a crucial function as a protective flood barrier for the millions of inhabitants in and around Kolkata (Calcutta) against the result of cyclone activity. Sundarbans is home to many different species of birds, mammals, insects, reptiles and fish. It is estimated that there may be found more than 120 species of fish and over 260 species of birds and more than fifty species of reptiles and eight amphibians. Many tourists go there to see the Bengal tigers, saltwater crocodiles, leopards and snakes cobra. Geographical data of Sundarban Latitude: 25.7667 Longitude: 88.7167 Average Height: 34 Time Zone: Asia / Dhaka Title: Lugar Poblado

5.4 Oceania

5.4.1 Australia and New Guinea

Main article: Australian mangroves

More than 5 species of Rhizophoraceae grow in Australasia[48] with particularly high biodiversity on the island of New Guinea and northern Australia.[48]

Australia has about 11,500 km^2 of mangroves, primarily on the northern and eastern coasts of the continent, with occurrences as far south as Millers Landing in Wilsons Promontory, Victoria[49] (38°54′S)[50] and Barker Inlet in Adelaide, South Australia.[51]

5.4.2 New Zealand

New Zealand also has mangrove forests extending to around 38°S (similar to Australia's southernmost mangrove incidence): the furthest geographical extent on the west coast is Raglan Harbour (37°48′S); on the east coast, Ohiwa Harbour (near Opotiki) is the furthest south mangroves are found (38°00′S).

5.4.3 Pacific islands

Twenty-five species of mangrove are found on various Pacific islands, with extensive mangals on some islands. Mangals on Guam, Palau, Kosrae and Yap have been badly affected by development.[52]

Mangroves are not native to Hawaii, but the red mangrove, *Rhizophora mangle*, and Oriental mangrove, *Bruguiera sexangula*, have been introduced and are now naturalized.[53] Both species are considered invasive species and classified as pests by the University of Hawaii Botany Department.[54]

6 Exploitation and conservation

Mangroves in West Bali National Park, Indonesia.

Approximately 35% of mangrove area was lost during the last several decades of the 20th century (in countries for which sufficient data exist), which encompass about half of the area of mangroves.[55] The United Nations Environment Program & Hamilton (2013), estimate that shrimp farming causes approximately a quarter of the destruction of mangrove forests.[56][57] Likewise, the 2010 update of the World Mangrove Atlas indicated a fifth of the world's mangrove ecosystems have been lost since 1980.[58]

Grassroots efforts to save mangroves from development are becoming more popular as their benefits become more widely known. In the Bahamas, for example, active efforts to save mangroves are occurring on the islands of Bimini and Great Guana Cay. In Trinidad and Tobago as well, efforts are underway to protect a mangrove threatened by the construction of a steelmill and a port. In Thailand, community management has been effective in restoring damaged mangroves.[59] Within northern Ecuador mangrove regrowth is reported in almost all estuaries and stems primarily from local actors responding to earlier periods of deforestation in the Esmeraldas region.[38]

Mangroves have been reported to be able to help buffer against tsunami, cyclones, and other storms. One village in Tamil Nadu was protected from tsunami destruction—the villagers in Naluvedapathy planted 80,244 saplings to get into the Guinness Book of World Records. This created a kilometre-wide belt of trees of various varieties. When the tsunami struck, much of the land around the

village was flooded, but the village itself suffered minimal damage.[60]

7 Reforestation

Mangroves in Bohol, Philippines.

In some areas, mangrove reforestation and mangrove restoration is also underway. Red mangroves are the most common choice for cultivation, used particularly in marine aquariums in a sump to reduce nitrates and other nutrients in the water. Mangroves also appear in home aquariums, and as ornamental plants, such as in Japan.

In Senegal, Haïdar El Ali has started the fr project, which (amongst others) focuses on reforesting several areas with mangroves.[61]

The Manzanar Mangrove Initiative is an ongoing experiment in Arkiko, Eritrea, part of the Manzanar Project founded by Gordon H. Sato, establishing new mangrove plantations on the coastal mudflats. Initial plantings failed, but observation of the areas where mangroves did survive by themselves led to the conclusion that nutrients in water flow from inland were important to the health of the mangroves. Trials with the Eritrean Ministry of Fisheries followed, and a planting system was designed to introducing the nitrogen, phosphorus, and iron missing from seawater.[62][63]

The propagules are planted inside a reused galvanized steel can with the bottom knocked out; a small piece of iron and a pierced plastic bag with fertilizer containing nitrogen and phosphorus are buried with the propagule. As of 2007, after six years of planting, 700,000 mangroves are growing; providing stock feed for sheep and habitat for oysters, crabs, other bivalves, and fish.[62][63]

8 National studies

In terms of local and national studies of mangrove loss, the case of Belize's mangroves is illustrative in its contrast to the global picture. A recent, satellite-based study[30]—funded by the World Wildlife Fund and conducted by the Water Center for the Humid Tropics of Latin America and the Caribbean (CATHALAC)—ndicates Belize's mangrove cover declined by a mere 2% over a 30-year period. The study was born out of the need to verify the popular conception that mangrove clearing in Belize was rampant.[64]

Instead, the assessment showed, between 1980 and 2010, under 4,000 acres (16 km^2) of mangroves had been cleared, although clearing of mangroves near Belize's main coastal settlements (e.g. Belize City and San Pedro) was relatively high. The rate of loss of Belize's mangroves—at 0.07% per year between 1980 and 2010—was much lower than Belize's overall rate of forest clearing (0.6% per year in the same period).[65] These findings can also be interpreted to indicate Belize's mangrove regulations (under the nation's)[66] have largely been effective. Nevertheless, the need to protect Belize's mangroves is imperative, as a 2009 study by the World Resources Institute (WRI) indicates the ecosystems contribute US$174–249 million per year to Belize's national economy.[67]

9 See also

- Blue carbon
- Ecological values of mangrove
- Mangrove restoration
- Salt marsh

10 Notes

[1] Giri, C. et al. Status and distribution of mangrove forests of the world using earth observation satellite data. Glob. Ecol. Biogeogr. 20, 154-159 (2011).

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13 External links

- Mangroves- At the Smithsonian Ocean Portal
- Fisheries Western Australia - Mangroves Fact Sheet
- Rhizophoraceae at DMOZ
- Mangrove forests at DMOZ
- In May 2011, the VOA Special English service of the Voice of America broadcast a 15-minute program on mangrove forests. A transcript and MP3 of the program, intended for English learners, can be found at Mangrove Forests Could Be a Big Player in Carbon Trading
- Water Center for the Humid Tropics of Latin America and the Caribbean (CATHALAC)

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14.1 Text

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Wang, Melburnian, Nbarth, Ctbolt, Colonies Chris, Arg, Darth Panda, Gyrobo, Can't sleep, clown will eat me, Addshore, Mr.Z-man, Smooth O, TedE, Richard001, Zero Gravity, Bejnar, Ren-z, Serein (renamed because of SUL), Anlace, MrDarwin, Kuru, Hlucho, Minna Sora no Shita, Mgiganteus1, Mr. Lefty, IronGargoyle, Beetstra, Jon186, 2T, Ryulong, Peter Horn, Pal5017, Darry2385, Istanbuljohnm, BranStark, StrangerAtaru, Kaarel, JoeBot, Tmangray, Erikgauger, CapitalR, Courcelles, Matthew Kornya, Tau'olunga, Tawkerbot2, Travisl, Violent Turaco, JForget, Codiferous, Lavateraguy, Wildpixs, Eleena100, Ollie Garkey, Peripitus, Gogo Dodo, Fuxya bxl, Studerby, Afinebalance, Thijs!bot, Poorleno, Epbr123, Pbeesley1989, Evelyn Z, Julia 2708, Oliver202, Headbomb, Marek69, Leonid Dzhepko, AntiVandalBot, Rhizophora, Luna Santin, Seaphoto, KP Botany, Jj137, Gdo01, Lfstevens, Qwerty Binary, Arx Fortis, Canadian-Bacon, Res2216firestar, JAnDbot, Gcm, Barek, Plantsurfer, Grant Gussie, Endlessdan, Udey, Chickencoop, Andonic, Noobeditor, PhilKnight, - bee -, Jaysweet, Bongwarrior, VoABot II, Nyq, JNW, JamesBWatson, Praveenp, Neweco, Bubba hotep, Bazzbee, Adrian J. Hunter, DerHexer, JaGa, Edward321, TheRanger, Peter coxhead, DancingPenguin, SammyV, MartinBot, Mermaid from the Baltic Sea, Mschel, Nono64, Gopal N, Das, J.delanoy, Pharaoh of the Wizards, BigrTex, Olaf Studt, Lonjers, Tina Cordon, Acurro, IdLoveOne, Devilsheir, PandoraX, AntiSpamBot, Londo06, Knulclunk, SJP, Affyarmy, KylieTastic, Smad29, Ja 62, Richard New Forest, Idioma-bot, Xnuala, VolkovBot, Indubitably, Lear's Fool, Philip Trueman, TXiKiBoT, Crustaceanguy, LaNicoya, Bbanakar, Sankalpdravid, Aymatth2, Someguy1221, Mangroves1, Crimpshrine27, Bloigen, LeaveSleaves, Mikeaphone, Adam.J.W.C., Enviroboy, Temporaluser, Brianga, AlleborgoBot, SieBot, Augustus Rookwood, Calliopejen1, Moonriddengirl, WereSpielChequers, BotMultichill, Mangroveorg, Caltas, Keilana, Flyer22, Radon210, JSpung, Oxymoron83, Steven Zhang, Ayecorumba, Sunrise, Moeng, Vice regent, Sean.hoyland, Denisarona, Neznanec, Servir bz, ClueBot, NickCT, Avenged Eightfold, Fyyer, The Thing That Should Not Be, IceUnshattered, Cyclingman, Dpmuk, Buxbaum666, Wysprgr2005, Der Golem, Wfordaggie10, DifferCake, Ninja kitty333, Acweldy, Diagramma Della Verita, Excirial, Nymf, Alexbot, Jusdafax, Starguy67, LeinSora, Doprendek, Thingg, Versus22, SoxBot III, Vanished User 1004, DumZiBoT, Qworensk, Chkenboy, BarretB, XLinkBot, Rror, Chanakal, Vojtěch Dostál, Skarebo, WikHead, Saad31, Alexius08, Noctibus, Turoturo88, HexaChord, Addbot, Some jerk on the Internet, DOI bot, Guoguo12, Betterusername, Aaronjhill, Crazysane, Alvinpiggy, Blechnic, Annielogue, TutterMouse, Skyezx, CarsracBot, Katfarris, EscapedGorilla, Blokenearexeter, LinkFA-Bot, CuteHappyBrute, Numbo3-bot, Issyl0, Tide rolls, Seizureonastick, Lightbot, आशीष भटनागर, Yobot, Ptbotgourou, The Earwig, THEN WHO WAS PHONE?, AnomieBOT, Rubinbot, Jim1138, Tucoxn, Xufanc, Lee2008, Shrekkie45, Sniperhail, Law, Materialscientist, Citation bot, ArthurBot, LilHelpa, Xqbot, Diptiprakashpalai, The sock that should not be, JimVC3, Capricorn42, Gigemag76, Anon423, Wikicrat, J04n, GrouchoBot, SassoBot, Doulos Christos, Shadowjams, Swanswanswan, A.amitkumar, Ljwillis, FrescoBot, Originalwana, TDM89034, PeterEastern, Karthikrpandian, BoundaryRider, Citation bot 1, Pinethicket, Jonesey95, Tom.Reding, Σ, RandomStringOfCharacters, AustralianMelodrama, PrinceRegentLuitpold, Elekhh, Lightlowemon, FoxBot, Trappist the monk, Yunshui, Lotje, Srinifromsalem, عل‌ی وی‌کی, Zink Dawg, Reaper Eternal, Tbhotch, Reach Out to the Truth, Whisky drinker, RjwilmsiBot, TjBot, Classical Esther, Kamran the Great, DASHBot, EmausBot, Orphan Wiki, Immunize, Look2See1, AlphaGamma1991, Dewritech, Racerx11, Jkadavoor, RenamedUser01302013, Tommy2010, EmmaClifton, Winner 42, TuHan-Bot, Wikipelli, K6ka, Hughph, Cerfa, ZéroBot, Pacotaco43, Fæ, Mobius Clock, Giffwin, Wayne Slam, OnePt618, Logginus, Gsarwa, 28bot, ClueBot NG, Ter-burg, MelbourneStar, Satellizer, Pl.ganesh, Sindhbadh, Cntras, Assarhaddon, Kevin Gorman, Kasirbot, MT Costa, ChristopherCruise, Plantdrew, BG19bot, Windexdor, Bobfishman123, Hershy101, ToshPointO, Zollo9999, MusikAnimal, Khaled0147, RennerSS, Dwergenpaartje, Guckoo, South19, Snow Blizzard, Trurl1, Begnome, Walkintalk, Shaun, BattyBot, Worlds9thwonder, Lierusi, Pratyya Ghosh, Mrt3366, ChandraGiri, Cyberbot II, ChrisGualtieri, IiJayden, Alicemeg, Miguel raul, Pgoss2, Asisman, Dexbot, Sirsynx, Leon petrosyan, Lugia2453, Ndiverprime, UNEPGRID-Arendal, Afbillin, Whatranch, Mlburgo, Fdahdouh, Epicgenius, IsDlr, Gokul.gk7, Galobtter, Alok Chowdhury, Claire.Edelman, Warwickf22, Monkbot, Lucyloo10, IGeorgiasophieR, ArabianOryx, Spastiplast, Lewatt, PuffinSoc, FourViolas, Eleonore123, Sydneymaerocks13, Saisundar.s, Dogman329, Clockman321, Organic Geochemistry at BGS, Ladygaga241, Page 271995, User1860, KasparBot, Bobwer and Anonymous: 708

14.2 Images

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