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Mangroves

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WHAT ARE MANGROVES?

Mangroves are a group of trees and shrubs that are capable of growing in marine, estuarine and, to a limited degree, fresh water. They occupy the fringe of intertidal shallows between the land and the sea.

The term 'mangrove' is used to describe individual trees or shrubs and also the general habitat, although the habitat is often called a 'mangrove forest' or 'mangal'.

As a group of plants, mangroves share several highly specialised adaptations that have allowed them to colonise and thrive in intertidal areas. In particular they have developed special ways of dealing with concentrations of salt that would kill or inhibit the growth of most other plants. These include:

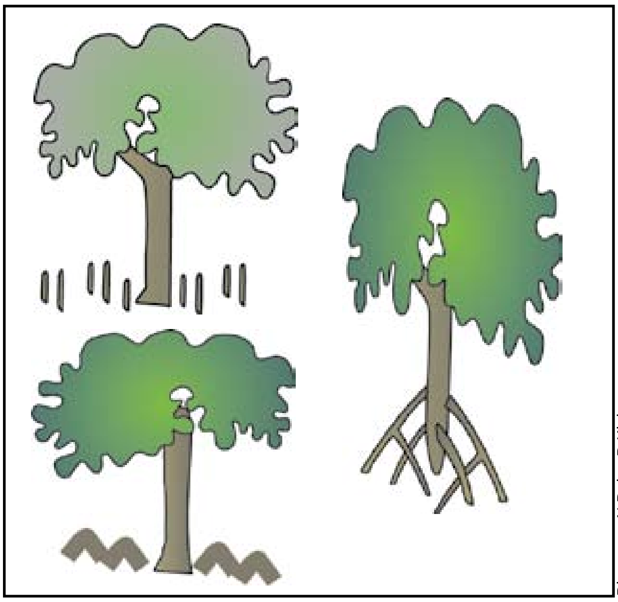
- salty sap (i.e. concentrations of salt in the sap),
- leaves with a waxy coating that limits saltwater penetration,
- salt-secreting pores on the leaves that allow the plant to get rid of excess salt, and
- removing salt by concentrating it in branches and leaves before dropping them.

The most visible adaptation of mangrove plants, and the one which most distinguishes them from other terrestrial plants, is their root system. An

Figure 1. Grey Mangroves with distinct peg roots, known as 'pneumatophores'.

Photograph: S Fairfull

obvious feature of the Grey Mangrove (*Avicennia marina* variety *australasica*) is its spiky vertical roots, called peg roots or 'pneumatophores', which can be seen at low tide protruding from the mud or sand. These roots act like snorkels, drawing air into the underlying root system, allowing the plant to breathe, survive and grow in soils that are too poorly aerated to allow other terrestrial plants to establish. Other mangrove species have a portion of their roots exposed and these look like stilts, or knee roots. The roots also spread horizontally beyond the tree canopy, providing the trees with a broad stable base, even when adverse conditions erode the soft mud away.



Diagrams: N Duke, D Kleine

Figure 2. Characteristic mangrove root features (clockwise from top left – peg, stilt and knee roots).

Photograph: M Stewart

Figure 3. Stilt and peg roots in a mixed stand of Grey and Red Mangroves.

Some mangroves are 'viviparous', which means that after flowering, their seeds germinate before becoming detached from the parent tree. This allows the seedlings to get a head-start before the seed falls into the water and disperses to new areas with the tides and waves. If the seed lodges in a suitable place on a mud or sand bank, the seedling can quickly become established.

Mangrove populations from different catchments are genetically quite isolated from one another. Studies have also found that Grey Mangrove populations have a low level of genetic variation, and populations can be genetically distinct within each estuary.

This factor needs to be considered when undertaking mangrove rehabilitation works so that mangrove seeds or seedlings are sourced from the local population rather than other catchments.

WHY ARE MANGROVES IMPORTANT?

In the past mangrove forests have been considerably undervalued. The wetlands in which mangroves occur have been considered 'wastelands', or breeding grounds for nuisance insects such as mosquitoes. As a result, many mangrove forests have been cleared, dredged, reclaimed, degraded or otherwise lost.

Our understanding of the value of this habitat has greatly improved over the past few decades and mangrove forests are now regarded as key fish habitats.

Because of their importance as habitat for fish, mangroves are protected in New South Wales (NSW) under the *Fisheries Management Act 1994* (see p.11 for further details).

Mangroves serve three key functions:

1. they provide habitat
2. they provide food
3. they act as a buffer; reducing erosion and maintaining water quality

1. Mangroves provide habitat

Mangroves provide shelter for the juveniles and adults of many fish species, including commercially and recreationally important species such as mullet, bream, whiting, luderick, flathead and shellfish such as prawns and crabs. Mangroves also provide habitat for other forms of wildlife including birds such as the threatened Mangrove Honey Eater.

2. Mangroves provide food

Mangrove trees produce large amounts of organic matter. The fallen leaves, seeds and seedlings enter the waterway and are directly grazed by some small animals. The litter is further broken down by bacteria and fungi. Decaying pieces of debris are eaten by other aquatic animals called detritivores (e.g. crabs). These in turn provide food for larger fish and other animals (see Figure 4).

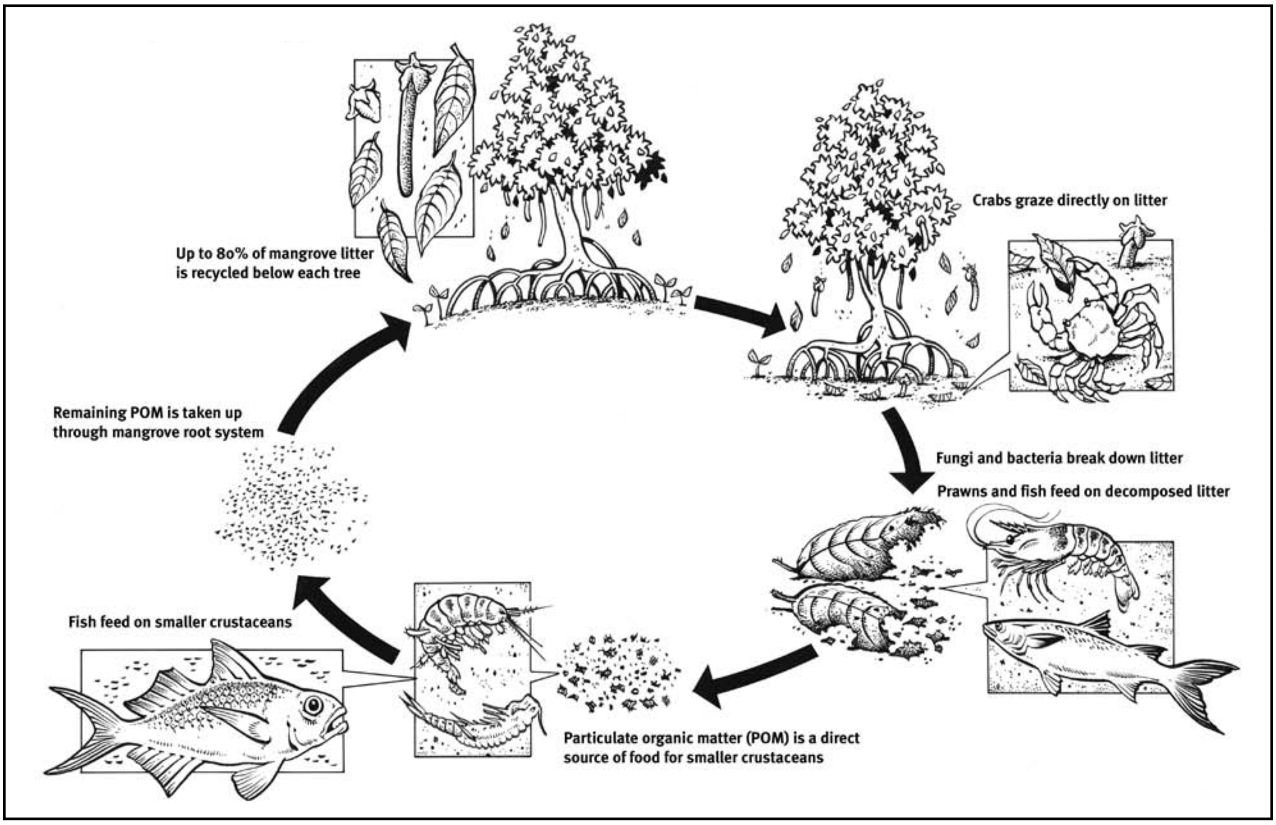


Figure 4. A simplified food chain in a mangrove community. (Source: A Hibbard, copyright P Lennon)

3. Mangroves act as a buffer; reducing erosion and maintaining water quality

Mangroves protect coastal land by absorbing the energy of tidal currents and storm-driven wind and wave action, creating a natural breakwater that helps stop erosion. Evidence from major storm and wave events, such as Cyclone Tracy in Darwin in 1974 and the tsunami in Asia in 2004, have shown the importance of mangrove forests in reducing storm damage to fragile coastlines and property. With predicted increases in cyclones, storm surge intensity and rising sea levels associated with climate change, mangroves will become increasingly important in protecting coastal land.

A mangrove community also provides a buffer between the terrestrial and nearby marine environments; trapping and stabilising sediment, nutrients and contaminants from runoff, thus helping to maintain water quality.

WHERE DO MANGROVES OCCUR?

Mangroves grow in the tropics as well as the temperate zone. There are at least 90 recognised species of mangrove in the world belonging to some 20 plant families. In the tropics of Australia, 37 species from 15 plant families occur; around 40 per cent of the total number of mangrove species found throughout the world. The number of species decreases southwards and, in temperate Victoria and South Australia, there is only one species present (the Grey Mangrove, *Avicennia marina*).

Australia has the third largest area of mangroves in the world; approximately 22% of the total coastline is covered in mangrove forest, totalling about 12 000 km^2.

Mangroves favour sheltered shores on tidal flats in estuaries and bays, the sheltered bays of offshore islands and on some coral reef cays. Mangroves grow best in areas where silt is brought down by rivers or is banked up by waves, tides and currents. Mangroves usually grow in-between the mean sea level mark in the Fringing Zone, to above the mean high water mark in the Landward Zone (see Figure 5). They are often found growing among saltmarshes and other coastal wetland communities.

MANGROVES IN NSW

There are at least five mangrove species found in NSW, with the two most common being the Grey Mangrove, *Avicennia marina*, and the River Mangrove, *Aegiceras corniculatum*.

The Grey Mangrove is found along the entire coast, and the River Mangrove from the Tweed River in the north to Merimbula on the South Coast. The other three species are all confined to the North Coast and include the Large-Leaved Mangrove,

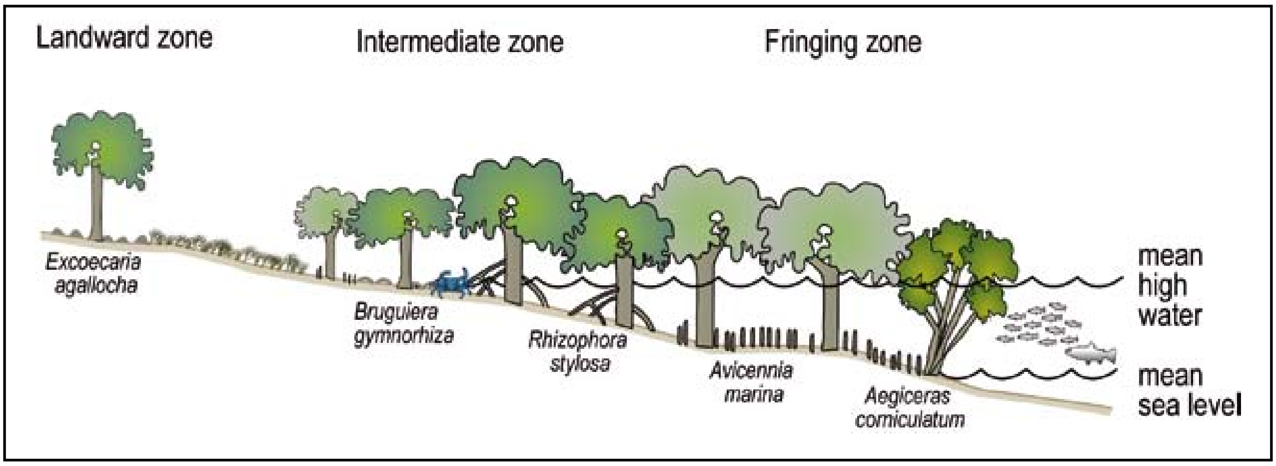


Figure 5. Zones where mangroves grow in NSW. (Source: image produced and supplied by N Duke and D Kleine, University of Qld 2007)

Bruguiera gymnorhiza, which grows from the Tweed River to the Clarence River; the Red Mangrove, *Rhizophora stylosa*, which grows from the Tweed River to the Macleay River and finally, the Milky or Blind-Your-Eye Mangrove, *Excoecaria agallocha*, which grows from the Tweed River to the Manning River (see Table 1).

The Milky Mangrove expels a white sap on breaking the stem or leaves which is irritating and poisonous on contact. Care is needed in handling this plant; avoid contact with the skin and eyes.

Mangrove species are often zoned parallel to the shoreline. The zone where each species occurs is determined by tide levels and soil conditions (e.g. salinity, oxygen, nutrients etc.). The River Mangrove generally occurs in the Fringing Zone, close to the mean sea level mark. The Grey Mangrove and the Red Mangrove are commonly found growing in a zone behind the River Mangrove between the Fringing and the Intermediate Zone. The Large-Leaved Mangrove and the Milky Mangrove are usually found growing within and above mean high water mark, with both species occurring between the Intermediate and the Landward Zone (see Figure 5).

Another important plant which occurs in mangrove forests in NSW, from the Tweed to the Clarence rivers is the Mangrove Fern, *Acrostichum speciosum.* This fern grows in the Intermediate to Landward Zones and may form dense undercanopy stands.

Figure 6. The Fringing Zone; River Mangrove in foreground, Grey Mangrove behind.

Photograph: M Stewart

Figure 7. River Mangrove: shrub, oval-shaped leaves

Photograph: M Stewart

Photograph: M Stewart

Figure 8. Grey Mangrove: tree, seedlings and pneumatophores

Photograph: C Jenkins

Photograph: M Stewart

Figure 9. Red Mangrove: tree, stilt roots, leaves

Photograph: M Stewart

Photograph: M Stewart Inset: M Stewart

Table 1. Characteristic plants of mangrove forests of NSW
(Source: Norm Duke and Diana Kleine, University of Queensland 2007; West 1985)

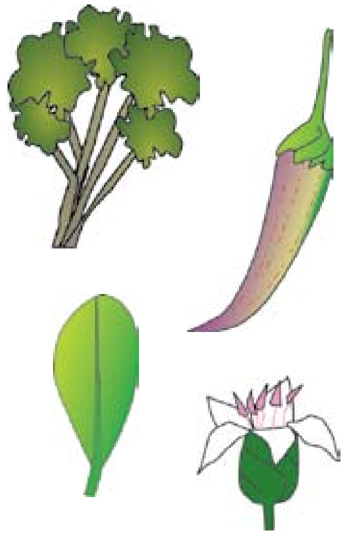
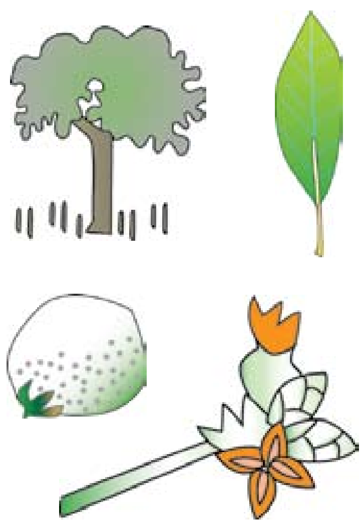
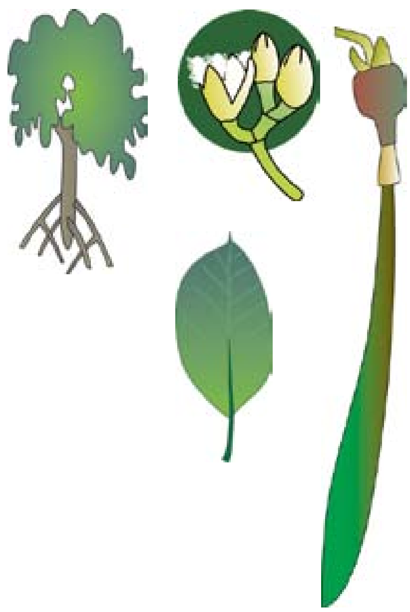
Common name(s)	Scientific name	Distinguishing features	Distribution in NSW	
River Mangrove	*Aegiceras corniculatum*	• Occurs in fringing tidal zone • Dark brown, smooth bark • Shrub or multi-stem tree 1–3 m tall • No above ground roots • Alternate oval leaves, ~7 cm long, rounded tips • Curved tapering fruit, pointed tip • Salt deposits on leaves	Tweed River to Merimbula River	
Grey Mangrove	*Avicennia marina* (variety *australasica*)	• Occurs in fringing to intermediate tidal zone • Pale-grey, smooth bark • Tree 2–12 m tall • Pneumatophores (vertical roots) • Opposite pale-green leaves, pointed tip and dull grey under-surface • Small pale-orange flowers, scented • Bulb-like almond sized fruit, 1–4 cm	Entire coast	
Red or Stilted Mangrove	*Rhizophora stylosa*	• Occurs in fringing to intermediate tidal zone • Grey-black, rough bark • Tree 2–8 m tall • Prop or stilt roots • Opposite dark-green glossy leaves, ~ 10–15 cm long, broad with a sharp abrupt terminal point • Yellow-white flowers with hairy petals • Long green/brown fruit, narrow and tapered, 20–30 cm long	Tweed River to Macleay River	

Table 1 (cont.). Characteristic plants of mangrove forests of NSW

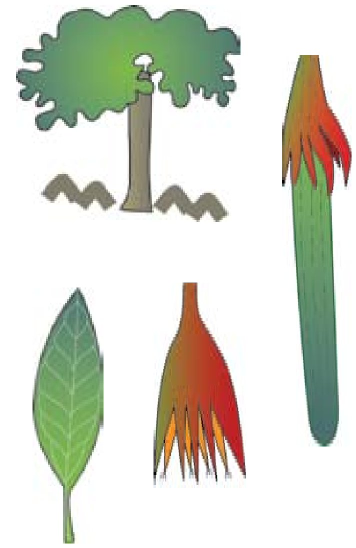
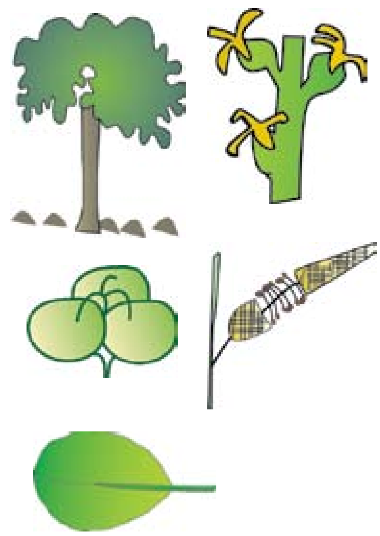
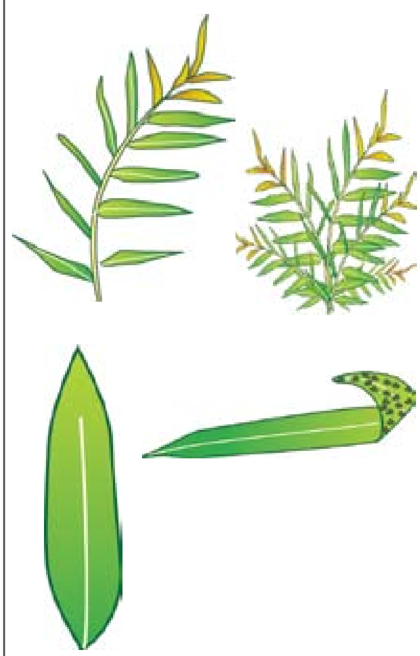
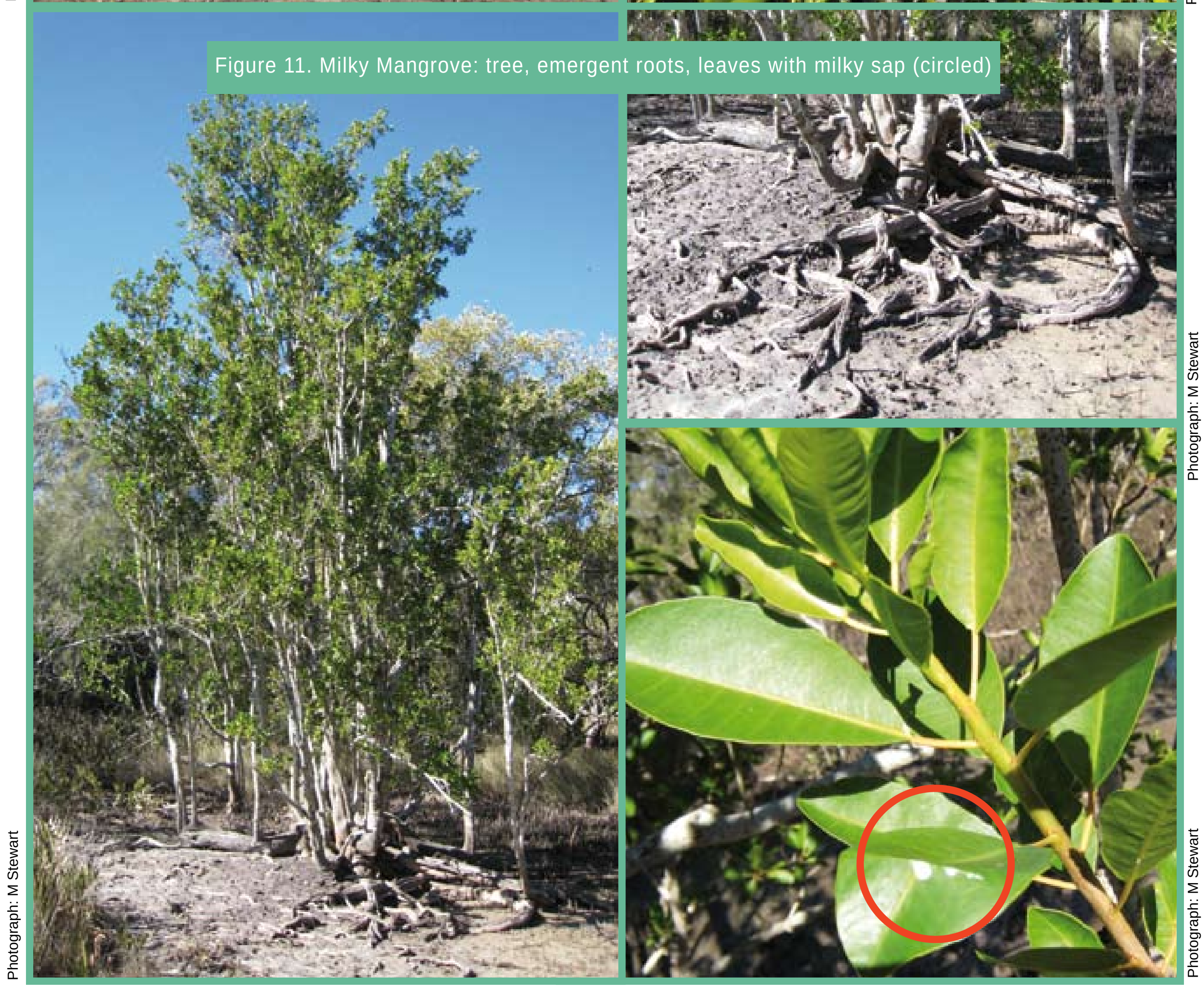
Common name(s)	Scientific name	Distinguishing features	Distribution in NSW	
Large-leaved Mangrove	*Bruguiera gymnorhiza*	• Occurs in intermediate to landward tidal zone • Dark-brown, rough bark • Tree 2–6 m tall • Buttress trunk and exposed knee roots • Opposite large leaves 10–20 cm long • Red flower with orange petals • Green fruit, cigar shaped, 10–20 cm long	Tweed River to Clarence River	
Milky or Blind-your-eye Mangrove	*Excoecaria agallocha*	• Occurs in intermediate to landward tidal zone • Grey, slightly-rough bark • Tree 2–6 m tall • Emergent roots • Alternate leaves ~ 6–10 cm long • Excludes milky sap • Male and female flowers on different trees • Fruit has peppercorn like seeds	Tweed River to Manning River	
Mangrove Fern	*Acrostichum speciosum*	• Occurs in intermediate to landward tidal zone • No stem • Fern, 0.5–1 m tall • Alternate leaves • Fronds with 15–20 leaflets • Golden brown sporangia under upper leaflets, no flowers or fruits • May form dense undercanopy stands	Tweed River to Clarence River	

Figure 10. Large-leaved Mangrove: tree, trunk buttresses and knee roots, leaves and flowers

Figure 11. Milky Mangrove: tree, emergent roots, leaves with milky sap (circled)



CURRENT STATUS OF MANGROVES IN NSW

Recent research indicates that the total area of mangrove habitat within NSW may actually be expanding. A survey in the early 1980s recorded 107 km^2 of mangrove. A more recent survey in 2005 has recorded at least 125 km^2 of mangroves situated within 86 estuaries and embayments. While the overall trend (an increase of 21.5 km^2) shows an expansion at 65 locations, nine other estuaries were found to have lost mangrove habitat. Only small changes, if any, appeared to have occurred at the remaining 12 sites.

Some of the overall increase may be a result of improved mapping techniques, but a rise in sea level of about 10 cm over the past 100 years, plus expansion of habitat associated with increased sedimentation rates, will have also played a part. NSW Department of Primary Industries (NSW DPI) is undertaking further analysis of the mapping results to determine possible causes for these changes.

Research has also indicated a trend of landward movement of mangroves into saltmarsh environments in the estuaries of south-east Australia and this poses a threat to saltmarsh habitat. This migration is due in part to increased sedimentation rates along the NSW coast, which creates habitat more suitable for mangroves to occur.

Dredging and sea level rise can cause the tidal prism to change within an estuary. An increased tidal prism may result in the migration and colonisation of mangroves further upstream and inland into areas which had previously been uninhabited by mangrove species.

As more people seek to live in the coastal zone, the risk to mangroves in these areas also increases. Greater pressure is placed on the mangrove environment from both direct impacts (removal of mangroves for water access, infrastructure and views) and indirect impacts (e.g. changes in natural tidal flow characteristics, pollution, weed invasion).

It is important that land use planning processes factor in the protection of mangrove habitats and address the cumulative impacts of developments on this and other key fish habitats to sustain healthy estuaries and fish stocks and to protect coastlines from storms and erosion.

THREATS TO MANGROVES IN NSW

Threats to mangroves include:

- tidal barriers, drainage and flood mitigation works
- uncontrolled stock access
- increasing demands for foreshore developments and uninterrupted water views
- foreshore protection works
- use of off-road vehicles
- dumping of rubbish/waste
- oil spills and toxic chemicals
- trampling by humans
- climate change and sea level rise

Tidal barriers, drainage and flood mitigation works and foreshore protection works

Dead and dying mangroves occur locally where tidal exchange has been impeded by foreshore structures such as floodgates, culverts and levee banks. Williams and Watford (1996) identified more than 4000 structures within NSW that impede tidal flow. Such structures often physically block the dispersal of mangrove seeds and render upstream water quality unsuitable for healthy mangrove growth. A single tidal barrier can impact on many hectares of mangroves upstream.

Developments or activities which have the effect of permanently draining water from a mangrove wetland or which impede normal drainage are likely to have negative effects, resulting in the death of the plants and loss of this key fish habitat.

Foreshore protection works that exclude the regeneration of mangroves are a threat to the future of mangroves and the wildlife that depend on them.

Photograph: T Daly

Figure 12. Foreshore protection works can limit natural regeneration and landward migration of mangroves during sea level rise.

Uncontrolled stock access

Uncontrolled livestock access can cause large scale damage to mangroves. Livestock feed on mangrove leaves and stems, killing young seedlings and stunting the growth of trees and shrubs. Stock trampling can destroy root systems

Photograph: H Shuttleworth

Figure 13. Uncontrolled stock access can compact soils, damage roots and seedlings and stunt tree growth.

and compact the soil, severely impacting on the habitat value of mangrove areas. Pugging of the soil caused by stock can result in water ponding and can also exacerbate mosquito nuisance. Pugging can also limit the movement of fish, major predators of mosquitoes, within mangrove habitat.

Increasing demands for foreshore developments and uninterrupted water views

Water frontages are considered to be prime real estate and are often gained by in-filling or clearing mangrove wetlands. Mangroves are also often illegally cut down, poisoned or trimmed by owners of waterfront properties to obtain water views and private access to waterways.

Figure 14. Illegal trimming of mangroves for development and waterfront views.

Photograph: C Ganassin

Use of off-road vehicles

Trail bikes and other off road vehicles can cause damage to seedlings and trees, destroy the roots and compact the soil. In these areas regeneration can be very slow and in some cases the mangrove plants may never occur again.

Dumping of rubbish/waste, oil spills and toxic chemicals

Mangrove habitats, particularly those near large urban centres, have also been degraded by the dumping of domestic and industrial rubbish.

Oil spills and toxic chemicals leaching from rubbish, washing into creeks and rivers from roadways or escaping from boat or shipping accidents are also highly destructive to mangrove areas and wildlife.

Trampling by humans

Humans walking through mangrove forests can trample and cause destruction to mangrove root systems, leading to the death of the tree over time. Seedlings can also be destroyed.

Climate change and sea level rise

Mangroves found along the NSW coast are at risk from climate change and rising sea levels. Climatic changes (e.g. changes in temperature and rainfall) can create conditions ideal for the spread of pests and diseases that can harm mangroves.

Urban and industrial development along the NSW coast has limited the locations where mangroves can exist. As sea levels rise, mangroves may be left with nowhere to migrate to, resulting in their loss from some urban coastal sites.

Alternatively, with rising sea levels mangroves may migrate upstream as the tidal prism changes; altering upstream ecosystems.

Loss of mangrove habitat would have significant impacts on water quality, coastal foreshore protection from waves and storms, and flow on effects to fisheries production and tourism associated with fishing and healthy estuaries.

ECONOMIC VALUE OF MANGROVES

Several studies have attempted to quantify the economic value of mangroves to both commercial fisheries productivity and to the community in terms of their ecosystem services. For example, Morton (1990) estimated that mangroves in Moreton Bay, south-east Queensland contributed approximately $8380 per hectare to commercial fisheries production based on the monetary value of catch rates of target fish caught in this habitat type. A 2006 report by the United Nations Environment Progam estimates that mangroves contribute an annual value of US$200 000 – US$900 000 per km^2 in services such as protecting foreshores, fisheries production and supply of building materials (e.g. timber), tourism and recreation and improving water quality.

Figure 15. Mangrove habitat is strongly linked to the economic value of commercial fisheries productivity.

PROTECTION OF MANGROVES

NSW DPI is responsible for the management of fish and marine vegetation, including mangroves, under the *Fisheries Management Act 1994* (FM Act). Any development or activity that may harm mangroves must be referred to NSW DPI for approval.

The FM Act sets out provisions to protect marine vegetation, including mangroves, from ‘harm’. ‘Harm’ under the FM Act means gather, cut, pull up, destroy, poison, dig up, remove, injure, prevent light from reaching or otherwise harm the marine vegetation, or any part of it. A permit is required from NSW DPI to harm any marine vegetation, including mangroves.

The maximum penalty for harming mangroves without a permit is $220 000 for a corporation or $110 000 for a person.

Policies and guidelines applicable to the protection of mangroves can be found on the Department’s website at www.dpi.nsw.gov.au or can be obtained from NSW DPI offices – see contact details section.

HOW CAN WE HELP TO PROTECT MANGROVES?

Some simple ways to help protect mangroves are:

- fence along the intertidal zone and prevent stock access to mangrove areas,
- design riverfront structures such as jetties or boat ramps to avoid or minimise impacts to mangroves,
- avoid walking, riding or driving through mangrove areas at low tide,
- dispose of rubbish, oils and chemicals in the correct manner, and
- report activities harming mangroves by contacting your nearest NSW DPI Fisheries Office or Fishers Watch Hotline on 1800 043 536.

CONTACT DETAILS

Conservation Manager – North Region

NSW Department of Primary Industries
1243 Bruxner Highway
Wollongbar NSW 2477
Phone: (02) 6626 1200

Conservation Manager – Central Region

NSW Department of Primary Industries
Locked Bag 1
Nelson Bay NSW 2315
Phone: (02) 4982 1232

Conservation Manager – Sydney Region

NSW Department of Primary Industries
PO Box 21
Cronulla NSW 2230
Phone: (02) 9527 8411

Conservation Manager – South Region

NSW Department of Primary Industries
PO Box 97
Huskisson NSW 2540
Phone: (02) 4441 8969

Conservation Manager – South Region

NSW Department of Primary Industries
PO Box 17
Batemans Bay NSW 2563
Phone: (02) 4478 9103

REHABILITATION OF MANGROVES

Along the coastline of NSW, numerous rehabilitation projects are being conducted to help restore areas where loss of mangrove habitat has occurred. Although often a slow process, the majority of these rehabilitation projects are proving to be successful. The degree of success depends on a number of environmental factors; including tidal range, soil type, and the intensity of wave energy at the rehabilitation site. It is vital that these circumstances be assessed prior to any regeneration attempt.

To assist with project planning, the following guidelines are provided and have been adapted from Weir et al. (2006). Please note the methods apply to the common Grey Mangrove only.

As mangrove habitats are very fragile, and mangroves are protected in NSW waters, any mangrove rehabilitation projects should be assessed by your local NSW DPI Fisheries Conservation Manager to determine if a permit is required before being implemented (see contact details section on p.11).

Options for mangrove rehabilitation include:

- natural recruitment
- seeding
- transplanting
- reducing wave energy

Natural recruitment

Where site conditions are suitable for mangrove regeneration, natural recruitment is the best and most cost-effective method. In such situations, often simply fencing the mangrove area and excluding cattle and other stock can result in substantial natural recruitment and recovery of mangrove forests.

Planting with seeds

Where high wave energy or a steep slope limits natural recruitment there are two major planting techniques used in mangrove rehabilitation. The ‘seeding’ technique involves planting the seeds directly into the ground at the location

Figure 16. Mangrove rehabilitation works, using Grey Mangrove seedlings, on the Shoalhaven River, south coast of NSW.

Photograph: A Lugg

of the rehabilitation site. The second technique involves planting or 'transplanting' the seedlings which may be grown in special nurseries or gathered from drains or sites where NSW DPI officers have agreed they can be sourced. Compared to transplanting, seeding is a quick and easy method of establishing mangroves, with survival rates of up to 95 % being achieved when seeds are planted correctly.

Seeds and saplings used for rehabilitation work should be sourced from local populations within the same catchment and should be appropriate species for that area. Only the seeds that have dropped from mangrove trees should be collected. When collecting seeds, be careful not to damage the root systems of established trees.

Seeds of the Grey Mangrove are generally most abundant and readily available between October and December. Seeds are gathered from the ground within the mangrove forest. Sometimes accumulations of seeds collect in protected pockets along the foreshore, where large numbers can be collected in a short time. Strong winds can dislodge immature seeds so it is best to choose the largest seeds possible as these are more mature and close to germination.

Grey Mangrove seeds are covered by a buoyant outer husk. The collected seeds can be placed into a bucket of water (fresh or salty) and left overnight. The next day the husks will have separated and will be floating on top of the water. These seeds are then ready to be planted and roots will begin to form within a few days.

Seeding is appropriate for sites that have been degraded, as well as for increasing the density of existing mangrove stands. However, seeding is not suitable for all locations, as intense wave and tidal action can easily dislodge the seed. The best sites to actively seed mangrove plants are those that are sheltered from wave energy and have gently sloping foreshores with a muddy or silty substrate. Sandy foreshores tend to be too mobile and may dislodge or smother seeds. Optimum growth and establishment success appears to occur at the Fringing to Intermediate Zones where the regeneration site has a suitable elevation, generally between 0–0.5 m above sea level, and where there is a good source of seed nearby.

The seeds can be hand-sown in selected locations. Using a stick or a finger to make a hole, sprouting seeds are placed only 1–2 cm deep into the substrate. If the seed is totally covered then it may rot. To stop floating debris (such as logs and dead seagrass) from pulling out the seed, the seed is positioned so that the sloping top edge is facing the water.

In exposed areas seeds are often washed out of the substrate by wave action. Wash out of seeds can be prevented to some extent by planting in short rows and pegging plastic or metal mesh (e.g. gutter guard) over the seeds until the roots have sprouted and anchored to the substrate. Construction of a plastic mesh fence parallel to the shoreline can significantly reduce the subsequent smothering of seedlings by floating debris and significantly increase survival. Alternatively, wave energy reducing methods may be used (see section on p.15). Ongoing management, repair, removal and replacement of deteriorating wave barriers are critical to limit the likelihood of this material becoming unwanted debris in our estuaries.

Photograph: A Lugg

Figure 17. Plastic mesh fencing can protect mangrove rehabilitation areas from smothering by floating debris.

Planting with seedlings

Transplanting seedlings

Trials have shown that the transplanting technique may not be as successful as the seeding technique. The lower survival rate is thought to be caused by damage suffered to the plant roots whilst transplanting. Transplanted seedlings often fall victim to wind, waves, boat wash and floating debris. The roots take time to re-establish and can be pulled out or knocked over before they gain hold in the foreshore. Transplanting is a viable method provided the seedlings are between 20–40 cm high, have 6–10 leaves and no peg root development. Transplanting is better suited to exposed locations where seeds tend to wash out too easily.

When transplanting a mangrove seedling, a vertical ring is cut at a radius of about one third of the height of the plant. A suitably sized PVC

Photograph: A Lugg

Photograph: A Lugg

Figures 18 and 19. Transplanted seedlings damaged by wind and wave action and floating debris.

pipe is generally effective. Soil is removed from outside the cut to enable a space for a shovel to be run underneath the plant. The objective is to minimise damage to the roots. The plant is then lifted out and placed on polythene and balled up for transportation.

Sometimes abundant small seedlings become established in very soft mud within or adjacent to mangrove forests. These can often be gently lifted out with little damage to the root system and transplanted elsewhere. Large quantities of these 'bare-rooted' seedlings can be much more readily transported than seedlings with the root substrate still attached. However, the mud needs to be very soft to minimise root damage.

Seedling planting method

Using a shovel, seedlings can be transplanted into the foreshore. The shovel is pushed into the substrate deep enough so that the seedling root remains vertical with no bends. The shovel is levered to the side to create an opening into which the seedling is placed. The shovel is slowly removed so the silt gap closes around the seedling and its roots. Any remaining gaps in the silt are left to be closed by the next rising tide. No pressure is applied around the seedling as this can damage the delicate roots.

Growing seedlings in pots

Seeds can be propagated in pots and planted out once they reach seedling size. The pots (150 mm) are filled with mud from the river foreshore.

Figure 20. Grey Mangrove seedlings growing in pots within the Fringing to Intermediate Zone to allow for tidal flushing. Note protective mesh barrier.

Photograph: A Lugg

Seedlings grown in pots must be watered twice a day for about two hours. This is done by placing trays of pots into a tank with 30% salty water and 70% freshwater pumped in to cover the pots or by placing the nursery in the intertidal zone. Seedlings should be protected by a fence and situated out of sight to prevent vandalism.

Reducing wave energy

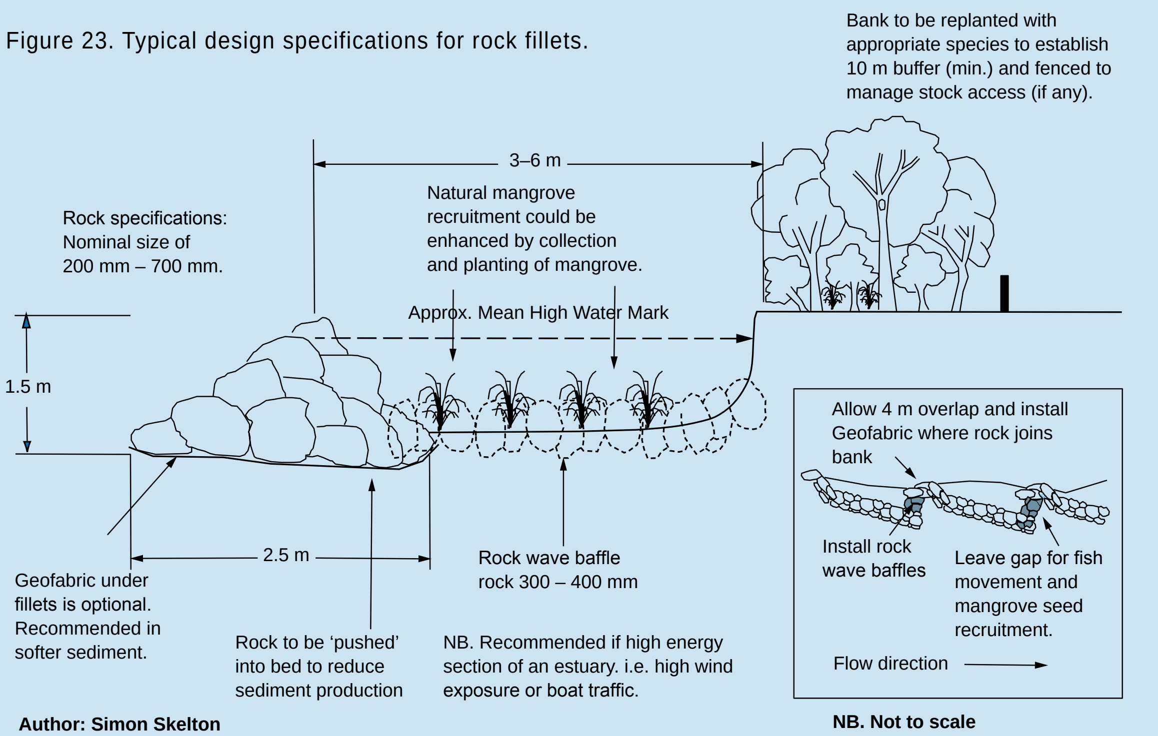
In areas that are subject to excessive wave action, several methods can be used to reduce wave energy, thereby allowing natural recruitment or seeding to take place. Rock fillets, timber or sediment fencing are energy dissipating methods constructed to mean high water level and placed about 3–5 m in front of an eroding bank. These structures absorb wave action and create an area of still water between the fillet or fence and the eroding bank. This still water area permits the accumulation of sediment and provides a habitat that is suitable for the natural regeneration of mangroves.

Generally, energy dissipation structures are laid parallel to the riverbank, overlapping each other at the downstream end, thereby allowing tidal flushing, fish passage and natural recruitment of mangrove seedlings. Demonstration of the success of such structures is evident in the Manning and Hastings River estuaries on the mid north coast where thousands of mangroves have germinated behind completed rock fillets.

Figure 21. Rock fillet method at Hastings River, mid north coast NSW.

Figures 22. Natural regeneration of mangroves behind a rock fillet, which will help protect the river bank from further erosion.

Figure 23. Typical design specifications for rock fillets.



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