COASTAL PLANNING AND MANAGEMENT MANUAL

A community guide for protecting and conserving the Western Australian coast

GOVERNMENT OF WESTERN AUSTRALIA

WESTERN AUSTRALIAN PLANNING COMMISSION

Coastwest

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FOREWORD

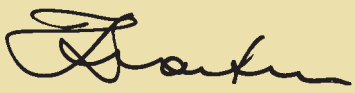
The coast is important to the lifestyle and livelihood of the people of Western Australia. It is a significant asset that contributes to the environmental, economic, social and cultural fabric of the State.

The majority of Western Australians choose to live close to the coast. An even greater proportion chooses coastal locations as tourism and recreation destinations, attracted to the many and varied natural coastal assets on offer. But there is also demand for access to the coast from fishing and aquaculture industries, ports and shipping, and mineral exploration. The coast is under increasing pressure from human activity and its conflicting user demands.

Coastal planning and management that is based on sound principles can help to resolve these conflicts and mitigate the impacts of how we utilise our coastal resources.

In addition to the coastal planning and management work done by government, over 160 community groups are actively engaged in coastal management around Western Australia. Production of this manual seeks to acknowledge the significance of this contribution through the provision of practical information on coastal planning and management.

Information in the manual focuses on guiding development and implementation of coastal management projects in response to local pressures. It has largely been compiled thanks to the skills and experience of the coastal community, and seeks to promote the exchange of ideas within that same community, for better outcomes.



TERRY MARTIN
Chairman
Western Australian
Planning Commission

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1. INTRODUCTION

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1.1 ABOUT THIS MANUAL

The aim of this manual is to provide community groups, local government and other land managers with a practical guide to coastal planning and management for Western Australia.

Preparation of the manual has been co-ordinated by the Western Australian Planning Commission, in response to requests from the coastal community, and in conjunction with other State agencies, local government and individual community members.

There are numerous organisations and groups involved in coastal management that may benefit from this information. However, it particularly recognises the information requirements of the 160-plus community groups that are actively engaged in coastal management and planning projects in their local areas, in conjunction with State and local government organisations that have responsibility for management of the coast.

It is not intended that the material offered here be a complete guide, but an overview of important considerations for planning and management projects seeking to protect and conserve the coast. Information has been included on planning for management; common coastal management problems; techniques for stabilisation and rehabilitation of coastal landscapes; coastal plants and revegetation; and coastal weeds and weed management. Figure 1-1 demonstrates how these sections fit together to support decisions and actions.

There are numerous issues not directly addressed by this manual that also require management action on the coast. These include the establishment of adequate foreshore reserves and coastal development setbacks, urban drainage disposal, groundwater impacts, and boating facilities (among others). Guidance on these matters is provided in the following policy statements: State Coastal Planning Statement of Planning Policy, and the draft Coastal Zone Management Policy for Western Australia. It may be appropriate to prepare guides to support these policy statements in the future.

The manual also includes a number of case studies and descriptions of where techniques are being applied around Western Australia. These case studies acknowledge that there is a wealth of coastal management knowledge and expertise within the West Australian community, and that we should facilitate sharing of this knowledge with other groups, and other areas.

The Western Australian coast is diverse. Solutions to management issues need to be developed based on site conditions and the type of activities occurring in an area. The information provided is necessarily broad to ensure that it is applicable across the range of coastal environments. However, through the presentation of case studies and examples, the manual offers implementation of management solutions that suit a range of local circumstances.

A number of other useful resources for coastal management have been developed both in Western Australia and elsewhere. Where relevant, references to these resources have been included, and a list of additional resources is provided in section 12: *References and Further Reading.*

Material is presented in a loose-leaf format to enable you to add resource material and to allow for updates in response to changing needs, experiences and legislation. It has also been produced as a CD-Rom, and will be placed on the Internet at www.wapc.wa.gov.au to maximise opportunities for the information to be accessed.

Resource material required to support coastal management in Western Australia should be in tune with, and reflect the dynamics of our coastal areas, which are constantly changing with the land, wind and oceans, and human activity.

Defining the coast

There has been much debate in planning and management documents about what constitutes the coast, and the coastal zone.

A working definition of "the coast" is:

- waters, the seabed, reefs and offshore islands, including gulfs and sounds under the jurisdiction of the Western Australian Government
- the mobile beach zone and modern (Holocene) dune systems, mangroves, wetlands, and flats subject to tidal influence
- rocky outcrops and headlands
- areas potentially subject to shoreline movements
- estuaries and coastal lagoons.

(adapted from Donaldson, 1995)

For the purposes of this manual and the information contained within it, the coast can be further defined as the area where coastal management problems are occurring, and coastal land managers and communities are working to address these.

Figure 1-1 Coastal planning and management components included in this manual

The Coastal Environment

Common Management Problems

Coastal Management Planning

Stabilisation and Rehabilitation

Revegetation

Weeds and Weed Management

Project Evaluation

1.2 COASTAL PLANNING AND MANAGEMENT PRINCIPLES

The principles set out below govern the type of information and management advice that has been provided throughout the manual. They are considered relevant for good coastal planning and management outcomes.

Sustainable management

The coast should be managed in a way that ensures that the opportunities for future generations to use and appreciate the coast are not diminished by current decisions and actions.

Identifying the limits of acceptable change

Coastal managers should be aware of the physical limits to change at their site. Where there is an imperfect understanding, the precautionary principle should be applied.

Maintenance of ecosystem integrity

The coast should be managed to ensure that fundamental physical and natural processes can continue indefinitely.

Consultation

Open and collaborative consultation with all interested parties about the coast is essential for fair and equitable planning and management.

Respect for and protection of Indigenous rights, interests, culture and heritage

The rights and interests of Indigenous people and their unique relationship with the coast should be recognised, and Indigenous culture and heritage protected.

Identification of management objectives

Clearly understood and measurable objectives should be identified for coastal areas. These objectives should govern planning and management decisions.

Staged management approaches

Management actions in coastal areas should be staged to accommodate available resources and respond to increased knowledge and experience over time.

Minimal intervention

Coastal management should involve doing as much as needed and as little as possible.

Site-specific management approaches

Each coastal site is unique in its features and use, and will require a management approach tailored to those unique characteristics. General techniques and approaches should be translated into what works for a particular coastal area.

2. THE COASTAL ENVIRONMENT

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2.1 UNDERSTANDING THE COAST FOR MANAGEMENT

The coast of Western Australia ranges from the wet-dry tropics of the Kimberley, through the arid environments of the Pilbara, to the cool temperate environments of the South Coast. It incorporates a very wide range of coastal landforms – beaches, dunes, tidal creeks and lagoonal environments within inlets, gulfs, reef-protected coast and open coast along the mainland.

As a result there is substantial variation in the profiles and distribution of landform and vegetation communities at any place.

Coastal environments are also highly dynamic and complex. They are subject to continuous and extensive changes in response to variations in weather, wave and sea level conditions. The nature of these changes depends on the way coastal processes interact with landforms and with sediments.

Coastal planning and management considerations are closely aligned to the nature and form of an area, the processes acting upon it, and its propensity to change. It is therefore important to get some understanding of these aspects and their interaction.

This section of the manual broadly provides:

- a description of the coast of Western Australia according to five designated regions
- an overview of coastal processes that affect landforms and shoreline movement and stability
- coastal landform descriptions, and the relevant considerations for management of each of these areas.

A major challenge in managing coastal environments is to understand coastal change and accommodate it in decision making. This can be difficult as, even when detailed environmental information is available, the extreme variability of the coast creates uncertainty. It is important that technical advice be sought to guide decision making, so that the implications of management action, or inaction, may be fully understood.

Figure 2-1 describes the typical features of a dynamic beach system.

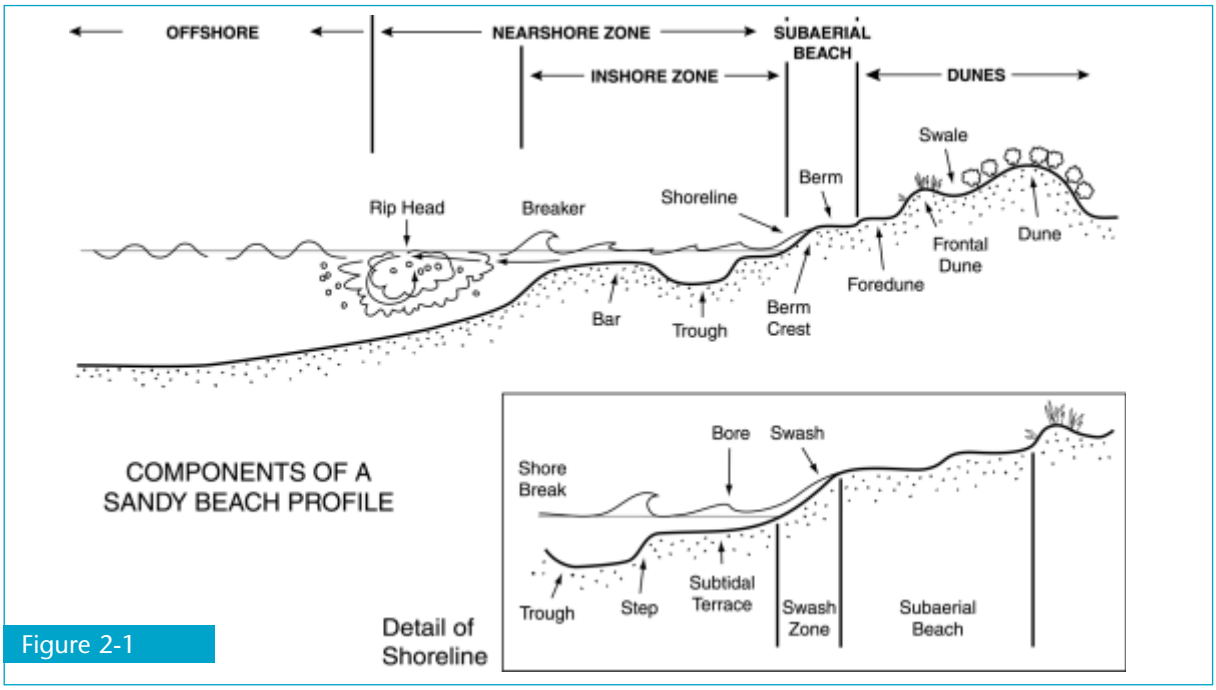


Figure 2-1

Cross section of a dynamic beach.

2.2 THE COAST OF WESTERN AUSTRALIA

Western Australia is largely made up of geologically old, igneous, metamorphic and sedimentary rocks. The remainder of the State consists of younger sedimentary rocks, mainly sandstones and limestones. Owing to the great age of rocks in Western Australia, they have been weathered and eroded for many millions of years.

The type of rock and its structure broadly determines the shape of a section of coast. However, landforms at any particular place are a result of the interaction of the local geology with coastal processes and biology.

Broadly, there are two types of coastal landforms: those composed of rock, and those composed of unconsolidated sediments, mainly sands and silts. For example, the cliffs of the Nullarbor, Zyptdorp and Kimberley contrast with the long sandy beaches of the Roe Plain, the coast between Cape Naturaliste and Geraldton, and Ninety Mile Beach along the South Coast.

Usually, the coast is a mix of rock and unconsolidated sediments, with unconsolidated sands and mud abutting or overlying basement rocks. Coast between rock outcrops is then based on the geology, sediment supply and intensity of coastal processes occurring.

There are 15 marine regions in Western Australia, as recognised in the Interim Marine and Coastal Regionalisation of Australia, and 12 terrestrial regions (abutting the coast) through the Interim Biogeographic Regionalisation of Australia. These national classification systems are based on a combination of attributes such as climate, geology, landform, vegetation, flora and fauna, land use, and other attributes as needed.

For the purpose of presenting information throughout the manual, these classifications have been grouped into five broader coastal regions for Western Australia. Within these groups, it is recognised that there remains considerable diversity.

These regions, and their geology, key coastal processes and landforms, are outlined in figures 2-2 to 2-6. The remainder of this section of the manual provides more detail on the coastal processes and landforms referred to in these figures.

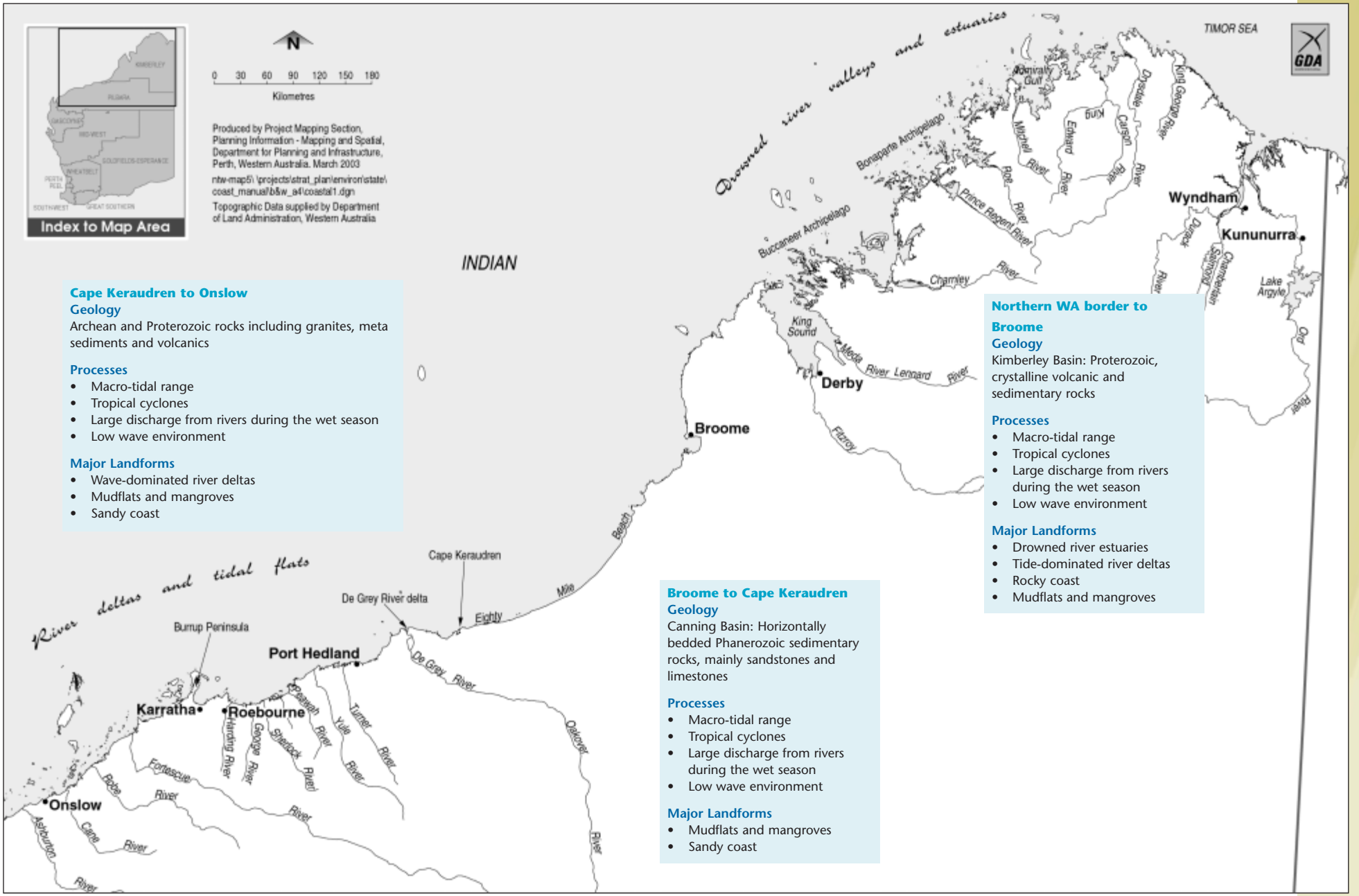


Figure 2-2 Pilbara – Kimberley Region (Onslow to northern Western Australia).

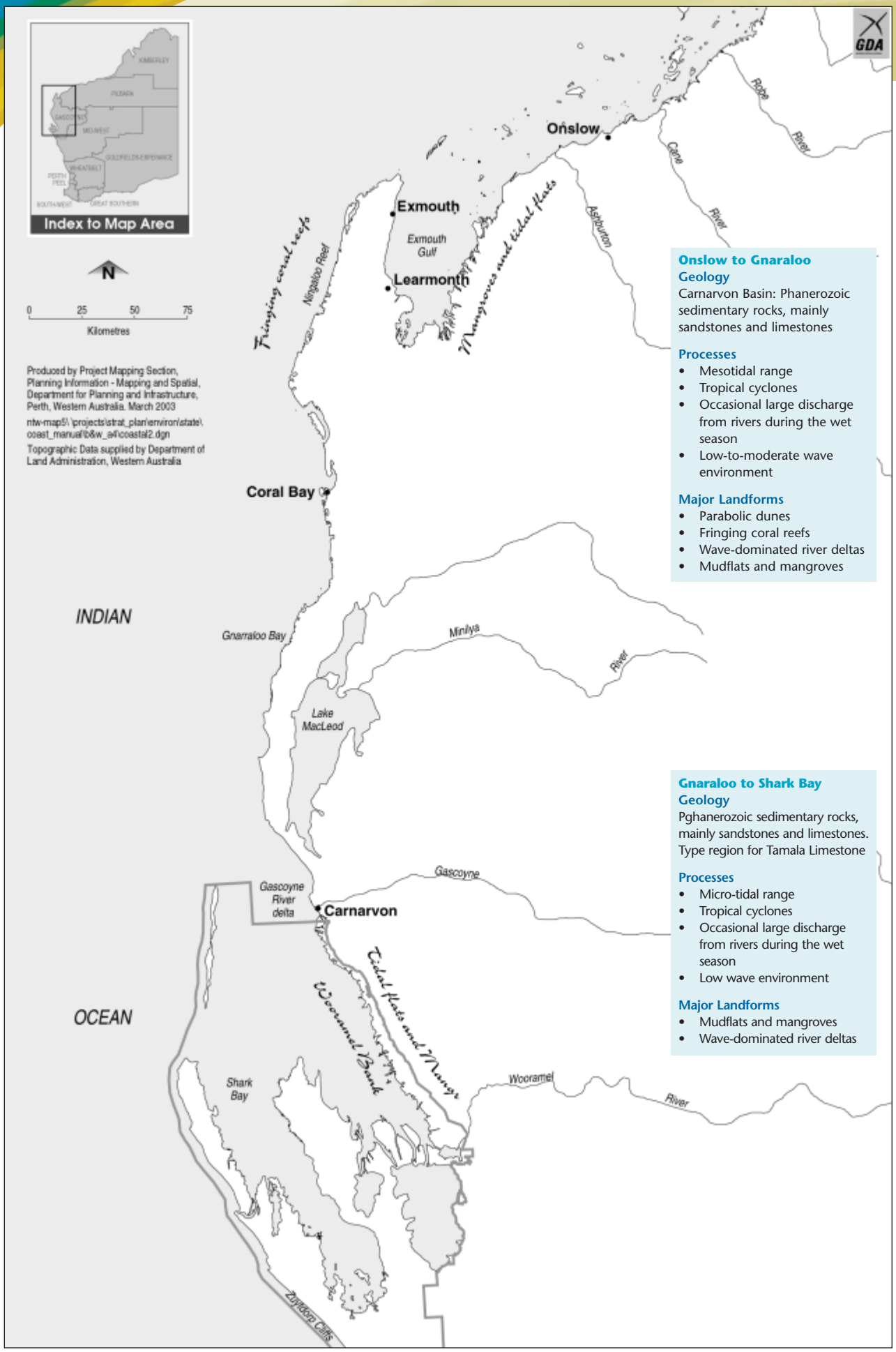


Figure 2-3 Gascoyne region (Shark Bay to Onslow).

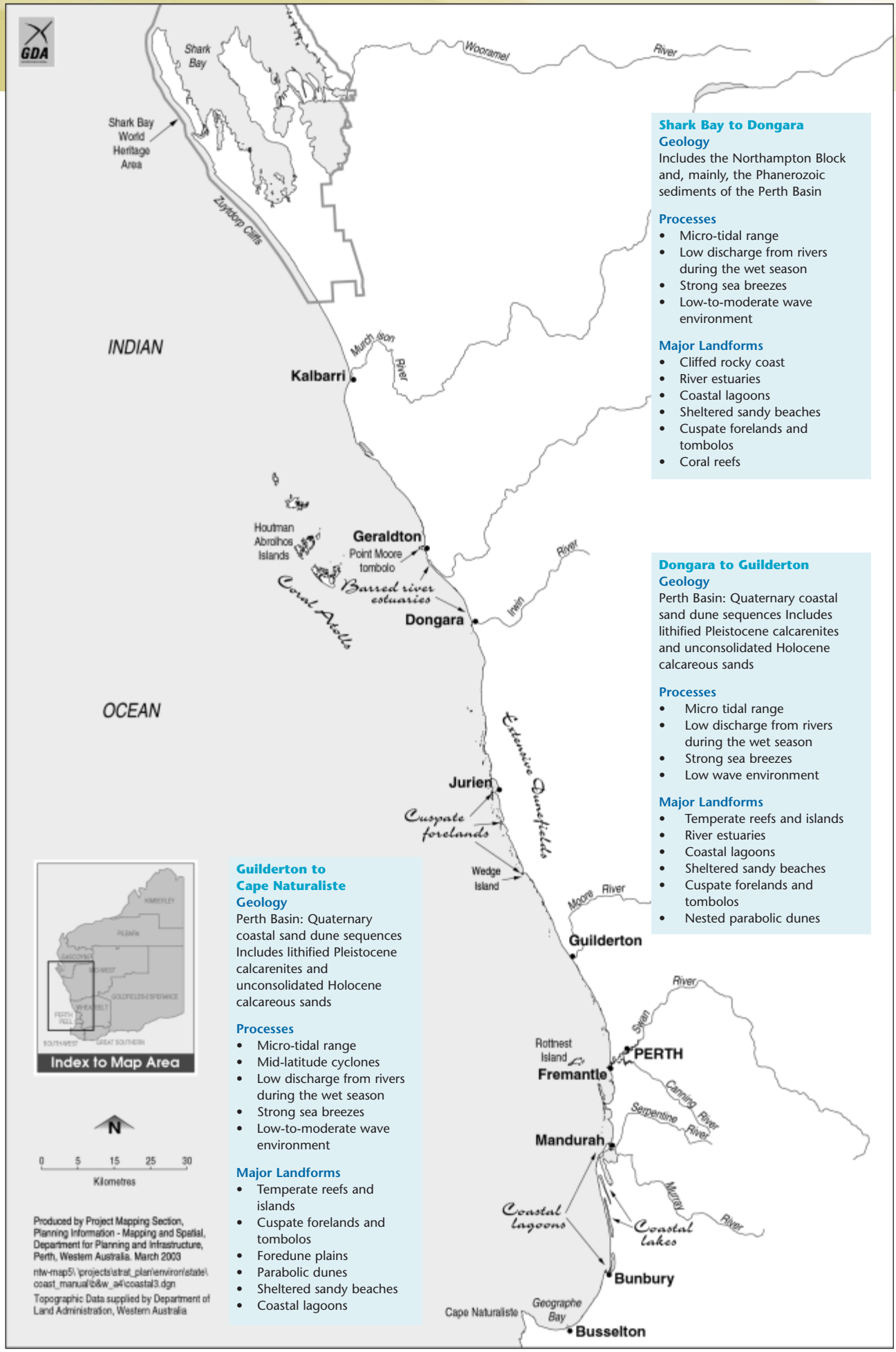


Figure 2-4 Central West Coast region (Shark Bay to Cape Naturaliste).

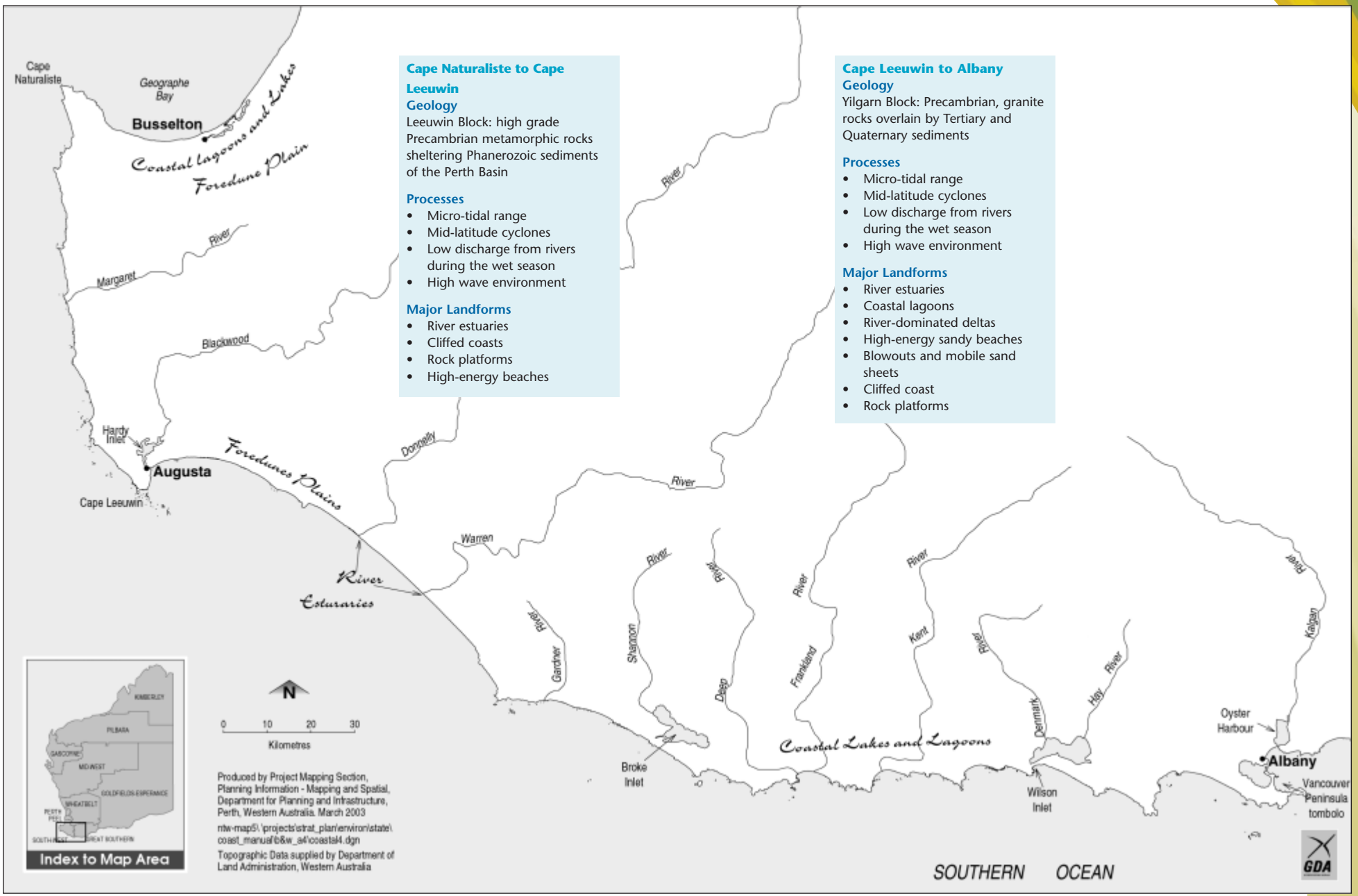


Figure 2-5 South West Capes region (Cape Naturaliste to Albany).

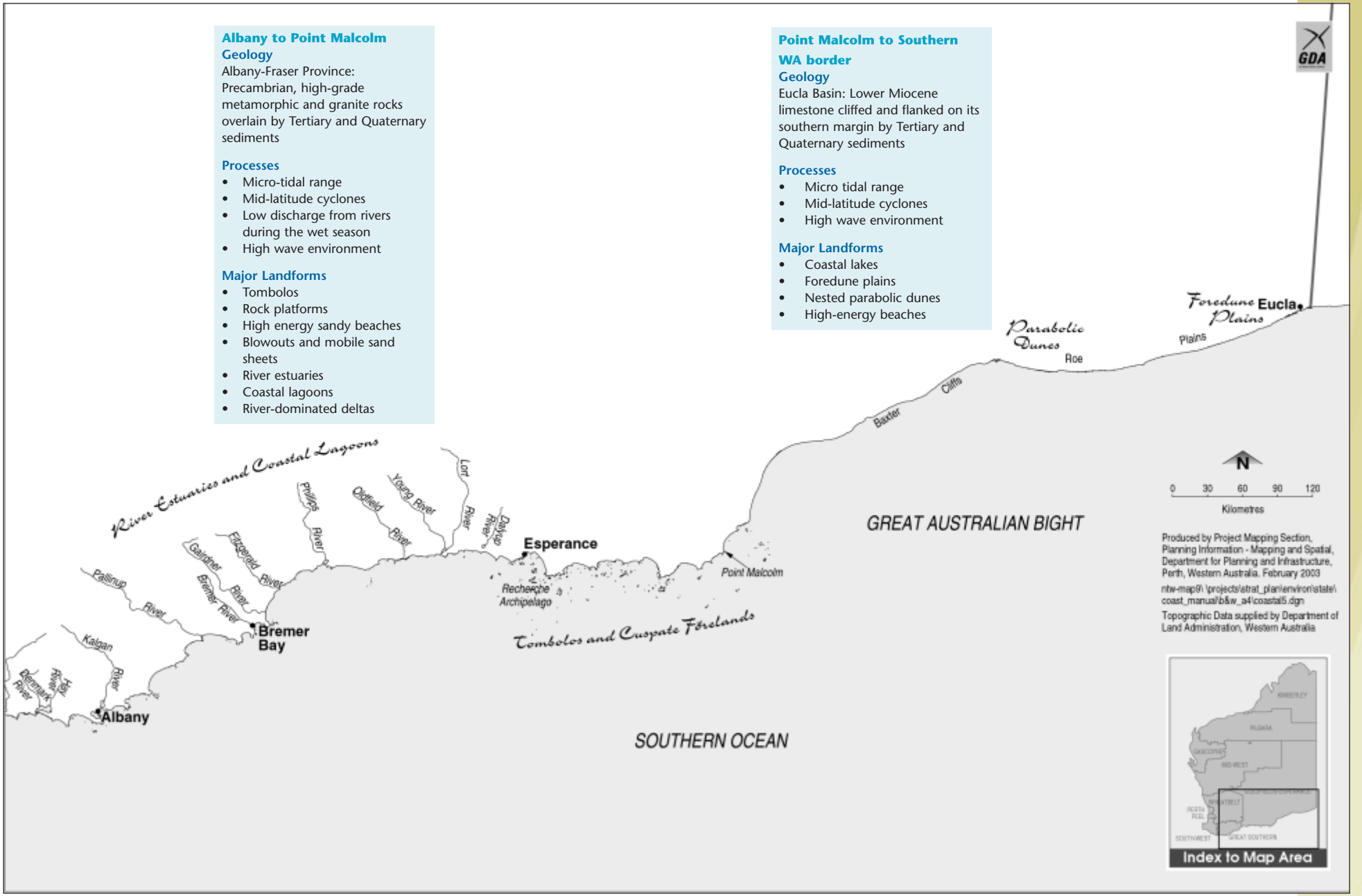


Figure 2-6 South Coast region (Albany to southern Western Australian border).

2.3 COASTAL PROCESSES

The key coastal processes that affect coastal landforms and movement of the shoreline, particularly on sandy coasts, are:

1. Weather and Climate: *air pressure, wind direction and speed, temperature and rainfall*
2. Tides: *tidal environment, form and range*
3. Sea levels: *storm surge, water level ranging, long-term change in sea level*
4. Waves: *sea and swell, attenuation and breaking*
5. Currents.

These processes interact with each other and with the local environment. They also drive a number of secondary processes. An understanding of these key coastal processes will help us see why changes are taking place, and the magnitude of change which is occurring—both in space and time.

The *relative intensity* of the tides, waves and sea level fluctuations, determines the nature of shoreline change.

Relative intensity implies the changes in water level based on:

- the modal value of the annual significant wave height
- the mean spring tidal range
- the modal value of the annual significant tidal residuals (the non-tidal fluctuations in sea level. For example, storm surge).

Beaches with very different wave heights, tidal ranges and tidal residuals can have the same relative intensity and, hence, similar types of shoreline change and management problems. Table 2-1 provides an example. Beaches with attributes such as those described in the table are likely to have similar landforms. However, the size of these landforms would be quite different.

Table 2-1 Relative intensity of tides, waves and sea level fluctuations.

Variable	Beach 1		Beach 2	
	Value (m)	Relative intensity	Value (m)	Relative intensity
Modal significant wave height	0.5	31%	2.5	31%
Mean spring tidal range	0.7	44%	3.5	44%
Mode of the tidal residuals	0.4	25%	2.0	25%

Changes like those that occur during extreme storms will produce significant changes in the position of the shoreline and shape of the beach. These changes can persist long after the storms have passed. It is important to consider extreme changes in shoreline position that have occurred in the past, as they have a high probability of recurring in the future.

2.3.1 Weather and climate

Prevailing *weather* conditions are defined by the atmospheric processes of temperature, humidity and wind conditions at any time and place. The *climate* and climate change is weather information collected over space and time.

The weather impacts on geomorphologic processes (the formation of landforms), as well as on local coastal processes. For example, energy exchange between the atmosphere and the sea surface generates waves, and ultimately drives long-term changes in coastal landforms. Further, broad-scale atmospheric processes that drive El Niño – Southern Oscillation (ENSO) events in the Pacific Ocean are related to the Leeuwin Current off Western Australia. Further information on the ENSO phenomena can be found on the Bureau of Meteorology website http://www.bom.gov.au.

Interactions between the atmospheric processes that define the weather, and local coastal processes are provided in Table 2-2.

Table 2-2 Atmospheric processes and their effect on coastal processes.

COMPONENT	EFFECT
Air Pressure	• A change in sea level is inverse to change in air pressure. For example, a 1 hPa fall in air pressure results in a 1 cm rise in sea level. Over time, a 1 cm rise in sea level results in 1.0 metre of shoreline retreat on sandy coast.
Wind	• Wind shear (drag) on the water surface enables energy exchange between the atmosphere and the ocean, and results in the generation of waves and ocean currents. • Water usually moves in the direction the wind blows. As a result onshore winds cause set-up of water level above predicted levels against the coast and offshore winds cause the water level to be set-down below predicted levels. • Winds transport sediment on the beach and influence the direction and degree of sand movement as well as the formation of dunes.
Temperature	• Radiative heating of the ocean surface results in thermal expansion, affects water density and contributes to the formation of ocean currents. • Temperature of the atmosphere and ocean also affects plant growth and human comfort.
Rainfall	• Rivers deliver sediment to coastal environments. • Fresh water from streams or rainfall affects ocean water density, and contributes to the formation of ocean currents. • Beach groundwater conditions change with seasonal variations in rainfall. • Rainfall affects plant growth in dunes, among other things.

2.3.2 Tides

Tides occur due to the gravitational pull of the moon and the sun on the earth. Unlike most other forms of water level fluctuation, tides are regular and highly predictable. Irregular fluctuations such as tsunami and storm surge are sometimes incorrectly referred to as tidal waves, but they are produced by factors other than true tides.

The largest tides, *spring tides,* are produced when the sun and the moon are aligned so that their gravitational forces are combined. This occurs at the times of full moon and new moon. Conversely the smallest tides, *neap tides,* occur at the time of half moon, when the sun and moon are least aligned and their planes are at right angles.

Three facets of tides should be described for any location:

1. Environment: Microtidal, mesotidal or macrotidal
2. Form: Diurnal, mixed or semi-diurnal, and
3. Range: Neap, spring and LAT to HAT[1] ranges

[1] The Lowest and Highest Astronomical Tides are the lowest and highest values predicted by reconstituting the tides from the astronomical components that drive them. The values are estimated over 19 years of tidal records.

Tidal environment

The range between low and high tide at any location identifies the tidal *environment.* Three categories of tidal range are recognised. All three categories occur on the coast of Western Australia. They are:

Microtidal:	Range less than 2 metres
Mesotidal:	Range 2 to 4 metres
Macrotidal:	Range greater than 4 metres

Tidal form

Tidal form is based on the constituents of the tide, which are the wave forms produced by gravitational interaction between the moon, sun and Earth. Three tidal forms are recognised according to the frequency of high and low tide conditions:

Diurnal:	One high and one low tide each day
Mixed:	Number of tides changes through spring and neap conditions
Semi-diurnal	Two high and two low tides each day

Tidal range

The *form* of the tide indicates whether ranges will be quoted as:

MLWN to MHWN	Semi-diurnal: Neap	Mean Low Water (MLWN) to Mean High Water Neap (MHWN)
MLWS to MHWS	Semi-diurnal: Spring	Mean Low Water Spring (MLWS) to Mean High Water Spring (MHWS)
MHLW to MLHW	Diurnal: Neap	Mean Higher Low Water (MHLW) to Mean Lower High Water (MHWN)
MLLW to MHHW	Diurnal: Spring	Mean Lower Low Water (MLLW) to Mean Higher High Water (MHHW)
LAT to HAT	Diurnal and semi-diurnal	Lowest Astronomical Tide (LAT) to Highest Astronomical Tide (HAT)[1]

Tidal ranges vary significantly around the coast. For example, Fremantle is in a *microtidal* environment. Tides of the region are predominantly *diurnal* in form, with *semi-diurnal* components apparent during the *neap phase.* They have a *spring tidal range* (MLLW to MHHW) of 0.7 metres and a *lowest to highest astronomical tidal range* (LAT to HAT) range of 1.2 metres. In contrast, Derby is in a *macrotidal environment.* Its tides are predominantly *semi-diurnal* in form. They have a *neap tidal range* (MLWN to MHWN) of 4.4 metres, a *spring range* (MLWS to MHWS) of 10.1 metres, and a *lowest to highest astronomical tide range* (LAT to HAT) of 12.1 metres (Department of Defence, 1999).

The principal reference for tides in Australian waters is Department of Defence (2002) Australian National Tide Tables, Australia, Papua New Guinea and Antarctica, Australian Hydrographic Publication 11, Australian Government Publishing Service, Canberra. It is updated every year and should be referred to in any publication. It includes descriptions of the tides for Standard Ports under Australian jurisdiction, and is officially used as the basis of information for navigational purposes.

2.3.3 Sea level fluctuations

Several types of non-tidal sea level fluctuations contribute to the formation of landforms on sedimentary coasts. They include long-term changes in sea level, storm surges and tsunamis, as well as wind waves. These occur over different lengths of time, and their impact on the coast should be considered in the context in which each occurs.

Long-term sea level changes

Long-term sea level changes have contributed to evolution of the coast and continue to do so. As recently as 18,000 years ago, the sea level was 120 metres below its present position, and the continental shelf surrounding Australia was exposed and vegetated. The shore off Fremantle lay over 20 kilometres west of its present position, a little west of Rottnest Island. As the earth began warming and ice melted, the sea level rose for 11,000 years at a rate of about 1 metre every 100 years. There is some evidence that suggests it was higher than its present position by a metre approximately 6,500 years ago, and settled to its current position by 5,000 years ago.

As the sea level rose, the sea transgressed (drowned) the land between Fremantle and Rottnest Island. Sediment was pushed landward with the rising sea and deposited at the shore. This sediment formed present day coastal landforms, which continue to develop.

For the future, models of global climate change predict sea level rise in response to greenhouse warming of the atmosphere. Predictions for sea level rise vary, with recent estimates ranging from a rise of 9 to 88 centimetres to 2100AD (Walsh et al, unpublished). Despite the apparent small change, it will potentially have a profound effect on low-lying and sandy coast. A 1 centimetre rise in sea level is likely to cause a 1 metre retreat of the shoreline on a sandy beach (Bruun 1983). The State Coastal Planning Statement of Planning Policy has accepted a figure of 38 centimetres for inclusion in their coastal setback for development guidelines.

Short-term sea level fluctuations

Short-term fluctuations in sea level occur with the passage of weather systems across the coast. They may cause severe erosion and affect coastal development. They also contribute to geological change over time.

Storm surge is a change in water level brought about by atmospheric forces associated with storms. It has three major characteristics: lowering of air pressure, increased wind shear on the water surface, and high breaking waves. These combine to cause water levels to exceed the level predicted for high tide. Conversely, in calm conditions rising air pressure, strong offshore winds and low wave activity cause water levels to fall below those predicted for low tide.

Figure 2-7

Trigg Island during calm conditions.

Both photographs were taken at a similar time when the tide was low. Beaches tend to erode under high water level conditions, and accrete during low-water-level conditions. [Photos: Ian Eliot]

Figure 2-8

Trigg Island during stormy conditions.

Calm and stormy conditions at Trigg Island are shown as an example in figures 2-7 and 2-8. The most damage to the coast occurs when severe storms coincide with high tides. Under these circumstances the surge and the tides combine to lift wave action high up the beach to erode dunes and cause damage to property and infrastructure. This is important to consider when locating buildings and infrastructure along the coast.

Seismic disturbances (sea-quakes) and massive slumping of undersea sediments on the continental shelf cause *tsunamis.* These waves have periods in the order of tens of minutes, wavelengths of hundreds of kilometres and speeds of up to 1,000 kilometres per hour. Tsunami waves can reach devastating heights. Their effect is greatest in seismic regions and where small landmasses are adjacent to a steep, narrow continental shelf. The islands of the Pacific Ocean are particularly vulnerable, especially the small atolls and island archipelagos. Tsunamis have been observed on the coast of Western Australia as a result of volcanic activity in Indonesia.

Conditions that have been experienced in the past are likely to occur in the future. Hence, 'worst case' scenarios with regards to sea level fluctuations should be considered in planning as a precautionary principle.

2.3.4 Waves

Waves are described by the parameters *height, length, period* and *speed.* They are subject to a number of processes, which are described below:

Wave generation

Waves are generated by wind blowing across the surface of the ocean. The area where they are generated is called the *fetch* and waves within the fetch are *seas.* The size of the waves generated is dependent on the length of the fetch as well as the speed and duration of the wind. Seas are of short length and period, the latter usually 2 to 10 seconds.

Wave dispersion

Once waves leave the area where they are generated and are no longer growing, they are sorted by wave dispersion. Waves become sorted by period, and have a regular form. This occurs because the longer period waves travel faster than shorter period waves. Swells are waves that travel in groups with a common length and period. The period ranges from 10 to 20 seconds.

Wave transformation

In deep water (greater than one third the wave length), wave shape and speed are independent of the water depth. However, their form changes as they travel toward the shore and lose energy to the beach. This transformation in height, length and speed occurs because waves entering shallow water interact with the seabed. The wave period does not change.

Wave refraction

Wave refraction occurs when waves entering shallow water change direction. The crests of the waves become aligned with the seabed. Wave refraction results in bending of the wave rays, a progressive decrease in wave height, an increasing alignment of the wave crest with the seabed and divergence of wave rays in the direction of travel.

Refraction causes waves to converge on headlands and reefs, and diverge when they enter embayments. It gives rise to variation in wave height along a stretch of coast, which influences nearshore currents.

Wave breaking

In deep water, waves break when they become too steep and can no longer grow. Waves break near the shore, when the water depth becomes too shallow for a stable wave to exist. Three main types of breaking waves occur near the shore: *spilling, plunging* and *surging*. A fourth type, *collapsing,* occurs in association with surging waves. The type of wave depends on the gradient of the beach and steepness of the wave. Spilling occurs on gentle beach gradients with steep waves, whereas surging breakers occur on steeply sloped beaches with less steep waves. Spilling and plunging breakers occur in the surf zone, whereas collapsing and surging breakers are generally restricted to the swash zone, where waves run up the beach. Different hazards are associated with each type of breaking wave and the currents they generate.

2.3.5 Currents

Ocean currents affect coastal weather and biology. The cold Western Australian Current flows north in the deep waters of the eastern Indian Ocean. Closer to shore the warm Leeuwin Current exists as a shelf boundary current, flowing south along the edge of the continental shelf. It is driven by El Nino-Southern Oscillation events in the tropics and its fluctuations in intensity affect the weather and fishing industries. In the south west of the State, the Capes Current flows on the outer margin of the continental shelf, between the Leeuwin Current and the reef chains extending along the coast on the Rottnest Shelf.

Close to the shore, currents are driven by tides and winds as well as density differences related to groundwater and river discharge along the coast. Currents occurring in the nearshore zone are of fundamental importance to coastal management as they are responsible for the movement of sand along and across beaches. Their impact can range from erosional to depositional, depending on the state of the beach between extreme low-energy and high-energy conditions (see the discussion of high-energy and low-energy beaches later in this section).

Nearshore currents exchange water between nearshore and offshore waters. Nearshore water circulation includes a combination of the following currents:

Wave oscillatory motion and *bed return flow* currents

These currents occur due to the action of waves, and account for approximately 90% of the water exchanged between the nearshore and offshore waters under moderate wave conditions. The currents recirculate sediment either towards, or away from the beach, thereby contributing to beach stability.

Cellular water circulation

Cellular water circulation accounts for the remaining 10% of water exchange between the nearshore and offshore waters, and incorporates the following currents: alongshore currents seaward of the breakers, landward movement of water by breaking waves, longshore currents in the surf zone, rip currents flowing seaward in a narrow jet, and rip head vortices.

The cellular system fluctuates between erosive, conservative and depositional states. As wave energy rises, the nearshore water circulation contributes to beach erosion through enhancement of flow in the rips. Under high-energy conditions the rips may extend kilometres offshore. They can be a major problem for inexperienced and unwary swimmers.

Each cell in the system maintains sediment in circulation, or deposits it on the beach as wave energy falls. The deposits occur as bars form and move landward due to the shoreward movement of water by breaking waves.

2.4 SEDIMENT MOVEMENT

Currents generated by tide, waves and winds move loose sediments (sands and silts) that form the coast.

Onshore-offshore movement

Wave action results in the onshore-offshore movement of sediment. On beaches with high wave activity (such as those described in section 2.7.2), the beach alternates between a dissipative beach with sand bars, and a reflective beach with broad berms. Beaches subject to low wave energy (section 2.7.3) move landward or seaward with rising and falling wave conditions. In both instances there is an exchange of sediment between the beach and the nearshore waters.

Littoral drift

Sediment is transported along the beach by longshore currents, including those in cellular water circulation systems, swash washing up and down the beach and wind blowing along the coast. The net effect is known as *littoral drift.* This leads to sediment accumulation against objects in its path, such as headlands or groynes. The direction of littoral drift is determined by the angle at which waves reach the shore. As this angle changes, sediment is moved from one end of the beach to the other. This means that some parts of a beach, particularly its ends, are more susceptible to change. This effect is well established along the Perth metropolitan coast between Fremantle and Trigg. Littoral drift is illustrated in figure 2-9 for the Geraldton foreshore.

Figure 2-9

Evidence of littoral drift on the Geraldton foreshore.

Information and data on long-term sediment movement and shoreline change may be available from the Department for Planning and Infrastructure for some areas.

The coastal sediment budget

Coastal change is linked to variations in the *coastal sediment budget*, which estimates the net balance in the volume of sediment supplied to, stored in and lost from a particular *sediment compartment*. Successive rocky outcrops provide natural boundaries for these sediment compartments, although other natural boundaries, such as tombolos and cuspate forelands, may also define these compartments. Components of a coastal sediment budget are indicated in figure 2-10.

An appreciation of the coastal sediment budget is important to an understanding of beach stability, and of siltation problems in the mouths of estuaries, coastal lagoons, groynes and marine entrances. It also enables the identification of sources of sand drift and coastal erosion problems.

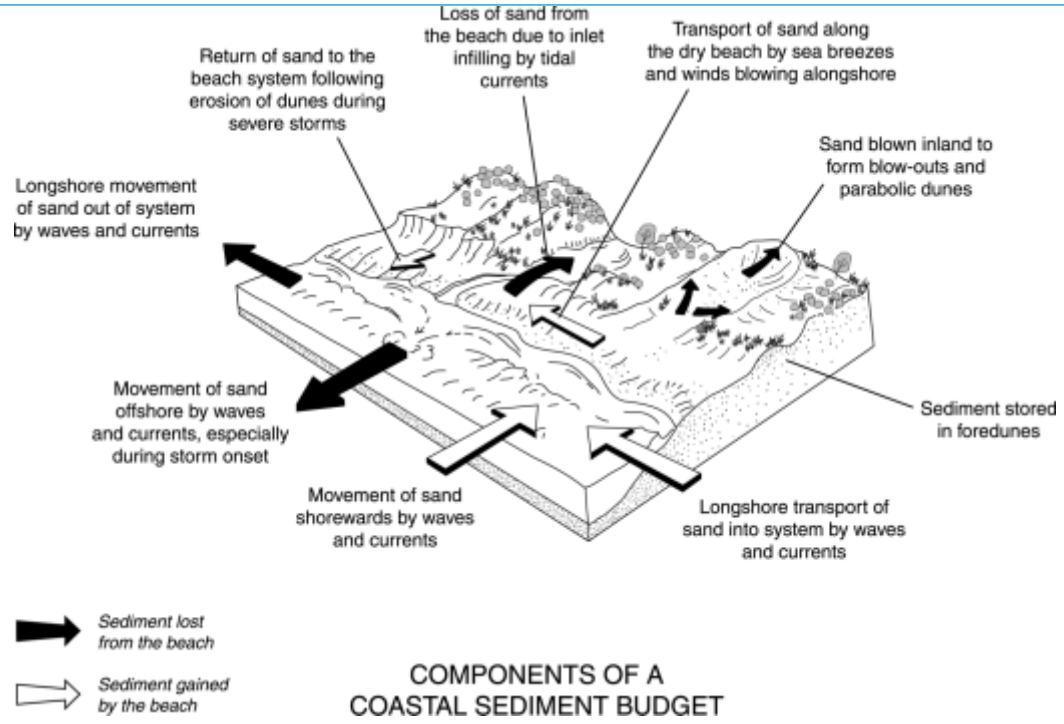


Figure 2-10

Components of a coastal sediment budget.

2.5 ROCKY COASTS

Rocky coasts occur where there is a lack of sandy sediment or where erosion has exposed the underlying rock. Three types of rocky coasts are discussed here – cliffs, offshore reefs, and intertidal platforms.

2.5.1 Cliffs

Extensive cliffs occur along the coast of Western Australia, with significant differences between south and north. Rocky coasts in the south of the State are either granite or limestone. Granite is the most common, forming smooth slopes where it is exposed to heavy wave action, or boulders where waves are less severe. Limestone coast is eroded by physical, chemical and biological means quite different from granitic coasts. This type of erosion can, depending on the force of wave action, undercut rock faces.

Figure 2-11

Granite coast at William Bay. [Photo: Ian Eliot]

Figure 2-12

Cliffs along the Great Australian Bight near Eucla. [Photo: Ian Eliot]

The higher tidal ranges and less severe wave action in the north mean that smooth intertidal slopes are not common. Rather, rocky coasts form rock piles or cliffs.

Examples of cliffs are the limestone Baxter Cliffs of the Great Australian Bight, the sandstone and limestone Zyptdorp Cliffs between Kalbarri and Shark Bay, and the sandstone escarpments of the Kimberley. Granite and limestone cliffs also outcrop along the South Coast and the South-West Capes, such as the granite cliffs near Albany and Cape Naturaliste, and the limestone cliffs at Point D'Entrecasteaux and in the South-West Capes region.

2.5.2 Offshore reefs

Limestone reefs exist in long chains approximately parallel to the present day shore between Cape Naturaliste and Geraldton. Offshore reefs mark previous shorelines and dune ridges that were deposited and became cemented at times of much lower sea level. Unconsolidated sediments were stripped from the ridges when they were drowned during the most recent sea level rise. Some of the sediments, mainly sands, were swept landward and along the coast, to form the modern coast. This process, which occurred during the past 10,000 years, is one that has been repeated several times in the past two million years, as is evidenced by the succession of Bassendean, Spearwood and Safety Bay sand deposits.

Reefs vary in distance from the shore, although are generally less than 10 kilometres offshore. Reefs are tied to the coast by tombolo formations in places, such as at Point Peron in Rockingham and Robert Point in Mandurah.

Western Australian reefs are significant parts of the marine landscape due to their high biological productivity, and because they contribute sediments to the coast through erosion and biological production of material such as shell fragments.

Reefs protect nearshore waters. In many instances, as between Guilderton and Geraldton and along the Gascoyne coast, the reefs impound lagoons that support extensive seagrass and macroalgae communities.

Human interference with temperate reefs and nearshore waters affects biological productivity and the coastal sediment budget. Hence, management of the reefs and nearshore waters is of fundamental importance to the maintenance of coastal biodiversity, as well as to the sustainability and well-being of the fishing industry.

The shape of the present-day coast is also influenced by the effect of these reefs on the distribution of wave energy, water levels and nearshore water circulation. They are often associated with the presence of cuspate forelands and tombolos along the mainland shore (described later in this section).

2.5.3 Intertidal platforms

Intertidal rock platforms are a feature of rocky coasts in Western Australia, and are usually cut into the Tamala Limestones of the South Coast, South-West Capes and Central West Coast regions. The platforms are exposed under low water conditions. They are commonly undercut and subject to collapse.

On some parts of the coast the platforms outcrop as nearshore reefs separated from the shore by narrow, shallow water lagoons. This occurs at West Beach and Eleven Mile Beach near Esperance, Starvation Boat Harbour, Hopetoun, the Yanchep Lagoon, Horrocks Beach and Port Gregory along the Central West Coast.

Rock platforms complicate the way shoreline retreat occurs, protecting the shore until waves and longshore currents remove any overlying sand. Accelerated retreat may follow, with a lagoon and embayments forming landward of the exposed reef, and strong rip currents flowing through gaps in the reef.

Management of rocky coasts

Rocky coasts can be hazardous because of the potential for cliff collapse in weakly cemented rocks, or the likelihood of people being swept from rocks and rock platforms by unexpected waves. Management issues relate to the need for community education about these risks as well as the provision of safe facilities in areas where visitors go.

2.6 CORAL REEFS

Coral reefs typically occur in the tropics, where the seawater temperature is between 18°C and 33°C with relatively clear water. However, in Western Australia coral reefs occur as far south as the Houtman Abrolhos and Rottnest Islands, due to the influence of the warm Leeuwin Current. Coral reefs occur in waters up to 50 metres deep, but more commonly depth is limited to 20 metres because corals require plenty of light.

Coral distribution, abundance, diversity and growth form are affected by water temperature, salinity, clarity, depth, movement and settlement substrates, source populations and interaction with fauna and flora. These variables not only determine the occurrence of coral reefs but also create distinctive zones within the reefs.

In general, Western Australia's significant coral reefs fall within the classifications of fringing reefs (such as Ningaloo Reef along the Gascoyne coast) and shelf atoll reefs (such as Rowley Shoals in the Pilbara-Kimberley).

Significant coral reefs in the north of the State occur around offshore islands and emergent points (shelf atolls) along the continental shelf where waters are less turbid. One of the most significant chains includes the Rowley Shoals, Scott Reefs, Seringapatam Reef and Ashmore Reefs. In general the reefs are elliptical in shape (with the exception of South Scott Reef which is crescent shaped) with well-developed lagoons. Some have sandy islands located within these lagoons.

The only significant nearshore coral reef in Western Australia is the Ningaloo Reef, which is Australia's longest continuous fringing reef, extending 260 kilometres along the coast southwards from the North West Cape. The close proximity to the coast is due to the narrow continental shelf, the arid nature of the adjacent coast and the Leeuwin current, which provides relatively clear warm water.

The Indian Ocean's most southerly 'true' coral reefs are located at the Abrolhos Islands. The coral reefs are unique in that they coexist with temperate macroalgae communities. Coral communities dominate on leeward reef slopes, while macroalgae communities dominate windward slopes and flats. Coral species also occur further south, such as the abundant corals at Rottnest Island; however, they do not form 'true' coral reefs.

2.7 SANDY COAST

Sandy coasts are dynamic. Their form changes with variation in the weather and associated changes in sea level and wave conditions.

Dramatic changes in beach form occur in response to storm activity, particularly when high sea levels (storm surges) coincide with high tides. Change also occurs seasonally where the coast is subject to calm and stormy conditions. Such variation is apparent between summer and winter in the southern part of the State, as well as between the dry (winter) and wet (summer) seasons in the north of Western Australia. The seasonal change occasionally is referred to as a 'sand cycle' although it is not truly cyclic. The amount of change varies from year to year in response to variation in the frequency, intensity and duration of the stormy season.

Three aspects of sandy coasts are outlined below: the large-scale landforms that constitute the modern coast; sandy beaches in exposed, high-wave environments; and sandy beaches in sheltered, low-wave locations.

2.7.1 Accretionary landforms

Large accretionary (gradually building) landforms such as *foredune ridges, parabolic dunes, cuspate forelands* and *tombolos,* have formed through long-term sea level fluctuations, with the most recent advance occurring during the past 10,000 years when the sea transgressed (drowned) the land. Sediment was pushed landward with the rising sea and deposited at the shore to form these landforms.

In some circumstances, as has occurred along the South Coast, this landward movement of sediment has impounded embayments and blocked river mouths. This has resulted in the formation of barred estuaries (Hardy Inlet at Augusta), coastal lagoons (Wilson Inlet near Denmark) and coastal lakes (Lakes Clifton and Preston south of Mandurah). In other places, extensive ridges of dunes, cuspate forelands and tombolos have been formed. Examples are the coast between Fremantle and Trigg, Winderabandi Point on the Gascoyne coast, and Point Peron near Rockingham. Continuous evolution of these landforms sets a context for coastal management. All of these landforms support sandy beaches along their seaward margins.

Foredune ridges and parabolic dunes are discussed further in section 2.8.

Figure 2-13

Tombolo – Point Moore, Geraldton.

Figure 2-14

Cuspate foreland – Island Point, Jurien.

Cuspate forelands and tombolos are sandy promontories (headlands) that occur adjacent to reefs, islands or engineered breakwaters (figures 2-13 and 2-14). These structures affect wave movement and direction (wave refraction) and sediment transport patterns.

Tombolos are common around Albany and are formed due to wave refraction associated with granite islands and offshore water depth.

Between Bunbury and Geraldton, and along the Gascoyne coast, the accumulation of sediment has resulted in the formation of large cuspate forelands. In these areas, shelter offered by offshore reefs affects swell, locally generated sea, longshore currents and tidal currents. The shape of the landforms has been skewed in the direction of longshore transport, so they do not occur directly adjacent to the offshore structures, but are displaced in the direction of longshore transport.

Beaches that occur alongside these landforms, particularly the cuspate forelands of the west coast, are highly changeable with variation in wave direction. Despite the instability, these beaches are popular recreation sites and can attract development interest close to the shore. These landforms can be regarded as nature's version of man-made shoreline stabilisation structures. Environmental changes to large-scale coastal landforms warrant close consideration by land managers.

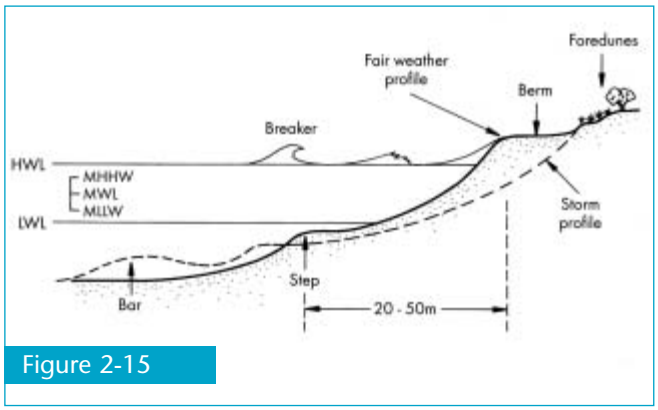


Figure 2-15

Reflective beach sketch. [Sketch: Ian Eliot]

Figure 2-16

An example of a reflective beach: Goode Beach, Albany. [Photo: Ian Eliot]

2.7.2 High-energy beaches

High-energy beaches occur on open coasts exposed to the full effects of sea, swell, tides and other fluctuations in sea level. Sand moves from a berm (on the beach) to a bar (in the water) when wave energy changes from low to high. The width of the beach depends on extreme high-wave conditions and tidal range. It can vary from tens of metres to kilometres. The extreme forms and a transitional state between them are described below.

Reflective beaches

A reflective beach is dry and wide. It is a steep beach that ends with a step into deep nearshore water. There are no bars. Beach sediment tends to be coarse grained. During low-energy conditions waves less than 1.0 metre high break at the shore, surge up the beach and are then reflected seaward from the steep face of the beach. Figure x shows Goode Beach near Albany as an example, with its narrow surf zone, waves breaking at the shore, and a steep beach face. A berm and cusps (curves) form high on the beach.

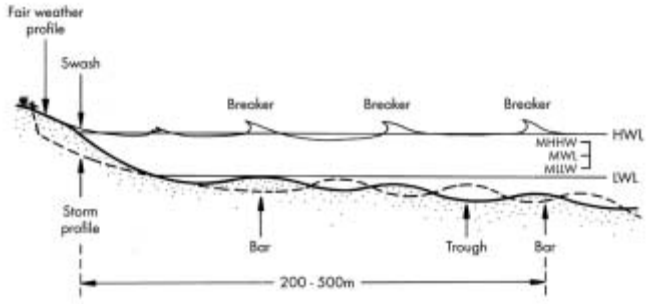


Figure 2-17

Dissipative beach sketch. [Sketch: Ian Eliot]

Figure 2-18

An example of a dissipative beach: Yokinup Beach, Thomas River Esperance. [Photo: Ian Eliot]

Dissipative beaches

Dissipative beaches form where the average height of breaking waves exceeds 2.0 metres. However, they may also prevail with lower waves where the sediment comprising the beach is very fine grained. Yokinup Beach, near Thomas River, and Leighton Beach in the Perth Metropolitan Area provide examples of dissipative conditions when large swells occur. The large waves break by continuously spilling, or reforming and breaking against submerged bars, as they travel across a wide surf zone. Their energy is substantially expended by the time they reach the shore.

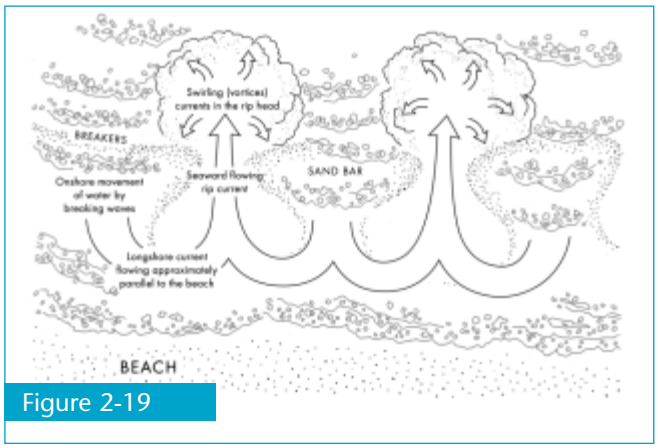


Figure 2-19

Transitional beach sketch. [Sketch: Ian Eliot]

Figure 2-20

An example of a transitional beach: Trigg Beach, Perth metropolitan region. [Photo: Ian Eliot]

Transitional beaches

Transitional beaches combine elements of reflective and dissipative beaches. They form between extreme low- and high-energy conditions on high-energy beaches. Longshore currents, swift-flowing rips and sand bars are common, and the shoreline fluctuates rhythmically along the beach. Such beaches combine elements of the reflective and dissipative states. They frequently form at times of seasonal change when the beaches become dangerous for inexperienced swimmers. Trigg and Scarborough beaches, north of Fremantle, provide good examples of transitional beaches.

2.7.3 Low-energy beaches

Low-energy beaches occur in sheltered locations protected from the direct effects of swell. These occur where there are reefs, deep bays and estuaries. The beaches may be exposed to the full effects of tides and other fluctuations in sea level. Breaking waves are predominantly less than 0.5 metres in height, often less than 0.25 metres, and seldom exceed 1.0 metre except during extreme weather conditions. Three profile forms are recognised: flat, segmented and rounded. The form of the beach profile is largely related to the size of sediments, and its scale in relation to the range of tide and sea level fluctuation. Seaweed is deposited in distinct lines along the beaches, and some beaches may be covered with large masses of seaweed.

Flat beaches

Flat beaches occur on Garden Island and at Lancelin and Coral Bay. They are made up of silty sediment or fine sand, and have a very low gradient extending from the foredunes to the nearshore waters. The nearshore water levels will change in response to low- or high-energy conditions. Swash bars (ridges and runnels where the water has washed over the beach) migrate across the beach with changes in wave and tide conditions. The upper beach and the subtidal area may be vegetated, the latter with seagrasses.

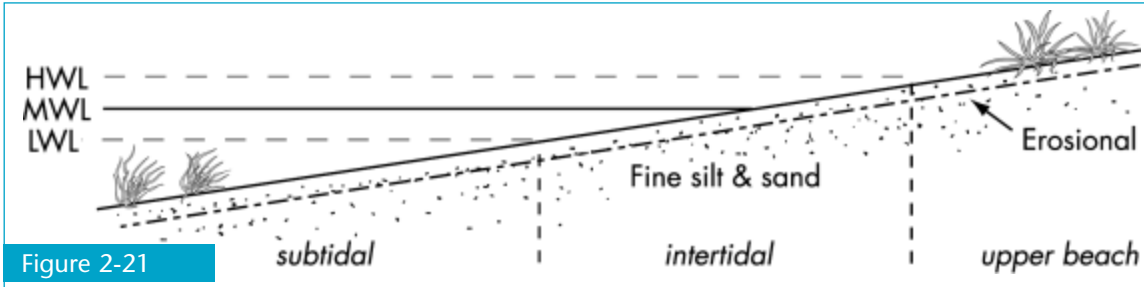


Figure 2-21

Flat beach sketch. [Sketch: Ian Eliot]

Figure 2-22

An example of a flat beach: Garden Island, Cockburn Sound. [Photo: Ian Eliot]

Segmented beaches

Segmented beaches, such as at Port Hedland, Karratha and throughout the Kimberley, largely comprise two distinctly different grain sizes. Very fine sand or silty sediment is found in the lower intertidal zone. In contrast to this, very coarse sand, even gravel and cobble, forms the upper part of the beach. Chenier beaches, formed along a lens of sand perched on a muddy base, fall into this category. The sand or cobble component of the beach is a *storm ridge*. Its sediments are deposited when storm surges wash over the landform.

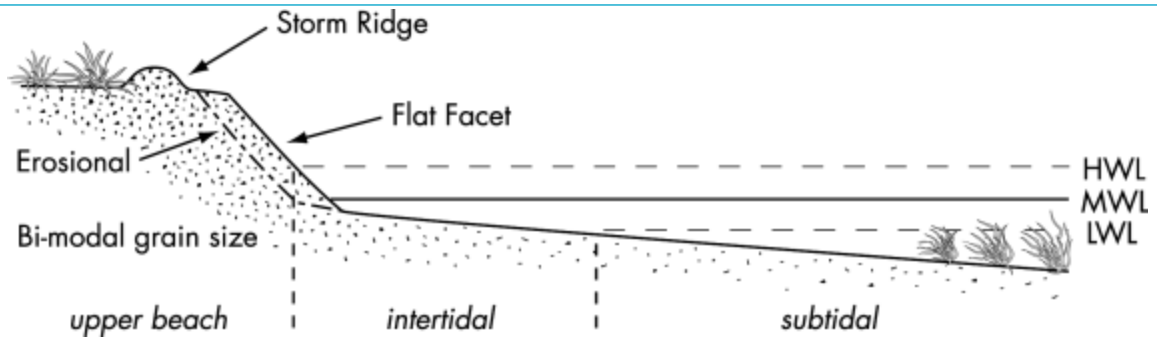


Figure 2-23

Segmented beach sketch. [Sketch: Ian Eliot]

Figure 2-24

An example of a segmented beach: Roebuck Bay, Broome. [Photo: Ian Eliot]

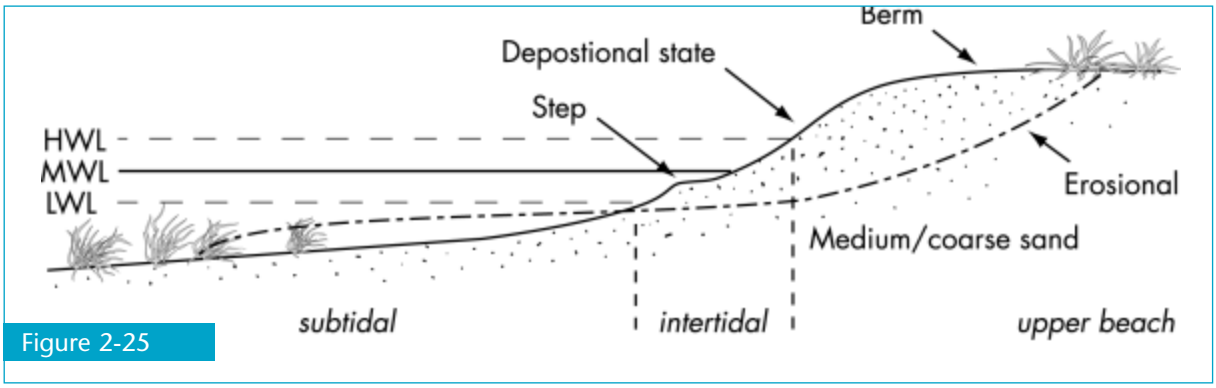


Figure 2-25

Rounded beach sketch. [Sketch: Ian Eliot]

Figure 2-26

An example of a rounded beach: West Busselton. [Photo: Ian Eliot]

Rounded beaches

Rounded beaches like those along the south-east of Cockburn Sound, at Exmouth and at Busselton are comprised of medium-grained sand. The beach varies from an upwardly convex to concave shape in response to changing wave and water level conditions. The beach commonly terminates with a step at the water line and from that merges with a subtidal terrace.

Ripples characterise the seabed in the nearshore waters. The sand moves between the upper and lower parts of the beach between berm and step in response to low- and high-energy conditions.

Beach change and the management of sandy beaches

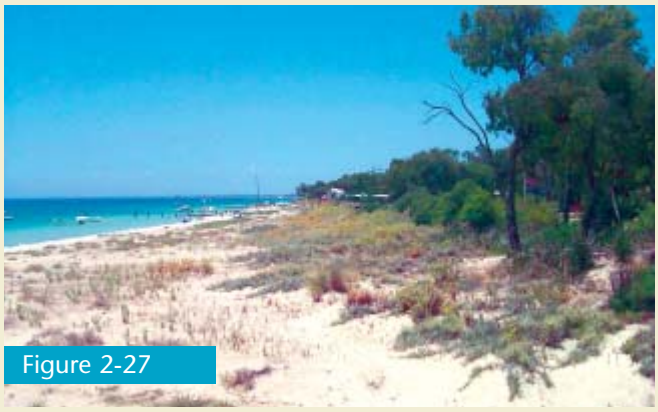


Figure 2-27

Siesta Park, Busselton: accreted.

Figure 2-28

Siesta Park, Busselton: eroded.

Accretion and erosion

Accretion is the accumulation of sand on beaches whereas erosion refers to its loss. The balance between the two is constantly changing in response to changing wind, wave, current and tidal conditions. The main mechanism for sediment exchange between the beach and the ocean involves interaction between waves, the tide and groundwater level. Wet beaches with high groundwater levels enhance erosion. On high-energy sections of coast, accreting beaches are commonly wide and contribute sand to the formation and growth of foredunes. In contrast, eroding beaches tend to be narrow and the foredunes are either absent or cliffed. The same beach near Siesta Park at Busselton is shown in Figures 2-27 and 2-28. The beach was eroded in 1978 but has accreted during the past two decades.

Figure 2-29

Back Beach, Bunbury during summer.

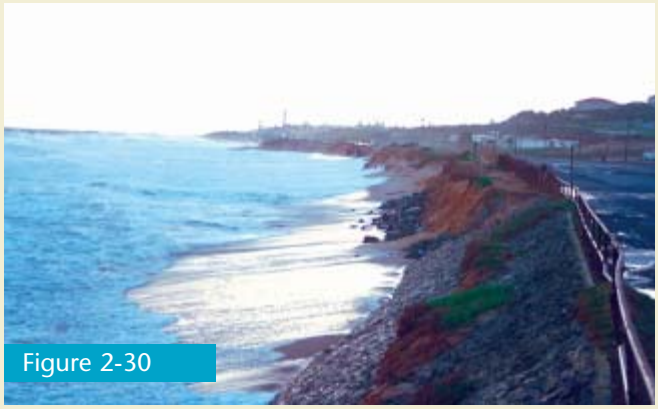


Figure 2-30

Back Beach, Bunbury during winter.

Seasonal changes

Storm activity is likely to be more frequent in one season in some parts of the Western Australia, although storms may occur throughout the year. Storm activity also varies markedly from year to year. The only constant is that sandy beaches adjust to wave and weather conditions by accreting or eroding. Where inter-seasonal variation is large, as it is in the southern part of the State, beaches tend to be eroded during the stormy season and accrete under calmer seasons. However, this does not wholly conform to intuition. For example, the coast from Geraldton to Busselton experiences two stormy 'seasons' per year. The first, the season of highest energy, is associated with winter storms and the second with strong sea breezes and frontal activity in summer. Calmer conditions prevail in autumn and spring in the South-West.

Hazards on sandy beaches

Beaches are intrinsically dangerous. Some of the worst accidents on sandy beaches in Western Australia have occurred in water less than waist deep (1.0 metre) with a wave height less than knee deep (0.5 metre). Drowning occurs most frequently in the strong rips of transitional and dissipative high-energy beaches, and people have had bones broken in the shore break on energy reflective beaches. Also, the sheltered environments of low-energy beaches present a further suite of dangers. The subtidal terrace common to many sheltered beach environments has a steep drop into deep water that may be a danger to children and inexperienced swimmers. Sheltered beaches often harbour stinging jellyfish and the accumulations of wrack in the nearshore waters harbour other stingers as well as juvenile fish.

2.8 COASTAL SAND DUNES

Coastal sand dunes form wherever there is a supply of sandy sediment, and onshore winds are strong enough to blow sand landwards from the beach. Sources of sand include material transported to the coast by streams and rivers, material eroded from rocky coasts, reworking of sediment from the continental shelf, and skeletal material derived from marine organisms. Once the sand has accumulated on a beach it may be shifted landwards by onshore winds to be trapped by vegetation and form dunes. The size of the dunes is dependent on availability of sand, wind strength and stability of the beach.

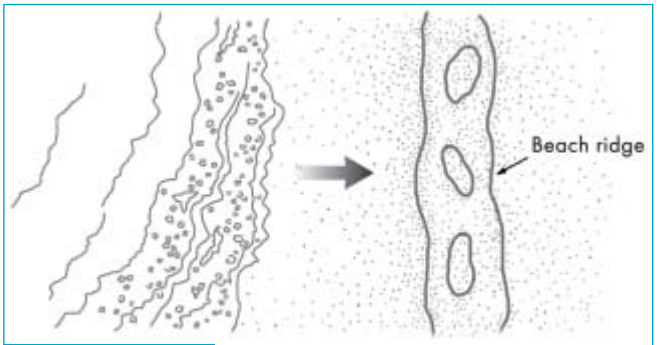


Figure 2-31

Sketch of foredune ridge. [Sketch: Ian Eliot]

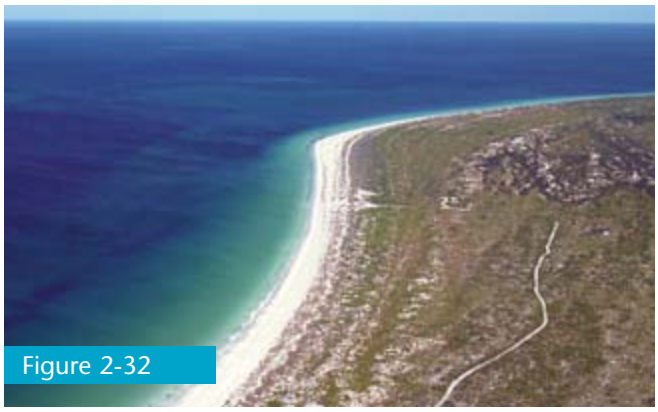


Figure 2-32

Aerial photograph of a foredune ridge at Leeman, Central West Coast.

2.8.1 Foredune ridges

Extreme shoreline movement involves an exchange of sediment between the dunes closest to the water's edge and the nearshore waters. When the beach is wide or during a storm, sand is blown landwards and trapped by small salt tolerant plants. The trapped sand accumulates in a distinct ridge. This is a *foredune ridge* or *beach ridge.* Its form is determined by the plant species, the rate of sediment supply from the beach and the level of energy to which the beach is exposed. The highest ridges tend to be those on the highest energy beaches. For example, the low foredunes in Geographe Bay contrast with the high foredunes along the South-West Capes region near Point D'Entrecasteaux.

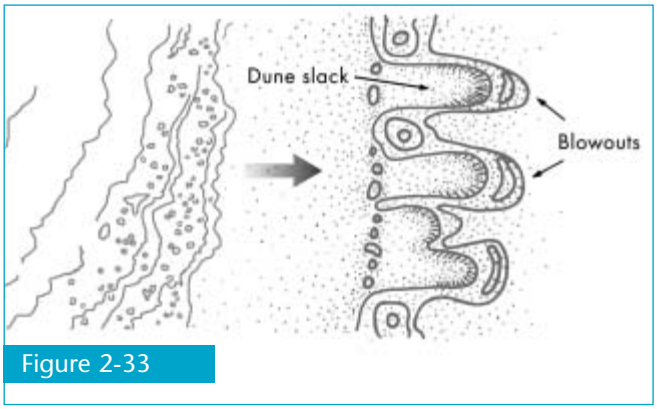


Figure 2-33

Sketch of blowout. [Sketch: Ian Eliot]

Figure 2-34

Aerial photograph of blowouts at Lake Preston.

2.8.2 Blowouts

The removal of vegetation cover from a foredune may cause it to be destabilised. This results in the exposed parts of the ridge being eroded by winds blowing onshore. The windblown sands are redeposited in dunes with a U-shape, *blowouts*. Elongate forms of blowout are referred to as *hairpin* or *parabolic* dunes. A blowout continues to form for as long as it is supplied with sand or until the hollow is eroded down to groundwater level or bedrock. When the latter occurs foredune vegetation becomes re-established, the foredune ridge begins to reform, and the sand supply to the blowout ceases or is severely reduced. Guidance on the active stabilisation of blowouts that are unlikely to repair themselves, or have been created by unnatural means, is provided in section 7: *Stabilisation and Rehabilitation.*

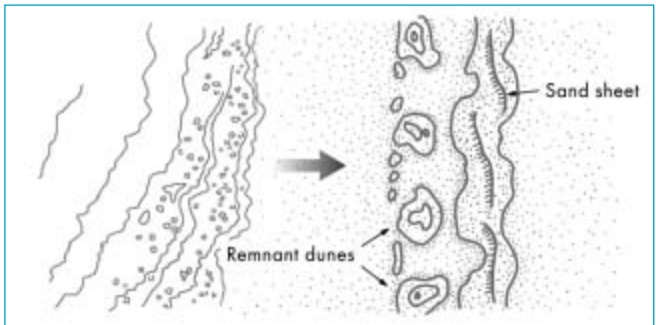


Figure 2-35

Sketch of sand sheets. [Sketch: Ian Eliot]

Figure 2-36

Aerial photograph of Geraldton sand sheets, Central West Coast. [Photo: Ian Eliot]

2.8.3 Sand sheets

Once detached from the frontal dunes individual blowouts may continue to migrate inland until they run out of sand or vegetation is re-established. However, blowouts from the same foredune ridge commonly join to form a broad sheet of bare sand. Both forms are mobile *sand sheets.* They tend to overwhelm landforms, including older dunes, in their path as they migrate. Where this happens the older sands are incorporated in the migrating sand sheet. Second order dunes form on the surface of the sand sheets in response to changing wind conditions. These may be *transverse,* running at right angles to the direction of the prevailing wind; or U-shaped, or crescent shaped – with the arms of the U projecting forward in the direction the dune is travelling.

Management issues for sand dunes

Sand movement on the beach and its deposition in dunes is well understood. Onshore winds are generally stronger than those blowing offshore. They are unrestrained as they blow across the ocean and beach and move sand towards the landward margin of the beach to be trapped by plants. Hence dunes need space and vegetation cover for their development. Dunes will continue to grow for as long as there is a sand supply from the beach. They are a major store of sediment lost from the active beach. During above-average phases of storm activity sand may be eroded from the dunes and reworked in the nearshore waters before being returned to the beach. In this respect dunes function as a barrier to coastal erosion. However, the loss and return is not always balanced, and less sand may be returned to reform the dunes, especially where coast is undergoing long-term erosion.

Without allowance for change, the dune sand is moved inland. It accumulates on roads and pathways, and against buildings. Maintenance costs for management of the foreshore reserve increase under these conditions. Similarly, removal of dunes removes the barrier to direct landward transport of sand by onshore winds. It also reduces the capacity of the coast to absorb phases of erosion during above-average storm activity and may increase the likelihood of property damage where facilities have been located close to the shore.

2.9 ESTUARIES

Estuaries are partly enclosed coastal water bodies where waters derived from terrestrial and marine sources are mixed. Water quality in estuaries is determined to a large extent by the water quality in the river catchments discharging into them.

Three types of estuary are located on the Western Australian coast:

1. *Drowned river valleys* (true estuaries), are common in the high tidal environment of the Kimberley.
2. *River estuaries* occur in the lower reaches and close to the mouths of streams along the coast, and are the major estuary form of the arid coastal environments between Guilderton and Kalbarri, and east of Esperance.
3. *Coastal lagoons* associated with barrier formation are common in the South-West, from Fremantle to Esperance.

2.9.1 Drowned river valleys

The drowned river valleys of the Kimberley provide numerous, spectacular examples of estuaries formed by the geological structure of the area. They are located in deeply incised bays with rocky headlands and contain archipelagos and reefs. Floodplains, river deltas, mudflats and mangroves are confined within the estuaries, for example at the mouths of the Ord, Roe and Prince Regent Rivers. In the wet season many of the rivers in the Kimberley discharge very large volumes of water into a macrotidal environment in their lower, estuarine reaches. A similar drowned river valley, although much smaller and in granitic rock, is the Waychinicup Estuary near Albany, the only one of its kind on the South Coast.

2.9.2 River estuaries

Bell-shaped estuaries are found in locations where waves overwhelm low levels of discharge at the mouths of small rivers and streams in microtidal environments. Examples are found around the coast from Poison Creek near Cape Arid (along the South Coast) to the Murchison River at Kalbarri (Central West Coast) and include the lower reaches of the Warren, Donnelly, Margaret, Moore, Irwin, Greenough, Chapman, Oakajee, and Bowes Rivers. The estuaries retain their river form as they flow though sediment filled basins to the shore. All are blocked at their mouths by sand bars, except during and immediately after times of high river discharge. A small, estuarine lagoon is developed immediately landward of the bar, however, it only functions as an estuary when the bar is open.

North of Exmouth the bell-shaped estuaries of the microtidal environments are replaced by funnel-shaped river estuaries that are more characteristic of tidal creeks. Examples include the Sherlock, Yule and Turner Rivers between Karratha and Port Hedland. The change in estuary form follows an increase in tidal range and indicates a near balance between river and tidal processes. The larger river systems of the Gascoyne and Pilbara have estuarine reaches. However, they are dominated by river discharge and large deltas.

Figure 2-37

Moore River, Chapman.

2.9.3 Coastal lagoons

Sea level fluctuation has resulted in the development of coastal sand barriers that now impound shallow basins around much of the Central West Coast and South-West Capes. Examples include the Stokes, Hamersley, Wellstead, Oyster Harbour, Wilson, Broke, Hardy, Leschenault, Peel-Harvey and Swan estuaries.

These sand barriers form a buffer between the ocean and the mainland. Further, streams discharge into lagoons, forming river deltas and coastal plains, thus preventing coarse sandy material being delivered to the coast.

Figure 2-38

Irwin Inlet.

Lagoons vary in their opening and closing regimes from permanently open, intermittently closed, intermittently open, and permanently closed. The opening regime of a lagoon plays a significant role in determining its water quality, salinity, the susceptibility of the low lands around its shores to flooding, and the type of biota it supports. Examples of permanently closed coastal lagoons are Jerdacuttup Lake and Lakes Clifton and Preston. Terrestrial sand and mud are deposited on the river delta by river processes. Fine terrestrial sediments and organic material accumulate in the deeper waters of the basin.

Estuary management

Estuary management requires full integration of catchment and marine management. Estuary environments have come under pressure as populations grow, and the demands for use of estuarine resources intensify. Pressures include catchment development which results in increased terrestrial run-off; sediment and nutrient supply to the estuary; estuary infilling by sediment deposition and landfill; development of environmental conditions that foster the frequency and extent of algal blooms occurring in some estuaries; and resource exploitation, which can lead to habitat loss or a decline in biological stocks.

Management of bar opening regimes to mitigate against floods are a matter of controversy since detailed records of bar opening and closing are sparse.

Wetlands within the estuaries sustain many species. Hence there is a need to balance the cost of their infilling and use as canal estates with the value of the recreational resources of the estuary prior to any modification of the estuary shores. Similar consideration also needs to be given where estuary hydrology is affected by development and affects the biota, as occurred with the excavation of the Dawesville Cut in Mandurah.

2.10 RIVER DELTAS

Sediments carried by rivers, particularly when they are in flood, are deposited at the coast where the river flow is slowed by estuary or ocean waters. A river delta forms when the sediment supplied by the river is larger than the capacity of the marine or estuarine processes to move it away from the river mouth.

Delta coasts are classified according to the dominant forces of river flow, waves and tides, and the shape of the delta, including the length of protrusion into the ocean or estuary. Deltas found in Western Australia are:

1. *Tide-dominated deltas,* found inside estuaries of the Kimberley
2. *Wave-dominated, or 'true' deltas,* protruding from the coast into the ocean between Broome and Kalbarri
3. *River-dominated deltas,* typically found inside the coastal lagoons and estuarine reaches of rivers in the South-West between Kalbarri and Esperance.

Figure 2-39

Ord River Mouth.

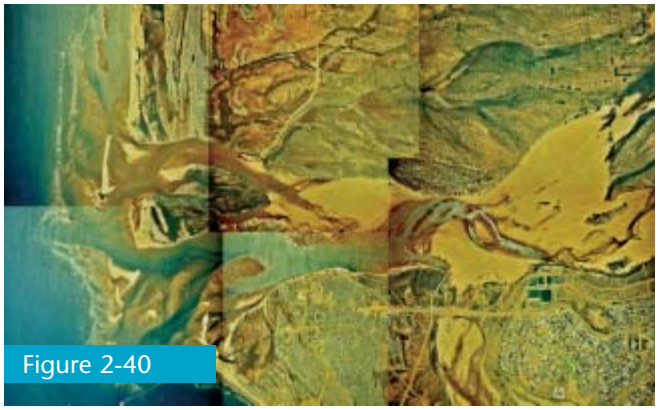


Figure 2-40

Gascoyne River, Carnarvon.

2.10.1 Tide-dominated deltas

The Kimberley coast is characterised by an irregular coastline and high tides. Heavy rains fall in the wet season (summer) and the rivers have an extremely high seasonal discharge. The tide-dominated deltas of the region are confined to the estuaries. They are funnel shaped with many outlets, bars and islands at their mouths. Tides can penetrate a considerable distance into the river.

2.10.2 Wave-dominated deltas

Wave-dominated deltas that are wide and smooth, approximately shaped like a triangle, are found between Kalbarri and Broome, in the Central West Coast, Gascoyne and Pilbara-Kimberley regions. These deltas have multiple stream outlets with shoreline arcs between them. Several of the wave-dominated deltas, such as those of the Gascoyne and De Grey rivers, are composite in form indicating that the main rivers have shifted position during their geological history. The summer rainfall and the number of streams increase with distance north. Hence the deltas of the region merge into extensive outwash plains and tidal creeks on this part of the coast. The coast between Port Samson and Port Hedland exemplifies this.

Figure 2-41

Harvey River mouth in the Peel-Harvey Inlet.

2.10.3 River-dominated deltas

Waves dominate the coast in South-Western Australia, confining the development of deltas to the sheltered waters of coastal lagoons and the estuarine reaches of barred river mouths. Deltas formed in the sheltered environments are mainly river-dominated. Long, narrow deltas protrude into the estuaries. Multiple distributaries are present and form lobes spreading from the main stream. The resultant landform is sometimes referred to as a birds-foot delta. Good examples are found at the mouths of the Murray and Harvey rivers where they discharge into the Peel-Harvey Estuary.

2.11 MUDFLATS AND MANGROVES

In Western Australia extensive mudflats are located in sheltered environments including the coast abutting the east arm of Shark Bay (Gascoyne region), the eastern shores of Exmouth Gulf, much of the Pilbara coast and part of the narrow coastal plains in the embayments of the Kimberley. The muddy coasts are characterised by the presence of a gently sloping coastal plain and nearshore region, turbid (muddy) nearshore waters and an absence of large breaking waves except under extreme cyclonic conditions. The shores are commonly vegetated with mangroves.

Figure 2-42

Mangroves at Cape Keraudren, Pilbara.
[Photo: Coastwest/Coastcare]

2.11.1 Mangroves

Mangroves are trees and shrubs that thrive in the intertidal zone, along the edges of brackish and marine shores. Western Australia has 17 of approximately 70 species of mangrove found throughout the world (Semeniuk *et al*, 1978). The species exist in discrete communities along the shore. Each community is called a *mangal*.

Mangals are best developed where there are:

- warm climates
- the shores are sheltered from the direct effects of swell and tidal currents
- waters are saline
- tidal inundation occurs (Semeniuk, 1994).

They are found as far south as Bunbury but are more common in the gulfs and estuaries of north Western Australia, particularly the Pilbara-Kimberley region.

Mangals are highly productive ecosystems. They support a wide variety of animal life and provide a haven for juvenile fish and crustaceans. The mangals also provide a sheltered environment conducive to the deposition of fine sediments. Their dense network of trunks and roots slows tidal currents and traps fine sediments. These combine with organic debris to form organically rich mud. The root systems of mangroves bind the mud to the extent that they can weather severe storms without extensive damage. Destruction of mangrove communities destabilises the mud and contributes to a loss of biodiversity, including a loss of fish and crustaceans valued for commercial and recreational purposes, and may lead to severe coastal erosion.

Figure 2-43

Derby.

2.11.2 Mudflats

Inland of mangroves, mudflats include narrow sand ridges called *cheniers* and unvegetated salt flats. Cheniers are long, narrow sand ridges that run approximately parallel to the coast and rest on finer, silty sand and mud. They are commonly comprised of shells, sand and storm debris and develop close to the landward limit of surge inundation, at the landward boundary between bare salt flats and marsh.

Mudflats require:

- a relatively stable sea level
- mesotidal to macrotidal range
- a supply of fine sediment from rivers and streams
- availability of coarse sand and shell in the intertidal mud
- a mechanism, such an intermittent reworking of the nearshore sediments, that leads to offshore winnowing of the fines and onshore deposition of the coarse material.

Further inland the unvegetated salt flats give way to salt marsh and to freshwater marsh above the spring high tide level. Tidal creeks or the estuarine reaches of rivers may cross the mudflats.

Mudflats are particularly sensitive to changes in sea level, especially where the mangrove fringe is destroyed by erosion or removed for other purposes. Such circumstances may lead to an acceleration of coastal erosion, changes to the hydrology of the tidal creeks, extension of the creeks and the inundation of freshwater lowlands, including billabongs and low-lying basins.

Figure 2-44

Roebuck Bay, Broome.

2.11.3 Tidal creeks

Sinuous channels and gullies (creeks) cross the mudflats. Water flow is driven by the tide, particularly during dry seasons. These tidal creeks are shallow depressions in the upper reaches of the mudflats where inundating waters spread onto mud fans at high tide level. Some fans merge with the distributaries of rivers and streams. This is a common pattern in the Pilbara where there is wet season river discharge and dry season tidal flows. The tidal creeks become deeper with proximity to the coast where they have funnel shaped entrances. In some places, such as along the Wooramel Bank in Shark Bay, the creeks carry strong tidal flows across the subtidal sand banks.

Mangroves line the upper banks (levees) of the tidal creeks, their landward extent up the creeks generally marking the limit of salt-water incursion. Their presence indicates the importance of the tidal creeks as habitats for a wide variety of marine organisms that use the creeks as part of their breeding cycle.

Management of mudflats and mangroves

Many mudflats and mangrove communities are in remote areas that are difficult to access, especially during the wet season. Nevertheless they are accessed in the dry season, and vehicle tracks that cut across them tend to persist for long periods. Access to these areas requires management to minimise environmental degradation.

3. COASTAL MANAGEMENT

CONTENTS

FIGURES

TABLES

3.1 PLANNING FOR COASTAL MANAGEMENT

3.1.1 Why plan?

Planning is a fundamental component of coastal management that:

- provides a framework for decision making
- allows for a better understanding of the issues affecting an area
- allows for all members of the community and other interested parties to have their say and participate in the future management decisions for an area
- creates a prioritised action plan that can be implemented over time
- provides a basis for the allocation of financial resources.

This section provides an overview of the principles and processes necessary for participation in any level of planning along the Western Australian coast. It also provides more specific guidance on local planning for management of a beach, amenities area, car park, and/or recreation area. Section 7: *Stabilisation and Rehabilitation,* provides guidance on planning a rehabilitation project.

3.1.2 Types of plans

Plans are developed at a range of scales, varying in the level of detail and the nature of the issues they address.

- *Regional* plans cover hundreds of kilometres, several local government areas and set broad direction for land use and/or management of an area
- *Local plans*, such as coastal and foreshore management plans are more detailed, address management of all or part of a local government area, and provide sufficient detail for management of key coastal nodes, and
- *Site plans* provide direction for on-ground management of a particular location.

Each of these planning 'layers' contributes to planning for sustainable management.

Ideally, planning is hierarchal, with broad regional plans setting the framework for more detailed plans. In some cases it may be necessary to prepare a localised plan to address urgent management issues without the guidance of broader plans. It is important to understand the processes that operate at each level of planning, to understand how plans complement each other. This is demonstrated in table 3-1

Further, figures 3-3 to 3-6 in section 3.6 *Mapping* provide an example of hierarchical planning in the Central West Coast region of Western Australia.

Before developing a management plan, ensure you are aware of any other plans that affect your area of interest, and be aware of any planned developments that could impact on the suitability or relevance of preparing a plan. For example: a subdivision on adjacent land could result in a requirement that the developer produce a foreshore management plan as part of the approval process. In an instance such as this, it could be a waste of time and resources to undergo a planning process before this outcome was determined.

3.1.3 Responsibility for coastal planning and management

Most of the Western Australian coast is in public ownership. The majority is vested for management in local government authorities, the Department of Conservation and Land Management, the Department of Land Administration, or pastoral lessees.

Smaller sections are vested for specific purposes in organisations such as Port Authorities, Inlet Management Authorities (for example the Peel Inlet Management Authority), or the Commonwealth. These bodies, which have legal responsibility for management of particular areas, are known as *land managers.*

Other agencies such as the Department of Fisheries, Water and Rivers Commission, the Department for Planning and Infrastructure or the Department of Environment also have a role in management of particular aspects of the coast according to their governing legislation. They, together with interest groups, including Native Title claimants and the broader community, may initiate or wish to be involved in development of a management plan. These groups are known as *stakeholders.*

Developers may also be required to produce and implement management plans for coastal areas as part of the subdivision approval process in liaison with State and local governments.

Appendix 1 provides a summary of the roles and responsibilities of government in coastal planning and management and the legislation governing these responsibilities.

Table 3-1 The hierarchy and characteristics of plans for coastal areas (adapted from Kay and Alder, 1999).

	REGIONAL PLANS AND STRATEGIES	LOCAL PLANS AND STRATEGIES	SITE PLANS
Scale and Coverage	1:25,000 to 1:100,000 100–1000km of coast	1:1,000 to 1:25,000 1–100km of coast	1:200 to 1:1,000 100m–1km
Example Types of Plans	• Land Use Strategy • Natural Resource Management Strategy • Coastal Strategy • Conservation Estate Management Plan • Issue Based e.g. Tourism, Transport	• Local Planning Strategy • Local Coastal Strategy • Rural Strategy • Coastal Management Plan • Greenways Plan • Foreshore Management Plan	• Revegetation Plan • Coastal Rehabilitation Plan • Recreation Management Plan • Walk Trail, Road or Car Park Design • Landscape Plan • Signage Plans
Scope of Plan	Incorporates several local government areas, and may include inland as well as coastal components. Determines broad scale patterns of land use and management.	Covers all or part of one local government area. Can provide more detailed planning for specific coastal nodes within the study area. Guides development of local policies, planning decisions and management direction. Designates development setbacks, coastal reserves and other areas of coastal utilisation. Also, rehabilitation areas, amenity sites and access ways for specific coastal nodes.	Outlines specific action to occur on the ground, such as detailed planning of infrastructure, landscaping and rehabilitation works within a foreshore reserve.

Table 3-1 The hierarchy and characteristics of plans for coastal areas (continued).

	REGIONAL PLANS AND STRATEGIES	LOCAL PLANS AND STRATEGIES	SITE PLANS
Plan Production	Usually State government in association with local government.	Usually local government in consultation with State government, or a developer meeting subdivision or approval requirements of State and local governments.	Land manager, local government, developer or community group.
Common Issues	• Land use planning • Urban development • Tourism development • Port and industrial development • Conservation estate planning • Management arrangements	• Development setbacks • Assessing land capability • Identifying sites for rehabilitation • Foreshore width determination • Protection of sensitive areas • Vehicle and pedestrian access	• Resolving conflicting uses • Designating vehicle and pedestrian access • Appropriate species for revegetation
Nature and Contents	• Designation of development zones • Coastal reserves • Recreation nodes and major conservation areas • Assessment of recreation opportunities • Assessment of conservation reserve boundaries	• Detailed designation of coastal nodes and areas for particular activities • Information on the coast • Allocation of areas for amenities and facilities • Assessment of recreation demand • Prioritisation of management resources, arrangements	• Location and design of infrastructure and recreation facilities • Detailed access provision • Detailed design of amenities and facilities, including landscaping • Detailed provisions for the protection of significant vegetation communities, wildlife, wildlife habitats, cultural heritage

3.2 PLANNING THE PLAN

Before embarking on a planning process its important to get organised and spend some time 'planning the plan'.

It is useful to prepare a *project brief.* This will guide the planning process and ensure there is a common understanding of the expected outcomes.

Aspects to be considered in a project brief include:

- purpose and scope
- the tasks to be performed
- project management arrangements
- community consultation
- timing, reporting and approvals processes
- budgets and funding.

Remember, a land manager's resources may be limited or fully committed at the time you are wanting to take on a planning project. The more advanced notice you can provide, the greater the level of support you are likely to receive.

3.2.1 Purpose and scope

Defining the purpose of the plan will determine how the process will unfold. The level of planning will be influenced by whether the purpose is to produce a strategic overview of the recreational needs of the area, or an action plan for managing the impacts of recreation at a site.

Consider:

- the geographical study boundaries
- the scope of issues to be addressed
- known opportunities and constraints of the area and its environment
- the vested *purpose* of the land (for example: recreation can not occur within a nature reserve)
- the relationship to other plans and management regimes that impact on the area.

3.2.2 Identifying tasks

Developing a list of tasks will help identify the skills and resources required, including whether it is necessary to appoint a consultant, or a team of consultants to assist with all, or part of the project. Section 3.10 provides guidance on developing a consultant's brief.

3.2.3 Project management

A steering committee or working group is the most effective way to oversee the planning process. Ideally, this group should be involved from the onset of the project through to implementation. Consider the skills of each member of the group, including skills that may be lacking.

A steering committee will need to be supported by a project manager to see to day-to-day management. Who ever takes on this role needs to have the capacity to attend to details and to see the plan through. The land manager may be able to assist with this role if the plan is recognised as a priority.

3.2.4 Community consultation

Community consultation is vital to developing a management plan. It can develop a sense of ownership and minimise potential conflicts in the future. The type of community input that is necessary will depend on the natural values of the area, the nature and intensity of use of the coastal area, and the issues being addressed. You should determine the nature and intensity of community involvement early to ensure timing and costs can be accommodated. Section 3.7 provides further guidance on community consultation methods which may be appropriate for planning processes.

3.2.5 Timing, reporting and approvals processes

Timing needs to be considered with regards to:

- the delivery of key aspects. For example, release of a draft plan or community workshops should not occur during holiday periods, and user surveys should be linked to peak user times
- the need to submit grant applications and the reporting requirements of funding bodies
- a date for completion of the plan. For example, if the planning process will produce a rehabilitation strategy, implementation will be dependent on suitable planting times, and on sufficient notice (minimum six months) for ordering revegetation stock, particularly if it is a large project
- the need for approval of the final plan by the land manager or funding agency. This might involve submitting the plan for endorsement at a local government Council meeting.

3.2.6 Budgets and funding

The amount of funds required to develop the plan will depend on factors such as:

- whether a consultant will be required
- the amount of available volunteer support
- the involvement of the land manager, or other agencies
- the type of community consultation to be included
- data requirements, such as maps, plans, surveys, beach erosion data, wind and wave information. *It may be possible to access much of this information at no cost. Consult the land manager for guidance on this in the first instance*
- the remoteness of the study area and associated travel costs
- photography needs
- printing requirements, such as whether it is necessary to produce and distribute draft and final reports, the size of the document, the use of colour, photographs, maps, and plans, and the quality of the production.

A full project budget that takes these costs into account will need to be prepared.

Funding support is available through a number of Federal and State government programs—both for the development of plans, and for materials and costs associated with implementation. A list of current programs and associated contact details is provided in appendix 2, and appendix 3 offers some guidance on writing a funding application. It is also worthwhile consulting with land managers such as the Department for Conservation and Land Management and local governments for up-to-date information about funding opportunities.

Content of a plan

Every plan will be unique in its layout and will vary with location, scale and issues. However most plans generally incorporate the following components:

Introduction: Background to the study area, the need for the plan and its context within the region, including the existing planning framework. The study area can be divided into smaller management sectors to allow greater detail in the analysis of issues and development of management proposals.

Description of existing natural, social and economic conditions: Describes the nature and condition of the natural, social and economic environments relevant to management. This information is often accompanied by a series of maps, and enables the identification of issues, opportunities and constraints.

Analysis of Issues: Each management issue is explored individually, including an assessment of its urgency for management, the causes of the problems, and opportunities and constraints.

Management Objectives: Objectives frame the future management direction of the study area. They can be established for the whole study area, or linked directly to particular issues.

Management Proposals: Alternative approaches for management are explored, and preferred approaches recommended.

Implementation: Outlines a strategy for implementation of management proposals. This can include the identification of responsibility, priorities, timeframes (including plan review), budget and sources of funds for implementation.

3.3 DESCRIBING EXISTING CONDITIONS

An existing awareness about management issues is often the catalyst for the preparation of a plan. Understanding factors such as the physical characteristics and conditions of the area, land use, patterns of use, and management arrangements will help to identify the nature and causes of these and other issues impacting on the study area. It will also assist in developing future management options.

The type of plan you are developing will dictate the level of information gathering and the community consultation required.

3.3.1 Information collection methods

Field visits

Field visits allow on ground observation of the nature and condition of natural features, built structures such as fences and walkways, and patterns of use.

You should be aware that coastal conditions such as shoreline movements and use of the area can be seasonal and some of the aspects observed at a particular point in time may be a component of this seasonality. You should conduct the visit with Indigenous and other people who are familiar with the area, as they can provide an indication of how conditions change over time.

Use a base map in the field to mark out key findings. Guidance and suggestions for suitable base maps are provided in section 3.6 *Mapping.*

Consulting stakeholders
Because of their history of involvement in the area, the land manager, user groups, State agencies, Indigenous groups and the community can provide information about a number of issues and aspects of an area, including whether any plans have already been produced.

Long-term residents can be particularly helpful for a historical perspective on development, nature and source of problems, and on such aspects as whether the coastline appears to be eroding, stable or accreting.

Stakeholders can also help with the prioritisation of issues. Methods of public participation and consultation during plan development are discussed in section 3.7.

Existing plans and policies
Existing plans and policies relating to the study area provide context for current management arrangements, an understanding of future use and development of the area, and information on natural and social aspects. In addition, your plan may have to comply with some of these existing plans and policies. Consulting these plans has the potential to save you considerable time.

Include reviews of broader strategic planning such as regional and local plans, local government policies, past site plans, and consider plans for areas adjacent to the study area.

Anecdotal evidence
Useful information such as user conflicts and historical information relating to the area can be obtained from anecdotal information sources such as newspaper articles and long-term residents.

Aerial photography/satellite imagery
Aspects such as vegetation cover, coastal access points, track management, shoreline movements, dune stability and other changes to the area over time can be collected via a comparison of aerial photographs. At a regional level, broad scale land use planning can be assisted by satellite image interpretation available through the Department of Land Administration.

User surveys
User surveys can gather information on patterns of use, and user attitudes. It is important to be aware of how to prepare and conduct surveys to reduce the introduction of bias into the information that is collected. Professional advice should be sought on aspects of survey design.

3.3.2 Types of information

The types of information that are useful to build a picture of existing conditions and management issues are outlined below. They have been separated into the natural environment, built environment, heritage aspects, and human uses and management.

It is easy to fall into the trap of collecting information without knowing how it will be used. You should consider the reasons for collecting various types of information, how it will help you manage the study area, and how it relates to the purpose of the planning process.

Natural environment

Climate

- What do the temperature, wind, rainfall and tidal data indicate about the site? Does it have any bearing on management measures that might be suggested? *The Bureau of Meteorology is a good source of information about climatic conditions.*
- Have there been any recent extreme climatic events (for example, cyclones) that may have a bearing on the current state of the site, or future management requirements?

Landforms and coastal processes

- What are the characteristics of the landforms in the study area? S*ome information on landforms can be obtained in section 2: The Coastal Environment.*
- Are blowouts naturally occurring, or human induced? *In some cases, blowouts are a natural part of the coast.*
- Does the topography need to be considered in the context of site design, such as the location of stairways and boardwalks?
- Are there coastal hazards or public safety risk areas that need to be accounted for?
- Coastal stability: is the coast eroding, stable or accreting? What are the patterns of shoreline movement? *The Department of Planning and Infrastructure may be able to provide information on shoreline movement for some areas.*

Vegetation

- What vegetation communities are in the study area?
- What is the current vegetation condition and degree of cover? Are there activities that can be linked to the current condition of the vegetation?
- Are there areas of active erosion or otherwise degrading and in need of rehabilitation?
- Does the area contain significant weeds? Which species?
- Are there areas of conservation significance?
- Is there a presence of any rare or threatened species?
- Are there known bush foods or medicinal plants?
- Is the fire history of the area known?
- *Section 8: Weeds and Weed Management, and section 9: Revegetation will be able to assist in the identification of plant species, and provide some guidance on vegetation management.*

Fauna

- Is there any information about the species found in the study area? *Species differ in their patterns of activity. Fauna surveys should be conducted over a sufficient timeframe to enable an appreciation of full species diversity and abundance.*
- Are there species of conservation significance, terrestrial or marine?
- Are there any pest species that are impacting on the site, such as rabbits or cats?

Built environment

- What is the location, condition and suitability of the built structures such as pedestrian access points (boardwalks, beach access paths, other walk tracks, steps); vehicle access points; 4WD tracks; car parks; toilets; boat ramps; fencing; groynes and/or seawalls in the area?
- Is user safety an issue?

Heritage

Aboriginal heritage

- Are Aboriginal cultural sites present in the study area?
- Are there any Native Title claims over the study area?
- *The Department of Indigenous Affairs (DIA) maintains the Aboriginal Sites Register. In some cases Aboriginal sites exist that have not yet been entered on the Register. The Aboriginal Heritage Act (1972) protects all Aboriginal sites in Western Australia whether they are known to DIA or not. Consult DIA before any ground disturbing works are conducted along the coast, and for advice about members of the Aboriginal community that need to be consulted from the concept stage of plan development. Section 4 provides more guidance on involving Indigenous people in coastal projects.*

European heritage

- What is known about the European settlement history of the area?
- Are there any listed heritage features, structures or natural features?

Aesthetics

- What are the visual qualities of the area? Do they require protection?
- Are there any negative aspects that need attention?

Human uses and management

Uses

- What are the main uses of the area?
- Are there conflicts between user groups?
- Is the area predominantly used by locals or tourists?
- What are the significant impacts from use?
- Is use influenced by seasons or times of the year? What are the peak use periods?
- Is it likely that there will be greater user pressure on the area in the future? How can this be accounted for when developing management proposals?
- Can the area cater for increased use without detriment to the natural environment?

Management arrangements

- What is the land tenure of the area, and who is responsible for management?
- Is the area being actively managed?
- Is there a ranger presence? At camping grounds, day sites?
- Is there evidence of previous rehabilitation or management measures and have they been effective?
- What existing plans and strategies impact on the management of the study area?

Surrounding land uses

- Do the surrounding land uses, such as groynes, marinas, urban developments or industry, impact on the study area?
- Do these impacts require management?

Commercial activities

- What is the nature and intensity of commercial uses? Commercial fishing, tourism?
- Is the use seasonal?
- What are the users' requirements?
- What are the impacts?

Community attitudes

- *How do the community, Indigenous or special interest groups feel about the site and how it should be managed?*

3.4 MANAGEMENT ISSUES

Each identified management issue should be explored individually.

The analysis of issues should include an understanding of:

- the causes of the problem
- the spatial expanse, the users and the site aspects most impacted
- the urgency of the problem and the implications of not addressing it
- opportunities and constraints associated with addressing the issue.

This information is gathered as part of the collection of information on existing natural, social and economic conditions.

It is important to differentiate between issues that can be managed within a State, regional, or local context, and those that can be managed at the site level. For example: conflicts between adjacent land uses may be able to be addressed in a regional plan, but at a site planning level, it is a matter of being aware of these conflicts and managing the impacts.

3.5 FUTURE MANAGEMENT

3.5.1 Setting objectives

Management objectives define the type of coastal area and nature of experiences expected by stakeholders and the broader community.

Objectives can be developed through the steering committee or through stakeholder workshops, and are often developed in response to particular issues. In some instances, broader planning processes may have already defined objectives for the area, and existing plans should be consulted where this is the case.

It is important that your objectives can be measured in some way to enable the success of your project to be determined.

3.5.2 Management proposals

Proposals for future management should be a response to identified issues and objectives, and form the basis of plan recommendations.

A range of immediate to longer-term strategies may need to be developed and prioritised to allow work to be staged as resources become available. Depending on the type of plan being developed, these can be expressed as strategies, policies, guidelines or actions. For example, a site plan would include detailed rehabilitation requirements, access, fencing, signage and general site protection measures.

An effective plan will develop realistic, implementable recommendations that will meet management needs.

In selecting the preferred approach you should consider:

- how it will contribute to meeting management objectives
- whether sufficient resources are available to implement it
- how urgent the issue is, and the implications of not addressing it
- how effective the approach will be in addressing the cause of the problem

- the on-going maintenance requirements
- the community's attitudes and expectations
- whether results can be easily measured to determine success.

3.5.3 Implementation

Plans should include an implementation schedule and budget. An implementation schedule should be agreed to during development of the plan and can:

- allocate responsibilities for implementation of particular actions
- prioritise activities and develop implementation timelines and schedules
- determine costs and identify funding sources
- determine monitoring and evaluation requirements.

Depending on the management arrangements for the area and who has been involved in preparing the plan, it may be necessary to submit the plan for formal endorsement by the local council, land manager or funding body before implementation.

3.5.4 Monitoring and evaluation

A way of evaluating the success of a plan should be identified from the outset. Evaluation usually requires some form of monitoring to be undertaken. This could be over a period of months or even years for some projects, depending on the plan's objectives. If the example in the boxed text is used (ensure a safe beach for all users), an indicator of success might be a reduction in the number of reported accidents over a three-year time period. In this case, an annual review for three years may be sufficient, with success determined from newspaper articles or local knowledge—it is the trend that is important.

However, success of a project aimed at dune rehabilitation may need be measured over a longer timeframe, and could involve the use of aerial photographs for large areas or photo-point monitoring for individual dunes. The latter simply requires photos taken from the same point at a regularly scheduled time (say, once a year) until the dune is successfully rehabilitated.

Section 5: *Project Evaluation,* provides some guidance on monitoring and evaluation methodologies for coastal management projects.

Monitoring does not need to be expensive. Again, this will depend on the objectives of the plan and how success can best be measured. It is important that the responsibility for monitoring is considered at the commencement of the project.

3.5.5 Review of plans

Future management directions established by a planning process are based on the consideration of a number of dynamic issues and factors acting upon an area.

These issues, and the impact they have on the site, will be subject to change over time. It is important that coastal management is responsive to these changes. Planning processes have a period of relevance, following which it is necessary to revisit issues and review the suitability of recommendations for management of the area. Every plan has a limited life!

Evaluating the success of the plan against the original objectives is therefore critical, as this provides guidance for future management planning and plan reviews. For further information regarding the evaluation of projects refer to section 5: *Project Evaluation*.

HYPOTHETICAL ISSUES, OBJECTIVES AND MANAGEMENT PROPOSALS

Three options to addressing the following hypothetical issue are presented. These options have been developed in response to the management objective that has been set for the area.

Issue	4WD beach use conflicting with other beach users
Management Objective	Provide for both 4WD access and passive recreation while ensuring a safe beach for all users

Management Proposal 1: Close the beach to all vehicles

Recommendations

- Establish legislative basis to prohibit all vehicles from the beach, through local government by-law, or gazettal through the Control of Vehicles (Off Road Areas) Act.
- Close off access to all 4WD tracks by fencing and brushing, or other means (bollards, boulders, earth moving).
- Develop a community awareness program including media, signage, and discussion of the management plan to raise awareness of the prohibition of 4WDs to the beach.
- Assess the need to increase the capacity of the carpark based on anticipated increase in use.

Advantages

✓ Removes conflicts between users

✓ Increases safety for beach users

Disadvantages

✗ May shift the problem to another area

✗ Eliminates use by 4WD user group

Management Proposal 2: Limit 4WDs to certain sections of the beach

Recommendations

- Establish legislative basis to prohibit vehicles from particular sections of the beach, through local government by-law, or gazettal through the Control of Vehicles (Off Road Areas) Act.
- Rationalise existing 4WD tracks: identify suitable access to remain open and close off others with fencing and brushing.
- Develop a community awareness program including media, signage and discussion of management plan to raise awareness of the new 4WD access areas, and responsible 4WD techniques.

Advantages

✓ Uses zoning to separate users in conflict

✓ Increases safety for beach users

✓ Enables 4WD user group to continue to use the area

Disadvantages

✗ May reduce but not eliminate conflict between users

Management Proposal 3: Provide an alternative 4WD beach access point away from the main beach entry/exit

Recommendations

- Identify suitable entry/exit point for 4WDs.
- Close off and rehabilitate old tracks with fencing and brushing.
- Develop a community awareness program including media, signage and discussion of management plan to raise awareness of the new 4WD entry/exit points, and responsible 4WD techniques.

Advantages

✓ Reduced conflicts between users at main entry/exit point

✓ Enables 4WD user group to continue to use the area

Disadvantages

✗ May not reduce conflict on the beach

3.6 MAPPING

Maps help to gather and analyze information. Maps can also help to present information and future proposals for management.

Maps are useful at a number of points in the planning process to:

- display geographical boundaries and the location of the study area
- understand the location and condition of natural, social and economic features
- assist with identifying constraints, opportunities and management issues
- develop and present future management proposals.

3.6.1 Selection of a base map

Existing plans, aerial photos or contour maps are useful base maps over which you can place information on aspects of the area or resulting proposals.

All maps should include a scale, north point, and a key describing the symbols used to represent features.

Scale

A suitable mapping scale will depend on the size of the study area, the issues and the resulting level of detail. Generally:

Regional Plans and Strategies	1:25,000 to 1:100,000 scale	covers 100–1000km
Local Plans and Strategies	1:1,000 to 1:25,000 scale	covers 1–100km
Site Plans	1:200 to 1:1,000 scale	covers 100m–1km

(Kay and Alder, 1999)

It is useful to divide the study area into smaller management sectors for the analysis of issues at a smaller scale. Figures 3-1 to 3-3 demonstrate how this has been achieved to provide guidance on the management of a section of the Hopetoun foreshore.

Supporting information

Supporting information such as land tenure, roads, paths, towns, or contours can provide context. This information should be included in a key, and should not detract from the main focus of the map.

The availability of appropriately detailed base maps may depend on the location of site, in particular its remoteness, and whether there have been any previous studies in the area that have involved the collection of mapping data.

Useful base maps

Beard's vegetation maps

Vegetation surveys of Western Australia published by Dr John Beard at 1:250,000 scale and 1:1,000,000 scale. These maps have been digitized and integrated onto a single database by the Department for Conservation and Land Management, and Department for Agriculture.

Marine charts

Many marine charts include adjacent coastal areas, and can show aspects such as sand drifts, existing tracks, prominent features and marine geomorphology.

Australian Coastal Atlas

The Australian Coastal Atlas (ACA) is a national network of marine and coastal information available to the public over the Internet. The Western Australian Land Information System (WALIS) co-ordinates the Western Australian node of the Atlas, which includes datasets on for example: topography, bathymetry, conservation reserves, habitats, commercial and recreational fishing data, and Aboriginal communities. It can be accessed via the WALIS web site at http://www.walis.wa.gov.au

3.6.2 Mapping information and management proposals

Information such as land tenure, zoning, fire management, landforms, soils, hydrology, vegetation, geology, dieback disease occurrence and hazard, areas of active erosion and/or requiring rehabilitation, coastal access and facilities, and land use can be effectively represented on a series of maps of the study area.

Presenting management proposals on a series of maps is an effective summary of the planning process.

The following mapping examples demonstrate:

1. Hierarchical Planning (figures 3-1 to 3-3) – indicates changes in scale and the nature of issues addressed at various levels of planning.
2. Site Planning (figures 3-4 to 3-6) to the development of a rehabilitation and recreation management plan for a section of the Hopetoun foreshore.

Example 1. Hierarchical planning

Figures 3-1 to 3-3 demonstrate how hierarchical planning has defined the proposed future use of North Head in the Shire of Dandaragan along the central west coast region of Western Australia.

The *Central Coast Regional Strategy* was produced in 1996. It provides strategic land use direction for a 250 kilometre stretch of coast covering the Shires of Gingin, Dandaragan, Coorow, Carnamah and Irwin (figure 3-1). The plan also developed planning and management guidelines for smaller 'planning units' within the study area to assist with the development of local plans and strategies.

The Shire of Dandaragan commissioned Landvision to produce the *Coastal Plan incorporating Structure Plan and Design Guidelines for Coastal Development and Management for the Shire of Dandaragan* in 1999. Utilising the regional framework established by the Central Coast Regional Strategy, this local plan provides guidance for future coastal development and management at two scales within the Shire of Dandaragan:

Coastal Nodes (e.g. Sandy Cape/North Head, figure 3-1)
The plan has identified an 18-kilometre stretch of the Dandaragan coast, the *Sandy Cape/North Head Node,* as a key coastal recreation area. It has determined the range and location of recreation opportunities, and identifies management requirements such as dune stabilisation and track rationalisation.

Coastal Sites (e.g. North Head, figure 3-2)
For key sites within each node, a concept plan has been developed which identifies rehabilitation and recreation measures necessary for effective site management. This includes the development of walk trails, areas requiring rehabilitation, and service facilities.

Prior to conducting work at North Head, it will be necessary to plan the design and implementation of each recommendation in figure 3-3. For example the actual alignment of boardwalks, car parks and walking trails.

Figure 3-1, see page 3.18

Regional land use plan, Central Coast

Key features of the map:

- scale 1:100,000
- focus information: proposed land use zones
- supporting information: townsites, major roads, infrastructure
- clarity: full colour to assist with differentiating between land uses
- inclusion of a north point, key, and scale

Source: Central Coast Regional Strategy (1996) Figure 14

Figure 3-2, see page 3.19

Local coastal plan, Sandy Cape/North Head, Shire of Dandaragan

Key features of the map:

- scale 1:50,000
- focus information: management recommendations for each major coastal site
- supporting information: existing and proposed land tenure, roads
- clarity: full colour to assist with information presentation
- inclusion of a north point, key and scale

Source: Coastal Plan incorporating Structure plan and design guidelines Shire of Dandaragan (1999) Figure 1

Figure 3-3, see page 3.20

Site concept plan, North Head, Shire of Dandaragan

Key features:

- scale 1:3,750
- focus information: location of rehabilitation and recreation management recommendations
- supporting information: contour lines, major, minor roads
- clarity: black and white, use of symbols for repetitive aspects
- inclusion of a north point, key and scale

Source: Coastal Plan incorporating Structure plan and design guidelines Shire of Dandaragan (1999) Figure 20

Figure 3-1 Regional land use plan, Central Coast.

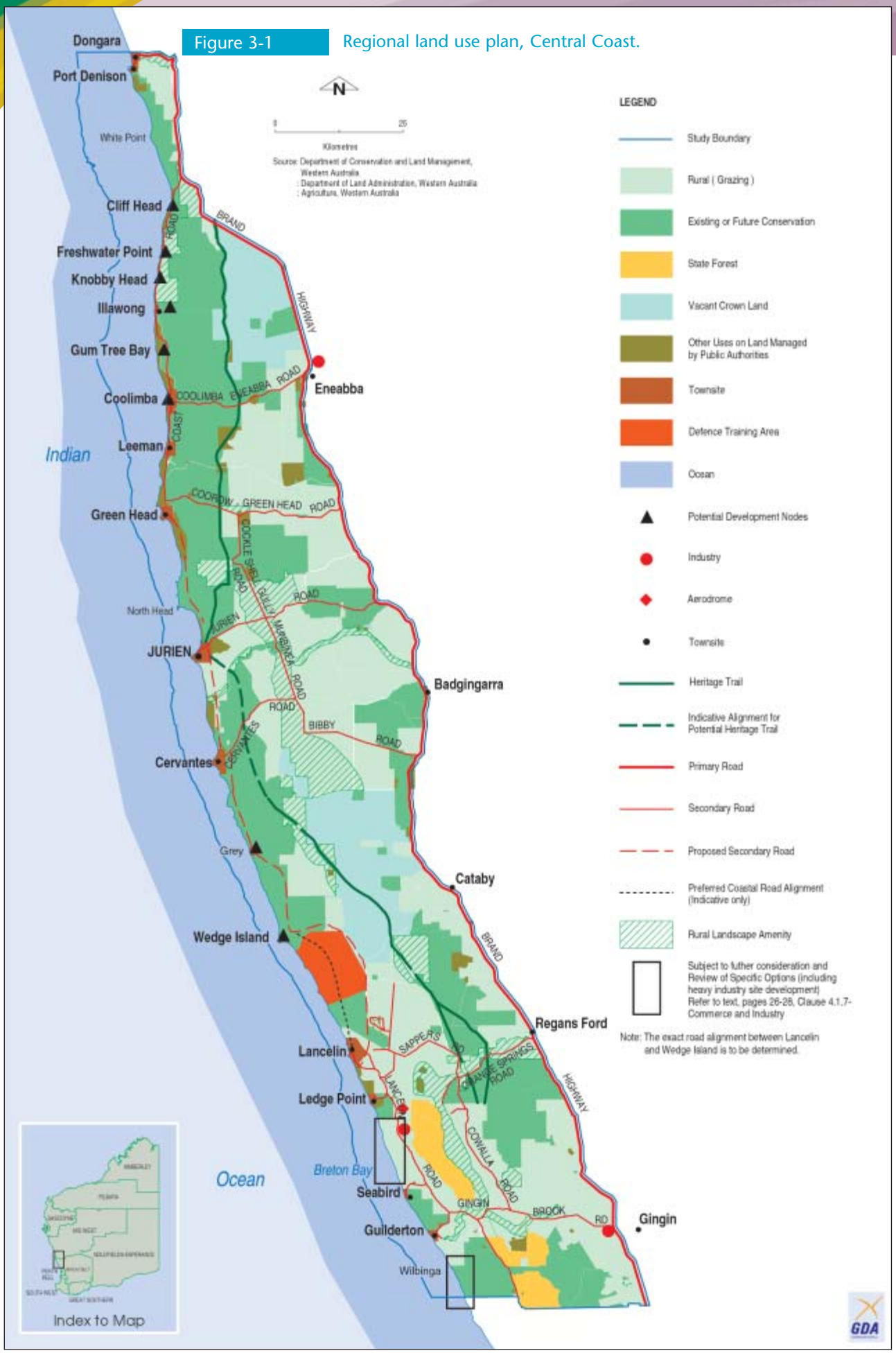
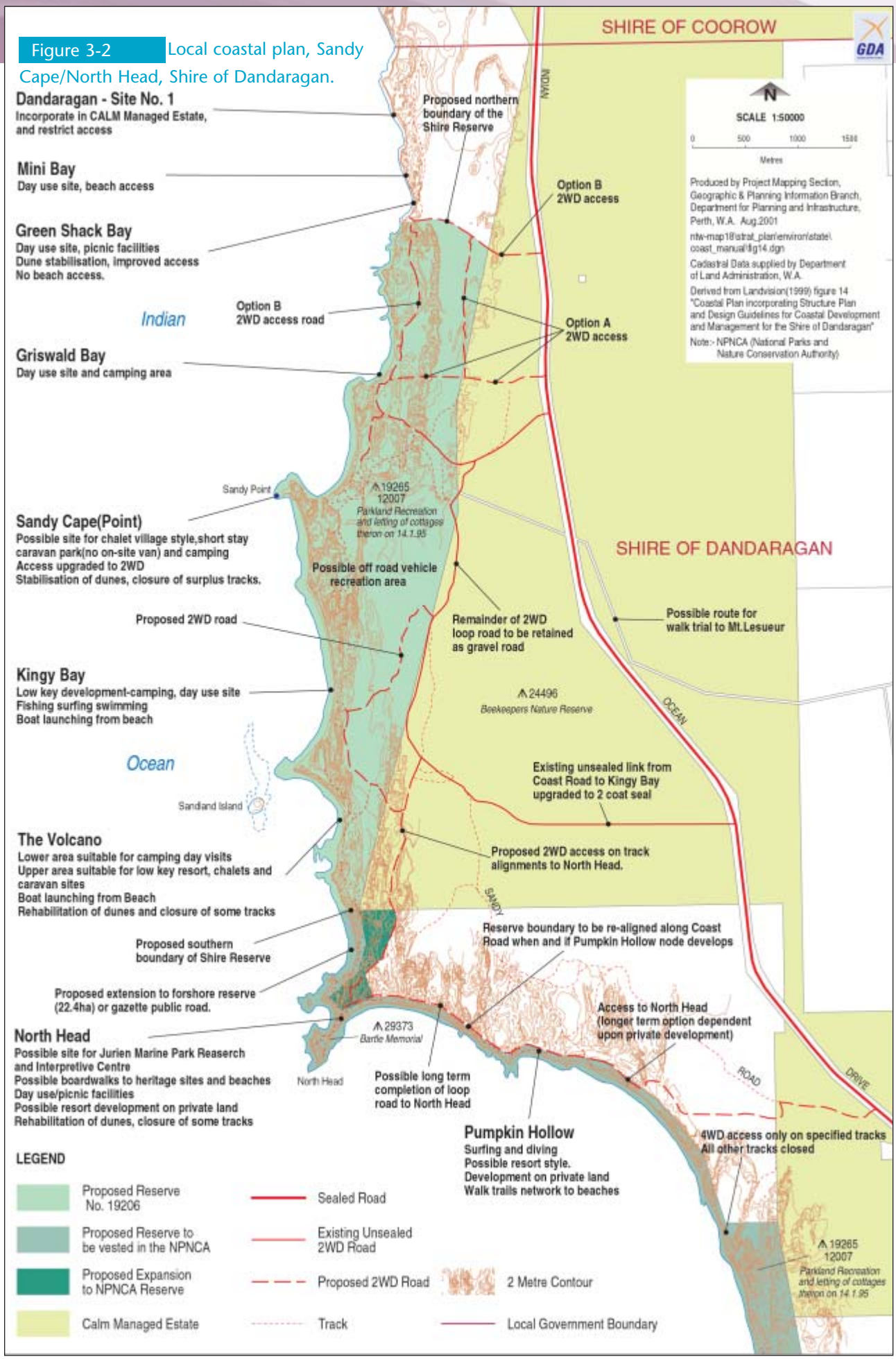


Figure 3-2 Local coastal plan, Sandy Cape/North Head, Shire of Dandaragan.



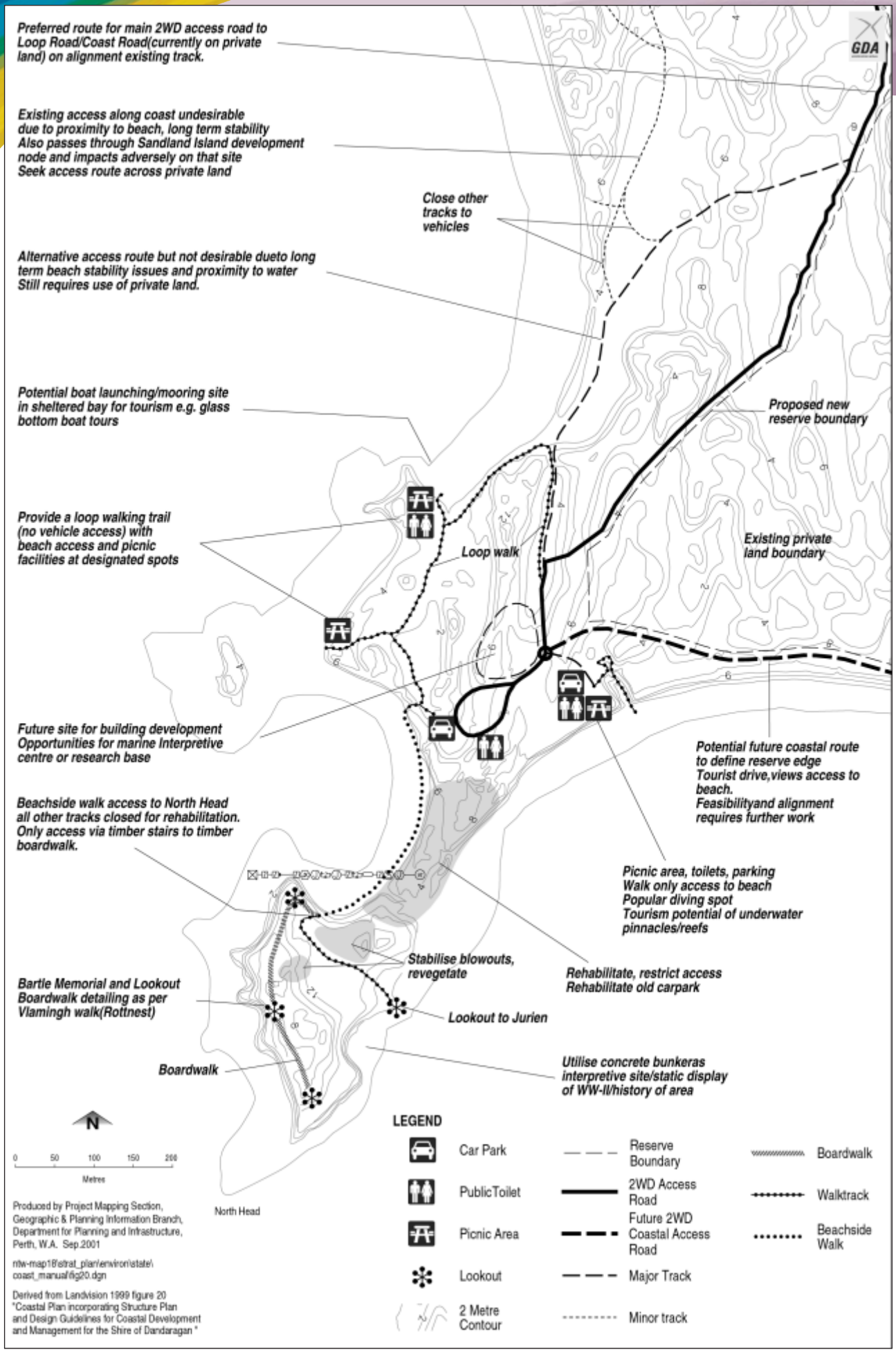


Figure 3-3 Site concept plan, North Head, Shire of Dandaragan.

Example 2: Site planning

Figures 3-4 to 3-6 demonstrate the use of maps to plan for a coastal access point along the Hopetoun foreshore.

The *Hopetoun Foreshore Management Plan* developed a management plan to address coastal access and use of the Hopetoun foreshore. The 3-kilometre stretch of foreshore was divided into four sectors (of up to 1 kilometre each), and proposals developed for the management of each of these. Further guidance was provided for the design and rehabilitation of key coastal access points (of approximately 100 metres of coast).

Figure 3-4, see page 3.22

Hopetoun foreshore

Key features of the map:

- scale 1:15,625
- focus information: coastal access points, management units
- supporting information: residential areas of the town, major roads, paths, location names
- clarity: management units overlayed in additional colour
- inclusion of a north point, key, and scale

Source: Hopetoun Foreshore Management Plan (1992) Figure 4

Figure 3-5, see page 3.23

Hopetoun west management unit

Key features of the map:

- scale 1:3,125
- focus information: management proposals
- supporting information: major roads, paths, vegetation, location names
- clarity: proposals overlayed in additional colour
- inclusion of a north point, key, and scale

Source: Hopetoun Foreshore Management Plan (1992) Figure 5

Figure 3-6, see page 3.24

West Beach coastal access point

Key features of the map:

- scale: 1:740
- focus information: placement and design of management proposals
- supporting information: existing paths, species information, existing infrastructure
- clarity: proposals overlayed in additional colour
- inclusion of north point, key and scale

Source: Hopetoun Foreshore Management Plan (1992) Figure 6

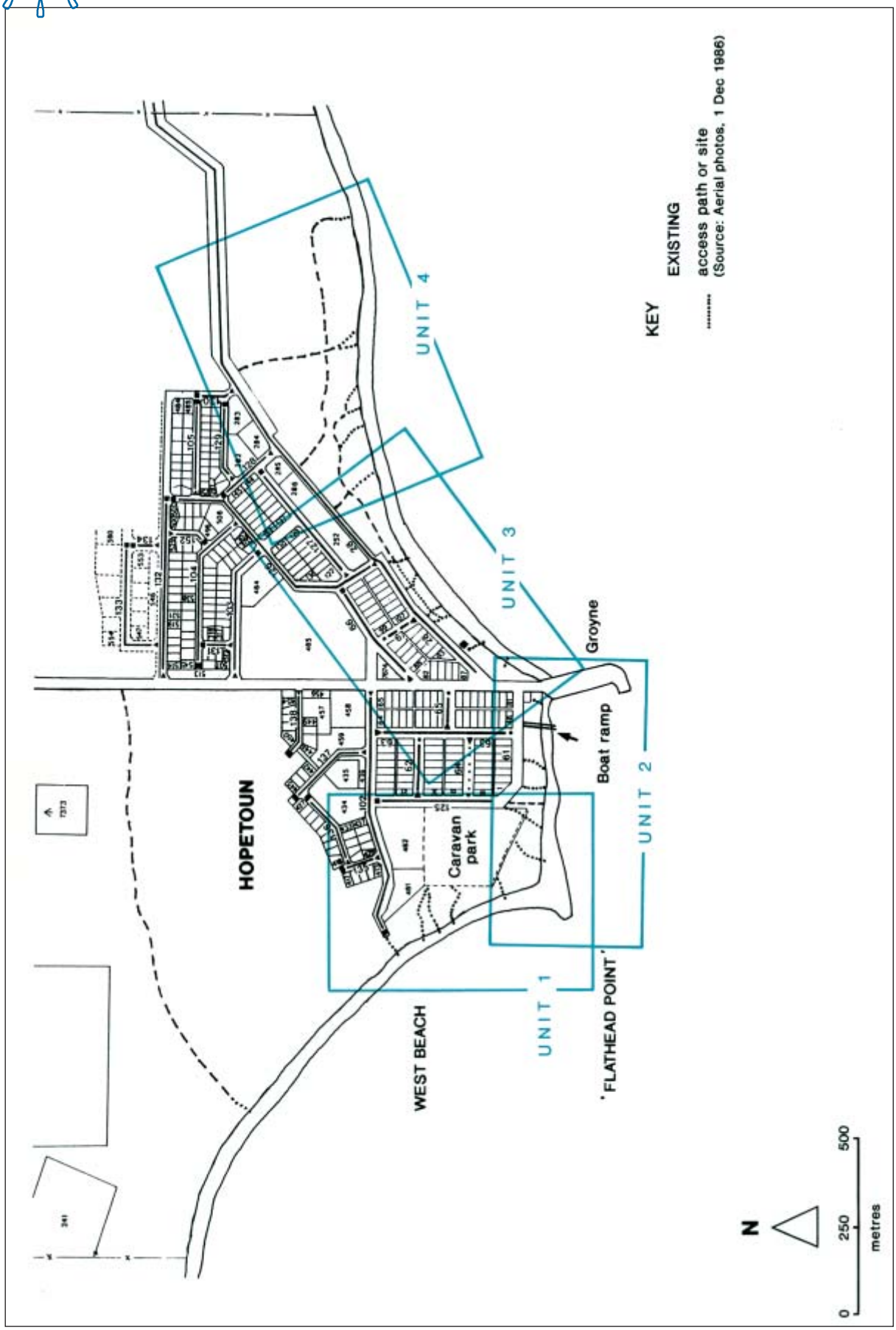


Figure 3-4 Hopetoun foreshore

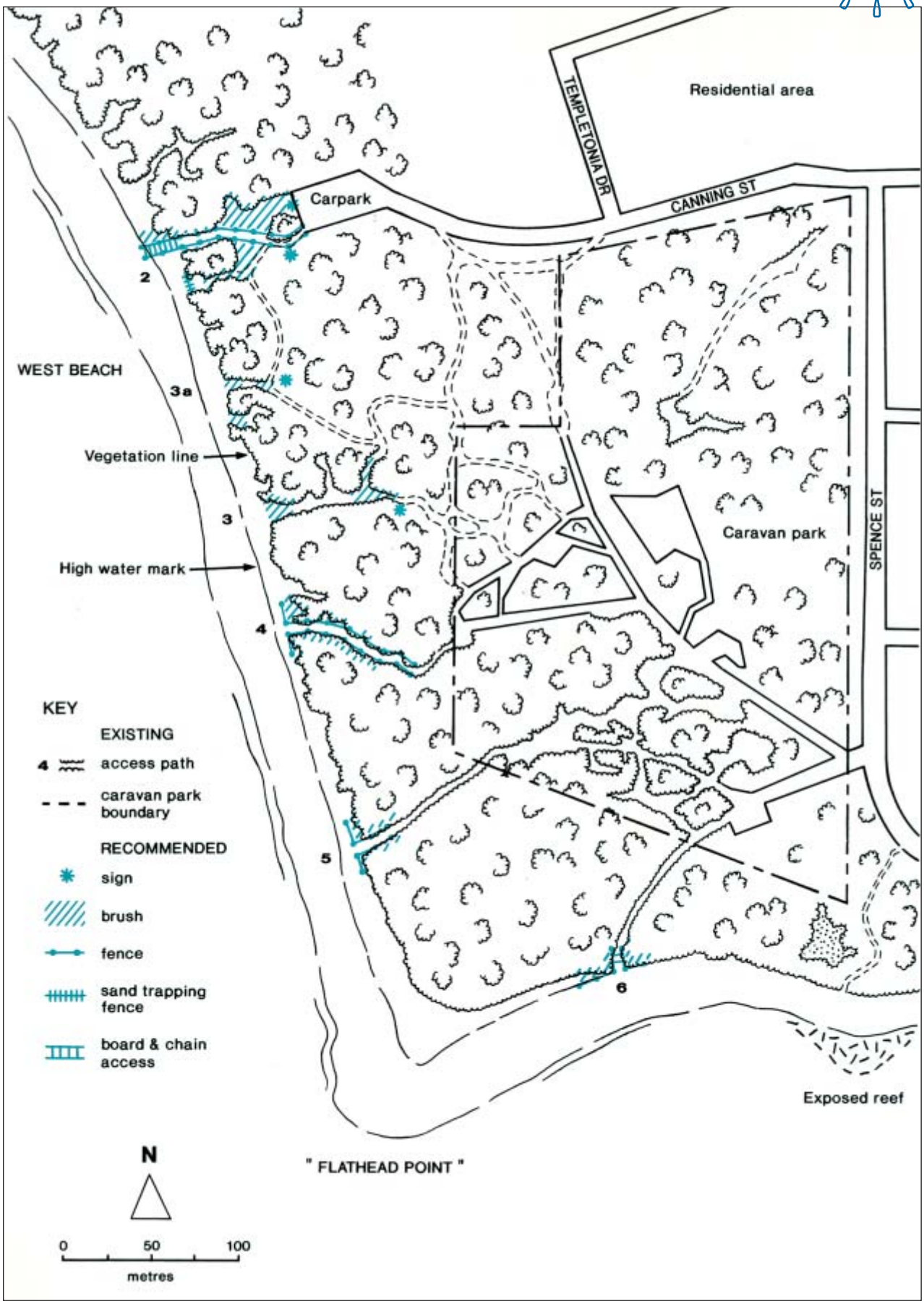


Figure 3-5 Hopetoun West management unit

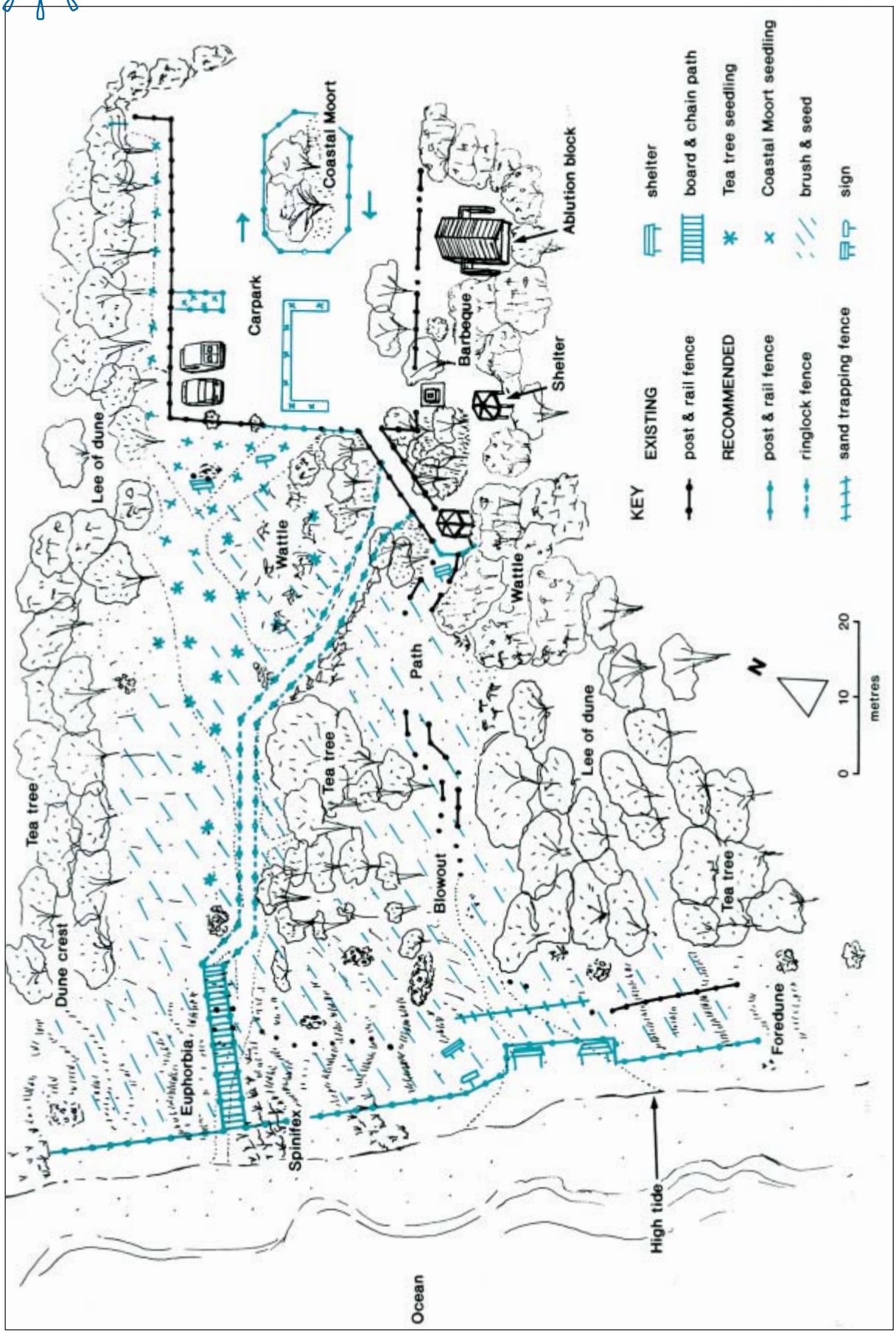


Figure 3-6 West Beach coastal access point

3.7 COMMUNITY CONSULTATION

Involving the community in the development of a plan helps to identify issues and encourages agreement and a sense of ownership about future management. Broad involvement in plan development can also assist with engaging support when it comes time to implement the plan.

Public participation and consultation can occur at a number of stages in the planning process, such as during:

- issue identification
- developing management options
- reviewing and evaluating recommendations
- implementation, and
- monitoring and evaluation.

The level of input sought from the community will depend on the natural values of the area, the nature and intensity of use, and the issues being addressed. If a section of coast with conflicting user needs is heavily used, it will be more important to ensure all concerned parties have the opportunity to participate in the planning process. This will necessitate a more structured public consultation program.

There are a number of methods available to engage the public to participate:

Preparation of a communication strategy
The use of press releases, a project newsletter, newspaper, radio, the Internet and email to distribute information about the plan as it is developed can be an effective way to increase awareness and involvement. A communication strategy should be linked to key activities that will benefit from public involvement or heightened awareness. This includes identifying community members to get involved in a working group, attend a community workshop, or comment on a draft plan.

Representation on the steering committee or working group
Community participation on a steering group provides an opportunity for key representatives to be involved in decision making. You should ensure key user and interest groups, and individuals have the opportunity to participate in the group as this aids the provision of information to and about, the plan.

Workshops and meetings
Workshops or meetings delivered at key points in the study can be effective in identifying issues, establishing objectives and determining and communicating management options.

These sessions can involve the general community (a public workshop or open day), or target a more focused group such as coastal users, agencies and organizations with an interest in the area, schools, or special interest groups. Focused group sessions are generally more effective for gathering information and opinions from the community, whilst public meetings can help to raise the profile of the planning process and communicate with a wider audience.

Effective workshops and meetings require careful planning. It is important to be clear about the intentions of the gathering and the role in decision making. You should give thought to structure and content, location, time and involvement of a good facilitator or chairperson. Ensure discussions are well documented, including the contact details of each attendee to allow distribution of further information. Techniques available to assist with the delivery of effective workshops and meetings are described in a number of references provided in section 12: *References and Further Reading.*

Surveys and questionnaires

Development and distribution of surveys and questionnaires can be useful when there is a need to canvass opinions from a large group, or when information needs to be gathered from people who live elsewhere, such as tourists. It is recommended that you seek advice on the preparation and delivery of surveys to reduce the introduction of bias into data.

Surveys and questionnaires can also assist with raising the profile of the study and can be used to evaluate the community participation process.

Preparing a draft plan

Preparing a draft plan gives the land manager, stakeholders and the broader community an opportunity to comment. The suitability of distributing a draft will depend upon the type of plan being prepared, and the level of community consultation considered necessary.

Once a draft plan has been produced, the public should be encouraged to provide comment on the suggested initiatives. It may be appropriate to display the draft plan or a map with the major recommendations at the local council, community hall, library, shopping centre or schools.

In order to encourage participation it is important to ensure there is sufficient awareness to enable all interested parties to provide feedback, and the public comment period is of sufficient length (6 weeks – 3 months) to give people time to respond. Try to avoid releasing the draft for comment over holiday periods.

3.8 PLANNING FOR RECREATION

Recreation is one of the primary activities along our coastline. It is essential to consider recreational uses and the needs of various user groups if efforts to manage the coast are to be successful. There are a number of publications which provide extensive guidance on recreation planning, such as the Department of Conservation and Land Management's Recreation Management and Planning Course Notes (see section 12: *References and Further Reading*).

3.8.1 Hierarchical recreation planning

At each level of coastal planning there are different decisions to be made in respect to recreational use. When collecting information, ensure that it will be relevant to the level you are working at.

Regional plans and strategies

- identification of major recreation nodes
- ensuring that there is a variety of experiences across a region.

Local plans and strategies

- deciding on the general level of access to the coast
- deciding which basic facilities should be located where, and to what standard they should be developed
- deciding on any requirements to segregate major user groups
- locating facilities at sites where they are needed
- zoning to keep conflicting user groups apart in space or time
- linking coastal nodes and regional settlements.

Site plans

- detailed siting and design of facilities
- landscaping plans, for example the inclusion of shade trees.

3.8.2 Considering recreation use

There are a number of steps to consider recreation use at a site. These are outlined below:

1. Assess recreation demand.
   Look at present and future use to see where the pressures and conflicts are now and where they will be in the future.
2. Consider recreation opportunities.
   What types of activities can take place at various coastal locations, including activities not currently occurring?
3. Consider the need to separate conflicting user groups.
   Are there problems between people using the same area for different activities? Can these people be separated from each other by using different parts of the site, or the same parts but at different times?
4. Assess recreation carrying capacity.
   How much use can the area or site sustain without the environment becoming unacceptably damaged, or people beginning to feel crowded?
5. Determine future options for recreation development styles.
   Is there a good range of levels of access, facility provision and intensity of management across sites in a region or local coastal area? Can more diversity be provided?
6. Consider available resources.
   Are the resources available to manage new recreation sites or access points if they are developed?
7. Consider monitoring requirements.
   What monitoring should be conducted to detect and change in environmental or social condition, and to ensure the original objectives are met and maintained?

3.8.3 Collecting information – current recreation use and needs

Field visits

Visit an area or site at busy times to see what pressures there are. Count people and vehicles, note where they are, and the activities they are undertaking. Visit any time to observe signs of current use – where are people going, what are they doing, are there activities which are causing problems?

Existing plans and policies

There may already be recreation surveys for your area, perhaps reported in existing planning documents. Even if these are old they can still be useful.

Anecdotal evidence

Ask local residents, rangers, coastal users and the general community how an area is used – when are the peak times, what are the problems for the users and the environment? Look for written evidence on these topics in newspaper stories and letters, community news sheets etc.

Aerial photography

One method used to gauge recreation use is to take low level air photos then count the people, vehicles etc. This is useful for covering a large area over a relatively short time.

User surveys

User surveys are generally either carried out on the site, with people filling out survey forms on the spot, or with people collecting forms somewhere else, such as at a motel reception desk or public library. There is a lot of skill and work needed to carry out a survey properly, and in many instances the other, simpler methods provide sufficiently accurate information.

3.9 DESIGN PRINCIPLES

There are a number of generic factors which need to be considered in any site design process. These are outlined below. Further guidelines specific to various types of coastal infrastructure, such as the placement and use of suitable materials for fencing and signage, are described in section 7: *Stabilisation and Rehabilitation*.

3.9.1 Aesthetics/visual impacts

Coastal landscapes are popular and highly visible. It is important to identify and protect features and views, for example, the natural character of the coastline, valued by the local community and/or tourists. Negative visual impacts of development and management should be reduced.

Principles:

- Retain open views to, from and along the coast, rather than obscuring important views with poorly located buildings, car parks, signs, clumped amenity planting etc.
- Retain the natural character of the coast by keeping structures and development to a minimum, siting them unobtrusively and designing them to fit into the landscape. This can be achieved by using local materials and colours, creating vegetated islands in car parks and breaking up building height and bulk.
- Aim at creating, improving or enhancing high aesthetic standards in both natural and built environments.

3.9.2 Costs

Facilities and structures by the coast incur high costs for installation and maintenance because of the need to withstand the exposed conditions. These high costs can be offset by the community's willingness to undertake coastal works on a voluntary basis.

Principles:

- Allow for extra costs for long-term maintenance of facilities, owing to exposure to storm conditions, regular strong winds and salt spray.
- Consider making use of recycled, locally-available materials for construction of facilities.

3.9.3 Social and cultural

The popularity of the coast can result in peak use crowding and conflicts between user groups. Coastal areas may support historic and cultural features valued by the community.

Principles:

- Where crowding occurs, large popular sites can be divided into smaller areas; for example, providing several smaller car parks or picnic areas instead of one large facility, or by use of screen planting to divide large areas. Temporary additional facilities can be provided at peak times instead of installing extensive permanent facilities that are unused for much of the year.
- Segregate user groups which may disturb other users; for example, animal exercisers, 4WDs, kite flyers, campers.
- Ensure the protection of archaeological remains such as Aboriginal middens, shipwrecks and heritage buildings or structures by obtaining expert advice prior to undertaking earthworks.

3.9.4 Safety

Safety risks relate to either the physical environment or social factors.

Principles:

- Discourage the use of coastal areas where there are hazardous conditions such as rips, king waves, steep slopes or cliffs. Where the use of hazardous areas is condoned, users need to be educated about the risks and facilities designed to address safety issues; e.g. handrails or barriers.
- Reduce hazards related to conflicts between vehicles and pedestrians, for example by segregating vehicles and pedestrians on beaches and beach access paths, and by providing safe pedestrian access to facilities such as toilets or kiosks.
- Discourage anti-social or criminal behaviour by providing unobscured entrances to toilets, and by locating toilets, car parks or picnic facilities in areas that are close to housing, but not screened from public view

3.9.5 Engineering

Structures and facilities need to be located and designed to take account of natural coastal trends, such as whether stretches of coast are eroding or building up over time, erosion of steep or rocky coastline, and dune formation and movement.

Principles:

- Avoid locating facilities too close to an eroding shoreline or on the eroding side of a groyne where there is a risk of damage or loss. If structures must be located where they are prone to damage, for example fencing or signs, they may need to be designed to be easy to relocate, or their likely loss factored into cost and maintenance schedules. The same applies to structures likely to be inundated with sand, such as timber or rubber belting placed on access tracks.
- Avoid building coastal structures which may induce shoreline erosion or dune movement, for example rock walls, solid boat ramps, concrete paths and steps onto the beach, closely-spaced timber slat fencing at the base of dunes.
- Avoid locating solid structures in exposed locations where sand may scour or accumulate around them. Stabilise adjacent exposed sand through planting or mulching the surface.
- Ensure that sealed car parks and paved areas do not drain directly onto adjacent beach access paths, as path edges may become eroded. Instead, hard surfaces may be drained into adjacent vegetated areas. Ensure that sealed paths are properly contoured and drained, to avoid soil erosion along their edges.
- Avoid use of non-galvanised metal, as it rusts easily when exposed to salt.

3.9.6 Environmental

On-ground works should not unduly disturb the natural environment and should be designed to assist in environmental protection.

Principles:

- Formalise pedestrian and vehicular access, and facilities such as parking, lookouts and toilets at sites where people are damaging vegetation and eroding dunes.
- Minimise earth disturbance to reduce weed spread. Although weeds provide some cover for dunes, they are a fire hazard when dead, their root systems tend to be shallow, they inhibit natural vegetation and reduce habitats for native fauna.
- Ideally, revegetation needs to duplicate the range of species naturally found at a site and utilise plants grown from seed or other plant material collected at the site.
- Provide fuel for BBQs, to avoid vegetation and brush material being removed for firewood.
- Retain some dead woody material, especially hollowed logs, to provide habitat for native fauna, although retaining large quantities of dead timber may constitute a fire hazard.
- Expert advice should be sought before removing seagrass from beaches to use as mulch or to surface paths, as the seagrass plays an important ecological role on the beach.
- Consider the risks to fauna before providing access to near-shore reefs, bird-nesting sites etc.

3.10 CONSULTANT'S BRIEF

In some cases it will be necessary to engage a consultant to carry out a part of or the entire plan, based upon required expertise and available resources. It is important to clearly articulate what tasks you are engaging a consultant to perform. This will help to ensure the job is accurately quoted, and that the resulting plan meets expectations.

Although the level of detail in a consultant's brief will alter depending upon the nature of the task, the following example of a brief to prepare a foreshore management plan for Geographe Bay by the Shire of Busselton demonstrates what a consultant's brief should look like, and could be followed for most situations.

EXAMPLE CONSULTANT'S BRIEF

Expressions of Interest
Foreshore Management Plan – Geographe Bay

Background

The coastline of Geographe Bay is a sensitive system and is exposed to increasing pressures from development, tourism, fishing and recreation. These pressures are particularly evident within the coastal foreshore reserves of the Shire of Busselton, which are bounded almost continuously by urban residential and tourist-oriented development. The Busselton Shire is currently experiencing extremely rapid growth and as a result, the existing pressures on the coastal foreshore reserves of Geographe Bay are likely to increase.

The Shire of Busselton, in partnership with the Geographe Catchment Council has received a Coast Care grant for the development of a foreshore management plan for the Geographe Bay coastline.

The foreshore management plan will form the basis of Council foreshore planning policies and for dealing with conditions for adjoining development within the Geographe Bay coastal zone.

Study area

The study area for the Foreshore Management Plan will include the foreshore from Forrest St in Dunsborough, around the coast of Geographe Bay to the south-western boundary of the Port Geographe canal development site in Busselton. The indicative area is illustrated in Figure 1.

This study area includes the developed coastal zone within the Shire of Busselton. In some areas these foreshore reserves form the only boundary between private property and the waters of Geographe Bay. In other areas the foreshore reserves are easily accessible and are subject to intense recreational use, while in limited sections private land extends to the high water mark or private right of ways exist on the foreshore.

Project objectives and outcomes

The objective of the project is to provide direction to the Shire of Busselton, developers and community groups by developing a framework for the future management, protection and preservation of the foreshore of Geographe Bay, both reserve and private areas.

As an outcome, it is expected that the final Foreshore Management Plan will differentiate sectors according to management issues; and include recommendations relating to rehabilitation, revegetation, access, boat launching facilities, dual use paths, recreational activities, community involvement and community ownership. The final recommendations will be presented to Council in a form suitable for incorporation into foreshore planning policies.

Scope of services

This contract is for the development of a foreshore management plan for the Geographe Bay coastline within the Shire of Busselton.

The project tasks are as follows:

- Review existing foreshore management plans and policies for the area, including policies and aerial photographs for integration.
- Undertake liaison and site inspections with Shire and community group representatives.
- Examine the existing and future human usage demands and patterns, identifying in particular issues such as access requirements, public safety, public and private boat launching facilities, commercial fishing and allow for increases in usage.
- Identify environmental issues associated with the foreshore with specific reference to the following:
  - dune erosion (natural, human and animal);
  - storm damage;
  - fire management;
  - protection and rehabilitation of indigenous vegetation;
  - rehabilitation and identification of important fauna habitats and breeding sites;
  - litter.
- Make prioritised recommendations regarding the future management of the foreshore by sector analysis.
- Consult with the general public and community groups, including indigenous peoples, on roles, needs and requirements on the foreshore, recommend a reference forum for consultation on these issues.

It will be the responsibility of the consultant to identify a suitable methodology to complete the tasks of the Brief.

Budget

The total budget available for the consultancy is $ xxx.

Deliverables

Two unbound copies of the Draft Management Plan and the subsequent Final Management Plan are required. The Management Plan should address each of the project tasks and include maps, plans and figures where appropriate to illustrate recommendations.

Selection criteria

Submissions should address the following selection criteria:

Qualifications	10%
Experience	25%
Price	15%
Commitment to completion	15%
Local knowledge	25%
Track record	10%

Expressions of interest

Any submission not received by the closing on Wednesday, September 22 19xx shall not be considered by Council.

Applicants must supply the information required in the General Conditions, Standard Conditions for Contractors and Sub-Contractors, Specific Conditions and the fully completed Expression of Interest Submission Form.

All submissions must be submitted on the Official Expression of Interest Submission Form. Council will accept additional supporting information supplied by the Applicant, provided that such information is attached to the signed Expression of Interest Submission Form.

Particulars must be stated in plain, legible, figures without erasure. Incomplete or unclear submissions may be rejected. Applicants must clearly print in block letters their name and address in the space provided.

Every submission must be enclosed in a sealed envelope marked on the outside:

Expression of Interest – Geographe Bay Foreshore Management Plan and be addressed to:

Chief Executive Officer

Shire of Busselton

P.O. Box 84

BUSSELTON Western Australia 6280

Contract period

The successful Applicant has four (4) months to complete the Management Plan from the date of issue of the Purchase Order.

Submission of prices, hours of work and methodology

The price on the Expression of Interest Submission Form shall be the maximum price payable by the Shire of Busselton to the successful Applicant. The price shall be all-inclusive (ie. including the cost of any equipment provision or serving charges, travel time, travelling costs, accommodation and meals, consumables, materials for the Final Report, etc.). It shall also reflect all rebates and accounts, and apply for the period of the Contract.

It will be the responsibility of the consultant to identify a suitable methodology to complete the tasks of the Brief.

Submissions should identify a suggested level of public consultation with the methodology supplied.

3.11 EXAMPLES OF COASTAL PLANS

Regional strategies and plans

- *Central Coast Regional Strategy: a strategy to guide land use in the next decade* (1996) Ministry for Planning; Central Coast Planning and Co-ordinating Committee, WAPC
- *Gascoyne Coast Regional Strategy* (1996) WAPC, March
- *Kununurra-Wyndham Area Development Strategy* (2000) WAPC
- *South Coast Regional Management Plan* (1992 – 2002) Department of Conservation and Land Management
- *Southern Shores 2001-2021: For Public Comment* (2001) South Coast Management Group

Local strategies and plans

- *Carnamah Coastal Strategy: A Plan for Land Use and Management in the Shire of Carnamah* (2000) Shire of Carnamah, February
- *Coastal Park Management Plan, Broome Western Australia* (1998) Griffiths, S., Shire of Broome, November
- *Coastal Plan Incorporating Structure Plan and Design Guidelines for Coastal Development and Management for the Shire of Dandaragan* (1999) January
- *Coastal Planning Study for the Town of Cambridge* (1998) Coastwise, Town of Cambridge, September
- *Exmouth Coastal Strategy: draft* (1992) DPUD
- *Exmouth-Learmonth (North West Cape) Structure Plan* (1998) WAPC, December
- *Esperance District Coastal Management Plan, draft* (1983) Department of Conservation and Environment, Report 11, Chape, S., Sansom, G., March
- *Foreshore Management Plan for Leeman and Green Head and an assessment of the coastal management works in the coastal reserve between the two townsites for the Shire of Coorow* (2000) Coastwise Coastal Planning and Management, O'Brien, R., Shire of Coorow, March
- *Foreshore Management Plan for Lot 614 – Yanchep* (1997) O'Brien Planning Consultants,
- Peet and Company Pty Ltd, March
- *Geographe Catchment Management Strategy (2000)* Geocatch.
- *Gnoorea Coastal Management Plan: For Public Comment* (1998) Coastwise, Shire of Roebourne September
- *Hopetoun Foreshore Management Plan: For Public Comment* (1992) Craig, March
- *Integrated Coastal Management Strategy for the City of Cockburn* (1999) Ecoscape Australia Pty Ltd, Coastwise, City of Cockburn, September
- *Irwin Coastal Plan: Environmental Assessment and Management Recommendations* (1999) P. Hammond and Assoc., Shire of Irwin, February
- *Jerramungup Coastal Management Plan* (1995) Shire of Jerramungup, June
- *Management Plan Port and Leighton Beaches* (1999) February
- *Mandurah Coastal Strategy* (1996) City of Mandurah, Peel Development Commission, WAPC
- *Port Hedland Coastal Plan* (1992)
- *Shire of Irwin Coastal Development Strategy* (2000) Landvision, Shire of Irwin, June
- *West Cape Howe National Park Management Plan* (1995 – 2005) Herford, I. Lloyd, M. Hammond, R. Department of Conservation and Land Management, August

Site plans

- *Cheyne Bay Management Plan: Cape Riche to Pallinup River, reserves 31240,14986 and 14987* (1999) Marlok Consulting, Wellstead Land Conservation District Committee; Department of Conservation and Land Management, May
- *Cosy Corner Management Plan* (2000), Price, M., Giles, D., and Davies, J., City of Albany, January
- *Denmark Foreshore, Wilson Inlet Management Plan* (1996) May
- *Foreshore Management Plan for the South Bay Subdivision, Green Head, Shire of Coorow* (1999) Coastwise Coastal Planning and Management, O'Brien, R., DOLA, July
- *Forrest Beach and Wonnerup Dunes Access Study*
- *Jurabi and Bundegi Coastal Parks and Murion Islands: Draft Management Plan* 1998 Department of Conservation and Land Management; Shire of Exmouth; NPNCA
- *Ledge Point Coastal Rehabilitation Plan* (1996), December
- *Management Plan for the Cottesloe Reef System Proposed Fish Habitat Protection Area* (2000) August
- *Nanarup Beach Management Plan* (1999), Price, M., Giles, D., and Davies, J., City of Albany, December
- *Prawn Rock Channel, Denmark – Concept Plan* (1997) April
- *Scarborough Environs Area Strategy* (2000), March
- *South Cottesloe Foreshore Management Plan*
- *Shire of Ravensthorpe Coastal Site Development Plans* (1996) Craig, Gillian, Shire of Ravensthorpe, December
- *Starvation Boat Harbour Coastal Management Plan* (1984) Van Stevenick, Burkin, Department of Conservation and Environment Bulletin 151, February
- *Warnbro Dunes Foreshore Management Plan*
- *Wedge and Grey Masterplan* (2000) Department of Conservation and Land Management; Wedge Island Protection Association Inc / Grey Community and Conservation Association Inc
- *Woolstores to Frenchman Bay Foreshore Management Plan* (1999)

4. INDIGENOUS INVOLVEMENT

CONTENTS

FIGURES

4.1 OVERVIEW

Indigenous involvement in coastal management is vital if we are to safeguard the coast and our cultural heritage, and to protect our coastal way of life for the benefit of future generations.

It requires collaboration and partnerships between government, Traditional Owners and other stakeholders, and a sustained effort to involve the Indigenous community in planning and management, and also the day-to-day care of the coast.

Indigenous people are Australians who identify as belonging to Aboriginal and Torres Strait Islander groups and who are recognised by their communities as belonging to those groups. A *Traditional Owner* is an Indigenous person with cultural connections to a specific area or tract of land or waters (regardless of historical or current land tenure), arising from Indigenous law and customs observed by the relevant land-owning group.

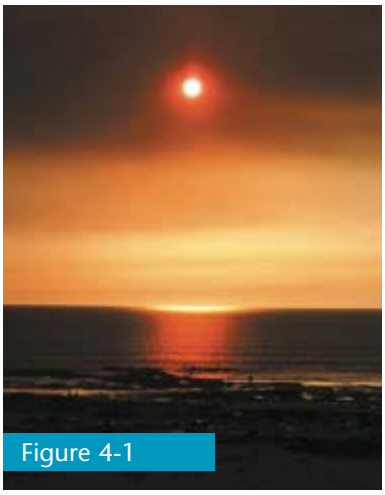


Figure 4-1

Sunset over Cable Beach, Broome. [Photo: Martin Heller]

This section of the manual discusses the strong interrelationship between the natural and cultural environment, and the social, economic and physical well-being of Indigenous people, and why it is vital that efforts be made to implement environmentally sustainable coastal planning and management strategies that *"recognize, accommodate, promote and strengthen the role of indigenous people and their communities."* (Agenda 21, 1992).

This section includes information on customary law and the responsibilities and rights that flow from the law. It gives a basic introduction to song cycles, provides an overview of how Indigenous people view and value the coast, and establishes the need to consult, negotiate and make agreements with Indigenous interests, for both legal and ethical reasons, and identifies the value and benefits in doing so. It also sets out what a community group or land manager may expect in response, as well as an accepted procedure for seeking to ensure cultural heritage sites on the coast are avoided in order to protect them.

Recommendations are made for a process of participation that enables Indigenous people to become actively and genuinely involved in defining their issues of concern, to make decisions that affect their lives and to formulate and implement plans and strategies to manage the coast.

The information in this section is based on generalisations that apply commonly throughout Western Australia. The diversity of Indigenous people across the State and the different cultural representations will need to be considered for a particular area, as these cannot be represented fully in this manual.

4.2 INDIGENOUS CUSTOMARY LAW, CULTURAL RESPONSIBILITY AND RIGHTS

Indigenous people have continuing cultural responsibilities and/or ownership of the coast and what happens on it through customary law – a law that is 'written' in the country.

Country refers to the cultural or spiritual place of origin of an Indigenous person. When Indigenous people talk of 'my country' they are referring to their clan or tribal area. Their membership of that clan country was given at birth and remains even if they move away and live on other 'country'.

To maintain cultural integrity there are certain practices and considerations that are to be followed according to this customary law. One of these is 'caring for country'.

4.2.1 Caring for country

'Caring for country' means ensuring people are doing the right things on 'country' (land and waters), and ensuring animals and plants have the right place to live. It is more than habitat protection, maintaining

biodiversity and caring for the coast in 'white fella' ways like dune protection and building beach access walks. It has strong spiritual links based on the cycle of life and responsibility to all living things and the natural environment.

Our law is alive, in the past, present and future because the earth is alive, so our stories are being enacted every day everywhere in everything that is form, shape and alive. Rocks, fish, birds, plants, waters, insects, crocodiles they all belong to the Earth and all give us stories." Wunambal Gaambera Aboriginal Corporation (2001).

4.2.2 Attachment to country

Each Aboriginal person is born with a strong and deeply-rooted spirit that comes from 'country'. It is best described in non-Indigenous terms as an internalised, overwhelmingly powerful sense of attachment to country, an intuition and gut feeling, an intrinsically personal connection to country and to ancestors. If there is damage to a person's country then there is damage to a person's spirit.

"We think of the environment as the physical entity – we know what happens when we pollute rivers and oceans. What people don't understand is how the people from the country are affected, how their liyan, their spirit, is affected. To some extent a measure of the health of the country is the health of the people. If the spirit of the people is not at its maximum level you can be sure the health of the country is not at its maximum level. This is a very simple co-relationship, one that governments and agencies need to bear in mind when they go about planning and managing country." Pat Dodson in Our Place Our Future. Kimberley Land Council (1998).

Custodians for country have the responsibility to ensure their law is not trespassed upon in ignorance and that the country is cared for in the proper way.

In some areas culture is obvious and strong. It would be wrong to assume that in areas where culture is not evident, or where the area has been developed, or Indigenous people live much the same as non-indigenous people, that culture does not exist, or that Indigenous people are just part of the general community and need not be considered outside of that.

A surface understanding of song cycles

Unlike western concepts of boundaries connected with fences or lines on a map, song cycles are much more than a certain length or width of land. They are the foundation of Indigenous people's connection to coastal and inland areas. There are salt-water and fresh-water people who are responsible for continuing their connection to their culture through song cycles. A deep understanding of belonging and knowing one's place results from Indigenous people living in their country and knowing their song cycles, law and culture, all of which are interconnected.

Song cycles are maintained and renewed though traditional ceremony in the law. This includes sharing modern stories that teach younger generations about history or the Dreamtime related to people, animals, plants, and all other living beings on or in the land, sea and galaxy.

Here is a story for the Dampier Peninsula that helps us to understand song cycles.

> *In Bugarregarre, (the Dreamtime) the first creative Naji (spirit beings) came to life. Simultaneously their movements created the burru (land) and three song cycles spread out across Australia in coastal and inland areas. The Naji beings appeared in a co-creation period where all living things came to life. The Naji's actions saw laws made to ensure that all life forms including country would be respected. The laws and Bugarregarre stories detailing song cycles, and intimate knowledge of country has been passed down to us since the beginning of time. We are the direct descendants of the Naji giving us culture and the responsibility to maintain and protect life.*

Song cycles take time to understand. Traditional custodians may choose to relate what is known as 'public' information; however, deeper knowledge of song cycles rests with those involved in traditional law and that information is not known as 'public'.

Song cycle information and story from Goolarabooloo.

4.3 HOW INDIGENOUS PEOPLE VIEW AND USE THE COAST

Indigenous people's relationship to the coast has some critical differences from that of the non-Indigenous community. This includes the definition, care and responsibility of coast, its resources and usage, the concept of 'ownership' and the values associated with land and sea. However, as in the wider community, there are differing views on managing the coast and a diversity of ways in which Indigenous people relate to the coastal areas of Western Australia.

4.3.1 What is coast?

Coast is part of 'country,' an all-encompassing term used by Indigenous people to describe all the areas that people traditionally used or occupied. This includes ocean, reefs, intertidal areas, land (on and below ground) and inland waters. Intertidal zones, surveyed boundaries, reserve areas, fences and property lines do not stop or start the cultural connections.

4.3.2 Use of the coast and resources

Prior to European settlement Aboriginal use of the coast embraced all aspects of social, cultural, spiritual and economic life. The resources of coastal land, sea, reef and creeks provided not only subsistence foods such as fish, turtle, dugong, shellfish, fruit, seeds, animals, roots and birds, but also materials for shelter, clothing, tools and weapons, as well as objects for ceremonial use. Smyth confirmed from his 1998 study of Northern Australia, *"that the current utilisation of the coastal zone by Aboriginal people involves some or all of the above pre-contact uses, depending on local history, tenure and legislation."* Smyth 1998 in Shire of Broome (1999).

4.3.3 Economic values and impacts

Many Indigenous people believe that in the wider society the coast is often valued as a commodity and economic growth is the primary goal, while most Indigenous people place a greater importance on culture. Indigenous traditions and cultural values should be recognised and accommodated in a way that contributes to strengthening the community and its values rather than undermining them.

Indigenous people in many parts of Western Australia continue to derive considerable economic benefit from subsistence hunting, fishing and gathering around the coast. Coastal resources provide a significant proportion of food (and nutritional requirements), and this forms an invisible non-cash part of the economy. The economic value becomes even more important when the low incomes on which the majority of Indigenous families have to survive is considered.

Increasing human impacts on the coast, declining food stocks, coastal development limiting access to traditional areas, an increasing population and their use of the coast for recreational and commercial uses, often result in Indigenous people having to travel further to get food.

4.3.4 Ownership

Figure 4-2

Minyirr Park meeting place. [Photo: Rubibi Aboriginal Land Heritage and Development Group]

Indigenous peoples are a diverse group of language and skin groups, each responsible for areas of country. Certain salt-water people may have 'ownership' of areas of coast with other groups having cultural rights and obligations for the same area, such as the right of access and the use of coastal resources.

For Indigenous people, traditional ownership comes through their culture from ancestors. Traditional ownership does not come from the exchange of money and title. It is a cultural inheritance with related responsibilities.

4.3.5 Natural disasters versus natural processes

Winds, storm surges, cyclones and tidal inundation are all natural processes and Indigenous people accept them as part of the cycle of life. Therefore many do not accept that there is a need to 'protect' the coastline, for example sand dunes, from these natural processes.

Indigenous people are often worried or uneasy when people build too close to the sea or dunes, as many believe that if you destroy or neglect country, it will result in some form of harm to people or places. Any disruption to the coastal area could destroy the integrity of the song cycle and, consequently, they would foresee the resultant loss of property or life to be caused by this disrespect for the environment.

Figure 4-3

Cossack Beach in the Pilbara exhibiting tidal inundation. [Photo: Rubibi Aboriginal Land Heritage and Development Group]

By and large Indigenous people do not make any distinction between the natural and cultural environment; therefore, the management of natural resources is inseparable from the maintenance of culture.

4.4 THE VALUE AND BENEFITS OF ACTIVE INVOLVEMENT BY INDIGENOUS PEOPLE

The involvement of Indigenous people in coastal planning and management projects has important practical consequences. It may influence the definition of what the problem is, the ways in which it may be resolved and who is responsible for taking action. Active involvement of Indigenous people and communities is preferable to consultation alone. Having Indigenous people actively involved in coastal projects can help to:

- reflect and take account of community needs and values and provide a foundation for the community's socio-economic development and positively affect the well-being of people in the community
- develop cultural identity and strengthen communities
- identify shared values and common ground
- foster the establishment of partnerships and establish a joint vision based on recognition of ownership and co-ownership
- minimise the potential for protracted negotiation that could occur if Indigenous people have not been properly consulted and involved in decisions
- incorporate Indigenous ecological knowledge in coastal planning and works and assist the development of quality information as a base for decision making including both traditional and scientific knowledge of species
- educate people about Indigenous cultural issues and utilise tourism as an opportunity for such learning
- recognise and strengthen Indigenous decision making over marine and coastal resources, for example in the review of license procedures, thus providing the means for Indigenous people to acquire equity in marine and coastal industries such as fishing
- understand the coastal landscape from a different perspective, providing an opportunity to learn stories that are not written down, but written on the land and in nature. *"They are there for everyone to see – not just read about."* David Mowaljarlai in Yorro Yorro.
- demonstrate reconciliation in action and help to break the distrust and alienation felt by some Indigenous people

- address conservation and environmental issues more effectively by developing protocols concerning access to and use of coastal country by tourist and commercial operators, as well as identifying appropriate community access to the coast
- increase the likelihood of gaining resources or attracting support, as more people know of the coastal work
- provide an increased recognition of Indigenous people, culture and traditions and incorporate these experiences and factors into the development and management of the coastal areas of Western Australia.

4.5 THE NEED FOR CONSULTATION AND NEGOTIATION WITH INDIGENOUS GROUPS

There are both legal and ethical reasons to consult and negotiate with Indigenous people prior to planning and implementing coastal works.

Over time, factors of an economic, social and historical nature have tended to limit the ability of Indigenous people and their communities to participate fully in coastal planning and management on their lands. As a result, many Indigenous people have powerful images and memories of past paternalistic attitudes, tokenistic recognition of their rights and exploitation of their country, cultural knowledge and intellectual property.

Indigenous involvement in coastal management involves much more than getting Indigenous people to identify where sites are; share their traditional knowledge for use in the management plans of others; act as a cultural heritage management service; or to provide a valuable cultural tourism product (Sinnerman, 1998). It is therefore important to foster the involvement of Indigenous people in all aspects of coastal planning and management.

While consultation infers people and communities will be referred to for information and asked their opinions, the process for meaningful involvement of Indigenous people in planning must go one step further to *actively engage* people in the decision making process. To do this we must first understand, acknowledge and show respect for Indigenous people's connection to 'country'.

The active involvement of Indigenous people who have connections to the coast is vital as cultural uses in many areas of Western Australia sit side by side with other uses such as tourism, sand mining, pastoral industries, commercial fishing, pearling, oil and gas exploration, ports, shipping activities and conservation.

Prior to conducting coastal projects, proponents need to be clear about the legal issues and responsibilities to consult and negotiate with the relevant parties. For Indigenous people, the Mabo and Wik decisions have established native title as a land title with legal rights, and Indigenous people, like all people who have title to land (ownership), or who hold responsiblities for land (management or custodianship), expect to be consulted about any impact that would affect their land interests.

Figure 4-4

Meeting between the Department for Planning and Infrastructure, Kimberly Land Council and Rubibi members. [Photo: Coastwest/Coastcare]

4.6 IDENTIFYING THE RELEVANT INDIGENOUS PEOPLE TO CONSULT

This manual makes reference to consulting with relevant Indigenous people and Traditional Owners in your area. Generally, this means approaching your local native title representative body (NTRB). It is important to contact the Aboriginal Lands Trust (ALT) for proposals on coastal land held by ALT. It is also worthwhile to contact your local Department of Indigenous Affairs (DIA) and Australian and Torres Strait Islander Commission (ATSIC) offices for advice, and also as a courtesy if you are considering a project in the area.

4.6.1 What is a native title representative body?

A *native title representative body* is a regional organisation determined through a formal process by the Commonwealth Minister for Aboriginal and Torres Strait Islander Affairs. NTRB's are funded by the ATSIC to represent Indigenous Australians on native title issues within a particular area. They represent and assist native title claimants to make applications for the determination of native title and assist them in negotiations and proceedings. NTRB's also have a role to play in assisting non-indigenous people in identifying the correct traditional owners for an area.

These representative bodies are responsible for servicing the needs of their clients in an effective and equitable manner and to act in their best interests. Those clients are the people who hold or may hold native title in their area.

Representative bodies in WA are:

- Kimberley Land Council
- Pilbara Native Title Service
- Yamatji Land and Sea Council (Geraldton)
- South West Aboriginal Land and Sea Council
- Aboriginal Legal Service
- Goldfields Land and Sea Council

Contacts for these bodies have been included in section 11: *Useful Contacts.*

Figure 4-5

Rubibi reconciliation walk. [Photo: Rubibi Aboriginal Land Heritage and Development Group]

There are other Indigenous organisations that operate in WA, including community councils, resource agencies and incorporated bodies. These operate for a range of purposes; for example, running an Aboriginal community, liaison with government agencies, providing administration and financial management, and organising housing and essential services. These organisations, however, may not have a legal interest in land or sea, nor control over its use or development, and may not have the mandate to make decisions without reference to the vesting body or NTRB unless they have a lease or licence for the coastal area.

Matters of land or sea use or development of interest to Indigenous people, should in the first instance be referred to the land managers, namely local government, the ALT, the Department of Conservation and Land Management, the Department of Land Administration (DOLA), or the vesting body, and then be referred to the relevant Indigenous people and Traditional Owners through the Representative Body.

4.6.2 Legal responsibilities

Before planning coastal works, have regard for the legal situation that exists or may exist, as cultural heritage and native title rights and interests are protected by legislation. These include State and Commonwealth Heritage Acts and the *Native Title Act 1993* (Commonwealth).

Both the Heritage Acts and the Native Title Act are complex acts of parliament. Community groups should first consult with the land management agency, local government, Department of Indigenous Affairs, Aboriginal Lands Trust, local Native Title Representative Body and/or the National Native Title Tribunal before they consider projects, approvals, clearances or determinations under this legislation.

4.6.2.1 Native Title

In 1992, the High Court's Mabo decision recognised the traditional property rights of indigenous people to their country. These are known as native title rights and interests. Native title is the communal, group or individual rights in land and waters according to the traditional laws and customs of the Aboriginal or Torres Strait Islander people for a particular area. These rights may be rights of ownership, possession and use of traditional country. In some cases these native title rights and interests may sit side by side and co-exist with the rights of others such as pastoral leases.

Aboriginal or Torres Strait Islander people who hold native title may have the right to continue to practice certain of their laws and customs over land and waters so long as those activities are consistent with Australian law. This could include living, hunting, fishing, gathering, ceremonies, access rights, use and occupation and visiting to care for and protect important places. It often includes the right to be consulted about activities or decisions that could affect the exercise or enjoyment of native title rights and interests. In most instances, the native title rights and interests will exist along side other rights and interests determined by the Crown.

4.6.2.2 The Native Title Act 1993 (Commonwealth)

The Federal Government's response to the High Court's *Mabo* decision included the enactment of new legislation, the *Native Title Act 1993* (Commonwealth), to provide for the recognition and protection of native title and to provide ways for working with native title. The Act was amended in 1998 following the High Court decision in *Wik.*

Specifically, the *Native Title Act 1993* (Commonwealth) establishes a 'future act' regime. Broadly defined, future acts are activities or dealings in relation to land or waters after 1st January 1994, that affect native title rights and interests. If a dealing or activity will affect (extinguish, impair or in some way limit) the continued existence or enjoyment of native title, then there are certain procedures in the *Native Title Act 1993* (Commonwealth) that may need to be followed. Under the future act provisions, native title holders and registered native title claimants are entitled to certain procedural rights. That means they have a right:

- to be notified of the proposed future act
- to object to the act

or

- any other right that is available as provided for in the *Native Title Act 1993.*

The rights may include:

- the opportunity to comment
- the right to be consulted
- the right to negotiate

or

- the same rights as an ordinary freehold title holder.

Different procedural rights apply to different types of future acts. However, the complexity of these provisions in the *Native Title Act 1993* (Commonwealth) can be avoided by developing an Indigenous Land Use Agreement (ILUA) with the native title holders or the registered or unregistered native title claimants. Indeed, the provisions for ILUAs in the *Native Title Act 1993* (Commonwealth) take precedence over other procedures for dealing with future acts.

An ILUA is a voluntary agreement about the use and management of land and/or waters made between a native title group and other people, organisations or government agencies, including local government. An ILUA can be negotiated at any time. It is not necessary to have a determination by the Federal Court about the existence of native title. The courts are not involved in the ILUA process. Once an ILUA is finalised, the parties can apply to the National Native Title Tribunal to have it registered. When an ILUA is registered it is binding on all the parties.

For more information on the Native Title Act 1993 (Commonwealth), native title determinations and applications in your area, and information about ILUAs, contact the National Native Title Tribunal (see section 11: Useful Contacts). The website has fact sheets and information to explain native title in greater detail (www.nntt.gov.au). The Australian Local Government Association's website also contains useful information about native title processes, especially for local government (www.alga.asn.au).

4.6.2.3 Aboriginal Heritage Act 1972 (Western Australia)

The *Aboriginal Heritage Act 1972* was introduced to protect Aboriginal heritage in Western Australia. This includes all places and objects that are important to Aboriginal people due to connections to culture. Sites may include ceremonial or law grounds, burial sites, middens (camping areas), gathering sites, waterholes and soaks, engravings and rock art, hunting and fishing areas etc. Under the Act it is an offence for anyone to excavate, destroy, conceal or in any way alter an Aboriginal site, or any object without the permission of the Minister for Indigenous Affairs. Such permission is determined under section 18 of the *Aboriginal Heritage Act* and is commonly known as a section 18 application or clearance.

This State Act provides for Aboriginal heritage sites to be listed on the Register of Aboriginal Sites, administered by the Department of Indigenous Affairs (DIA). However, many sites are not registered owing to the complexities of Aboriginal heritage, the nature of archaeology, and changing community expectations.

Some areas of cultural significance may not come to light until the process is under way and many sites may not be widely known or in fact registered. This could be for a number of reasons, such as:

- Vegetation or other features may obscure archaeological material.
- Archaeological deposits or burials may be present but under the land surface.

or

- The Aboriginal community/individuals may identify sites, places or features of ethnographic significance or express concerns about potential environmental impacts.

IMPORTANT All Aboriginal sites whether registered or not, are protected by Federal and State laws.

With the diverse nature of Aboriginal sites and interests in country (land and sea), it is difficult to identify specific ways to recognise a site or to set criteria or procedures to follow, that can be applied in every circumstance that may be encountered. Therefore, always assume that you need to find out.

If there is reason to suspect the presence of an unreported site, this should be reported to the DIA or to the police, and works ceased immediately. It is generally preferable to treat finds of skeletal material as Aboriginal burials. This will ensure that the material is dealt with appropriately and that, if it proves to be an Aboriginal burial, community sensitivities have been respected from the start.

For further information on Aboriginal heritage sites and surveys conducted in your area, contact the DIA. They have offices throughout regional WA.

DIA's website, www.dia.wa.gov.au is a great resource with lots of information and frequently asked questions (FAQs) for people interested in Aboriginal heritage matters, including those matters covered by other legislation. It includes an Aboriginal Heritage Procedures Manual containing information for developers and Aboriginal people to assist with development of land where Aboriginal sites may exist.

4.6.2.4 Aboriginal and Torres Strait Islander Heritage Protection Act 1984 (Commonwealth)

The *Commonwealth Aboriginal and Torres Strait Islander Heritage Protection Act 1984,* provides a means for Aboriginal and Torres Strait Islander people to gain protection for areas and objects of significance in accordance with their tradition.

Under the Act, the Minister for Aboriginal and Torres Strait Islander Affairs can make a declaration protecting significant objects or areas anywhere within Australia or Australian waters. The Act also encourages heritage protection through mediated negotiation and agreement between land users, developers and Indigenous people.

This legislation was enacted to provide an avenue of last resort – that is, to allow the Commonwealth Minister to protect Indigenous heritage where State and Territory heritage laws or processes had failed.

Be aware that no matter how well the known procedures are followed, Aboriginal heritage issues might still arise during the course of coastal planning and works.

As part of coastal planning and management, land managers, community groups, local government and other key bodies can maximise the potential for Indigenous support and involvement in a project and minimise the risk of inappropriate actions by adopting a precautionary approach in both heritage and native title matters.

4.7 THE CONSULTATION PROCESS

The key to making community involvement work is to involve Indigenous people early in consultation, to allow for cultural differences and to build trust and true partnerships. The message is to respect the rights of Indigenous Australians and treat those with land and sea interests as you would wish to be treated.

4.7.1 How to approach the consultation process

Once you have identified the relevant people to speak with about your coastal project, consider the following.

- Find out what the Indigenous community's or group's protocols are for consultation, before going into a community or attending a meeting. Each has its protocols that should be followed.
- Show leadership by implementing culturally appropriate consultation methods in all phases of planning and development of the coast. Methods you may use for other stakeholders, such as writing a letter or inviting one representative along to a meeting, may not be appropriate.
- Request a meeting or ask to address Indigenous people at their meetings. Be clear about what is wanted or needed.
- Ask permission to go onto the coast and let Indigenous people know well ahead of time what it is you need, setting down clearly what you plan to do and what you would like the Indigenous people to do; for example, give permission for revegetation work, visit the site with you, make comment on a proposal.
- Invite participation by Indigenous people, and where possible take them to the coastal site you are discussing.
- Look for common ground. For example both parties may want to protect the turtle rookeries, all stakeholders may acknowledge the need for appropriate beach access, both commercial and recreational fishers agree with Indigenous people on the priority to maintain fish numbers etc.
- Recognise the tensions between cultural protection and the speed of development, as the differing needs can create frustration and misunderstanding. Address the issue with key stakeholders early in the process.
- Consider making an agreement about the use and management of coastal land or waters between the native title claimants or title holders groups and other key stakeholders.

4.7.2 What response could a community group or local land manager expect?

When seeking the involvement of Indigenous people in coastal planning and management, the same range of responses can be expected as those from any group of people in the community – from enthusiasm and interest to disinterest, or anger if people feel their rights or interests are threatened.

Indigenous people have a history and experience of being disenfranchised and taken away from their country (and sometimes people) thus denying them the right to practise and understand their obligations and rights from a cultural perspective. Too often they have been alienated from decisions affecting them and their country. In some people this has built a sense of worthlessness, shame, mistrust and apathy.

Though people were often resettled away from their coastal country, Indigenous people do not relinquish their attachment to their traditional country. However an offer to be actively involved in coastal planning and management will not necessarily be taken up. People have other priorities to address in their lives. Therefore do not be disheartened if Indigenous involvement is not forthcoming. This does not mean you do not have to try to consult.

It is important to set out for Indigenous people, your own obligations, such as timeframes, the need to publicly advertise a proposal, to report to a committee, to liaise with the land managers (e.g. ALT or Shire) or to request permission to work on unallocated (vacant) Crown land through DOLA. Make it known if Ministerial or other levels of approval are required. Remember to keep Indigenous people 'in the loop' and continue to seek their advice, support and involvement.

4.7.3 Extended decision making

Decision making and discussion in Indigenous societies involves maximum participation and representation because responsibilities and authority for 'country' go beyond the individual and family unit. It will also involve on-site visits with relevant Aboriginal interests.

Be mindful of the tensions at play between individual rights and family and communal obligations, and between the 'objective' application of rules of law as against the greater weight given to tradition and clan in decisions. Remember that community representatives may also have limits on their negotiating power.

Allow flexibility in your work schedule to ensure adequate time is given to Indigenous groups to allow them to consult widely and spend time in discussion, understanding and reaching agreement.

4.7.4 Request for confidentiality, privacy and respect for intellectual and cultural property

Confidentiality, privacy and respect are major issues with Indigenous communities. There may be a reluctance to participate in projects or to give information, because, in the past, many Indigenous people gave their time, resources and knowledge only to discover later that their information had been used to identify and exploit country or resources, or to develop traditional lands or desecrate sites.

Indigenous people and communities have cultural and intellectual property rights for all their knowledge. This includes sites, languages, stories, kinship and other social rules, ceremonies and arts, as well as the values, laws and protocols for managing them. The owners of information or material must be informed about what the full-intended use is, and their permission given for its use, prior to it being used or stored. Media releases, comments or the mention of names and places should never be made without the prior agreement of the Indigenous people/community concerned.

4.8 HOW TO MAXIMISE THE OPPORTUNITIES FOR PARTICIPATION

Ensure from the start that there is community ownership of the coastal planning or management process to be undertaken.

Invite representatives of local Indigenous groups to participate in meetings or committees on relevant topics such as fisheries, boating use, coastal development etc. rather than only issuing invitations to attend when there is a specific project. Keep in mind that for many Indigenous people formal meetings are not culturally appropriate. People often feel more comfortable in an informal or familiar setting.

- Take people out to the coast and sit quietly and listen. This will assist the consultation process and give more people an opportunity to be involved, heard and understood.
- Make decisions by consensus. It may take longer but the decision is more acceptable to everyone. If, instead, a majority-voting situation is used, then those who 'own' the country and have responsibility for its care normally get outvoted! Ensure Traditional Owners get the final say and have the casting vote.

Create opportunities for a variety of Indigenous involvement in coastal work, for example:

- Encourage involvement in a range of tasks and responsibilities like management, supervision, on-ground work, being spokesperson, writing newsletters, site planning, guided walks or the provision of interpretative materials etc.
- Set some short-term goals with measurable objectives so there is a sense of achievement for participants early in the project.
- Promote Indigenous employment and training opportunities in project development, management and land care, for example as coastal rangers or guides.
- Display respect for Indigenous rights and roles.

When employing people in coastal work, give special consideration to the Traditional Owners. Have an Indigenous representative on the selection panel for new employees or when appointing consultants. The selection of people to plan, manage or work on areas under native title should be carried out by the Traditional Owners, or be suitable to them.

Figure 4-6

Dune stabilisation at Minyirr Park. [Photo: Rubibi Aboriginal Land Heritage and Development Group]

5. PROJECT EVALUATION

CONTENTS

5.1 EVALUATION

Evaluation involves the systematic collection of information about the activities, characteristic and outcomes of an activity or action, in order to determine its worth or merit (Dart et al, 1998). It is a major part of learning, and can provide a wealth of useful information on the outcomes of a project or action, and the dynamics of those who undertook the work.

Through the identification of the highlights and lowlights of the project, evaluation draws conclusions which can inform future decision making, and assist to define future projects and policies (Patton, 1997).

Evaluation of coastal management projects and actions are undertaken for a number of reasons:

- to ***contribute information,*** for example for the review of a coastal management strategy
- to be ***accountable*** to those who are funding the project
- as a ***debrief*** to the group on the completion of a project
- to ***reflect*** on how you're developing as a group or organisation, and whether you need to improve the way things are being done
- to ***review and adjust*** the management methods and techniques used in an area
- to ***develop the skills and understanding*** of people involved in a project by enabling them to reflect on, and learn from, their experiences
- to provide information for planning ***future projects***
- to determine the ***worth*** of a coastal management project
- to ***justify and promote*** a management action to the wider community
- to ***create a historical record*** of management success over time
- to ***review management methods and techniques,*** and how effective they were
- to see if the work is ***contributing to the management objectives*** for an area
- to determine whether you have ***met project objectives.***

It is important to be aware of the reasons for undertaking an evaluation before commencing, as this will define how the evaluation process should be designed, and what outcomes are expected as a result.

5.2 TIMING

Evaluation can take place at any time in a project. However, the most appropriate timing will be governed by the nature of the project, and the reason for carrying out the evaluation. It will be most effective when it is built in as a fundamental part of your overall project, and should be considered while the project is being designed.

You may decide that you will:

- carry out an initial baseline exercise against which to compare progress at the end of the project
- refine the project on an ongoing basis; therefore, evaluation will be part of your regular project activities

OR

- evaluate the project at agreed milestones, for example on a tri-monthly basis.

Apart from required reporting on the project, the timing and intensity of a project's evaluation is up to project participants. Many coastal management actions will benefit from being evaluated over a longer period of time, such as one to five years after the project has been completed. This can allow for the impacts of management action on aspects such as dune stability and vegetation health to be evident.

5.3 UNDERTAKING EVALUATION

There is no one way to carry out an evaluation, with strengths and weaknesses apparent in most approaches.

A suitable approach should be developed in consultation with stakeholders such as the community, local government, relevant coastal management groups, State government or the funding body. It is important to ensure all relevant parties have an understanding of the evaluation process, and its anticipated outcomes.

Regardless of the method or approach, steps involved with any evaluation should include the following:

1. Design and plan the evaluation

- Clarify the specific purpose or intended outcomes of the evaluation. Why are you doing it? Will the evaluation be in the form of a report or a series of stories?
- Determine the questions you want to answer.
- Identify stakeholders, such as the community, local government, coastal management groups, State government or funding body, and their requirements. They may provide you with important guidance, which could make the evaluation more relevant.
- Identify possible sources of data.
- Identify potential methods, approaches and techniques.
- Agree on the evaluation purpose and procedures including timeframes and indicators.
- Prepare any materials required, such as questionnaires.

2. Gather information

- This may be an ongoing requirement or staged at key points during the project.

3. Analyse the information

- This may involve preparing a report. Check that your conclusions respond to the outcomes which the evaluation was originally seeking.

4. Use the conclusions

- Once you have evaluated the worth or merit of your project tell others about what you have learned and achieved so they too can benefit from your experience. This can empower others to undertake similar projects and make their journey easier and more enjoyable.

5.4 EVALUATION METHODS

Once you have worked out the questions you would like the evaluation to answer, you need to consider what methods to use to collect relevant information or data. The table below provides a list of some available methods. Advice on the limitations of each method is included as well as some additional references. It is intended to inspire some ideas towards how to evaluate a project. You should seek further advice and read additional references before undertaking your project evaluation.

5.4.1 Asking people

Structured interviews

Structured interviews require that all interviewees be asked the same questions, in the same order. Structured interviews can be conducted in person, and are also often used in surveys and opinion polls.

Interview questions must be selected carefully as there is no room to change the questions once the process has commenced. The way questions are constructed can also introduce bias into responses, and expert advice should be sought if you wish to undertake a conclusive interview.

Questions are of two basic types: closed and open. Closed questions limit the respondent to a yes/no answer, or to indicating a rating or ranking on a scale presented to them. Open questions, on the other hand, invite the respondent to provide an opinion. Questionnaires may contain both types of question.

Open question example: *Through your involvement with the group and project how has your understanding of coastal plants increased?*

Closed question example: *Through your involvement with the group and project has your understanding of coastal plants increased:*

A: significantly

B: slightly

C: not at all?

Useful further reading on structured interviews can be found in Foddy (1996) *Constructing Questions.*

Semi-structured interviews – In person

Semi-structured interviews are informally guided. Some questions are predetermined and new questions are developed from the discussion. Questions are mainly open, providing an opportunity for the respondent to provide an opinion.

Semi-structured interviews are used to understand an interviewee's experiences and impressions.

Open question example: *How effective do you believe the group has been in addressing the original objectives of the project?*

Patton (1990) *Qualitative methods in Evaluation and Research* provides further reading on semi-structured interviews.

Questionnaires

Questionnaires can be conducted in person, by telephone, or by mail. They are used to quickly obtain information from a wide variety of people.

Questionnaires are typically inexpensive, can be completed anonymously, and are easy to compare and analyse. It is possible to involve many people, although it may only appeal to a certain section of the community, and responses from certain sections of the community may be limited.

Useful further reading can be found in De Vaus, D. (1995) *Surveys in social research.*

Evaluation stories

Evaluation stories are based on collecting and reviewing stories of significant change associated with the activity or action being evaluated. Stories are collected from those most directly involved in the project.

Example question before the project: *What is the proposed project area like at the moment? How could the project area be improved?*

Example question after the project: *What was the project area like before the project was undertaken? How do you believe it has changed?*

Photographic history

A photographic record of the site can be used to evoke memories of what a place use to be like and what it is like today, and prompt comments and discussion useful for evaluation. Recording may be in the form of an evaluation story or benefit an interview situation.

5.4.2 Physical methods

Photographic records

Photographic records capture the appearance of a coastal site, and allow comparisons of before and after management actions and are useful for on-ground projects. The use of photographic records is useful as a method to monitor a site over time, and can be used as an evaluation tool combined with other methods.

An historical record of the area's changes from before the project through to project completion are visible.

In building photographic records, you should:

- Choose a point at the project site where photos can be taken to best represent the project, and take photos over time from the same point. Mark this spot to ensure repeatability.
- Photos should be taken at the same time of day, in the same season, at the same place with the same view, and with the same camera settings and film type, in order to support comparisons. This should ensure that the only change noticeable in a succession of photos is on-ground change.
- Take photos with distinguishable features included (large trees, buildings, car parks) to help compare photos.

Aerial photographs

Taken on a frequent (annual or bi-annual) basis, aerial photographs can be used in conjunction with other evaluation methods to record change at a site. An example of the useful application of aerial photography is to provide information on how dune damage has occurred and may differentiate between natural dune movement and physical damage.

Aerial photographs should also be considered as an important part of initial project planning.

Direct measurements

Direct measurement of an aspect of the site is considered objective and less prone to bias as it physically exists (or doesn't exist). Direct measurements can be combined with other evaluation information.

Examples of direct measurements are:

- plant survival rates
- increased number of local volunteers working in the area
- a reduced incidence of vandalism
- reduced presence of weeds
- evidence of trespassing in fenced areas
- reduction in the level of sand blow
- degree of community support of changes to management direction
- degree of implementation of management recommendations
- land manager support and involvement with project

Participant observation

Data is collected by listening, watching, and documenting what is seen and heard. Through asking questions, and by noting comments, behaviours and reactions, useful information is provided to the evaluation process. The participant observation method gathers accurate information about how a group and project operates in the field.

6. COMMON COASTAL MANAGEMENT PROBLEMS

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6.1 COMMON MANAGEMENT PROBLEMS

The coast is a source of livelihood and recreation for many Western Australians. In addition to its inherent ecological value, the coast is valued for a variety of commercial, social and cultural uses. This can create significant challenges for those responsible for managing the impacts of these diverse interests according to community expectations.

This section presents an overview of a number of common management problems encountered by land managers and communities as a result of human use, and suggests strategies to help address them.

These problems include:

- uncontrolled pedestrian movement
- uncontrolled vehicle use
- sandboarding
- unmanaged camping
- conflicts between recreational users
- visitor safety
- fire management.

A complete list of common coastal management problems is much longer. It includes, but is not limited to, issues such as commercial activities and tourism, impacts from adjacent areas, feral and domestic animals, commercial and recreational fishing, and recreational horse and camel riding.

Management problems are often complex, and it is unlikely that simple solutions are available to solve them. In most cases, a multifaceted approach will be needed. It is important that you understand the factors that underlie a management problem and how a particular activity, or use of a coastal area, affects the natural environment as well as other uses.

Addressing a management problem generally involves a combination of:

- **Planning** – to consider the physical and social aspects of the site and the wider area
- **On-ground works** – to provide facilities that reduce the impact of certain activities, and to rehabilitate areas that have been degraded, or pose a degradation threat to the area
- **Regulation and enforcement** – to enforce acceptable behaviour
- **Education and awareness raising programs** – to inform users and encourage an understanding and sense of responsibility about the impact of activities on the environment, and on other users.

6.2 UNCONTROLLED PEDESTRIAN MOVEMENT

Uncontrolled pedestrian movement along the coast can trample coastal vegetation, disturb the soil surface, and leave the area prone to erosion. This can result in soil loss and the formation of blowouts and mobile sand sheets in sandy areas. In heavy rainfall areas, erosion can be extensive due to loss of soil cover.

Managing the movement of pedestrians should take account of the type of coastal users attracted to the site, the type, intensity and patterns of use, and the area's sensitivity to pedestrian traffic.

In addition to physical damage and loss of biodiversity resulting from excessive tracking, there is a significant reduction in the aesthetic value of coastal landscapes in which coastal access is uncontrolled. Over time, extensive track networks can develop as users make new paths. This increases the size of the affected area and the risk of degradation.

For example, dunes that are adjacent to a popular surfing location may be used as a vantage point to assess wave conditions. Over time, these dunes will be damaged. Recognising this use pattern by surfers may result in installation of steps and a lookout platform to take the pressure off the degrading dune.

In another example, extensive track networks may often be created between the beach and the area where vehicles are parked, as pedestrians take the most convenient and direct route from their vehicle. Installing car parks and paths which are convenient to use and environmentally suitable can direct the flow of traffic, minimise impacts and reduce the risk of degradation.

Figure 6-1

Pedestrian access to beach, south-west of Jerdacuttup Lakes, pre 1996 was ad hoc and damaging vegetation. [Photo: G Craig/Shire of Ravensthorpe]

Figure 6-2

Informal tracks leading to Boiler Beach, Albany have resulted in the loss of stabilising vegetation and erosion of sand. [Photo: B Green]

Table 6-1 Uncontrolled pedestrian movement

Strategies	Implementation Considerations
PLANNING ***Site planning*** *can assist in determining the required level and form of pedestrian control, the links between site features, and the need to prohibit access to sensitive cultural and environmental areas.* ❖	Need to consider: • the relationship between activities occurring at the site and pedestrian movement • the coastal environment, and its ability to attract and accommodate various uses • the likelihood that users will voluntarily comply with directions.
ON-GROUND WORKS **Formalising pedestrian access ways** *into and around the site will direct and control movement. Works can include paths, erecting barriers or fencing, and directional signage.* *It is important to carefully site and design pedestrian access ways to encourage use, and avoid new paths being created.* *Once access has been formalised, it may be necessary to* **rehabilitate or stabilise areas that have already been degraded** *using techniques such as brushing, fencing and planting.* ✹ ❧ ✱	Need to consider: • suitable path alignment and design, including: visitor safety, links between key aspects of the site, ensuring a safe and comfortable surface, the need for steps or boardwalks, disabled access and avoiding path alignment in the direction of the prevailing wind • use of signage, fencing, bollards and/or trail markers to direct pedestrian movement • the most suitable rehabilitation techniques to use on degraded areas • the choice of materials to suit and complement the character of the area • the risk and potential impact of extreme climatic conditions, such as cyclones or heavy rainfall • ongoing maintenance costs of infrastructure.
REGULATION/ENFORCEMENT *Once on-ground works have been established, a regular* ***management presence*** *at the site can help ensure users stick to designated paths, and remain away from sensitive rehabilitating areas.*	Need to consider: • the resources available to provide a management presence • available options to address non-compliant use • the adequacy of fines for non-compliance.
EDUCATION AND AWARENESS *There are a number of education and awareness raising strategies which can help ensure success of on-ground works, encourage pedestrians to use designated paths and protect fragile or rehabilitating areas.* *Strategies include the use of* ***signage*** *to direct users to paths; the use of hazard warnings (e.g. 'beware of snakes') to deter users from leaving paths;* ***promotion of on-ground works*** *through media releases and articles, and* ***involving the local community*** *such as schools and Coastcare groups in the on-ground work and overall management of the area.* ✹	Need to consider: • the target audience for signage and education campaigns • your choice of communication styles, which may include signs, brochures, media, newsletters and displays • opportunities for community involvement in management of an area. **Refer to the following sections of the Manual:** ❖ 3 Coastal Management Planning ✹ 7 Stabilisation and Rehabilitation ✱ 8 Weeds and Weed Management ❧ 9 Revegetation

6.3 UNCONTROLLED VEHICLE USE

People use vehicles along the coast for transport, recreation (driving 4WD vehicles) or as part of other coastal activities such as fishing, camping, or boating.

Vehicles in dunes, and above the high-tide mark on the beach can cause significant damage, including loss of vegetation, soil disturbance, and the creation of blowouts and sand sheets. Other impacts include disturbance of fauna such as ground-nesting birds, especially Hooded Plovers, Little Terns and Fairy Terns which nest in dunes and on sandy beaches. Disturbance can also occur in turtle nesting areas. Soil compaction can occur, which can contribute to flooding, and there is the potential for dieback to be distributed across large areas. Vehicles on beaches also create safety issues and affect the recreation experience of other users.

Approaches to managing the impacts of coastal vehicle use differ significantly based on the reasons vehicles are accessing coastal areas. For example, if vehicles are transporting people to the coast, you could consider creating a car parking area off the beach and behind dunes to alleviate the problem. However, if vehicles are accessing the beach as a recreation activity in itself, it would not be appropriate to restrict access to the beach without considering of the implications of this, both on the site itself, and adjacent areas.

Both licensed and unlicensed (off-road) vehicles are used in coastal areas. Licensed vehicles, which are most common, are generally easier to manage. Local Government Rangers can identify the vehicle, and track the owner through the licence plate. Unlicensed Off-Road Vehicles (ORVs) are more difficult. They seldom carry unique identification, and many, such as motorbikes and 4WD bikes are very fast, making identification or apprehension of the driver difficult.

Some information on the legislation specific to vehicle management is provided in the example below, as well as an outline of how the City of Rockingham uses this legislation to manage coastal vehicle use in their area.

Control of Vehicles (Off-road Areas) Act, and its use in the City of Rockingham

The *Control of Vehicles (Off-road Areas) Act 1978* operates to low water mark. It restricts off-road vehicle activity to private land where the user has specific prior consent to use that land and to any permitted areas which are specifically set aside for recreational off road vehicles. This act covers all National Parks and Nature Reserves throughout the state, and all metropolitan water catchment areas. The Act also operates in all metropolitan local governments, the Shire of Gingin, the Cities of Bunbury, Geraldton and Mandurah, a portion of the City of Albany, all the land on the seaward side of the Old Coast Road in the Shires of Waroona and Harvey and the seaward side of the Bussell Highway in the Shires of Capel, Busselton and Augusta – Margaret River.

Responsibility for administering and enforcing this Act is with local government, however the police are required to co-operate with Councils in this task. The Act allows for registration of unlicensed off road vehicles, and provides for areas where off road vehicle use is permitted. Information concerning the Act, and options under it, can be obtained from the Department of Local Government.

The City of Rockingham is within the area of operation of the *Control of Vehicles (Off-road Areas) Act 1978*. With the exception of permits provided to five professional fishermen, vehicles are banned on all beaches within the City. The Council works with the WA Police and Department of Conservation and Land Management to conduct weekend blitzes on off-road vehicles, especially motorcycles, in the coastal area. The blitz is advertised in advance to deter very occasional users, and uses a combination of aerial and ground crews. Offending equipment is confiscated for 12 months, so the blitz is usually effective in deterring offenders for that length of time.

Figure 6-3

Random unmanaged off-road vehicle tracks have caused extensive damage to dunes at Torbay Inlet, Albany.
[Photo: Coastwest/Coastcare]

Figure 6-4

Off-road vehicle disturbance at Gnoorea Beach, Pilbara Coast.
[Photo: B Green]

Table 6-2 Uncontrolled vehicle use

Strategies	Implementation Considerations
PLANNING ***Planning*** *can determine the type of vehicle control that is required, which coastal features require road links, and whether access to all or part of the coast should be prohibited.*	Need to consider: • the type and intensity of vehicle uses • frequency and timing i.e. when are the busiest times? • linked activities, such as fishing, surfing or boating • vehicle movement patterns and coastal access requirements, both within and adjacent to the site • the capacity of the area to accommodate vehicles • designation of areas suitable for off-road vehicle activities • traffic management and accident liability issues.
ON-GROUND WORKS ***Formalising vehicle access ways, or improving damaged sections of existing tracks*** *can alleviate some of the impacts of vehicles along the coast.* *Where vehicles are to be restricted from all or part of the coast,* ***car parks*** *linked to pedestrian paths can formalise and direct vehicle movement into and around the site.* *Regular* ***monitoring*** *of off-road vehicle use, regular surveys for new tracks followed by* ***erection of barriers and rehabilitation work*** *may be required to deter drivers, and to allow problem areas to be protected.*	Need to consider: • the impacts of improving coastal access through track formalisation or upgrading, on the overall use of the area, and the likelihood of a resulting increase in overall use. • financial and labour requirements for track maintenance • closing off and rehabilitating unwanted tracks • the possibility of involving 4WD user groups in track rehabilitation.
REGULATION/ENFORCEMENT ***Local laws*** *can designate where vehicles are permitted, and establish penalties for infringement. Local laws operate to high water mark, and responsibility for enforcement is with local government.* *The* ***Control of Vehicles (Off-road Areas) Act****, as described in the box on page 6-5, can be used in some areas to assist with vehicle control.*	Need to consider: • the most appropriate regulation for the location and type of users • the capacity to enforce regulations, and fine and prosecute offenders • the need for fines associated with local laws to be a significant deterrent to offenders.

Table 6-2 Uncontrolled vehicle use (continued)

Strategies	Implementation Considerations
EDUCATION AND AWARENESS *Education strategies should seek to **work in conjunction with local 4WD or interest groups,** to raise awareness about responsible use of vehicles in coastal areas. The provision of maps of the area which clearly identify 4WD tracks and warn against driving off designated tracks can assist with ensuring users understand acceptable use of vehicles.*	Need to consider: • communication methods most likely to reach your target audience • establishing a volunteer ranger program to educate users and issue warnings • the type of users and reasons for use of vehicles along the coast. **Refer to the following sections of the Manual:** ❖ 3 Coastal Management Planning ✹ 7 Stabilisation and Rehabilitation ✱ 8 Weeds and Weed Management ❧ 9 Revegetation

6.4 SANDBOARDING

Sandboarding – sliding down a dune face on a board or mat – has developed a considerable following among surfers, young people and adventure tourists. World championship competitions are held, adventure tourism operators in coastal areas commonly offer sandboarding as an activity, and a significant commercial sandboard manufacture and retail industry has emerged, along with the home manufacture of boards by young people.

Sandboarders prefer steep dune environments that face into prevailing winds with little vegetation on the exposed slope. These environments are particularly susceptible to erosion.

The continued use of an area by sandboarders smoothes out the surface of the dune, reducing its appeal. Hence, sandboarders continually seek new locations, creating difficulties with the designation of particular sites for the activity.

Some of the strategies employed by land managers to assist with management of sandboarding are provided in the boxed text below, along with a case study on sandboarding management in the City of Mandurah.

Managing sandboarding in the City of Mandurah

By 1996, sandboarding had caused significant damage to dunes in the City of Mandurah. Investigation of the problem found that local schools were running educational activities where students were making sandboards – to combine students' leisure interests with vocational training.

Rangers, environmental planning and public works departments from the City of Mandurah worked together with Mandurah Coastcare groups to develop a management response, which has included the following:

- *Planning* – A lack of safe, legal activities available to youth in the City of Mandurah was identified as a contributing factor to the popularity of sandboarding. This resulted in the inauguration of a skateboard park, as an alternative venue for youth.
- *On Ground Works* – 2.5m fences with coppice log posts and weldmesh net were erected to restrict access to the dune areas. The community rehabilitated areas damaged from sandboarding.
- *Regulation/enforcement* – The City's Consolidated Local Laws were amended to incorporate a clause into Part III – Beaches Reserves and Jetties, stating section 3.4, subsection [r] [ii] [Prohibited

Activities] that " A person shall not on any beach or reserve to which this Part applies: drive or ride any vehicle on or over a sand dune, or engage in sand boarding or other similar activity." The Schedule penalty for infringement is $100.00.

- *Education and Awareness* – A public education and awareness campaign was mounted through local radio stations, brochures and a large information sign posted on all main beaches in the City. Volunteer Rangers were appointed and provided with uniform hats and t-shirts, and supplied with brochures. They have no formal powers. However, as volunteers with City of Mandurah support, they remain instrumental in educating people about the impacts of their behaviour. Rehabilitation works were implemented by local coastcare groups, and involved local students in an effort to give them a sense of ownership of the site. Contact was made with local schools, to make them aware of the potential flow-on impacts of promoting sandboard manufacture.

The key elements of the Mandurah experience were the involvement and participation of a number of areas of the City's administration, involvement of community groups and local schools, and the development of a multifaceted approach incorporating on-ground works, regulation and education. Sandboarding in the City of Mandurah remains an issue which requires ongoing management resources. Whilst there has been a reduction in the use of sandboarding as a result of the management strategy, some of the brushing used in the rehabilitation of degraded areas has been used to light fires and the activity has still not been totally eradicated.

Table 6-3 Sandboarding

Strategies	Implementation Considerations
PLANNING ***Planning*** *can consider whether the area has the capacity to sustain sandboarding and the need to restrict the activity or identify other, less sensitive environments where it may be acceptable.* *Stakeholder groups should be involved in this planning and decision making process.*	Need to consider: • few sites are likely to be capable of sustained sandboarding due to the instability of the dunes and the high impact of this activity • there is a tendency for the user group to seek new areas to conduct the activity over time • there are social implications from closing an area off to sandboarding completely – including the need to identify alternative activities, such as skateboard parks.
ON-GROUND WORKS: *Fences will control or* ***restrict access*** *in and around sensitive areas and enable degraded areas to rehabilitate. In most cases* ***physical barrier fencing*** *will be required.* ***Degraded areas should be rehabilitated*** *where relevant.*	Need to consider: • closing undesired access points with physical barriers to allow regeneration of degraded spots and reduce access opportunities • replacing barriers with less intrusive fencing as the area recovers • selecting designs and materials that are less susceptible to vandalism.

Table 6-3 Sandboarding (continued)

Strategies	Implementation Considerations
REGULATION/ENFORCEMENT: ***Local laws*** *can be introduced to prohibit sandboarding in some or all of a local government area.* *However, laws are only likely to be effective in conjunction with an increased* ***management presence.*** *It may be possible to appoint* ***special voluntary rangers*** *to provide a management presence, and increase awareness of the regulations and the environmental impacts of sandboarding. However, it is essential that the warnings issued by volunteer rangers are followed up in the Courts*	Need to consider: • the suitability of methods for enforcement of laws or regulations.
EDUCATION AND AWARENESS *Messages on* ***signs, brochures and media releases*** *should be directed at sandboarders and the wider community to raise awareness of the impacts of sand boarding.* *The* ***involvement of local schools, residents, or coastcare groups*** *in rehabilitation, maintenance and monitoring of sites can be an important aspect of dealing with sandboarding.* ✹	Need to consider: • the social context in which sandboarding is operating in a particular area • involving local schools in rehabilitation works on site can foster ownership, and strengthen understanding about the importance of rehabilitation of sensitive areas. **Refer to the following sections of the Manual:** ❖ 3 Coastal Management Planning ✹ 7 Stabilisation and Rehabilitation ✱ 8 Weeds and Weed Management ❧ 9 Revegetation

6.5 UNMANAGED CAMPING

Unmanaged camping in coastal areas can damage vegetation from trampling and stripping for campfires; disturb native fauna; increase the risk of wildfires from open fires; result in the random disposal of human waste, grey water, and rubbish; and cause conflict with day-use visitors and adjacent land holders.

The use of coastal reserves for camping often exceeds the capacity of the land manager to provide a management presence. Available resources for management are limited, and the coastal reserves are often located in remote areas. These problems are exemplified by an increasing popularity of coastal reserves for camping, due in part to guide books which promote 'free camping' areas, and the increasing use of caravans and mobile homes.

The challenge for local government and communities is to find a level of management that will contain the impact of visitors without requiring unsustainable levels of management. An example of the management issues of a coastal reserve on the South Coast is provided on the following page.

Figure 6-5

Unmanaged camping behind foredunes in the Wanagarren Nature Reserve along the Central West Coast. [Photo: Dept. of Conservation and Land Management]

Figure 6-6

Inappropriate disposal of rubbish around remote coastal camping locations results in significant damage to aesthetic, social and environmental values. [Photo: Coastwest/Coastcare]

Campsite management at Boat Harbour

Boat Harbour, south of Wellstead and 90km north-east of Albany, has long been a salmon fishing and camp site for the local community and the broader community in the surrounding hinterland.

Located on unallocated crown land, the campsite has formed in two areas, one right on the beach, and other on a small gully which has developed into a clearing a little smaller than a football oval. For two generations, a professional salmon fisher provided a sense of management to the site with a presence during the winter salmon season. With no facilities, campers carted water and used makeshift toilet arrangements in the surrounding bush. A steady loss of vegetation occurred over the years.

Since 1999 the number of campers at the site has soared dramatically. A nearby campsite at Cape Riche became a pay for use site, the professional salmon fisher returned his licence, and a booklet listing free campsites including Boat Harbour was published. Over Easter 2000 there were 110 people and numerous dogs camping at the site.

The Wellstead Coastforce Group, a member of which lives on a farm adjoining the campsite, developed a short-term management response that has assisted in managing camping activity at Boat Harbour. This has included:

- *Planning* – A community based management strategy was developed to guide management of the area, given limited resources and no management presence.
- *On-Ground Works* – On-ground works included road improvements to formalise access and camping areas; copper log bollards to define camping area boundaries; and installation of a composting toilet block, a large rubbish bin, and an honesty box to collect donations. The neighbouring farm family maintain the toilet facilities and empty the bin.
- *Education and Awareness* – The group have been impressed by co-operation of campers who volunteered donations when they saw community members at work cleaning up the site.

The Group now faces the challenge of considering the longer-term management response that is necessary for the site. This needs to respond to considerations such as How much work can be done voluntarily? Who besides the adjacent landholder can be involved in management? Should the facilities be further upgraded and fixed fees charged? Could the site support some form of renumerated caretaker, maybe shared with an adjacent site?

Table 6-4 Unmanaged camping

Strategies	Implementation considerations
PLANNING ***Management planning*** *can establish a strategy for dealing with camping in coastal reserves, which marries the nature of the camping experience and level of management to be provided with availability of resources.* *However, planning for a particular area should also encompass a broader* ***assessment of camping activity within the region*** *and the impacts of management actions on other sites in the area. For example, imposing camping fees in one area could result in increased visitor numbers at other sites throughout the region.* ❖✹	Need to consider: • the facilities and camping experiences available throughout the region, as strategies put in place to manage one site can influence the level of visitation at adjacent camp sites and visitor nodes • visitor pressure and the impact from activities • the capacity of the land manager or community to manage the site.
ON GROUND WORKS *Installation of facilities and infrastructure, such as* ***vehicle and pedestrian access ways, barriers to define camp sites, signage, rubbish bins, toilets*** *and* ***rainwater collection facilities,*** *can minimise the impacts of camping activities.* *Donation boxes can be installed to assist with maintenance and management costs at the site.* ✹❧✱	Need to consider: • maintenance requirements of facilities and infrastructure installed • camping bay and access alignment and design, to minimise the impact on the environment, and maintain the desired experience • including signage and fencing to direct movement and protect sensitive areas • the need to stabilise sensitive or degraded areas around paths with rehabilitation techniques such as brushing and planting.
REGULATION/ENFORCEMENT *Regulations have limited role without a means of enforcement. In some circumstances, council staff, a local community group or even a caretaker can be identified to maintain facilities and provide a* ***management presence.***	Need to consider: • capacity to enforce regulations.
EDUCATION AND AWARENESS *Encouraging changes in the behaviour of site users will significantly assist to minimise the impacts of unmanaged camping. However, an effective education and awareness strategy should recognise that some users will not be located in the surrounding area, and so will not be subject to the usual communication mechanisms, such as local papers.* ***On-site signage****, that appeals for co-operation and raises awareness of the potential impact of camping activities, and* ***information brochures*** *distributed with local Visitor Information Centres are most effective.*	Need to consider: • wording of signage and information to appeal for voluntary co-operation of site visitors. **Refer to the following sections of the Manual:** ❖ 3 Coastal Management Planning ✹ 7 Stabilisation and Rehabilitation ✱ 8 Weeds and Weed Management ❧ 9 Revegetation

6.6 CONFLICTS BETWEEN RECREATIONAL USERS

Conflicts between recreational users can occur when the needs of one group are compromised by the activities of another. This usually involves competition for access to the same resource, either in space or in time. Conflicts can also occur when one group negatively affects the quality of the experience, or compromises the safety of another.

Examples of common conflicts that can occur between coastal recreational users are:

- horses, dogs, walkers and motorised vehicles
- boats launched from a hard sand beach amongst young children and swimmers
- surfboards and sailboards travelling at speed and compromising swimmers' safety
- jet skis, creating a safety issue for swimmers and reducing the quality of the experience for other users due to their loud noise.

Resolving such conflicts will inevitably require some compromise. Solutions often include the need to physically separate activities through the designation of zones, or areas of acceptable activity. Careful planning, involving stakeholders and affected users groups, can assist in analysing problems and understanding user needs.

Figure 6-7

Vehicles on the beach in the Nilgen Nature Reserve along the Central Coast leaves no room for other beach activities.
[Photo: Dept. of Conservation and Land Management]

Figure 6-8

Beach congestion from squatter shack dwellers and day visitors, Wedge Island.
[Photo: Dept. of Conservation and Land Management]

Table 6-5 Conflicts between recreational users

Strategies	Implementation Considerations
PLANNING *Preparing a **management plan** for an area will allow conflicts to be identified. Planning processes will be most effective if they **include stakeholders and user groups** in planning for an area.* *Planning can reduce conflicts through the designation of **zones** for particular activities; recommending **site design** aspects that will reduce conflicts; or **prohibiting** incompatible activities.* *Planning should also encompass a broader **assessment of activities in the region** to identify other areas that may be more suitable for certain activities to take place without conflict.* ❖	Need to consider: • the patterns of use of the site • options for resolving conflicts by separating incompatible activities, either in space or in time • whether changes to site design and layout can help to address conflicts. For example, appropriate access to car parks and toilets/change rooms to avoid pedestrians having to interact with vehicles.
ON GROUND WORKS *Installing infrastructure to accommodate particular activities can help to reduce conflict between groups. For example, providing a windsurfing rig-up area or a boat ramp can assist these users to function effectively without disturbing others.* *If zones of activity are established, **fencing and signage** can help to control and direct movement into and around the site.* ✹	Need to consider: • the use of fencing, walk trails, vegetation and signage to guide site use • patterns of use of the site and the needs of particular user groups.
REGULATION/ENFORCEMENT ***Local laws** can be established to separate activities into designated zones, and/or prohibit certain activities.*	Need to consider: • community support for introduced regulations • the use of signage to ensure awareness about regulation • the capacity to enforce regulations.
EDUCATION AND AWARENESS *A **site map** at a focal point, for example, in the main car park, can inform visitors of the overall plan and areas designated for certain activities.* ***Signage** can also inform users of any regulations that relate to use of the site. Where conflicts are caused due to irresponsible, or inconsiderate actions by one or more groups of users, **signage can be targeted to particular groups** to encourage more responsible behaviour.* ***Key user groups** and the broader community should be encouraged to be involved in planning and on-ground works to develop a sense of ownership and an understanding of the needs of various groups and to encourage compromise.* ❖✹	Need to consider: • the opportunities for community involvement in management of the site • the establishment of effective community consultation processes • design of signage or other educational material to explain why regulations are necessary. **Refer to the following sections of the Manual:** ❖ 3 Coastal Management Planning ✹ 7 Stabilisation and Rehabilitation ✱ 8 Weeds and Weed Management ❧ 9 Revegetation

6.7 COASTAL VISITOR SAFETY

Management of public areas, including coastal foreshores and reserves, requires serious consideration of safety risks to users.

This includes the risks associated with environmental features, such as unstable cliffs or the presence of strong rips, as well as the risks associated with such management actions as the design and construction of site infrastructure; the management and direction of users in and around a site; and users' awareness of the potential dangers.

It is important to ensure that safety risks are minimised and that users are aware of potential dangers. In the event of an accident, a land manager may be liable for damages if due regard has not been given to minimising the risk of accidents occurring.

It is beyond the scope of this manual to offer detailed advice in the area of risk assessment and management, although there are many ways of mitigating risk. This section has been included to draw attention to the need to consider safety implications of coastal management. However, it is advisable to seek expert advice on issues associated with visitor safety and opportunities to maintain safe conditions.

Figure 6-9

A lookout platform and signage at Point D'Entrecasteaux helps to minimise safety risks for visitors enjoying the spectacular coastline. [Photo: Coastwest/Coastcare]

Table 6-6 Coastal visitor safety

Strategies	Implementation Considerations
PLANNING *Planning for visitor safety can establish the level of risk associated with various aspects of the site and develop appropriate **risk management** strategies to address them. **General hazard** or **geophysical surveys** can be undertaken, depending on the nature of risk and safety to be investigated.*	Need to consider: • the safety implications of all management actions, including site and infrastructure design, and choice of materials • the need to communicate potential hazards and risks to users.
ON-GROUND WORKS ***Signage and safety barriers** can advise visitors of site risks, and restrict access to particularly hazardous areas.*	Need to consider: • the use of fencing as a physical barrier • design and use of materials for site infrastructure such as pathways, steps and seating.
REGULATION/ENFORCEMENT ***Local laws** can be introduced to prohibit certain activities at a site. For example, the prohibition of diving from groynes.*	Need to consider: • whether existing regulations are sufficient to deter hazardous activities.
EDUCATION AND AWARENESS *On-site signage is an important aspect of promoting awareness among users of the potential risks. Careful consideration should be given to placement of signs and wording to ensure clarity of messages.*	Need to consider: • seeking professional advice about signage placement and content, including graphics. **Refer to the following sections of the Manual:** ❖ 3 Coastal Management Planning ✹ 7 Stabilisation and Rehabilitation ✱ 8 Weeds and Weed Management ❧ 9 Revegetation

6.8 FIRE MANAGEMENT IN COASTAL RESERVES

Fire management involves minimising the risk of a fire, as well as ensuring an adequate capacity to respond to fires should they occur, hence minimising their impact.

Coastal areas are particularly vulnerable to degradation following fires. Vegetation cover is the primary means of stabilising coastal environments, and creates a protective barrier from strong winds and damage from vehicles, people and animals.

The typically sparse nature of coastal vegetation, negligible nutrient storage in the soil, the low moisture content of coastal sands and strong on-shore winds can make plant establishment following fires very difficult. Coastal vegetation communities, from coastal heath, shrub and herb to mangrove and woodland, vary significantly in their susceptibility to fire.

Many coastal reserves are located adjacent to residential areas, so the risk of wildfire causing injury or loss of property is high, and can result in community pressure to undertake regular controlled burns. However, fires which occur too frequently can deplete regenerative plant stocks, change the structure of plant communities, and leave the area susceptible to weed invasion and erosion.

There are a number of strategies which can be used to reduce the risk of fire in coastal reserves, including considering the risks and impacts of fire when planning the location and design of new subdivisions adjacent to coastal reserves; undertaking site design and layout of the coastal reserve; and conducting site maintenance and on-ground works.

The Western Australian Planning Commission has produced *Planning for Bushfire Protection* (2001) and *Development Control Policy 3.7 Fire Planning* (2001), which provide guidance for planning new subdivisions with regards to fire management considerations.

Table 6-7 Fire management in coastal reserves

Strategies	Implementation Considerations
PLANNING *All levels of planning should incorporate fire management issues, and can minimise the risk of fires and facilitate quick response times.* ***Land use planning** can consider fire risks at the stage of re-zoning adjacent land for subdivision and development.* ***Site planning** for coastal reserves should consider opportunities for **site layout and design** to minimise fire events and their impacts.* *Local governments and volunteer fire authorities may **develop fire control strategies** which address the long-term management needs of each reserve, yet allow prompt action when emergencies arise.* ❖	Need to consider: • the nature of use of the area surrounding the coastal reserve.

Table 6-7 Fire management in coastal reserves (continued)

Strategies	Implementation Considerations
ON-GROUND WORKS *On ground works include the installation of adequate **firebreaks**, slashing/mulching a fuel-reduced zone or planting stands of fire inhibiting vegetation (low growing, fleshy species). **Infrastructure and paths** can be sited and designed to reduce fire risk and susceptibility to fire.* ***Adequate buffers** should be provided between coastal reserves and built structures that are at risk of fire damage.* ***Fire prevention** can also be assisted by good **on-ground maintenance and management practices.** These include frequent rubbish removal, fencing around brushed areas, not brushing adjacent to access ways, and the installation of gas rather than wood barbeques.* ✹❧✱	Need to consider: • the siting and design of infrastructure to minimise fire risk, and assist in quick response times when fires occur • the erosion and weed invasion risks associated with mineral earth firebreaks • utilising slashing or mulching areas in preference to mineral earth breaks.
REGULATION/ENFORCEMENT *Most local governments have **local laws** associated with fire management. These refer to the need to install firebreaks and not starting fires outside the fire season.*	Need to consider: • the capacity to enforce regulations • promoting the idea that residents can obtain advice on the use of fire from local government, the Fire and Emergency Services Association and Department of Conservation and Land Management.
EDUCATION AND AWARENESS *Education and awareness strategies that **educate residents** about minimising the risk of fire adjacent to coastal reserves, and the impact of fires on conservation objectives of coastal reserves can assist with fire management. Messages should include education on potential sources of ignition, such as motorbikes in dry grassy areas, and inappropriate activities, such as illegal campfires, and burning without a permit.*	Need to consider • design of signage or other educational material to explain why fire management is important, and effective ways risk can be minimised. **Refer to the following sections of the Manual:** ❖ 3 Coastal Management Planning ✹ 7 Stabilisation and Rehabilitation ✱ 8 Weeds and Weed Management ❧ 9 Revegetation

7. STABILISATION AND REHABILITATION

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7.1 STABILISING AND REHABILITATING COASTAL LANDSCAPES

The coast is constantly changing as a result of natural processes such as wind, rain, tides, changes in sea level, cyclones, storm surges and strong winds. Without additional disturbance, natural coastal environments can generally adapt to this change.

However, human activities such as coastal developments, pedestrian and vehicle access, and the increased occurrence of fire are accelerating the rate of change along the coast and reducing the capacity for fragile coastal areas to absorb impacts. This increasing instability and resulting degraded environments in some cases need to be actively rehabilitated to protect existing infrastructure, and allow expectations of continued use to be maintained.

Rehabilitation is the restoration, repair or stabilisation of a degraded system to as natural a state as possible. *Stabilisation* is ensuring that sediment contained in a system is maintained and that loss caused by human activity is minimised.

Rehabilitation usually involves stabilising the area and introducing management measures to enable the site to continue to be used. Ideally, this should occur with minimal disruption to natural processes and minimal maintenance costs.

Approaches to stabilise and rehabilitate coastal areas vary in cost, the amount of effort required, timeframes and suitability of techniques to particular sites and situations. This section of the manual provides an overview of some common stabilisation and rehabilitation techniques, including:

- managing coastal use through the introduction or upgrading of access, fencing, barriers, signage and other management infrastructure
- the application of stabilising materials
- the construction of wind fences
- dune reconstruction.

It will assist you to select rehabilitation techniques most suited to your area.

This section of the manual has been collated from a number of publications dedicated to coastal planning, management and rehabilitation. In particular, material has been adapted from Coastcare (1999) *Coastal Rehabilitation Workshop Course Notes;* Department of Agriculture (1992) *Coastal Rehabilitation Manual;* and Department of Environment and Heritage (2001) *Coastcare Community Handbook.* These and other relevant publications are listed in section 12: *References and Further Reading.*

7.1.2 The value of vegetation

Vegetation is essential for long-term stability of the coast. Some degraded sites will re-establish vegetation naturally if the causes of degradation are being managed, while others may require introduced planting to either accelerate or complement natural growth. Revegetation efforts on the coast may have a low survival rate, so planting or seeding may be required in subsequent years, or after some vegetation has established to provide protection for emerging plants.

Section 9: *Revegetation* provides guidance on planting to rehabilitate degraded areas, propagation and planting techniques, and common plant species found in Western Australia.

7.2 PROJECT PLANNING

Before embarking on any coastal project, it is important to spend some time planning your activities. Each project is unique and will require careful planning to determine which techniques are most suited to the issues affecting your area. Some projects will require earthworks, others won't. Some may rehabilitate naturally, others never will. Planning will assist to identify the problem and the most suitable methodology for addressing it given the available resources.

A list of questions for you to consider is provided below. Section 3: *Coastal Management Planning* provides further guidance on planning and should also be consulted when planning a coastal project.

All coastal projects should be discussed in detail with the relevant land manager and relevant stakeholders prior to commencement, and appropriate approvals sought.

7.2.1 Getting Started – the questions you should ask

It's important when planning a coastal project that you have a good understanding of the site, and the following questions should be considered. They are not placed in any order of importance, although they follow a logical sequence.

Should you develop a plan for rehabilitation or stabilisation?

Yes. Plans can help you keep on track and also let others know what you intend to do and how you are going to do it.

What photography is available?

Aerial photos or photographs taken from photo-point stations can help provide an overview of the problems and processes affecting the site and provide information on the size of the site and access to it. They are also helpful when talking about your project to other people who may not be familiar with the area. Aerial photographs can be purchased from the Department of Land Administration (DOLA), which can also help determine a suitable scale. Depending on the area involved, the required scale may be 1:1,000 to 1:2,000. For larger areas, a scale of 1:5,000 may suffice. Examining a series of photographs taken over a period of years can help determine the variability of coastal processes operating.

What is your budget?

Produce a realistic costing for the project and then look at how you can make your expectations fit the budget, or the budget fit your expectations. Be a little generous. It is better to over-estimate than under-estimate. Don't forget to consider labour requirements to ensure you can get the job done in the required time frame. Staging the project will allow for grants or allocations from land manager budgets.

What has caused the problem?

Some possible causes of degradation could include off-road vehicles, pedestrian traffic, sand boarding, animal exercising, fire, rabbits, grazing, strong winds or other extreme events. Section 6: *Common Coastal Management Problems* provides guidance about some of these issues, and suggests strategies to help address them.

Is the cause still present?

Visit the site at different times of the day, week, month, or year to understand use patterns and user needs. Where available, a series of photographs taken over time can help appreciate seasonal variability, or the impact of extreme events. Local residents and long-term users of the area are a good source of information.

What can be done to manage the cause?
Solutions should manage the cause of the problem. It might be necessary to introduce infrastructure such as fencing, bollards, paths, lookouts, signs, bins, car parks, barbecues, toilets or shade shelters. Refer to section 5.3 *Undertaking Evaluation* for further guidance on managing coastal use. Talk to users to get an understanding of their needs and expectations and try to involve them. Planning for users makes future management much easier.

What were the dune shape, size and topography before the problem began?
Look at the dune system either side of the problem area, or at another nearby which is still intact, or source old photographs of the area.

Are earthworks needed?
Earthworks may be required to rebuild the natural coastal profile or to construct car parks, beach access, and other management infrastructure.

Can the area repair itself? What are the implications of doing nothing?
Some coastal areas can repair themselves. For example, plants might recolonise or spread across degraded areas relatively quickly. If this is the case, you're miles ahead! Manage the cause to protect the site from further degradation and let nature take care of itself. However, in some areas, lack of attention to addressing degraded areas may result in an acceleration of the problem.

Do you need to introduce plants to the degraded site?
Introducing plants to a site can accelerate the rehabilitation process. Planting can involve a significant amount of work, risk and expense, and requires careful planning. Consider whether the vegetation will be able to re-establish naturally if the cause of the degradation is addressed.

What plant species were here before the problem began?
Degraded areas often have reduced plant cover and species diversity, and you will need to consider what natural species were present before the degradation. Local naturalists or old plant surveys for the area may assist. Look at the coast near your degraded site and pick an area which has had minimal disturbance, ideally one with the same aspect, slope, soil type and depth as your site. Observe the species in the undisturbed coastal area, and where you see them.

Have you considered local provenance?
Local provenance refers to plants that grow within the same recognised botanical province and which may not differ genetically. It should be considered when planting in an area, especially if your site is close to a conservation reserve, or has some intrinsic conservation value. Plants or seeds of local provenance can maintain these values.

Are selected species available from a nursery as seed or seedlings?
Determine whether to use seeds, seedlings, or both. Consult your local nurseries, commercial seed suppliers, your Regional Coastcare Facilitator (see section 11: *Useful Contacts)*, and other people who have done rehabilitation work in areas with similar rainfall and temperature to your site.

If seeds or seedlings are not available, you could consider collecting seed and/or cuttings from the area for you, or an established nursery, to propagate. Nurseries may talk to you about seed collection and may even collect the seed for you. There are also a number of seed collection and propagation courses offered in Western Australia.

A permit is required from the Department of Conservation and Land Management to collect seed, and written permission from the land manager if you are not working directly with or for them. It will also be important to allow extra time in your project scheduling, as seed collection and propagation can be time consuming and extend across a whole year depending on the species.

How much seed and/or how many seedlings?
The amount and number of seeds and/or seedlings will vary according to the size of the area and available resources to purchase and plant them. As a guide, one seedling per square metre, and greater than 3kg of seed per hectare, will be required. On a bare site, three to six plants will be required per square metre. More than this can be introduced, as some seedlings won't survive and many seeds won't germinate. You can also use less, although this decision should be made carefully, with expert advice if possible. Choose the number of species based on your local observations and form an understanding of the role each species plays in the environment and where it grows. See section 9: *Revegetation* for common species and their place in the coastal environment within your region.

Does the soil need stabilising?
In most situations the answer to this question will be yes. An overview of stabilisation techniques and source of stabilising materials is offered in this section of the manual.

When is it best to undertake stabilisation or rehabilitation works?
Table 7-1 provides information on the best times for stabilisation or rehabilitation activities in the different regions of Western Australia.

Do seeds and seedlings need protection from predation, wind and/or sand blast?
Seeds or seedlings may be under threat from native or feral fauna (mammals, insects, reptiles or birds), strong winds and/or sand blast. Protective measures such as plastic tree guards for rabbits, and brushing to protect against wind may be required. Look for signs of animal presence, such as digs or dung. Check the plants in the local area for signs of defoliation which could have been caused by wind and/or sand blast. Note which species appear to tolerate strong wind and/or sand blast and which don't.

7.2.2 Timing

Climatic conditions around Western Australia vary from tropical conditions in the north to temperate conditions in the south resulting in differing suitable times for coastal rehabilitation and stabilisation projects to occur. It is best to undertake projects when there is sufficient rainfall to ensure the soil is wet and stable, and moist enough to promote growth of seeds and seedlings. Planting closer to the start of the rainfall period, but after good opening rains, usually improves survival rates.

Table 7-1 shows the preferred months to undertake stabilisation and rehabilitation in each region of Western Australia. This is a guide only and you may need to look into the rainfall distribution for your particular area in greater detail. The solid lines indicate the best time to undertake coastal work and the dashed lines indicate times when work can occur but it may be less successful because of decreasing rainfall and increasing temperatures.

Table 7-1 Months in which stabilisation and rehabilitation could generally occur given expected rainfall

REGION	J	F	M	A	M	J	J	A	S	O	N	D
Pilbara/Kimberley (WA border to Onslow)												
Gascoyne (Onslow to Shark Bay)												
Central West Coast (Shark Bay to Cape Naturaliste)												
South-West Capes (Cape Naturaliste to Albany)												
South Coast (Albany to Eucla)												

7.3 MANAGING COASTAL USE

The introduction or repair of coastal infrastructure such as fencing, pathways, steps, boardwalks, signage or lookouts can be effective in addressing coastal management problems, thus reducing the risk of dune instability and allowing areas to rehabilitate naturally. By removing the pressure from sensitive or degraded areas, they are able to rehabilitate naturally.

The early introduction of appropriate infrastructure is also a proactive management approach which can:

- prevent degradation
- reduce the amount of work required at a later stage
- help change patterns of user behaviour which may be contributing to the degradation.

You should consider the introduction of infrastructure as part of the overall planning for the area. If not properly planned, new facilities may attract increased use that is unsustainable, or detract from the experience for which people current use the site. Section 3: *Coastal Management Planning* provides further guidance on planning for a coastal area.

Some land managers will have design standards that guide the construction of coastal infrastructure such as fences, signage and pathways. It is important to discuss the design of any coastal infrastructure projects with the land manager to ensure plans comply with standards being used. Additional manuals and guidelines provided in section 12: References and Further Reading, provide further information on design specifications for coastal infrastructure.

7.3.1 Access control

Managing human use and access to the coast is vital as coastal areas are often severely degraded by ad hoc and unmanaged access. Fencing and other barriers can be erected to exclude pedestrians and vehicles from fragile or rehabilitating areas, and ensure they keep to designated access ways, assisting with rehabilitation.

It is important that the design of access is linked to the way the site is used, the area's sensitivity to degradation, and that it be accompanied by fences and signage where relevant.

Formalising and upgrading access can sometimes attract increased use of the site. Whilst access improvements can increase the carrying capacity of some locations, these implications should be considered at the project planning stage to ensure improved access does not contribute to overall site degradation.

Give careful consideration to path alignments, surface materials and fencing or other barriers. Inappropriate designs can initiate undesirable water movement and erosion, or exclude disabled access. It is also important to ensure they do not negatively impact on site aesthetics and landscape values.

7.3.2 Fencing/barriers

The location of fences should consider the landform, existing vegetation and surrounding developments such as car parks. Fencing can be positioned along the front or back of dunes, or along either side of access ways. All access control fencing should have a low wind resistance to avoid the accumulation of sand.

The type of barrier constructed will depend on its purpose and location, available materials, budget and characteristics of the site.

Figure 7-1

Clearly defined vehicle and pedestrian access at Hangover Bay have greatly improved the amenity and carrying capacity of this popular coastal location. [Photo: B Green]

Typical fence types used in coastal locations include:

Post and plain wire

This type of fencing is useful as a physical barrier for pedestrians although it may not totally prohibit access as people (especially children) can easily slip between the wires. Post and plain wire fencing is simple and cheap to erect. The wire should ideally be galvanised or PVC-coated for endurance in salt air.

Post and rail

Post and rail fences are aesthetically pleasing in coastal locations. However, their high cost often restricts their use to amenity areas such paths around, and leading from, car parks or facility areas.

Wire mesh

Wire mesh fencing works as a more physical barrier, and is useful in keeping traffic away from sensitive or rehabilitating areas. In sandy locations, the fencing can become buried and should be lifted regularly to avoid this. The wire mesh should be galvanised or PVC-coated for endurance in salt air.

Horizontal pine posts

Low horizontal pine posts are typically used to direct and guide vehicle movement in coastal areas, although they have also been used to guide pedestrian traffic where a psychological rather than physical barrier is required. The cost of these barriers can be high, and they are typically used around car parks, or to block vehicles from continuing onto the beach.

Bollards

Similar in function to horizontal pine posts, bollards serve as a guide for directing vehicle and pedestrian traffic in and around a coastal site. In many instances this may be all that is required to stop people wandering into sensitive areas.

Less common than the barrier types outlined above, boulders, railway sleepers and disused telephone/power poles have also been used as vehicle barriers.

7.3.2.1 Pedestrian paths

Generally, pedestrian paths should be wide enough for comfortable movement, but not wide enough for vehicle use, unless the paths need to provide access for emergency vehicles, or accommodate particular users such as windsurfers. Paths should follow the natural profile of the dune. If sloped, they may require steps. It is important to ensure that accessways at sandy sites are not aligned directly into the prevailing wind, to reduce the likelihood of erosion.

Paths that link facilities and attractions, such as carparks, toilets, a lookout or the beach, should be convenient to use and provide the shortest safe distance from point to point. It may also be necessary to provide paths for recreational activities such as walking. Dual use paths, for cycling and walking, are generally aligned parallel to the coast, with links to the beach and adjoining roads or recreation areas. These paths should be located in stable areas and set back from the coastline.

Consideration should be given to:

- whether the path needs to be surfaced (for example, to provide secure footing)
- whether the sides should be confined with fencing or hand rails
- whether lookout points or interpretative signage may be useful
- the impact on the aesthetics of the site
- the opportunities to accommodate disabled access.

The type of material used should depend on the nature and intensity of use and the site conditions. Consider the ability of the material to reduce erosion and minimise the amount of ground movement.

Options for surface materials include:

Crushed limestone

Crushed, water-compacted or cement-stabilised limestone is a good, cheap option. It will provide a firm surface, and is visually compatible with coastal landscapes. As with all hardened surfaces, drainage may be needed to reduce the likelihood of erosion.

Natural sand

Natural sand may be useful in sheltered areas or areas with little sand movement, where pedestrian movement will compact the surface over time. Sand paths are unsuitable for exposed areas or steep slopes.

Timber boardwalks

Timber boardwalks enable the natural ground surface to be protected, and vegetation to grow under and close to the path. They are especially useful in fragile areas, or where surface drainage is a problem, and they enable disabled access. However, boardwalks are typically expensive.

Timber steps

Timber steps provide low-impact access down steep or unstable slopes. The natural ground surface and vegetation is retained, reducing the likelihood of ground slippage, although sand between timber steps tends to erode away. The natural appearance of the timber is suited to the character of coastal landscapes.

Board and chain walkways

Walkways can be constructed with treated pine slats, whole or half-round logs, placed across the path and connected with chains. Flat timbers are easier to walk on in bare feet. These walkways provide a non-slip surface which can accommodate slopes and be lifted to remove accumulated sand, although they can become completely buried. They are often not favoured by pedestrians who may walk down either side if fencing permits.

Concrete and asphalt paths

Concrete and asphalt paths are more likely to be used in urban situations, and for dual-use paths. They are relatively formal, hard surfaces which may not be suited to some natural coastal landscapes. Their visual impact can be reduced by adding colour or texture to concrete paths, or colouring asphalt, for example, red asphalt. Drainage may be needed to reduce the likelihood of erosion.

Concrete beach access steps

Concrete, or stone and concrete steps are sometimes constructed down steep slopes to the beach. They are unsuitable for use on unstable sandy slopes, as they can break up without adequate foundation and may exacerbate dune erosion around their base. These solid steps are better suited to rocky slopes. The beach end of the steps may be better constructed of raised timber or steel decking, to reduce erosion.

Woodchips, mulch, shell grit, gravel

Loose materials such as woodchips, mulch, shell grit or gravel are cheap and easy to spread. However, they readily become covered with sand and can be unpleasant for users with bare feet. This may discourage use of the path by these users.

Used car tyres

In some areas, used car and tractor tyres have been used to construct beach access down sandy slopes to the beach. They are free and easy to install. However they may not be easy to walk on, resulting in some users avoiding them and walking along the side of the path instead. Use of tyres is generally considered a stopgap measure. There may be a need to comply with EPA restrictions associated with the number of tyres used at a location.

Seagrass

Seagrass has been used to stabilise pedestrian paths in some areas. It tends to require frequent replenishment, as it blows away or becomes buried easily. The notes for use of seagrass as a stabiliser later in this section are also applicable to pedestrian paths.

Figure 7-2

A dual use path behind dunes at Warnbro. [Photo: Coastwest/Coastcare]

Figure 7-3

Timber steps have been installed at Lefthanders in the South-West to assist with beach access and rehabilitation work. [Photo: Coastwest/Coastcare]

7.3.2.2 Vehicle access

Formalising vehicle access to and along the coast involves:

- identifying where and why vehicle access is required
- identifying appropriate alignments, design and construction materials to accommodate vehicle use without causing further degradation
- blocking off unwanted or illegal tracks.

Identifying the nature and frequency of use will assist with determining suitable access way alignment and materials.

It may be appropriate to allow vehicles on the beach for activities such as commercial and recreational fishing, boat launching, off-road vehicle use, site maintenance work or emergency access. Where vehicle access to the beach is restricted, users can be accommodated in car parks adjacent to the coast.

Road base materials can be used for coastal access in some situations, such as when the site is heavily used, to reduce pressure on the site. It is important to separate vehicles and pedestrian movement where possible to improve safety.

Existing tracks that are no longer needed should be blocked off, for example, by construction of a bund, or the placement of large rocks, bollards, or a fence to restrict access. Blocking off tracks should be supported by other rehabilitation and stabilisation techniques such as brushing, planting, and signage to redirect traffic movements and allow degraded areas to recover.

If site maintenance or emergency access is required, a locked gate can be included to allow restricted access. This should be accompanied by appropriate signage.

7.3.3 Signage

Well planned signs can enhance user experiences, demonstrate that the area is cared for by the local community, promote a land care ethic, raise awareness of particular issues and guide and inform users about appropriate use of an area.

Signage requirements should be considered as an integral part of overall management of an area.

There are three types of signs applicable to coastal areas:

- *directional signs,* which tell users where to park and where access paths and facilities are located
- *regulatory signs,* which inform users about regulations associated with use of the site, such as use of boat ramps, skiing areas, removal of marine life and restricted access to rehabilitation sites
- *interpretive signs,* which provide information explaining the reasoning behind regulations or rehabilitation pertaining to the natural features of the site.

The Department of Conservation and Land Management has produced a Signage Manual, which is a useful reference for the development of effective signs.

When incorporating signage at a site, the following aspects should be considered.

Budget

Signs can be expensive, resulting in a significant additional project cost. Signage should be considered at the project planning stage to ensure this item is sufficiently budgeted for.

Frequency and location

Too many signs can detract from the message – only use signs where they are serving an express purpose. Signs should be located where they are clearly visible, but do not detract from the aesthetics of the area. Typically, signs are best located near pathways, car parks, and beach entry and exit points.

Wording and design

Messages need careful thought. Avoid technical terms or jargon and focus on simple, user-friendly, positive information. In general, keep messages short. The use of international standard pictograms is encouraged and in cases of visitor safety may be essential.

It may be relevant to get input from professionals or local groups in developing messages and designing interpretive signs. Local artists may provide ideas or even artwork.

Construction materials

There is a vast array of examples around the coast. The design and choice of materials for signage should consider aesthetics of the site, the likelihood of the sign being vandalised or souvenired (including the need for anti-graffiti coating), and its durability given exposure to the elements. Anodised aluminium or treated timber is common, as these materials are durable in coastal conditions and harder to vandalise. Materials might also reflect the surrounding natural environment, such as the use of limestone with an information panel attached to it.

Figure 7-4

The Mandurah community has produced a number of signs to promote the community's work and communicate with users about acceptable behaviour. [Photo: Coastwest/Coastcare]

Figure 7-5

The Kempton Street project sign helps others understand important restoration work is in progress.
[Photo: Friends of Bluff Point Foreshore]

Figure 7-6

'Tribal Law' signage at Margaret River mouth communicates with a particular user group.
[Photo: Coastwest/Coastcare]

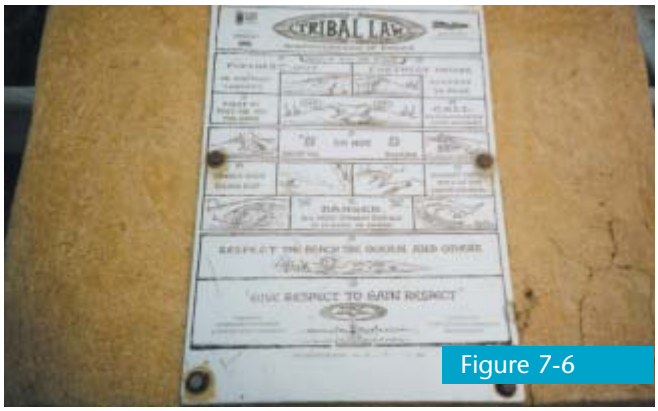


Figure 7-6

7.3.4 Other management infrastructure

Additional to fences, paths and signs, other infrastructure can mitigate against coastal degradation resulting from human use. A decision to incorporate any of these facilities should be based on observing how the site is being used and identifying impacts that these uses are having on the stability of the area. Further, before installing new facilities, it is important to consider the maintenance requirements, and who will be responsible for maintaining these facilities.

Potential additional facilities include:

Toilets

These are especially needed at day use sites to prevent vegetation being trampled. They should be located where they are unobtrusive but visible from car parks, can be reached without having to cross a car park or vehicle access way, and where effluent will not pollute the marine environment.

Barbeques

Barbeques are useful at camping areas, where people are likely to build their own fires unless they are provided. Fuel must be provided to prevent damage to vegetation.

Formal campsites
Formalising camping areas can reduce vegetation damage typically found at informal campsites. If an informal camping area is poorly located it may need to be completely closed off.

Lookout platforms
These are useful at popular surfing or sightseeing locations, where people climb dunes to reach vantage points. Access to lookouts should be provided from each direction from which users are likely to approach; otherwise new informal paths will be formed.

Windsurfing set-up areas
Without a windsurfing set-up area, windsurfers often resort to setting their equipment up on dunes. Set-up areas need to be located on the coastal side of car parks and linked to a suitably wide access path to the beach.

Rubbish bins
Rubbish bins will be well used wherever they are located. However, it is best not to install them if they cannot be emptied regularly; for example, at isolated day use sites, where they will tend to attract other rubbish. Rubbish bins need to be designed in such a way that dogs, crows, seagulls and other fauna cannot easily remove rubbish. If bins are not provided, it may be useful to erect a sign to explain why, and requesting users to take their rubbish home with them.

Shade/windshelters
In some areas coastal users enter areas of natural vegetation to shelter under trees or shrubs, or damage cliff overhangs to create shelter. Providing shade for users minimises this behaviour. However, the design of such shelters should consider that nearby residents may complain if structures or shrubs and trees are located directly in front of their properties.

Fish cleaning facilities
These can be beneficial at popular recreational fishing sites to avoid users leaving offal rotting on the beach or dumping it in the water.

The exact siting of management infrastructure and facilities such as those listed above should be considered as part of the overall planning for the site. However, they should generally be located where they will be less susceptible to erosion, degradation or vandalism; where they are most likely to be used; where they will be most likely to reduce pressure; and where they will not intrude on the vistas from adjoining properties.

The following figures demonstrate the use of management infrastructure to reduce use pressures and enable a site to be rehabilitated.

Figure 7-7

A hang glider platform was constructed in West Cape Howe National Park to stabilise cliff edges being used for this activity. The platforms also double as lookout platforms for the general public. [Photo: B Green]

Figure 7-8

Composting toilets at Peppermint Grove beach in Capel helps to minimise the impacts of visitors.
[Photo: Coastwest/Coastcare]

7.4 TECHNIQUES FOR STABILISING DEGRADED AREAS

The introduction, establishment or protection of native coastal plants within a degraded site is by far the best long-term coastal stabilisation technique. Revegetation techniques and common coastal plant species are discussed in detail in section 9: *Revegetation,* and should be referred to for guidance in this area. However, plants often need help to become established in the short term. The stabilisation techniques discussed below will only be a temporary or short-term measure until natural vegetation cover can return either naturally or through planting.

The suitability of stabilisation techniques and materials will depend on local conditions and available resources. Table 7-2 provides a comparative description of the aspects of each of these techniques and materials to assist in the selection of the right material for your site.

7.4.1 Stabilisation materials and methods

7.4.1.1 Brushing

Brushing is the most commonly used method of stabilisation. It is extremely labour intensive, but has proved to be effective. Ideally, brush should consist of cut tree or shrub branches of native coastal plants which have a tight stem arrangement. Examples include *Melaleuca lanceolata, Acacia rostellifera,* and *Eucalyptus platypus.* However, if care is taken with selection of material, non-coastal plant species can also be used. Conifer branches have proved effective because of their tight stem arrangement. Brushing material can be difficult to source in some coastal areas. Large quantities may be obtained from pruning of plantation forestry operations.

Brushing is effective because it lies slightly proud of the surface and creates a shaded microclimate where seedlings are protected from the sun and wind. For this reason it is more effective than finer mulches. Branches from non-local plants which are known to easily propagate from cuttings or which may regenerate easily from seed should be avoided. Example include Lantana, Olive trees, Victorian Tea Tree, Oleander, Japanese Pepper, Tamarisk and the African Flame Tree. Fronds from palm trees should also be avoided because they often have sharp edges and are difficult to handle.

Material should be laid in a similar pattern to roof tiles – overlapping and interlocked – although in the reverse order to roof tiles (from the top down). The brush can be pinned to the ground with lengths of wire if the site is very steep or exposed to very strong winds, although this should be avoided unless necessary, as wire often outlasts the brush and can cause problems later. If extremely large areas are to be brushed, an excavator with a grab can be used to spread the brush to reduce manual labour requirements.

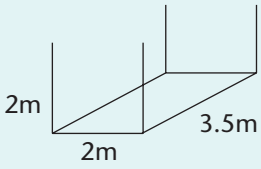
If large quantities are required, brush can be sourced in bales. Larger compacted bales are usually tightly knit, may be difficult to pull apart and can be as large as 25-30 cubic metres. Spreading with machinery is recommended for bale dispersal.

Brush quantities: Depending on the density of application, between 250 and 600 cubic metres of brush will be required to cover one hectare. Lower rates will not provide total cover, but are economical and can still achieve adequate stabilisation. Higher rates provide greater protection to young seedlings and therefore facilitate faster plant establishment. Approx 5-15 cubic metres of brush can be transported in a 6 x 3 foot trailer. In areas which might be subject to vandalism, brushing may be thinned to limit the likelihood of arson.

Brush Balers

Brush balers can be constructed from galvanised steel tubing.

A bale frame 3.5 metres long, 2 metres high, and 2 metres wide was constructed at Margaret River for $800. These dimensions fit on a tip truck or trailer. Larger bales can only fit on an articulated truck, thereby increasing transport costs.



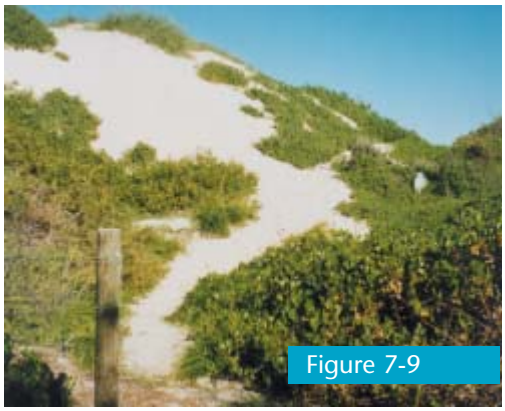


Figure 7-9


Figure 7-10

Brushing used to protect an exposed dune face at Hillarys Beach, before (figure 7-9) and after (figure 7-10). [Photos: The Church of Jesus Christ of Latter Day Saints]

7.4.1.2 Fibre matting

Fibre matting is made from jute and coconut fibre, which form a strong material when constructed as mats and can be laid like carpet. It is used to suppress weeds and stabilise sand from the effects of wind blow on severely degraded dunes. The matting usually requires pinning or edge burying, to stop it blowing around.

Some fibre mat products are made from recycled material and are totally biodegradable. It is available from specialised suppliers.


Figure 7-11

Fibre matting has been used to retard weed growth and allow planted seedlings to gain a foothold in dunes at City Beach. [Photo: Coastwest/Coastcare]

7.4.1.3 Seagrass/seaweed

Seagrass and seaweed, sometimes called *wrack*, are the dead or dying remnants of marine plants which have been washed up on a beach. Most commonly used where there is a high build up of seaweed, it has been used on exposed sandy areas as a stabiliser.

Seaweed has significant ecological benefits to the marine and beach system and removal from its natural environment can be negative as it:

- plays an important role in the food chain of the near shore environment as shelter and food for many marine animals
- may assist in stabilisation of the beach where it has accumulated and can provide some buffering protection against waves which may erode a beach
- contributes nutrients to the natural system.

However, in situations where seaweed is blocking boat ramps or beach access, permission may be granted to remove it for use in rehabilitation projects.

Permission must be sought from the land and/or marine manager before removing seaweed from its natural environment.

7.4.1.4 Straw

Straw is the left over stalks of harvested grain crops. Straw should be differentiated from hay, which may contain seed heads, and should be avoided. Straw can be bought in bales of varying sizes straight from farms or through agricultural supply outlets and is used to cover the soil surface. In wind prone sites straw should be applied as bales, or partially buried.

7.4.1.5 Spray-on paper mulch

Spray-on paper mulch is shredded newspaper and water mixed to a consistency that can be applied with specialist hose spraying equipment. Seeds can be added to the mix to randomly distribute them at the time of spraying. Spray-on mulch is not a favoured method of dune stabilisation, and is not suited to high wind sites, but may be a useful emergency or 'stop-gap' measure for very large areas or when immediate short-term stabilisation is required. Spray-on paper mulch is typically used to stabilise new subdivisions. It is expensive and vulnerable to disturbance in high use areas.

7.4.1.6 Coarse mulch

Coarse mulch is shredded plant material, available through specialist suppliers who screen for weed seeds, or through local governments that collect and process green waste. It is sometimes referred to as tritter. Screened mulch is preferable because the risk of introducing weeds is greatly reduced. Coarse mulch has a number of advantages in urban areas where it is cheap and readily available, and may be suitable for intensive areas such as car park landscaping or amenity areas.

Figure 7-12

Wind fence erected in Quarrum Nature Reserve along the South Coast to provide guidance to off-road vehicles and to stabilise mobile sand dunes. [Photo: B Green]

Coarse mulch can inhibit regrowth if applied too thickly. However, it does stop sand grains bouncing across the surface of the sand and by its abrasive action ringbarking new plants. Mulch used for coastal rehabilitation should be very coarse and heavy to lessen the likelihood of it blowing away when dried out.

7.4.1.7 Wind fences

Wind fences can be constructed in many different configurations and dimensions. They are generally made of timber with timber struts, or have hessian, brush, mesh or shade cloth stretched between supporting bearers or ringlock. Wind fences are ideal when there is a need to reduce wind velocity or protect a site from the raw impact of wind.

Wind fences differ from the sand trapping fences, which are discussed later in this section, in that they are not necessarily designed to be porous, although a degree of porosity is still desirable to ensure they are not undermined. Invariably though, they will trap some sand.

Table 7-2 Coastal stabilisation methods and materials

	Brushing	Fibre Matting	Seagrass/ Seaweed	Straw	Spray on Paper-mulch	Coarse Mulch	Wind Fences
Source and Costs	Can be obtained for free, although transport costs need to be considered Can be obtained by slashing overgrown blind track curves and firebreaks Suitable material may be difficult to obtain in some areas	Can be expensive	Only available in some areas, and at certain times of the year	Widely available	Tends to be expensive, although may be cost-effective for large areas Can be costly Limited availability in remote locations	Widely available	Can be costly
Installation Consider-ations	Can be laid out manually or with machinery Labour intensive if laid manually	Labour intensive to install Can blow around if not pinned properly Adheres to and takes on the shape of the soil surface	Can be laid out by machinery Labour intensive if laid out manually	Easy and fast to apply May pose a short term fire risk	Easy and fast to apply	Can be laid out manually or with machinery Labour intensive if laid out manually	Can be labour intensive to construct
Usefulness on Steep Slopes	Can slip on steep slopes unless tied or staked	Effective in stabilising very steep slopes, such as drain sidings and cuts adjacent to pathways	Will slip on steep slopes		Ineffective on steep slopes as it will break up if soil slides	Can be effective on steep slopes	

Table 7-2 Coastal stabilisation methods and materials (continued)

	Brushing	Fibre Matting	Seagrass/ Seaweed	Straw	Spray on Paper-mulch	Coarse Mulch	Wind Fences
Conditions for Plant Growth	Branches can contain fruit or seed pods, and can trap wind-blown seed Can be used in combination with planting Provides protection from predators (rabbits) Can cool the soil surface and retain moisture in the soil profile Micro-climatic conditions enhance plant growth and seed propagation	Planting can be labour intensive as slits need to be cut in the material before holes can be dug Can cool the soil surface and retain moisture in the soil profile, although dries out quickly in hot conditions Inhibits emergence of natural regrowth Organic decomposition adds nutrients	Can contain seeds of coastal species such as *Atriplex cinerea* which add to rehabilitation efforts Can act to cool the soil surface and retain moisture in the soil profile Does not necessarily enhance growth of plants or seeds Organic decomposit-ion adds nutrients	Can cool the soil surface and retain moisture in the soil profile Organic decomposition adds nutrients	Seeds can be added to the mulch before it is sprayed Some water retention capacity, although dries out quickly in hot conditions Limited protection for emerging plants Seed can be eaten by birds or rabbits	Can cool the soil surface and retain moisture in the soil profile Limited protection for emerging plants Can inhibit regrowth if applied too thickly	
Impact on Weed Growth	If not screened, brush material can sometimes contain weed seeds	Can act as a weed barrier		Weeds can be introduced if the straw isn't 'clean'	Can promote the propagation of weed seeds which settle on it	Can be a source of weeds, but can suppress weed growth	

Table 7-2 Coastal stabilisation methods and materials (continued)

	Brushing	Fibre Matting	Seagrass/ Seaweed	Straw	Spray on Paper-mulch	Coarse Mulch	Wind Fences
Wind Protection	Lifts wind from the soil surface Provides wind protection for seeds and seedlings	Stabilises the soil when fully covered Does not protect emerging plants from wind or sand blast	Lifts wind from the soil surface		Stabilises large areas of soil in a short period of time Limited protection for soil surface from wind Does not lift the wind from the soil surface	Stops sand grains bouncing across the surface of the sand and by its abrasive action ringbarking new plantings	Has the potential to provide a vertical wind shadow of nearly 20 times its height reducing wind velocity for a significant horizontal distance Can provide some wind protection for seeds and seedlings
Ability to Deter Pedestrian/ Vehicle Access	Can deter access	Does not deter access	Can deter access		Does not deter access	May not deter access	Can deter access
Impact on Amenity	Can be untidy in appearance	Neat, but can be detract visually from an area	May be odorous for a short period	Can attract rodents such as mice and rats		Accepted landscape material	Can impinge on visual amenity
Sediment Trapping	Acts as a sediment trap when sand is mobile, forming more naturally-shaped dunes	Gets buried	Acts as a sediment trap initially, when sand is mobile	Traps sediment when used in bales	Does not trap sediment	Minimal sediment trapping	Acts as a sediment trap and limits sand movement

Table 7-2 Coastal stabilisation methods and materials (continued)

	Brushing	Fibre Matting	Seagrass/ Seaweed	Straw	Spray on Paper-mulch	Coarse Mulch	Wind Fences
Maintenance Consider-ations	May be collected for fire fuel by beach users May be blown about in strong winds	Some manufactur-ers use netting which can cause long term maintenance problems	May be blown about in strong winds	Can blow away easily	Easily disturbed Easily covered by mobile sands	May be easily covered by mobile sands, depending on laying thickness	May need regular maintenance, depending on construction strength Sand may build up against wind fencing where it is not wanted
Expected Life Span	< 2 years Depends on conditions: very mobile sand may bury brush quickly. Additional layers may need to be laid	> 2 years	> 1 year Depends on conditions and laying thickness	< 6 months Depends on conditions	> 6 months Depends on weather conditions and ability of surrounding soil	< 2 years	> 5 years Depends on construction strength and material used
Exposure Tolerance*	High	High	High	Low	Low	High Depends on coarseness and laying thickness	High

* Exposure Tolerance: High – Suited to be in close proximity to the beach. Will generally withstand strong wind conditions and sand movement

Low – Not well suited to be in close proximity to the beach. Will not withstand strong wind conditions or sand inundation

7.4.2 Dune reconstruction

It may be necessary to reconstruct dunes when the shape, size or topography has changed significantly, and in a way which will impede rehabilitation efforts or leave the dune in a contorted configuration following rehabilitation work. Several methods of dune reconstruction are presented here.

Dune reconstruction should involve the preparation of working drawings that outline the extent of works, and the volume and shape (contour) of earthworks. Before committing your group or organisation to any machinery costs it is strongly recommended that you arrange an on-site meeting with the officers from the relevant land managing agency to discuss what equipment is appropriate and the likely cost.

You may need to consider access requirements for the types of machinery you will need to undertake dune reconstruction work, depending on whether it is a bobcat, front-end loader, bulldozer, or excavator. Tracked machines are able to climb dunes more easily than those with tyres. Tip trucks can't usually tip their load when on a steep slope because they can become unbalanced and may roll over. They may be unable to access areas of exposed rock for fear of tyre puncture. Bogging in soft sand may also be an issue.

7.4.2.1 Blowout repair

Dune blowouts occur when vegetation is weakened or removed and sand then blows across localised areas of the landscape in large quantities. Blowouts are usually teardrop in shape with a narrow opening to the beach which funnels wind across the exposed area. Sand generally moves with the prevailing wind, resulting in blowouts being able to 'travel' or extend inland for large distances, smothering the vegetation at the outer edge of the blowout. Blowouts can occur as natural, long-lived features in the coastal landscape. Natural blowouts can repair themselves without intervention as they reach maturity, if not exacerbated by human activities. When blowouts threaten to engulf infrastructure such as roads, car parks, buildings, dual-use paths or important flora or fauna communities, blowout stabilisation becomes a consideration.

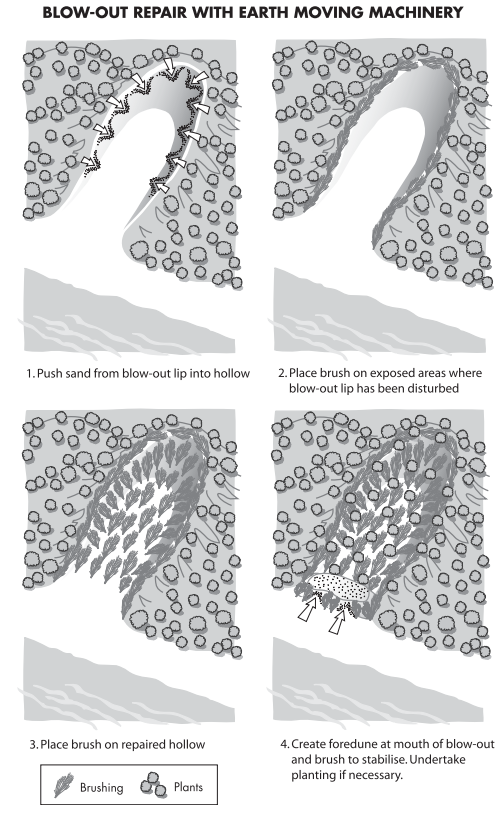


Figure 7-13

Repairing blowouts begins with closing the narrow opening through which the wind is funnelled by reconstructing or creating a foredune. This can be achieved by using sand trapping fences, brushing techniques discussed earlier in this section, or by pushing sand up from the beach berm or from sand deposited by erosion to the rear of the frontal dune, using earthmoving machinery.

It may also be necessary to relocate sand which has accumulated at the outer edges of the blowout, putting it into the blowout hollow to repair natural contours and strengthen funnel closure.

Once the blowout has been re-contoured it will be necessary to use other stabilisation and rehabilitation techniques such as brushing and planting. These techniques may also be useful if it is impractical to remove sand from the beach or outer edges of the blowout.

Blowout repair with earthmoving machinery.

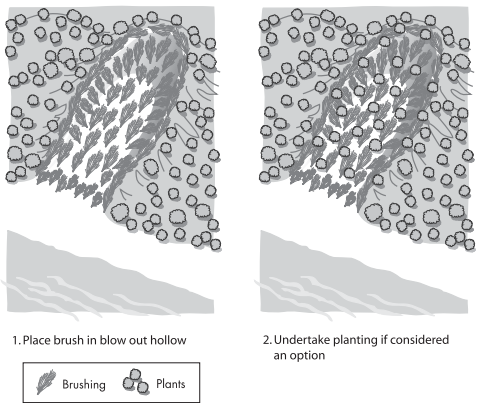


Figure 7-14

Blowout repair without earthmoving machinery.

7.4.2.2 Sand-trapping fences

Sand-trapping fences are used to trap sand for building dunes. They also reduce wind velocity by offering a partial wind shadow for up to 20 times their height.

Sand trapping fences usually comprise timber supports with hessian, brush, shade-cloth or mesh spread between supports. They are generally oriented at right angles to the direction of the prevailing wind and should be designed to let 30-50% of the wind blown sand through the hessian, brush, shade-cloth or mesh. The height of the fencing should vary according to the situation, and can be calculated based on the wind shadow required.

An alternative method is to plant the stakes in along the planned fence line with gaps in between.

For sand-trapping fences to work effectively it is important that is an upwind source of mobile, wind-blown sand. If there is insufficient wind blown sand slowed or stopped by the fence, wind may scour out the toe of the fence, resulting in sand loss instead of accumulation. Advice on design and alignment of sand-trapping fences should be sought prior to their construction.

To obtain an appropriate dune height, three to five fences may need to be built in succession, as shown in figure 7-15. This can significantly add to the cost of this technique, as buried fencing material cannot be retrieved.

Windrows of brush can perform the same function as fencing, albeit more slowly, but they are biodegradable and usually significantly cheaper.

7.4.2.3 Soil reintroduction

In some situations a substantial amount of soil may have been lost from an unstable area. Areas of shallow limestone, clay and granite can be particularly prone to soil loss following vegetation disturbance. If there is not enough soil available to enable revegetation it may be necessary to reintroduce soil from another area. The re-establishment of soil profiles is a specialist exercise with correspondingly high costs. Technical advice is essential.

Soil can be obtained from mobile dune areas, coastal areas being cleared for development, or quarries. The soil should be free of rubble, rubbish, weeds and dieback. Waves will not penetrate loam or clay soils in the same way as sand, resulting in erosion problems at the site, and a poor substrate for plant growth.

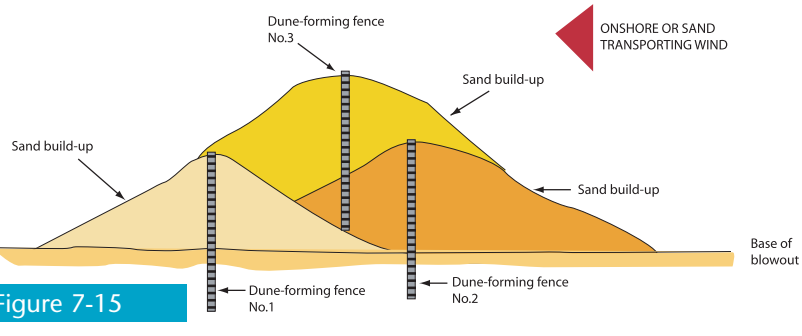


Figure 7-15

Sequence for the progressive installation of a sand-trapping fence. [Sketch: Soil Conservation Service, NSW (1990)]

Reintroduced soil should not be placed higher than the surface level of the soil that has been eroded away. The soil's porosity and capacity to support plant growth is most important. Ideally soil should be coastal in origin, have some organic content in the topsoil component

and be of similar grain size and colour to the original soil. Consult land managers about suitable sources in your area.

7.4.2.4 Sand renourishment

Commonly known as *beach renourishment,* this is typically used to artificially replace sand which has been eroded from a beach due to large scale alteration of the beach. The beach may have been affected by construction of a groyne or seawall nearby, or be a result of natural processes.

In many situations natural removal of sand, such as by storms or cyclones, won't have major, long-term impacts on the area and renourishment will not be necessary. Where infrastructure such as adjacent roads or buildings are threatened by sand loss, sand renourishment may be a necessary course of action.

Sand renourishment is typically an expensive capital works activity that is unlikely to attract community grant funding and will usually require development approval. Experienced land managers, geomorphologists and/or oceanographers can advise about the extent of the problem and whether it is likely to occur again, or whether the sand removed will return naturally as part of a natural erosion/accretion cycle.

7.4.3 Earthmoving machinery

In many situations dune reconstruction requires the use of earthmoving machinery. However, there are some limitations, such as:

- expense
- disturbance to the area caused by large machinery
- difficulty of accessing coastal sites
- machinery noise and movement, which may disturb coastal users and wildlife.

Be sure to discuss machinery needs with experienced engineers, works personnel and machinery operators to make sure that you can afford the machinery you want, that it can do the job you need and that it can get where you want it to go.

Skid-steer loaders

Skid-steer loaders, commonly known as *bobcats,* can be effective in small areas as the bucket is usually the desired width for creating pathways through dune areas. A double or triple bucket width could clear small-scale vehicle access ways. Bobcats can also be used to roughly level ground. Because of their small size, bobcats are not very effective for moving or placing large amounts of sand quickly and they may not be safe to use on steep, unstable sandy slopes.

Front-end loader

Front-end loaders are very manoeuvrable and can work in a tight space. They can move large amounts of sand quickly and can be used to level areas. They are also effective for loading basic raw materials such as sand or gravel onto tip trucks.

The bucket width is effective for creating wider paths, or roads, and they can also be used to move large rocks. Front-end loaders may need to be delivered by a semi-trailer, limiting their access to some coastal sites. Distance from storage yard to work site generally governs whether the front-end loader will be delivered by truck or driven.

Bulldozer

Bulldozers have caterpillar traction. Their blade width and power enable bulldozers to be effective in clearing for new roads or car parks. They can be useful in moving large amounts of compacted sand or rock in large open areas, or when large areas need to be levelled. Many bulldozers can also be fitted with a 'ripper' which can plough soil and rock to make planting easier. Because of their size they need to be delivered by a semi-trailer, which may limit access into some coastal sites.

Excavator

Excavators have an extendable arm with a digging bucket, grasper or auger attachment. The digging bucket can move large quantities of sand or rock in a short space of time, the grasper can be used to collect and spread large quantities of brush, and the auger can be used to break rock or dig holes for fencing or bollards. The extendable arm can be useful when steep slopes make access for other machinery difficult. Larger excavators, and those with caterpillar traction, need to be delivered by a semi-trailer, which may limit access into some coastal sites. Excavators are particularly versatile for fine work.

Earthmoving machinery at work along the coast

Figure 7-16

(a) a front-end loader;

Figure 7-17

(b) a bulldozer; and

Figure 7-18

(c) an excavator.

7.5 OFF-ROAD VEHICLE TRACK STABILISATION

Vehicles travelling along the coast can create networks of tracks that crush vegetation and compact or dig up soil, resulting in instability and degradation.

Tracks in sandy areas can lower the ground surface over time, making it bumpy, inundated, boggy or impassable. Over time, drivers construct new tracks adjacent to existing tracks to improve drivability. This pattern can be duplicated many times, leaving the area dominated by old and new tracks and erosion scars.

The management of vehicles along the coast should be considered as part of an overall management planning process that considers vehicle use in relation to site characteristics and ability to withstand pressure, and the compatibility of the activity with other uses. The planning process should also rationalise the number and alignment of tracks.

Once the nature of access and preferred alignments have been determined, vehicle impacts can be reduced. Suitability of methods will vary according to the environmental conditions and the amount of traffic to be accommodated. Generally, the materials and techniques described here will be useful in problem areas such as track intersections and steep slopes and corners, rather than an entire length of track. Table 7-3 provides a comparison of these techniques.

The Department of Conservation and Land Management has extensive experience in providing off-road vehicle track stabilisation measures and may be able to assist in determining needs for your area.

7.5.1 Track grading

The use of machinery such as front-end loaders or road-graders to reshape problem areas may be all that is required to maintain access and minimise track duplication. This can involve using available site materials to fill problem 'bogs', or simply knocking off centre ridges. Often this will reduce the creation of new tracks by continuing to offer the easiest access option.

7.5.2 Road base materials

Hard materials such as gravel, marl and crushed limestone can be used to patch problem sections of tracks. Beach sand can also be used to fill tracks that have become lowered, although it will need topping up periodically.

Where track duplication and erosion are severe on dune crests, some road base fill on the least eroded track may suffice in making it passable to vehicles.

7.5.3 Railway sleepers

Generally solid timber, railway sleepers have a high load capacity. Sleepers can be laid lengthwise, two deep and two wide, in a brick pattern an axle width apart as demonstrated in figure 7-19. This arrangement provides stable access for a variety of vehicles. Sleepers can be pinned into the ground for greater stability. Pins should not be exposed or of a kind which can puncture tyres.

Figure 7-19

Timber sleepers have been used to stabilise a sandy slope in Walpole/Nornalup National Park which is a popular off-road vehicle destination. [Photo: B Green]

7.5.4 Industrial rubber belting

Rubber belting, which can be sourced second hand from mining companies, is laid flat on the ground, an axle width apart. Belting can be cumbersome to handle, which is a consideration, particularly for installation. The belting can be pinned, but may be prone to splitting.

7.5.5 Treated pine chain tracks

Treated pine chain tracks consist of lengths of pine of strong dimensions, laid the width of a track (approximately 3 to 4 metres) and chained and bolted together at their ends approximately 10 to 20 centimetres apart. Whilst effective, they are expensive and tend to only be used in high use, problem areas.

7.5.6 Seagrass/seaweed and sand

Seaweed and sand laid in consecutive layers until a firm surface has been developed have been used for stabilisation of remote beachside vehicle tracks. The sand prevents the seaweed from rotting and the seaweed binds the sand. Vehicle movement over the material further consolidates it over time. Earthmoving machinery may be required to install this material in large-scale applications, and approvals are required to use seaweed as removal from the beach may interrupt natural ecological processes associated with the nearshore environment (see earlier discussion of seagrass and seaweed at section 7.4.1.3).

7.5.7 Coarse mulch

Consecutive layers of coarse mulch and sand can be used to stabilise a track in much the same way as seaweed. Care needs to be taken with the choice of mulch as too coarse a material may result in tyre puncture whilst less coarse material may not bind together to become firm.

Table 7-3 Track stabilisation techniques and methods

	Road Base Materials	Railway Sleepers	Industrial Rubber Belting	Treated Pine Chain Tracks	Seagrass/ Seaweed and Sand	Coarse Mulch
Source and Cost	If there is a nearby source of material it can be used to patch and maintain trouble spots	Relatively cheap	Can sometimes be obtained very cheaply or free of charge, although transport costs can be high	Expensive	Materials are often readily and naturally available from the coastal environment Use of earthwork machinery, required to transport and distribute the material, may be costly	Widely available at reasonable cost Use of earthwork machinery, required to transport and distribute the material, may be costly
Installation	Will require use of earthwork machinery (loader and 4x4 tip truck) Need to ensure machinery and raw materials are free of weeds and dieback	Relatively uncomplicated to construct although heavy manual work May require use of earthwork machinery May contain weed seeds/dieback Can dislodge if not installed properly	Can dislodge on steep inclines if not pinned		Relatively easy for spot application to dry, sandy trouble spots	Earthwork machinery may be required to distribute the material
Situations for Use	Can be useful for corners, intersections, boggy patches and hill crests Useful where lengths of track have cut below the natural ground level	Provides traction on steep slopes Provides a hard surface in boggy areas Allows vegetation to recover around sleepers	Provides stable and smooth vehicle access Provides a hard surface in boggy areas Can be slippery when wet and provides limited traction	Provides traction on steep slopes Can be used to provide traction on wet or flooded tracks if pinned down	May not be effective on steep slopes	May be ineffective on steep slopes

Table 7-3 Track stabilisation techniques and methods (continued)

	Road Base Materials	Railway Sleepers	Industrial Rubber Belting	Treated Pine Chain Tracks	Seagrass/ Seaweed and Sand	Coarse Mulch
Maintenance	Minor. The track surface should prevent erosion.	Requires regular maintenance Can be buried quickly if sands are mobile. Difficult to locate once this has occurred Prone to rot and termites	Requires regular maintenance Can be buried quickly if sands are mobile Won't rot. Long lived and durable	Can be lifted and replaced to avoid burial with sand over time Logs can be broken by heavy vehicles if ground is unstable Not susceptible to termites Materials may be attractive to thieves	Can be buried quickly if sands are mobile May break down quickly in wet environments	Can be buried quickly if sands are mobile May break down quickly in wet environments, generally long lived

7.6 ONGOING MANAGEMENT

Following any coastal management project, additional time will be required to ensure that hard work is maintained and to assess whether methods and techniques chosen were the most appropriate for the site and its issues. This ongoing monitoring and evaluation is an important aspect of any coastal project.

Maintenance will be ongoing and can be an expense in itself. It is important that you include maintenance costs in your initial rehabilitation budget and that you know who will take on this responsibility once your rehabilitation is completed. Voluntary community groups who undertake rehabilitation on behalf of local or State government will need to discuss the issue of ongoing maintenance with the relevant agency to ensure all parties are willing to be involved in the short-term and long-term maintenance. Without adequate resources and support much of the effort of rehabilitation can be wasted.

Those responsible for maintenance may find it useful to develop a Maintenance Checklist which can be used to evaluate the site regularly. Maintenance Checklists are easy to develop and use. Make a list of things to be checked each time the site is visited, such as where work is required or how the project is progressing in general.

The following is an example of a Maintenance Checklist, which can be developed to fit your situation. For a large site it may be worth printing a map on the reverse side so you can mark the location where maintenance is required.

MAINTENANCE CHECKLIST

This sheet refers to a map of the site [note the map reference and where it is kept, ideally it should be provided on the back of this sheet]. If maintenance of infrastructure or works is required, indicate the location on the map and describe the work required in the space provided.

If maintenance is required, please tick.

FENCING .....

Comments .....

.....

.....

CARPARK .....

Comments .....

.....

.....

SIGNS .....

Comments .....

.....

.....

REVEGETATION .....

Comments .....

.....

.....

BEACH ACCESS – Pedestrian .....

Comments .....

.....

.....

BEACH ACCESS – Vehicle .....

Comments .....

.....

.....

.....

BARBECUES .....

Comments .....

.....

.....

TOILETS .....

Comments .....

.....

.....

Shade shelters, picnic furniture, bins, vegetation cover and weeds are other possible headings.

8. WEEDS AND WEED MANAGEMENT

CONTENTS

FIGURES

TABLES

8.1 WHAT IS A WEED?

Weeds may be either introduced plants or native plants growing as weeds outside their natural range.

WA's State Weed Plan defines a weed as:

"A weed is defined as a plant which has, or has the potential to have, a detrimental effect on economic, social or conservation values." (Definition adopted in WA.)

Coastal weeds fall into the category of environmental weeds. They occupy a unique niche in a harsh environment with a limited number of competitors. They have developed survival mechanisms to allow them to cope with the extreme coastal elements such as wind, low nutrients, salt, lack of protection and water. Some coastal weeds stabilise mobile dunes, thus preventing the damaging effects of natural processes, such as sand movement, from engulfing infrastructure. The function of a weed in an ecosystem needs to be considered when deciding on a course of management and control of weeds in the coastal zone.

The impact of coastal weeds may differ from site to site. For example the common coastal weed *Tetragona decumbens* (Sea Spinach) provides a functional role stabilising the foredunes, occupying a niche that often has no local equivalent. However, this species also grows in more stable areas such as hind dunes and cliff tops; in these areas it is competing with the locals and compromising the ecological integrity of the ecosystem in which it is growing.

Figure 8-1

Example of *Tetragona decumbens* providing a functional role.

8.2 THE IMPACT OF WEEDS IN COASTAL ENVIRONS

Weeds impact the coast by:

- reducing biodiversity at a site, and so threatening local plant and animal species
- disrupting ecosystem processes, for example weeds may increase the frequency of fire
- disrupting coastal processes, for example weeds may contribute to erosion at some sites and alter dune configuration
- inhibiting coastal rehabilitation strategies
- requiring resources for their control.

8.3 HOW DID THE WEEDS GET THERE?

- The *feral wheelbarrow* – many weeds start life as garden plants that are dumped in the scrub across the road.
- Many escapees from neighbouring gardens or landscape works.
- Weeds have a variety seed dispersal mechanisms such as sticky or hooked seeds that can hitch a ride on humans and animals.
- Some seeds are dispersed though the guts of animals and birds (including humans – did you know that tomato seedlings germinate in the sludge left after sewerage has been though the entire treatment system!).
- Car tyres may have thorny seeds lodged in them.
- Building materials, especially road base, may contain weed seed.

- Past coastal rehabilitation efforts have introduced, for example, Marram grass, Pyp grass, Victorian Tea Tree and *Spinifex sericeus.*
- An altered environment, for example increased nutrients and water, may encourage the germination and growth of weeds that otherwise wouldn't be have been able to grow in the coastal environment.
- Where there is access for people, vehicles and animals, there is access for weeds.

8.4 RATING OF WEEDS

Weeds can be prioritised in terms of the amount of damage, both economic and environmental, they cause. However, this rating becomes subjective especially when considering different regions or a site's environmental characteristics. The rating of a weed species may also change with time.

Table 8-1 Rating of weeds

Rating	EWSWA	Management Response
1	**High** – invasive weed with a wide distribution and environmental impacts	Prioritise control, seek funding to ensure control
2	**Moderate** – a weed that is either – invasive and has a wide distribution, or – invasive and impacts the environment or – has a wide distribution and impacts the environment.	Control if funds are available. High level of monitoring
3	**Mild** – a weed that is either – invasive, or – has a wide distribution or – impacts the environment.	Control where appropriate. Monitor spread.
4	**Low** – a weed that is neither invasive, does not have a wide distribution nor impacts the environment.	Low level of monitoring

The Environmental Weed Strategy for Western Australia (EWSWA) uses three key criteria to rate weeds: invasiveness, distribution and environmental impacts. The three key criteria can be applied to any weed species found on the coast to provide an indication of management response required and which ones to tackle first (Table 8-1).

8.5 TYPES OF WEEDS

Many weed species successfully establish themselves by having more than one mechanism for reproduction. This is especially true for perennial species. To control or eradicate these species from a site, a three-pronged attack may be necessary to:

1. kill/remove the adults
2. kill newly emerged seedlings
3. block the opportunities for further introduction.

The control of invasive weeds can vary from site to site depending on the conditions present at the site and the seriousness of the particular weed species that is being tackled. Guidelines for weed control are based on generalisations about the occurrence of the weed species and its growth habit. Many weed species will fall into more than one of the following categories depending on the stage of growth the plant is at.

Woody trees

The removal of the adult tree may only be half of the issue dealt with when removing woody weeds. Many woody weeds, for example the Victorian Tea Tree (*Leptospermum laevigatum*), produce thousands of viable seeds. Removing the adult only provides space for 'kids' to take over from where the parents left off. Being able to identify the seedlings and remove them before they flower is paramount for successful eradication.

Small woody shrubs

Small woody shrubs are mostly perennial plants. They are difficult to spray or slash and may require the same manual removal techniques as woody trees.

Herbaceous plants

Herbaceous plants make up the vast majority of coastal weeds. They are not woody and can be broad leafed, succulents or fleshy plants.

Grasses

Grasses are narrow leafed plants that have a variety of growth forms, they can form distinct clumps, for example veldt grass, or they may be more spreading, such as couch, or pyp grass. Small clumps of grasses can be manually removed; distinct patches of spreading grasses can be successfully killed by solarisation (see section 8.6.1). It is important to note that some grasses found along the coast such as Marram grass and pyp grass have been planted to stabilise dune blowouts and any removal strategy should have an immediate erosion control strategy in place.

Vines and scramblers

Vines and scramblers, such as Bridal Creeper and Stinking Passion Flower, are usually perennial plants with woody or partially woody stems adapted for climbing. In coastal environments where vegetation is usually low growing, vines and scramblers can form a mat over the top of the vegetation. Often there is more than one main stem so, if using the cut and paint technique of eradication, ensure all main stems are cut. It will usually be obvious the day after treatment if not all of the main stems have been cut as the cut stems will wilt.

Bulbs, tubers and rhizomes

Bulbs, tubers and rhizomes are all modified underground stems that are capable of generating new plants. Removal strategies for these plants must ensure the underground part has either been killed or entirely removed. Hand removal of these plants should focus on the removal of all underground parts while creating the least amount of soil disturbance. Examples include *Trachyandra divaricata* and *Pelargonium.*

8.6 WEED REMOVAL TECHNIQUES

Prevention is the best weed management tool. Direct control has to be part of integrated management of an area, which includes complementary coastal management practices.

Managing ecosystems to prevent and control weed invasion requires:

- An understanding that weed control is only one aspect of the rehabilitation and conservation of a site
- Identification of the priority weeds in the system and controlling them first
- Complementary rehabilitation techniques to prevent other weeds occupying the vacated niche
- Dedication and monitoring to ensure quick action is taken to tackle the weed before it becomes a problem
- Focus on the invaded ecosystem rather than the invader. Surrounding activities that may be encouraging the spread of weeds such as the use of weed infested fill for construction or nutrient runoff
- Education. People need to be aware of how their actions and presence at a site may impact on the natural environment by the introduction or spread of weeds.

THE KEY TO SUCCESSFUL WEED CONTROL

- Know your weed.
- Watch you feet, (avoid trampling innocent bystanders).
- Don't give weed seed a free ride in your clothes or equipment.
- Minimise soil disturbance.
- Do not over clear.
- Allow time for natural regeneration.
- Persistence.

8.6.1 Physical/manual control

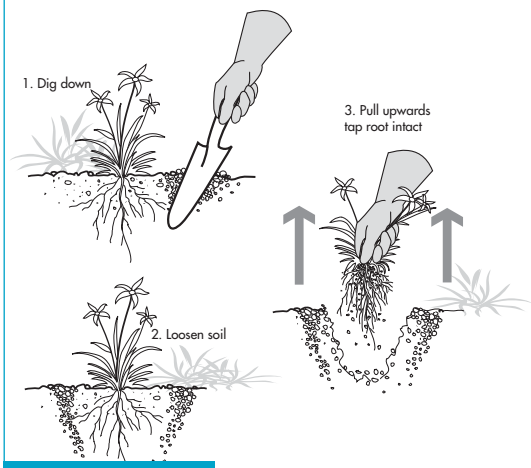


Figure 8-2

Hand pulling.

Cultivating

Cultivating is the turning over of the soil to bury and kill weeds. However, in some cases, it may have the opposite effect of chopping up and spreading propagules. It is important to know what you are dealing with before this method is used.

Hand pulling

Hand pulling is the most environmentally friendly and labour intensive method of weed control. It requires the use of many hands. The key to hand pulling is to remove the entire plant, ensuring propagules are not left behind to prosper.

Ringbarking

Ringbarking involves cutting away a complete ring of bark from a tree trunk, which prevents movement of nutrients from the roots to the leaves.

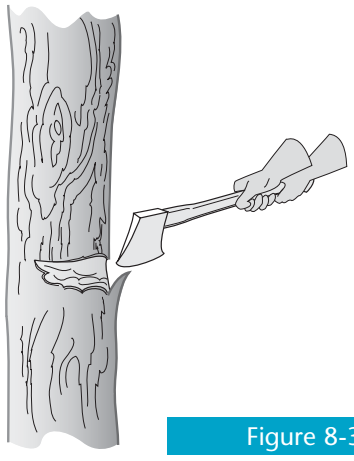


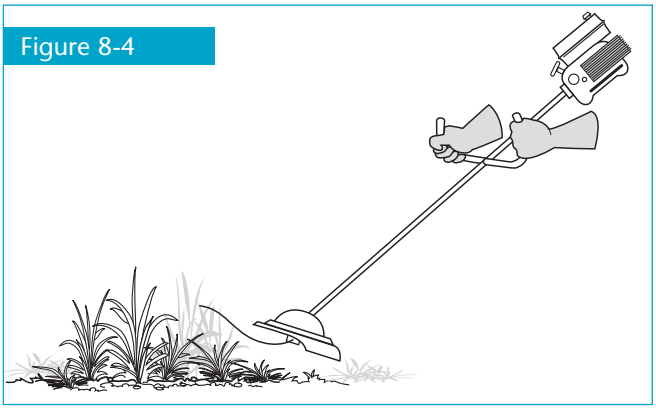
Figure 8-3

Ringbarking.

Slashing

Slashing involves mowing down, or brushcutting, aboveground biomass. It is very useful for the removal of flowers and seed heads but is rarely useful on its own.

Figure 8-4



Slashing.

Topping

Topping is cutting the top off a plant. For woody weeds this maybe done with a chainsaw or handsaw, and for smaller herbaceous weeds it can be done with secateurs.

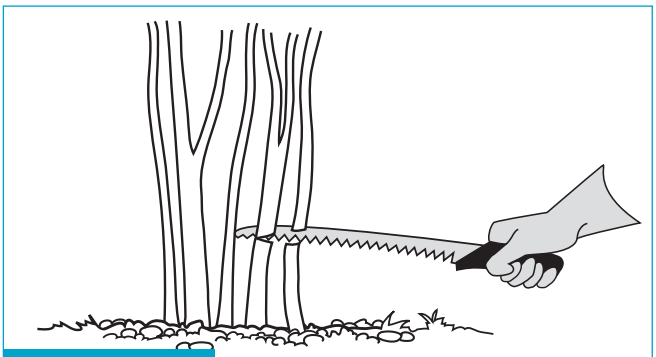


Figure 8-5

Topping.

Solarisation

Solarisation is smothering with plastic sheeting until seeds or plants have been cooked. Solarisation to kill weeds and sterilise soil can be achieved by laying good quality, UV resistant black plastic sheeting over areas of low weeds or newly turned soil and leaving undisturbed for 2-3 weeks. For best results the black plastic should be in direct sunlight and the soil should be damp. This encourages the weed seeds to germinate, after which they die due to the high temperatures under the plastic. The best success is achieved during summer and early autumn.

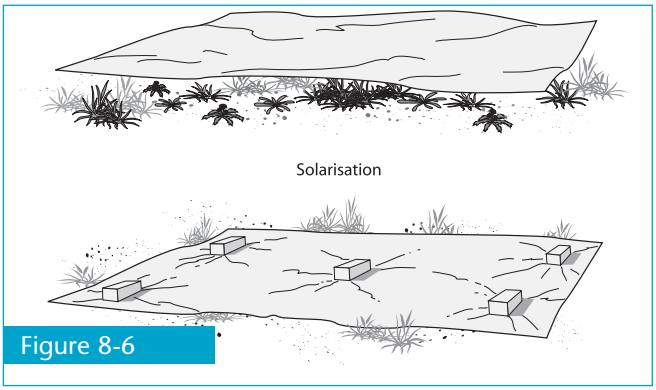


Figure 8-6

Solarisation.

Suppression – e.g. mulching

Mulch provides a physical barrier that suppresses the growth and germination of weeds. Any number of biodegradable materials may be used as mulch including newspapers, wood chips and wood shavings, tree prunings, old carpet and underlay (must be biodegradable) or commercially available mats. It is important that high nutrient mulches, such as green waste and grass clippings, are not used in the nutrient starved coastal environment as they may promote the growth of other weed species.

Figure 8-7

Suppression.

Smothering (out-competing weeds)

Planting native colonising species, such as *Acacia cyclops, A. saligna, A. rostellifera, Zanthia* and *Olearia axillaris* at densities of 4 to 6 plants per square metre will allow the natives to out-compete some weed species. Once the native vegetation is taller than the weeds it reduces light and space available for the lower growing weeds, which reduces their vigour and population. This method works especially well for suppressing the growth of Marram grass and some Euphorbias.

8.6.2 Biological – introduction of natural predators or disease

This method of weed control has only been successful for a handful of species and is not likely in the short- to medium-term to be a useful control mechanism for most coastal weeds. There are currently biological controls for two coastal species: these are a leafhopper and fungus for bridal creeper and Bitou bush. Both of these biological control agents may not kill the plant but weaken it and make it more susceptible to other control techniques.

8.6.3 Ceasing irrigation

Ceasing irrigation or irrigation overlap onto areas of native dune vegetation can reduce the competition of exotic species (especially lawn grasses) with natives.

8.6.4 Chemical control – the use of herbicides

There are four key types of herbicides: residual, contact, translocated, and selective. The attributes of these are described below, together with example products. However, there are over 140 herbicides currently available. The examples listed are the most commonly known and can be substituted for other brands with the same active ingredient.

Residual

These herbicides remain active in the soil and are absorbed into the plant by the roots. They are not recommended for areas to be planted or direct seeded. An example is Ronstar®.

Contact

These herbicides only kill the plant material they come into contact with. Not effective for plants with underground propagules such as bulbs, rhizomes or stems. An example is steam, Basta®.

Translocated

The most commonly used herbicide, this chemical is translocated into the roots of the plant killing the above and below ground parts. An example is Roundup ® or glyphosate)

Selective

Examples of selective herbicides are Verdict® and Fusilade®. They are very useful especially for targeting grasses in native vegetation. Low concentrations of some of the hormone-based herbicides containing 2,4-D amide, for example Ally® and Brushoff® can also be safely sprayed amongst native vegetation without killing it. The key coastal weeds these herbicides target are Bridal Creeper and Pelargonium. As a precaution native vegetation, especially seedlings, should be guarded from direct spray.

Herbicides should always be used as per specifications on the Material Safety Data Sheets (MSDS) supplied with all herbicides. Off label licenses for the use of some herbicides can be issued. Further information can be obtained from Department of Agriculture.

A herbicide training course detailing the use of herbicides should be taken before using any herbicides. These training courses may be available through your local Landcare Centre or TAFE college.

The use of some herbicides is restricted and may require a licensed operator to use them.

Herbicides can be applied in a number of different ways. These are demonstrated by the diagrams below:

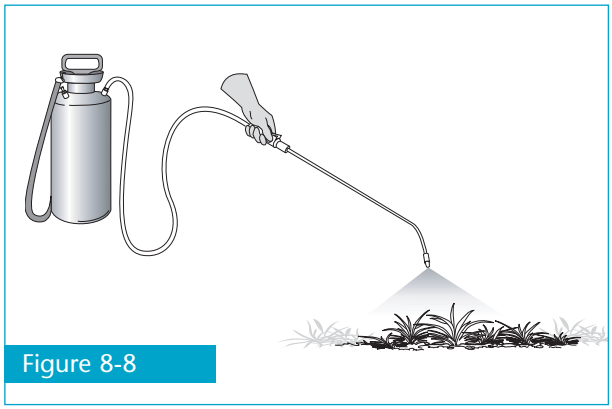


Figure 8-8

Foliar spraying.

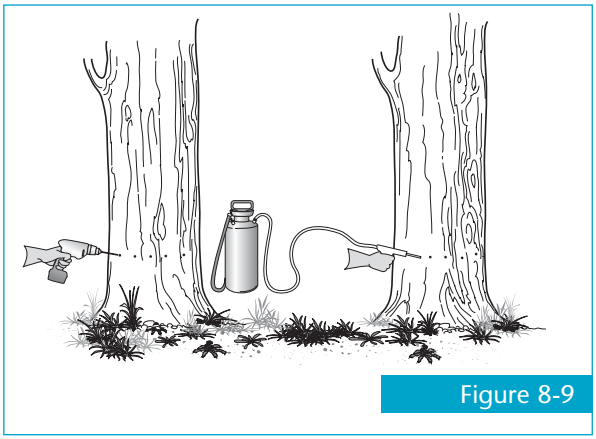


Figure 8-9

Drilling (or chip/cut) and injection.

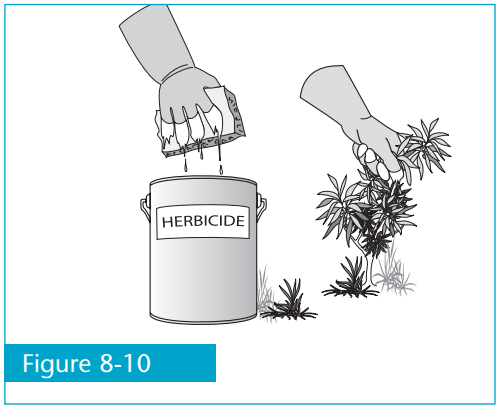


Figure 8-10

Wiping.

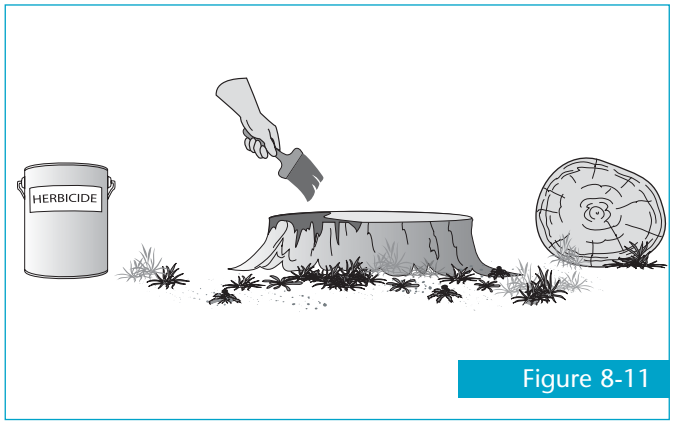


Figure 8-11

Cutting and painting.

Table 8-2 Summary of weed control techniques

	Woody weeds	Shrubs	Herbaceous plants	Grasses	Vines and scramblers	Bulbs, tubers and rhizomes
Mulch/ smother			all year	all year		all year
Solarisation			spring and summer	spring and summer		spring and summer
Topping	all year	all year			all year	when flowering
Ring Bark	all year				all year	
Pull	all year	all year	all year	all year	all year	all year
Cut and Paint	spring	spring			spring and summer	
Slash			all year	all year	all year	all year
Foliar Spray			spring	spring and summer	spring and summer	spring and summer
Inject	spring				spring	
Wipe					spring	prior to flowering

NB Seasonal timing for the southern temperate zone. Check growth and flowering times of individual species to ensure weeds are targeted at the optimum time.

8.7 DISPOSAL OF WEEDS

It is important to thoroughly dispose of weeds once they have been removed to ensure the waste material doesn't become a weed problem. The seed heads of many plants remain intact while they are attached to a living plant but once a seed head is cut off or pulled out the plant material will quickly dry out, especially in a coastal area, and release seeds. All plant material should be removed from the site the same day and disposed of at the tip, or stacked and burnt in a hot fire. (Fire restrictions may apply).

Large volumes of material such as tree branches that have to be carried through the bush for disposal should be placed onto a tarp and wrapped up while being carried to the disposal site ensuring no litter is dropped en route.

8.8 SAFETY

Protective clothing, sturdy shoes and gloves should always be worn when undertaking bushland work. Wear glasses/goggles when removing spiny plants. Wear the appropriate protective clothing, such as chaps, goggles and gaiters, when using motorised equipment or handling chemicals. Protect yourself from the sun by wearing sunscreen, glasses and hat. Always have plenty of water nearby, and a first aid kit on hand.

Look out for:

- spiders and biting insects
- spines and prickles
- rocks
- snakes
- irritating sap
- sharp rubbish such as broken glass, tin and syringes.

8.9 WEED MANAGEMENT STRATEGY

Weed control is a single component of an integrated range of techniques that are required to ensure successful management of a coastal rehabilitation project. It is crucial that weed control is fully integrated with an overall plan of management for a particular site. Section 3: *Coastal Management Planning* provides further guidance on the preparation of a coastal management plan.

A checklist of key considerations for developing a weed management strategy for an area is provided below:

1. Identify weeds at the site

   A herbarium (pressed plants) or photographic records can be helpful. Being able to identify weed seedlings will also be extremely helpful.

2. Map weed infestations

   See the Environmental Weeds Awareness Network (EWAN) web site for techniques.

3. Determine the weed species that represent the most serious threat

   Weeds that are the most serious threat can be determined from the following criteria:

   - Invasiveness – based on how it reproduces
   - Distribution – how widely is it distributed?
   - Impact – is it displacing native vegetation?

4. Work from light infestations to heavy infestations

   Once the distribution of the weeds has been identified, it will be possible to identify a starting point for weed control using the principle of working from light infestations to heavy.

5. Draw up a calendar for the timing of weeding events

   This should include:

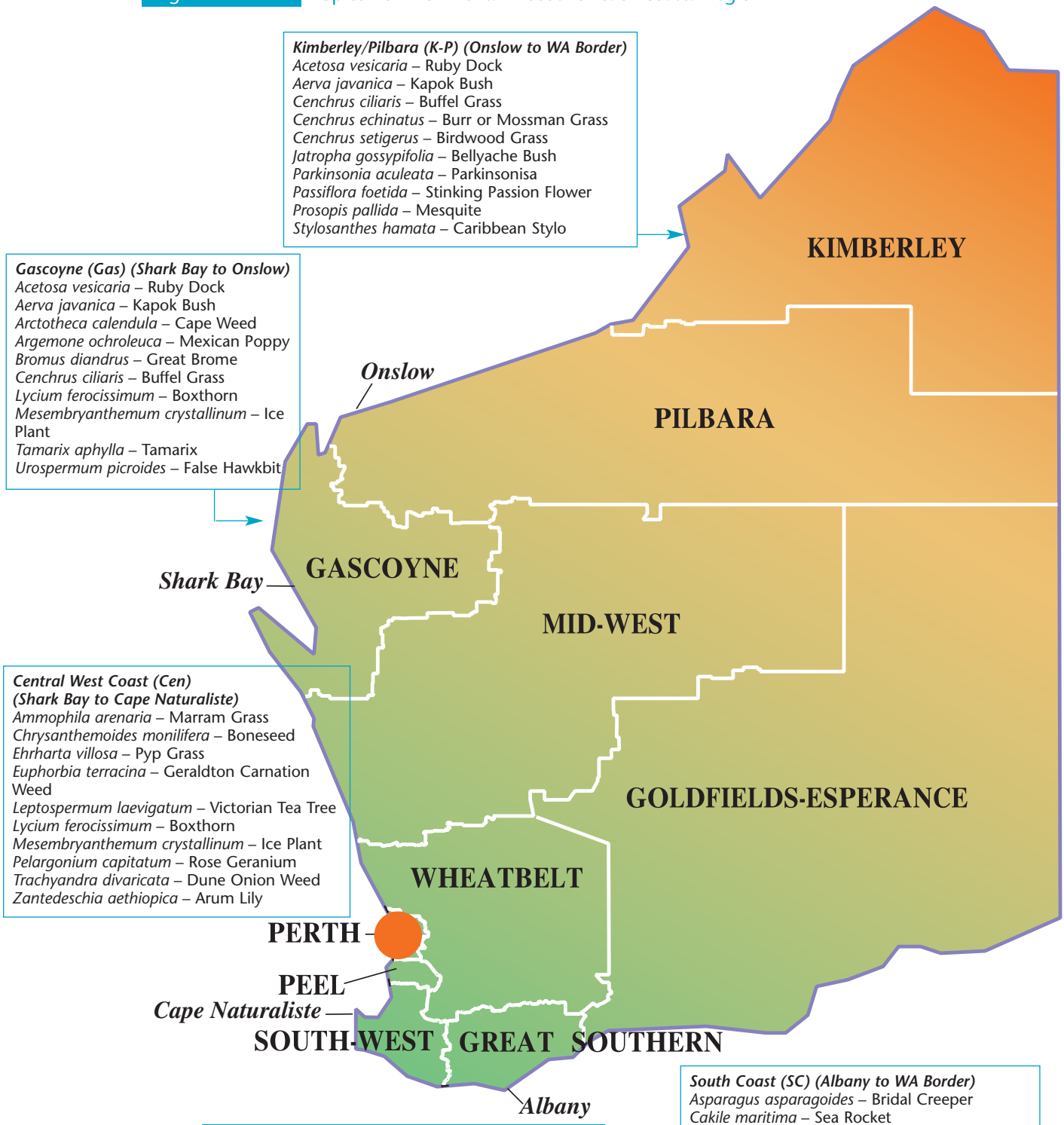
   - the best timing to undertake control for the individual species to be targeted (i.e. spraying prior to seed set, or hand pulling of seedlings after spraying). This will identify a suite of weeds that can be targeted at a particular time.
   - how weeding activities fit in with other activities at the site, such as plantings, or stabilisation work
   - a scheduled follow-up program
   - identifying the weeds that require chemical spray, such as *Pelargonium* and scheduling these activities before hand weeding of seedlings should be considered.

Weed control is an ongoing task and will always require follow-up to ensure success. This should be recorded on the calendar.

8.10 COASTAL WEED SPECIES

The *Top Ten* lists of environmental weeds for each of the coastal management zones have been compiled based on information from coastal managers from each of the areas. No analysis of distribution or invasiveness has been used to determine a rating for inclusion on the lists and it is highly likely the Top Ten weeds for a particular stretch of coast will vary from the given lists for the five regions. Details for all of the top ten species from each of the coastal management zones are provided. Photos, a description and control strategies are detailed for all the listed 'Top Ten Species'.

Figure 8-12 Top ten environmental weeds for each coastal region



8.11 DESCRIPTIONS OF THE "TOP TEN" WEEDS FROM EACH OF THE COASTAL REGIONS

This section contains information about the Top Ten weeds listed for each of the regions The descriptions are arranged in alphabetical order rather than on a region by region basis as some the Top Ten weeds occur in more than one region. Table 3 provides a comprehensive list of the weeds of the Western Australian coastal zone. All of the comments on control strategies in this section and Table 3 are intended as a guide only.

Images of the individual weed species used in this section of the manual were generously provided by the Plant Protection Society of WA (Inc.) from the book Western Weeds –a guide to the weeds of Western Australia which was compiled with the assistance of the Gordon Reid Foundation for Conservation. The Western Australian herbarium's FloraBase, was used to check current species names and status as an exotic species.

Acetosa vesicaria Ruby Dock [Photo: KEN ATKINS]

Fleshy hollow stemmed herb 0.2 to 1m
Distribution K-P, Gas
Form Herb
Lifecycle Annual
Flowering Red-pink flowers, July to Sept.

Comments
No specific information available on control for this species. Suggest hand pulling for small plants. Wear gloves as sap may cause skin irritation. Fleshy herbs tend to respond best to low concentrations (20mL in 10L of water plus 0.25% wetting agent) of hormone based herbicides such as 2,4-D amine.

Aerva javanica Kapok [Photo: GREG KEIGHERY]

Branched erect herb 0.4 to 1.4m.
Distribution K-P Gas
Form Herb
Lifecycle Perennial
Flowering Woolly white flowers, Jan. to Oct.

Comments
No specific information available on the control of this species. Suggest solarisation, hand pulling for small plants, slash to remove flowering heads prior to seed set or foliar spray Glyphosate (50mL in 10L) when actively growing prior to flowering.

Ammophila arenaria Marram Grass

[Photo:GREG KEIGHERY]

Rhizomatous grass 0.4 to 0.7m
Distribution Cen, SWC
Form Grass
Lifecycle Perennial
Flowering Green flowers, Oct. to Jan.

Comments
Marram Grass has historically been planted to stabilise dune blowouts and aid in sand accumulation. Care should be taken to ensure the removal of the Marram Grass does not cause further degradation of the dunes. Methods for controlling this species include foliar spraying with either Glyphosate or one of the selective grass herbicides or solarisation. Once killed the below ground biomass should be left in place (as it will continue to provide dune stabilisation) while new vegetation cover is established.

Arctotheca calendula Cape Weed

[Photo:JON DODD]

Low growing herb usually found in wastelands and cultivated areas. 0.03 to 0.3m.
Distribution Cen, SWC, SC
Form Herb
Lifecycle Perennial
Flowering Flowers yellow with black centres, Aug. to Nov.

Comments
Cape weed readily invades bare and overgrazed areas. Control methods include solarisation, hand pulling, repeated slashing to remove flowering heads prior to seed set, and foliar spray using Lontrel® or Glyphosate (100mL in 15L of water). The related plant Arctotheca populifolia (Beach Daisy) can be treated using the same techniques.

Argemone ochroleuca Mexican Poppy

[Photo:PENNY HUSSEY]

Blue green spiny thistle with poppy flowers and yellow sap.
Distribution Gas, Cen, SWC,
Form Herb
Lifecycle Annual
Flowering Yellow, orange or white flower, Nov. to Feb.

Comments
Noxious weed in WA. Control of young plants can be achieved by solarisation, hand pulling and repeated slashing prior to seed set. Chemical controls include; hormone-based herbicides (2,4-D amide) for young plants in bushland and Glyphosate in non-selective areas.

Asparagus asparagoides Bridal Creeper [Photo: ROD RANDALL]

Winter-growing tough-stemmed climbing vine.
Distribution Gas, Cen, SWC
Form Tuberous vine
Lifecycle Perennial
Flowering Greenish white flowers, Aug. to Sep.

Comments
Biological controls have been developed for this species, which interfere with the growth, thus weakening the plant and making it more susceptible to chemical treatments. This species can be successfully eradicated by foliar spraying with a hormone-based herbicide. Ally ® or Brushoff ® (0.1gm in 10L water plus 25% wetting agent) prior to flowering. Experimental applications of a mixture of glyphosate and brushoff have been used to successfully eradicate bridal creeper from bushland areas in Perth (Kings Park and Bold Park).

Bromus diandrus Great Brome [Photo:GREG KEIGHERY]

Tufted grasslike herb 0.2 to 0.7m
Distribution Gas, Cen, SWC,
Form Grass
Lifecycle Annual
Flowering Purple, yellow, green, cream flowers, Aug. to Nov.

Comments
Selective grass herbicides can be used on Bromes. Foliar spray before flowering using Fusilade® or similar (at a rate of 2L per ha). Small populations can be controlled using solarisation or hand pulling. The seeds have sharp bristles that can pierce the skin.

Cakile maritima Sea Rocket [Photo: ROD RANDALL]

Lobed wavy leafed, succulent, low spreading herb. Found on beaches and seashores.
Distribution Gas, Cen, SWC, SC
Form Herb
Lifecycle Annual
Flowering Four petalled white, pink and purple flowers, Jan. to Dec.

Comments
This species is considered beneficial in some situations as the roots bind sand dunes. The control of this species is usually dependent upon the immediate replacement with local species. Control by hand pulling or with selective herbicide such as Metosulam ®. No application rates suggested. This species is similar to Cakile edentula (American Sea Rocket), which can be treated in the same manner.

Cenchrus ciliaris Buffel Grass [Photo:PENNY HUSSEY]

Tufted grasslike herb
Distribution K-P, Gas, Cen
Form Grass
Lifecycle Perennial
Flowering Purple flowers, Feb. to Oct.

Comments
Buffel grass is considered a valuable feed for cattle in the north. However, it produces allelopathic substances that prevent the germination and growth of native plants in coastal and bushland environments. It may be difficult to control using manual techniques due to the vigorous growth once it is established in an area. Foliar spray with Fusilade ® or Glyphosate (20mL/10L) when actively growing. Related grasses that can be treated in a similar manner include Cenchrus setiger (Birdwood Grass), C. echinatus (Mossman Grass).

Cenchrus echinatus Burr or Mossman Grass [Photo: PENNY HUSSEY]

Tufted grasslike herb with low growing stems that root at the nodes.
Distribution K-P, Gas, Cen
Form Grass
Lifecycle Annual and perennial (rarely)
Flowering Green with purple flowers, Jan. to Aug.

Comments
Noxious weed in WA and NT. It is an aggressive pioneer plant that readily establishes in denuded areas. The spines can cause foot injury in recreation areas and can cause eye, mouth and foot injuries in dogs and horses. It may be difficult to control manually due to sharp spines. Foliar spray with Fusilade ® or Glyphosate (20mL/10L) when actively growing prior to seed set. It is important to eliminate all plants in the area as the masses of seed produced by a single plant are readily spread by the wind. Related grasses that can be treated in a similar manner include Cenchrus setiger (Birdwood Grass), C ciliaris (Mossman Grass). See Queensland DNR fact sheet for more information on Mossman Grass.

Cenchrus setigerus Birdwood Grass [Photo: PENNY HUSSEY]

Rhizomatous tufted grass like herb.
Distribution K-P, Gas, Cen
Form Grass
Lifecycle Perennial
Flowering Purple, black or green flowers, Feb. to Aug.

Comments
This species is similar to the other Cenchrus species. May be difficult to control manually. Foliar spray with Fusilade ® or Glyphosate (20mL/10L) when actively growing.

Chrysanthemoides monilifera Boneseed [Photo: ROD RANDALL]

A bushy woody erect shrub up to 1m
Distribution Cen, SWC
Form Shrub
Lifecycle Perennial
Flowering Yellow flowers with brown centres, Jun. to Oct.

Comments
Listed as a weed of national significance. Boneseed was planted in the Eastern States during the 1950s and 1960s to stabilise sandy areas. It produces toxins from the leaf litter and fruit that inhibit germination and the vigour of neighbouring plants. Two biological controls have been developed for this species: Bitou tip moth and a rust fungus. Hand pull seedlings; larger shrubs can be cut and painted with glyphosate. Cut material should be burnt on site to prevent seeds being spread.

Conyza bonariensis Flaxleaf Fleabane [Photo: PENNY HUSSEY]

A leafy hairy erect plant usually less than a metre tall, with fluffy seed heads.
Distribution K-P, Gas, Cen, SWC, SC
Form Herb
Lifecycle Annual or biennial
Flowering White to yellowish flowers, Sept. to May

Comments
Hand pull and bag prior to seeding. Gloves should be worn as the sap causes skin irritation. Foliar spray with Glyphosate (10mL in 10L). This species may naturally decline with heavy plantings of native species.

Ehrhata villosa Pyp Grass [Photo: GREG KEIGHERY]

An erect vigorous rhizomatous grass that sets little viable seed.
Distribution Cen, SWC
Form Grass
Lifecycle Perennial
Flowering Purple–green flowers, Oct. to Nov.

Comments
Pyp grass was introduced and planted for erosion control on beaches. It can spread between 4 and 9m per year. Hand pulling should be avoided as the pulling up of the vigorous rhizomes will severely disturb the site and possibly lead to erosion. Solarisation can effectively kill Pyp Grass. Foliar spraying with Glyphosate (20ml per L with 25ml of wetting agent).

Eragrostis curvula African Love Grass [Photo: PENNY HUSSEY]

Dense tufted grass like herb 0.3 to 1.2m tall.
Distribution Cen, SWC, SC
Form Grass
Lifecycle Perennial
Flowering Purple–green flowers, Aug. to May

Comments
Hand pull small infestations. Foliar spray using either a selective herbicide Fusilade® (2L per ha) or Glyphosate (20ml per 10L).

Euphorbia paralias Sea Spurge [Photo: GREG KEIGHERY]

Erect bushy herb 0.2 to 0.6m grows in white beach sands and dunes.
Distribution Cen, SWC, SC
Form Herb
Lifecycle Annual
Flowering Yellow to green flowers Oct. to Jun.

Comments
Care should be taken when handling any of the Euphorbias as the milky sap irritates the skin and may cause temporary blindness if it gets into the eyes. Foliar spraying using hormone herbicide such as 2,4-D amine (0.05g in 10L with 10ml of wetting agent). Mechanical slashing is not recommended due to increased possibility of contact with the toxic sap.

Euphorbia peplus Petty Spurge [Photo: ROD RANDALL]

Erect herb 0.05 to 0.4m.
Distribution K-P
Form Herb
Lifecycle Annual
Flowering Green-yellow flowers, July to July

Comments
Care should be taken when handling any of the ***Euphorbias*** *as the milky sap irritates the skin and may cause temporary blindness if it gets into the eyes. Foliar spraying using hormone herbicide such as 2,4-D amine (0.05g in 10L with 10ml of wetting agent). This small Euphorbia can be effectively controlled using solarisation.*

Euphorbia terracina Geraldton Carnation Weed

[Photo: JON DODD]

Erect herb branching at ground level, 0.1 to 0.5m.
Distribution Cen, SC
Form Herb
Lifecycle Short lived perennial
Flowering Aug. to Dec.

Comments
Geraldton Carnation Weed is a noxious weed of WA and SA. Care should be taken when handling any of the ***Euphorbias*** *as the milky sap causes skin irritation and may cause temporary blindness if sap gets into the eyes. Manual removal should ensure the entire root system is removed. Slashing is only effective after seeding. Seeds can not germinate if buried deeper than 5cm in the soil. Foliar spraying using hormone herbicide such as 2,4-D amine (0.05g in 10L with 10ml of wetting agent).*

Jatropha gossypifolia Bellyache Bush

[Photo: GREG KEIGHERY]

Erect sticky shrub often confused with castor oil plant.
Distribution K-P
Form Shrub
Lifecycle Perennial
Flowering Red to brown flowers, Feb. to May

Comments
Bellyache bush is shallow rooted and can be effectively removed by hand pulling. Care should be taken as the sap may cause skin irritations. Foliar spray using 2,4-d amine (Brushoff® 10g/100L plus wetting agent).

Leptospermum laevigatum Victorian Tea Tree

[Photo:ROD RANDALL]

Tall woody shrub or scrambling tree.
Distribution Cen, SWC, Esp
Form Tree
Lifecycle Perennial
Flowering White flowers Apr. to Oct.

Comments
Slash or fell thickets, then burn when dry. Alternatively remove all brush from the site immediately as the seeds are released from the capsules upon drying. Foliar spray regrowth with Garzon® (100mL in 10L water plus 25mL wetting agent). Herbicide mixed with diesel sprayed onto the lower trunk is reported to kill trees. Landcare groups in Esperance have used a Glyphosate soaked sponge attached to the tree using a wire clip to successfully kill trees.

Lycium ferocissimum Boxthorn [Photo: ROBIN KNOX]

A spiny woody semi-deciduous, shrub reaching 5m with branches at right angles.
Distribution Gas, Cen, SC
Form Shrub
Lifecycle Perennial
Flowering Purple to white flowers, Apr.-May to Aug.-Dec.

Comments
Boxthorn was introduced as a hedge plant. It readily regenerates from pruning fragments. Manual removal is difficult because its thorny seedlings tend to break off and regrow from the root. Cutting and painting with 1L of Garlon ® in 30L of diesel has achieved effective control. Successful eradication has also been recorded for thickets that have been removed using a bulldozer followed by spraying of regrowth with Glyphosate for up to three years. A number of alternative chemicals are registered for the control of Boxthorn (some information is contained in a Queensland DNR Fact sheet).

Malva dendromorpha Tree Mallow [Photo: ROGER COUSENS]

Erect herb 1 to 3m
Distribution Cen, SWC, SC
Form Herb
Lifecycle Biennial
Flowering Blue-Purple flowers, Aug. to Dec.

Comments
There are a number of **Malvas** *that are weeds of the coastal zone and islands of WA. Manual removal must ensure the removal of the taproot.* **Malvas** *can be difficult to control using herbicides. Chemical control using Glyphosate (20mL per 10L water) should be applied as soon after the second leaf stage as possible. Larger plants can be cut and painted.*

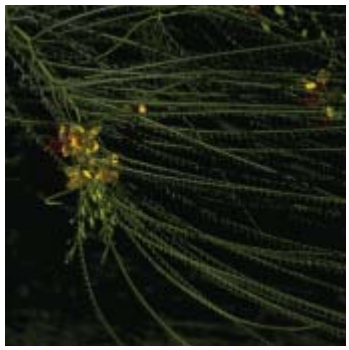
Mesembryanthemum crystallinum Ice Plant [Photo: ROD RANDALL]

Low growing herb covered with large glistening wart on the leaves and stems 0.05 to 0.15m
Distribution Cen, Esp
Form Herb (succulent)
Lifecycle Annual/Perennial
Flowering White flowers with many thin petals, Sept. to Dec.

Comments
Ice plant is difficult to control. As this species holds its seeds until the onset of rain, manual removal strategies should be undertaken in summer before the seed is released. However, the fractious nature of the vegetative structure of the plant makes it difficult to remove manually. Solarisation may be successful. There are no specific recommendations for herbicide control of this species; most succulent species can be controlled using a hormone-based herbicide (e.g. 2,4-D amine). Herbicide control should be undertaken well before seed set. This species may be the only soil stabiliser in erosion-prone sites; ensure site is suitably stabilised immediately following treatment.

Parkinsonia aculeata Parkinsonia [Photo: JON DODD]

Spiny shrub or tree with zigzagged drooping branches up to 8m; can form dense thickets.
Distribution K-P
Form Tree
Lifecycle Perennial
Flowering Flowers yellow and orange, Mar. to Dec.



Comments
Manual removal is effective. Larger trees can be cut and painted using a hormone based herbicide. Smaller trees and seedlings can be hand pulled. Removal may encourage seed germination so a follow-up visit to remove the seedlings will be necessary. Herbicide control using foliar spray (using 2,4-D amine) or cut and paint immediately (within 15 seconds) using Tordon®. Three species of insects have been introduced as biological control agents. Contact CSIRO for further information.

Passiflora foetida Stinking Passion Flower [Photo: ROD RANDALL]

Woody vine with an unpleasant smell.
Distribution K-P
Form Vine (woody)
Lifecycle Perennial
Flowering Cream, white and blue flowers, Feb. to Nov.

Comments
Cut or scrape and paint with glyphosate; small seedlings may be hand pulled or spot sprayed.

Pelargonium capitatum Rose Pelargonium [Photo:ROD RANDALL]

Smelly, straggling, greasy and softly haired herb 0.1 to 1m
Distribution Cen, SWC, Esp
Form Herb
Lifecycle Perennial
Flowering Pink purple and white flowers, Feb. to Dec.

Comments
Large infestations can be sprayed initially with 2,4-D amine (10mL in 10L water plus 25% wetting agent) followed up with hand removal of new seedlings. Manual removal of larger plants is rarely successful as stems and underground parts readily regenerate.

Prosopis pallida Mesquite [Photo: JON DODD]

Spiny tree or shrub, 4 to 10m.
Distribution K-P
Form Tree/shrub (spiny)
Lifecycle Perennial
Flowering Green to yellow flowers, Aug. to Sept.

Comment
Mesquite was deliberately introduced as a shade tree around homesteads. The seed is long-lived and may remain dormant for years. Cut and paint (immediately within 15 seconds) larger trees; small seedlings may be hand pulled or spot sprayed. Plants bearing pods should not be sprayed. See Queensland DNR Fact Sheet.

Stylosanthes hamata Caribbean Stylo [Photo: ARTHUR CAMERON]

Low growing herb or shrub to 0.4m
Distribution K-P
Form Herb
Lifecycle Perennial
Flowering Yellow flowers, Apr. to Sept.

Comments
Small plants and infestations can be controlled by hand pulling. Foliar spray using glyphosate (10ml in 1L of water).

Tamarix aphylla Tamarisk [Photo: GREG KEIGHERY]

Tree to 10m.
Distribution Gas, Cen
Form Tree
Lifecycle Perennial
Flowering Pink and white flowers, Feb. to May

Comments
Mechanical removal using a dozer can be very effective. Suckering from the roots usually only occurs where the roots have been exposed and worn down such as on paths and roads. The most effective method for chemically controlling Tamarisk is to make incisions around the entire trunk of the tree using a small hatchet and filling the incision with Tordon (50% solution).

Trachyandra divaricata Dune Onion Weed [Photo: ROGER COUSENS]

Rhizomatous herb to 0.35m.
Distribution Cen, SWC
Form Herb
Lifecycle Perennial
Flowering White flowers Aug. to Nov.

Comments
Solarisation, hand pull, foliar spray using glyphosate. This species may naturally decline with the planting of native vegetation.

Urospermum picroides False Hawkbit [Photo: PENNY HUSSEY]

Erect herb to 1.2m
Distribution Gas, Cen
Form Herb
Lifecycle Annual/Biennial
Flowering Yellow flowers, Aug. to Dec.

Comments
Solarisation, hand pull, foliar spray using glyhposate.

Zantedeschia aethiopica Arum Lily [Photo: JON DODD]

Distribution Cen, SWC
Form Bulb
Lifecycle Perennial
Flowering White flowers July to Nov.

Comments
Foliar spray with Brushoff®. This will require several applications. Try to spray before flowering to stop seed set. In wetland areas only use Biactive Roundup®. Manual removal has proven to be ineffective.

9. REVEGETATION

CONTENTS

FIGURES

TABLES

9.1 PLANTING TO REHABILITATE DEGRADED AREAS

9.1.1 Benefits of planting

Coastal stability is largely maintained by vegetation. Plants growing in coastal areas perform important functions. Plants:

- contribute to the nutrient cycle of the system
- anchor the soil and act as a buffer against wind and water erosion
- act as a wind, sand and salt trap protecting the vegetation directly inland
- provide habitat for native fauna
- provide important food sources and material for cultural ceremonies for indigenous Australians
- are aesthetically pleasing.

Figure 9-1

Revegetation of an exposed dune at City Beach Perth.
[Photo: GF Craig]

The establishment of any type of plant cover on bare sand requires proper planning. The objective of a rehabilitation program must be clearly defined to ensure that revegetation is warranted and to determine timing and intensity. Questions to ask include:

- What do you want to achieve?
- How urgent is the problem? What are the implications of undertaking no treatment, minimal treatment or full treatment?
- What is causing the vegetation decline, and how large is the area that needs to be revegetated?
- Will the area revegetate naturally once it has been stabilised, or are faster results required? Do particular species need to be reintroduced into the area?
- What funding is available/required?
- What is the level of community use of the area, both current and future?
- What local knowledge is available to assist with planning (e.g. nurseries, indigenous Australians, government agencies)?
- What development plans, if any, are envisaged by local government or private enterprise?

A program of stabilisation and restoration should be planned in advance so that plants have the best chance of survival. It may take a number of years to achieve a self-sustaining environment.

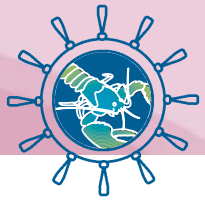
9.1.2 Plant succession

Plant adaptation to different environments is reflected in patterns of vegetation that vary over space and time.

Revegetation programs must consider the various stages of succession that need to occur to achieve stability in the area that is being rehabilitated. Depending on the degree of exposure, a foredune may require stabilising with primary colonisers in Year 1, planting with secondary colonisers in Year 2, and with tertiary colonisers in more protected areas in Year 3. In contrast, a stable dune area further inland could be planted with tertiary colonisers in Year 1 and, once established, species with special requirements, for example shade-preferring species such as Boronia alata (winged boronia), could be established.

Rehabilitation can opt for fast or slow evolution of a plant community:

- slower rehabilitation, allowing more natural succession from primary colonisers through to tertiary species, is associated with a low cost approach
- intensive rehabilitation, using high cost temporary protection, permits rapid community evolution.



Spatial succession refers to communities that vary in character along an environmental gradient. In a coastal setting, the degree of exposure to salt spray, windblast and inundation by sand provides important environmental gradients that determine community character.

Exposed dunes are most influenced by salt spray, windblast and inundation by sand. The zone includes the beach above high water mark and the seaward-facing slope of the foredune. *Primary colonisers* are capable of stabilising areas of bare sand. They trap and bind sand by means of rapid root and shoot growth. Examples of primary colonisers include *Spinifex hirsutus* (hairy spinifex), *Spinifex longifolius* (beach spinifex), *Ipomoea pes-caprae* subsp. *brasiliensis* (beach morning glory) and *Atriplex isatidea* (coastal saltbush).

Secondary *colonisers* are adapted to the seaward slopes of foredunes that have been stabilised by primary colonisers. These are generally hardy shrubs, such as *Olearia axillaris* (coastal daisy bush), *Nitraria billardierii* (nitre bush), *Leucophyta brownii* (silver cushion bush), *Scaevola crassifolia* (thick leaved fanflower), or rushes and sedges, typically *Lepidosperma gladiatum* (coastal sword sedge) and *Isolepis nodosa* (knotted club-rush).

The term *Sheltered dunes* refers to partially protected areas, such as the landward slope of the foredune, the first swale and the secondary dune. A wider range of shrubs is able to establish here; they include the secondary colonisers mentioned above and tertiary colonisers such as many of the *Acacia* species (wattles), *Rhagodia baccata* (berry saltbush), *Melaleuca lanceolata* (Rottnest tea tree), and *Myoporum insulare* (boobialla).

Stable dunes are consolidated and have richer soils. Wind has less impact and salt spray is not as concentrated as nearer to the shore. Plant communities are usually diverse, both in species composition and growth forms. Many of the species are localised in their distribution and have particular requirements, such as part-shade, proximity to the water table or higher fertility soils.

Rocky coasts frequently support a different suite of species to those found in dune environments, although a number of species inhabit both situations, for example *Carpobrotus* species (pigface), *Templetonia retusa* (cockies' tongues), *Atriplex cinerea* (grey saltbush) and *Alyxia buxifolia* (sea box).

Temporal succession refers to the evolution of a plant community over time. Individual species alter the local environment, which permits the introduction of other species with different environmental needs and adaptations. For example, primary colonisers provide initial stability and create a microenvironment for secondary colonisers, which in turn provide added shelter, litter deposition and soil enrichment to allow for the development of tertiary colonisers.

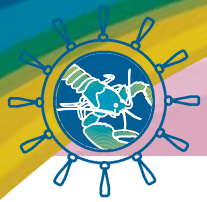
Factors that can influence the evolution of a plant community over time include coastal stability, climate, people pressure, weed invasion, grazing animals and fire.

9.1.3 Importance of using local native plants

When formulating a revegetation program, suitable native species should be selected for particular sites and purposes. The term *local plants* refers to those species that occur naturally in a particular area. *Native plants* include all the thousands of species that grow naturally in Australia. Use of local native plants is desirable as they are in harmony with each other and their environment. They provide essential food for local insects and other small creatures, and in turn support many local birds and other animals.

Local native plants are already adapted to the local climate and soil type, and as a consequence:

- no or minimal soil preparation is necessary
- watering is reduced to a minimum
- fertiliser requirements are lower or unnecessary.



Local forms are also important when choosing plants, especially if the species has a wide range. Different genetically controlled features are likely to be present over the range of a species, having developed in response to differences in soil, climate and other evolutionary selective pressures. For example, plants propagated from a population growing on the south coast are probably less able to withstand a Perth summer drought than would a Perth population. Furthermore, forms selected from coastal habitats will have greater ability to withstand salt spray and windblast than inland populations of the same species.

How local is local? Some plants have been found to have slightly different genotypes over a distance of only 100 metres, although other plants are alike over much larger distances. As a general guideline Main Roads defines local provenance (i.e. collection site) seed as that which is collected within 15km of the site to be revegetated, while Greening WA prefers to consider provenance collections in the same catchment or subcatchment to be 'local'.

9.2 IMPORTANCE OF RETAINING AND RESTORING BIODIVERSITY

Biodiversity refers to the range of variation or differences among living things. It reflects the number of species found in a given environment, their genetic resources and evolutionary distinctiveness. A primary goal of all land managers must be the conservation of biodiversity. The main idea of biological conservation is to conserve plants and animals in their natural place of occurrence, and that natural systems be self-sustaining with respect to the flow of energy and the cycling of nutrients and water.

At present our plants are under enormous threat from reduced and fragmented habitats caused by clearing, from disturbance (e.g. fire and trampling) and from competition with weeds. The best method of restoring and maintaining the health of local reserves is through regeneration work. Management is also important, as without some management framework (e.g. bushland plan) regeneration will not succeed in the longer term.

To maintain biological diversity, plants grown from seed are preferable to those grown from cuttings. This is because seeds are genetically different from each other, having been produced by sexual reproduction, while cuttings are genetically identical to the parent plant. Genetic variability aids long term survival of a species, thus growing plants from seed will do more to conserve the species.

9.2.1 Plant selection for coastal rehabilitation

To select species suitable for rehabilitating particular sites, one must first determine why the subject area is being rehabilitated. Once this is determined, it will have an overriding influence on the selection of appropriate species. It is highly recommended that a survey be carried out in nearby areas to determine the local native species and that selection of species be based on the following criteria:

- **natural distribution** of the species
- **position in the landscape** and the location on the dune which determines the degree of exposure to salt spray, sand blast, wind buffeting and inundation by sand
- **type of sand/soil** and depth to clay or rock
- **soil moisture** and drainage
- **temperature, rainfall** and **relative humidity**
- **size of area** to be planted
- **amount of artificial protection,** if any, that is to be provided or is already present
- **purpose** for which the plant is required and the preferred shape, size and growth rate of plants, and if there are any imposed pressures (e.g. recreational demands, pedestrian use)
- **availability** and **cost** of suitable native seed or seedlings (tube stock).

9.3 PLANTING AND ESTABLISHMENT TECHNIQUES

9.3.1 How to establish native plants

There are number of techniques for propagating and establishing native plants. The recommended propagation method of selected coastal species is given in the next section, 'Plant What Where'.

Licences and permission are required to collect seed and cuttings from plants growing on public land. Licence applications should be submitted through your local Department of Conservation and Land Management office to the Department's Wildlife Protection Branch in Kensington. Permission must also be sought from the manager of the land. On private land, permission to collect needs to be obtained from the owner. The local council can provide information on land tenure.

9.3.1.1 Direct seeding

Direct seeding of perennial species has had limited success along the coast, and results are often disappointing, although some experienced operators can have good success rates. Annual herbs may produce a good stabilising cover when direct seeded over moderately large areas. This is only worthwhile (in terms of both human and financial resources) when seed can be harvested quickly and cheaply, for example Ptilotus species (mulla mulla).

Experience has shown that where small areas are to be revegetated, or where there is a large edge to area ratio, it is more efficient to place barriers, such as branches and sticks, which create niches for annual herbs to rapidly recolonise the regeneration area.

The optimum quantities of seed can only be gained by trial and error, and experience. Quantities of seed from 3 kg/ha (light seed, such as daisies) to 10 kg/ha (heavy seeds, such as wattles and peas) have been recommended. Generally, a quantity of between 4 and 5 kg/ha of seed is suggested where mixed types of seed are used. To sow seed by hand, bulk the seed with clean dry sand or the organic trash produced from seed processing, before spreading evenly over the area to be revegetated.

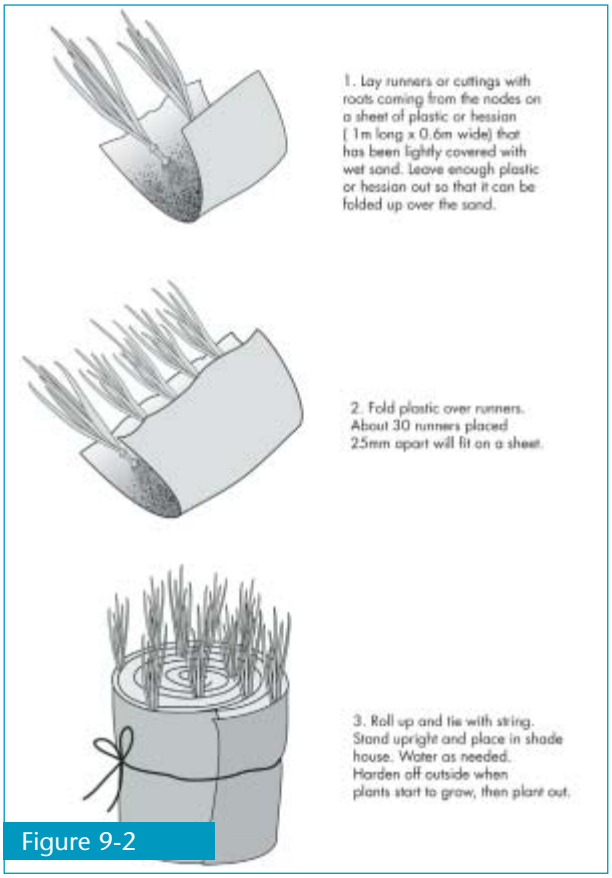


Figure 9-2

Native plant establishment technique

9.3.1.2 Direct transplants

Direct transplanting of rooted cuttings of grasses (e.g. *Spinifex hirsutus* and *Sporobulus virginicus*) and creepers (*Carpobrotus* species) that grow on the seaward slope of foredunes gives good results. Roots of cuttings must be healthy and either yellowish or white in colour. The transplant site should be well moistened. Fresh cuttings of both Spinifex species have been direct planted into bare dunes using a hose water jet to make the hole and water the plant in one operation.

Alternatively, rather than directly transplant the cuttings, use the technique demonstrated in figure 9-2, which has been successfully used for *Spinifex longifolius*.

9.3.1.3 Nursery-raised seedlings

Nursery-raised seedlings provide the most reliable method of establishment for the majority of coastal plants. These plants should not be large, but sturdy, healthy and hardened specimens grown in pots 50-75mm wide and 125mm deep. It has been recommended that seedlings be grown as tall as possible, then planted as deep as possible. *Acacia* species, *Olearia axillaris* and *Leucophyta brownii* can be grown up to 300mm tall and then planted with only 50-75mm above ground. This is mimicking nature, in that plants are covered by moving sand, but grow up through it. In planting so deep, the roots are much further below the surface in dry months.

Seedlings can be raised from seed, by cuttings or by division.

Seeds

Seeds should be collected from healthy plants when they are ripe. A number of species require treatment, to break seedcoat dormancy, before they will germinate. Methods include:

- **scarification,** where small seed lots are manually pierced, chipped, nicked or filed. Larger seed lots can be scarified by tumbling the seed with hard sand such as used in sandblasting, by using abrasive disks or by using an abrasive tumbler. Seed scarifiers are available commercially
- **hot water treatment** where water is brought to the boil, then seeds immersed in the boiling water for one minute, then removed from the heat source and seed allowed to soak for several hours as the water cools. Seeds that have swollen are planted, and those that have not are re-treated. Note, some softer-seeded species may need only immersing in near-boiling water for a few minutes, followed by cold water to prevent cooking of the seed
- **smoking** of seed can be achieved either by (i) diluting 1 part of smoked water with 10 parts of water, and watering seed pots just once with this solution. 'Smoked water' is prepared by bubbling cooled smoke through a container of water; the products of smoke that trigger seed germination dissolve in the water. Smoked water is available from some nurseries and from the Friends of Kings Park; or (ii) a combination of fresh and dry plant material is allowed to smoke, but not flame, and the smoke cooled as it is piped to a second chamber where seeds are exposed for about one hour. Seeds are then sown as normal, although watering is kept to a minimum to prevent leaching of the smoke factor.

Cuttings

Cutting is a method of propagating good forms of many plants. The cutting-grown plant will flower much earlier that one grown from seed. *Tip cutting* is where new growth, 10-15cm long is cut just below a node and two thirds of the leaves trimmed off. The cut end is dipped in rooting hormone then placed in wet potting mix. There are many readily available books on gardening and plant propagation that describe techniques for taking cuttings, and it is recommended that a novice to the technique refer to these.

Division

Division describes the method of dividing the root system of a plant into two or more new plants.

Layering

Layering is a technique of producing roots on a branch while it is still attached to the parent. For further information on this method, refer to specialist gardening books.

Inoculation of nursery soils is recommended for species such as acacias, eucalypts and casuarinas. These plants have developed symbiotic relationships with certain soil bacteria and fungi. Inoculation induces a mild form of disease so as to produce immunity. It can be readily achieved by taking surface soil from beneath healthy plants of the host species. The soil can be either added to the potting mix (10-20% soil inoculum) or, as seeds start to germinate, slurry made with the soil and water, and the decanted solution used to water the seedlings. The disadvantages of this approach include the risk of introducing undesirable pathogens and weeds.

9.3.2 Planting out

Planting and direct seeding should be carried out once the wet season or winter rains have started and the ground is sufficiently moist to a depth of 20-30 cm. It should be done as soon as practicable in the wet season, so that plants can take full advantage of the residual warmth in the soil and to allow maximum time for plants to establish before the summer dry period.

Table 9-1 shows the preferred months to undertake stabilisation and rehabilitation in each region of Western Australia. This is a guide only and you may need to look into the rainfall distribution for your particular area in greater detail. The solid lines indicate the best time to undertake coastal work and the dashed lines indicate times when work can occur but it may be less successful because of decreasing rainfall and increasing temperatures.

Table 9-1 Months in which stabilisation and rehabilitation could generally occur given expected rainfall

REGION	J	F	M	A	M	J	J	A	S	O	N	D
Pilbara/Kimberley (WA border to Onslow)	----	——	——	----	----							
Gascoyne (Onslow to Shark Bay)				——	——	——	——	——	----			
Central West Coast (Shark Bay to Cape Naturaliste)				----	——	——	——	——	——	----		
South-West Capes (Cape Naturaliste to Albany)				----	——	——	——	——	——	——	——	----
South Coast (Albany to Eucla)				——	——	——	——	——	——	——	——	----

Seedlings are best placed in groups of the same species, although in bare dunal areas intermixing of species is recommended. Primary stabilisers should be planted on the most exposed locations and a mix of secondary plus primary stabilising species in more protected locations. The following steps should be followed for planting:

1. Seedlings should be well watered some hours before planting out so that the soil around the roots is moist. Bare-rooted plants should be covered with a wet bag and stored out of the sun and wind while transplanting continues.
2. Dig a hole that is a little wider than, but the same depth as the container. In well-drained dune areas, *Acacia, Olearia* and *Leucophyta* can be planted deeper, so that only 50-75mm of foliage protrudes above ground.
3. Snip off any emergent roots from the base of the container. Remove the plant from the container by placing your hand over the pot surface, with the stem of the plant between the second and third fingers. If the plant doesn't come out easily, tap the edge of the container on something solid. Gently remove the plant in one piece. *Never plant a plant by leaving it in the bag or container!*
4. Examine the roots. If there is any sign of root curl, straighten them out by gently teasing the roots. Should the curling be so bad that they cannot be straightened, some *root pruning* will be necessary; also, the taproot should be cut off if it keeps springing back in a coil. If this is not done, the plant will eventually strangle itself or be knocked over by the wind.
5. Position the plant in the hole with all roots pointing downwards.
6. Return the soil to the hole around the plant and tamp it in firmly around the plant with your hands or by heeling or foot pressure. *Firming the soil and elimination of air spaces are vital to the planting success.*

The plant should finish up slightly below or at the same height in relation to the soil level as it was in the container. Do not cover the plant with more soil, as the stem may rot, although in exposed sand dunes, deep planting of *Acacia, Olearia* and *Leucophyta* seedlings and covering with sand so that only 50-75mm of foliage is above ground, has given good success rates.

7. Create a saucer-shaped depression around the plant to aid water harvesting. Watering of seedlings after planting will help in establishment.
8. Planting out should be avoided during hot dry conditions.

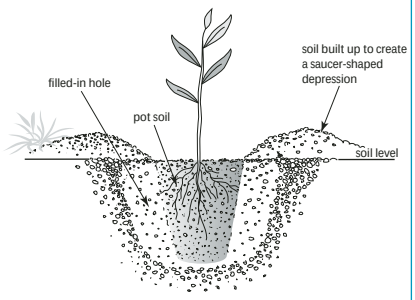


Figure 9-3

Planting out native plants.

Spacing of plants should be carried out with knowledge of the ultimate height and spread of the species and growth rate. Spacing should allow for losses – hence it should be closer than final size of a species would suggest. In areas where cover plants are required to stabilise the dunes, closer spacings down to 0.5m may be required. In a barren dunal situation, it is better to plant too densely, than to plant too thinly and end up with inadequate cover. For many of the species described in this manual the data needed to determine the optimum spacing for plantings is unavailable. Planting densities are given for those species regularly used in revegetation projects and can be used as a guide for other species of a similar size. Allowance must be made for seedling deaths or low germination rates – a closer spacing than is ultimately hoped for when the plants are fully grown is recommended.

Staking should not be done unless absolutely necessary as stakes force growth upwards at the expense of trunk thickness. The stems or trunks of shrubs and trees are naturally strengthened by swaying in the wind, and should a plant fall over, it will regrow even more strongly from the base. If, however, a plant will not stand erect or is in an area of high wind risk, staking may be required. The stake must be positioned at least 15cm away from the tree and sited so that its top is not rubbing on the tree. The best ties are made of pliant material (e.g. stockings, rubber bands or plastic) and tied in a figure-of-eight configuration.

9.3.3 Water requirements

Watering is unnecessary if native plants in small pot sizes are planted out at the beginning of the wet season or winter rains. The plants will establish themselves over the rainy season and, as the rains diminish later in the year, the roots will follow the moisture down and equilibrium will be established. Watering can be helpful, if not too difficult and costly, at time of planting as it can give seedlings a good start and help dispel air spaces around the roots.

If planting is carried out at other times of the year, or larger plants are used, watering will be necessary during the first summer or dry season until the following rainy season when plants should be left to adjust themselves.

In some situations, such as amenity plantings, an increased growth rate can be achieved by supplementary watering. Good growth can be achieved on 9 litres a plant per week during heat wave conditions or 4.5 litres a week during cooler periods. After the first year of growth watering can be reduced to monthly applications to keep the plants healthy and green.

9.3.4 Site maintenance

It is important to control all weed growth, especially where plants are to be grown with minimal or no water. Weeds compete for moisture to the detriment of native plants.

Maintenance of the area being restored must continue until conditions are reasonably stable. This is achieved when species from either natural regeneration or nursery-grown stock have become well established and form a dominant part of the cover. Replanting may be required where there are excessive plant losses.

9.3.5 Use of fertilisers

Fertilising in exposed coastal environments is not recommended, especially for leguminous plants such as *Acacia*, *Hardenbergia* and *Templetonia*. Fertilisers can cause plants to produce excessive soft growth that is easily damaged by strong winds and sand blast. Also, too much early leaf growth can lead to unnecessary stress during drought.

In areas where increased growth rates are required to stabilise dune areas, fertilisers may have a role. Trials using nitrogen and slow release fertilisers have promoted growth of *Spinifex sericeus* in the eastern States and New Zealand. Similar trials with Western Australian *Spinifex* species have not shown any benefits, thus fertilising *Spinifex* has not been recommended or practised here.

In sheltered situations, native plants will respond favourably to fertiliser applications. In sandy soils, only small applications should be applied otherwise damage can result. This occurs because there is a lack of humus and clay particles to buffer the fertiliser, so the plant receives the fertiliser in its concentrated form.

The concentration of the particular fertiliser brand should be known before it is applied. All general fertilisers contain the elements nitrogen (N), phosphorous (P) and potassium (K). The most damaging element is nitrogen. Slow release fertilisers, which are available in pellet or pill form, are the best fertilisers to use. One fertiliser tablet per plant given in the second wet season after planting has been recommended. A fertiliser that contains most of its nitrogen in an organic form is also suitable. The fertiliser dose can be applied in a circle or in small holes spaced 15-30cm from the plant.

9.3.6 Pest and disease control

Snails

Snails can be a problem in some coastal areas. Snail baiting is not particularly practical or effective in dunes, as snails reinvade once the pellets have been eaten or have deteriorated in the rain. Strategic baiting may be worthwhile where susceptible plants can be intensively managed. It should be noted that snail baits may be toxic to some animals, and should not be used in some places, for example where dogs are regularly exercised. Snail baits can also have a negative impact on some native birds such as mud-larks.

Figure 9-4

Plastic tree guards can protect seedlings from rabbits.
[Photo: GF Craig]

Rabbits and kangaroos

Rabbits and kangaroos may need to be controlled as they can devastate freshly planted material. Rabbits are very selective eaters and will consistently graze particular species, thus severely hampering revegetation programs. Weed invasion and accelerated erosion can be closely associated with the presence of rabbits. Control rabbits by:

- baiting using either 1080, which can be controversial near residential areas due to the possibility of domestic animals being poisoned, or Pindone which can poison native animals. The Department of Agriculture can provide advice on rabbit baiting program and they, and/or the land manager, should be consulted before baiting of any kind is conducted
- fencing the whole project area with rabbit proof netting – a costly method which requires maintenance
- guarding plants individually with plastic (or wire) guards, sometimes referred to as 'bunny bags'. One-litre milk cartons are a cheap and often effective way of protecting seedlings from rabbits.

PLASTIC GUARDS

Advantages

- ✓ creates a humid, warm environment which promotes plant growth
- ✓ dew settles on the inside of the plastic which runs down to water the plant
- ✓ protects plant from wind and salt damage
- ✓ protects plant from rabbits in particular
- ✓ makes the plant prominent in the landscape and protects them from potential trampling
- ✓ helps protect the plant from sand inundation
- ✓ increases survival rate of plantings.

Disadvantages

- ❖ time consuming to install and maintain
- ❖ not practical for large revegetation projects
- ❖ damage the plant if loosely installed and allowed to flap about
- ❖ eddying of wind around the guard can lead to wind scour of sand and exposure of the seedling's roots
- ❖ blow away in strong winds and become a litter problem
- ❖ snails can be attracted to the plants
- ❖ expensive (sometimes more than the plant itself).

Fungi

Fungi can cause major diseases of local plants. *Phythophthora* root-rots, *Armillaria* root-rot, stem cankers and rusts can cause severe dieback or death of plants, although some species are more resistant than others. If numbers of plants are dying in quick succession, consult Department of Agriculture or the Department of Conservation and Land Management for advice on the cause and appropriate treatments.

9.4 PLANT WHAT WHERE

This section describes plants that are suitable for planting in different areas of coast. The categories are meant as a guide to selection and may not be applicable to every coastal situation due to local variation in topography, exposure, soil type and climate. The plant species have been grouped into five broad habitat types – intertidal zone; exposed dunes; sheltered dunes; stable dunes and limestone outcrops – and then according to general growth forms, such as perennial herbs, medium shrubs, trees and mallees. The symbols in each species header indicate a 'use' category:

▼ Shade	✸ People control (prickly)
❒ Windbreak/shelter	● Stabiliser/sand-binder
♦ Ornamental	

More extensive lists of species suitable for each region are given in Appendix 5.

Many of the plants that grow on foredunes occur widely on Western Australia's coastline. Moving inland, the range of plants increases and the species tend to become more restricted in their distribution. A distribution map is provided for each species[1]. Selection of species for a particular area needs to consider the exposure to salt spray and high winds, and, in the frontal zone especially, wave erosion and sand movement. Section 2. *The Coastal Environment* provides further detail on coastal environments.

[1] Distribution maps were derived from information on the Western Australian Herbarium's FloraBase database [see http://florabase.com.wa.gov.au]

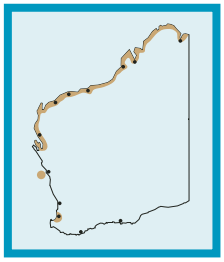
9.4.1. INTERTIDAL ZONE

9.4.1.1 Mangroves

Mangroves in the Kimberley Pilbara region are primarily confined to intertidal areas between approximate mean sea level and the level of the highest astronomical tide. Below mean sea level mangroves are limited by the amount of time available between tides to absorb oxygen from the air through their modified 'breathing roots' or pneumatophores.

In Western Australia there are 17 species of mangrove. Two of those considered suitable for revegetation projects are described below, although many of the other species have the potential to be used.

Avicennia marina AVICENNIACEAE ● *Grey Mangrove, White Mangrove*



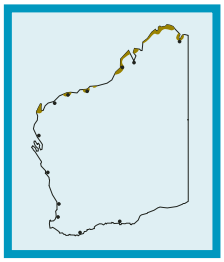
A shrub or tree to 5m tall. Numerous, pencil-like 'breathing roots' arise from the radiating cable roots. Leaves are opposite, dark glossy green on the upper surface and have white or silvery, short, matted hairs beneath. The yellow or white clustered flowers are scented. The fruit is a compressed capsule bearing a solitary seed.

This is the most widespread of mangrove species in Western Australia. It is commonly found in pure stands on the seaward edge of mangrove communities and is also common in mixed stands further landward.

Flowering *November-January (north); March-April (Bunbury)*
Seeding *December-May (north); April-June (Bunbury)*
Propagation *Seeds germinate while still attached to the parent, then drop and take root around the parent. Readily propagated by transplanted seedlings.*

GF Craig/ Dept of Agriculture

Rhizophora stylosa RHIZOPHORACEAE ● *Spotted-leaved Red Mangrove*



Single- or multi-stemmed tree, 5-12m tall, with long arched 'breathing roots' extending for several metres over the surface of the soil. Leaves are opposite, elliptic, have margins that roll backwards toward the underside, glossy green upper surface, and a paler lower surface marked with red-brown glands. Flowers have white feathery-hairy petals. Fruits are oval-shaped. The single seed germinates while the fruit is attached to the tree.

Common in sheltered bays, in estuaries and on fringing islands. It grows best in areas of tidal waterways that remain brackish for most of the year.

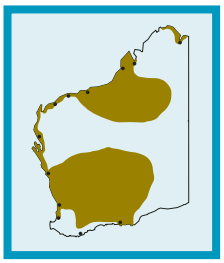
Flowering *February-October*
Seeding *February-October*
Propagation *Seeds germinate while still attached to the parent, then drop and take root around the parent. Readily propagated by transplanted seedlings.*

GF Craig/ Dept of Agriculture

9.4.1.2 Samphires

Salt marshes are characterised by low shrubby glassworts, popularly known as 'samphires'. In the Kimberley Pilbara region they mostly occur in sheltered environments adjacent to the landward margins of mangrove dominated tidal creeks and inlets. They usually extend from near mean seal level to the extreme upper tidal limit where they abut terrestrial vegetation. Elsewhere in Western Australia, samphires are associated with estuaries, saline lakes and salt pans.

Halosarcia halocnemoides CHENOPODIACEAE ● *Shrubby Samphire*

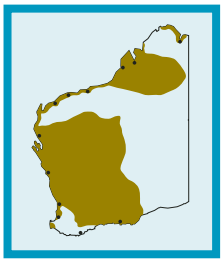


Low shrub, to 50cm high. Flowers are in terminal spikes. Fruits are separated from each other by a constricted joint, which gives the spike an undulate outline. A widespread and variable species, which includes five subspecies.

Flowering *January-November*
Seeding *January-March*
Propagation *Seed or cuttings. Harvest mature fruiting segments and spread on ploughed soil a few weeks before wet season.*

GF Craig/ Dept of Agriculture

Halosarcia indica CHENOPODIACEAE ● *Samphire*



Low, spreading to robust erect shrub, 0.15-1.3m high. Flowers are in smooth, terminal spikes up to 4cm long. Fruiting spikes are leathery, spongy or corky. A widespread and variable species with three of the four subspecies occurring in Western Australia.

Flowering *August-November*
Seeding *August-November*
Propagation *Seed*

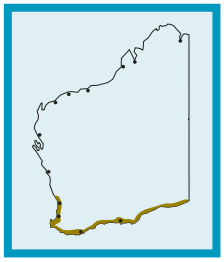
GF Craig/ Dept of Agriculture

9.4.2. Exposed Dunes

These grasses, herbs and shrubs are adapted to the most exposed locations, including the entire seaward face of the foredune and above high water mark on beaches. They are either primary or secondary colonising species (see previous section), adapted to strong onshore winds, excessive salt spray, sand blasting and some inundation by sand.

9.4.2.1 Grasses, creepers, perennial herbs and low shrubs

Spinifex hirsutus POACEAE ● *Hairy Spinifex*

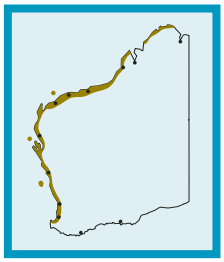



A robust, perennial grass with much-branched, stout, creeping stems that root at the nodes. Leaf blades are flat and covered with soft, grayish-green hairs. Male and female flowers are borne on different plants. Male inflorescences are hemispherical with numerous erect spikes to 8cm long. Female inflorescences are spherical in outline, to 30cm across; seeds are clustered at the centre. Female inflorescences often break off and tumble before the wind.

Flowering *October-January*
Seeding *November-March*
Propagation *Transplant rooted cuttings by taking 40-60cm long cuttings with several rooted nodes and planting 30-50cm deep and 80-100cm apart; direct seed whole heads (collect seed where male and female plants grow close together, examine seed heads for fertile seeds otherwise germination may be poor); establish tip cuttings in nursery 2-5 months before transplanting; or nursery-raised seedlings. Heated nursery beds may improve growth of cuttings. Plant at 1-2m intervals.*

GF Craig/ Dept of Agriculture

Spinifex longifolius POACEAE ● *Beach Spinifex*

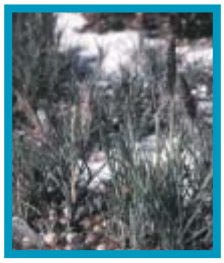
A stout perennial grass which forms tussocks 1m high and 2m wide, with stems creeping at the base. Leaf blades are narrow, rigid, thick, up to 60cm long. Male and female flowers are borne on different plants. Male inflorescences have spikelets alternately arranged on clustered spikes. Female inflorescences are spherical in outline, up to 25cm across; seeds are clustered at the centre. Female inflorescences are straw-coloured when mature, and break off from the stem to be blown away by the wind.

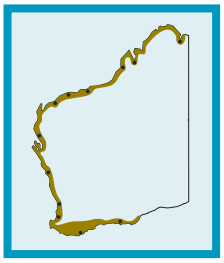
Frost sensitive. The fast-growing hybrid *Spinifex alterniflorus* has characteristics intermediate to *S. hirsutus* and *S. longifolius;* fertile seeds have been collected where the male and female plants grow close together between Bunbury and Perth.

Flowering *May-September (north), August-November (south)*
Seeding *August-October (north), November-December (south)*
Propagation *Transplant rooted cuttings; direct seed whole or half heads (collect seed where male and female plants grow close together, examine seed heads for fertile seeds, germination may be slow but can be successful after up to 2 years); seed can be threshed and scattered before brushing; or seed heads can be germinated in pots in the dry season and sprouted heads planted out in the wet season. Cuttings grown on heated nursery beds have been successful. Plant at 1-2m intervals.*

GF Craig

Sporobulus virginicus POACEAE *Marine Couch*





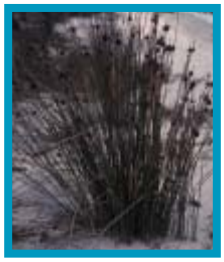
Tussock-forming, perennial grass with numerous, creeping stems that root at the nodes. Leaf blades are rigid, inrolled, 2-10cm long, with a fine sharp point. Inflorescences are erect, cylindrical in outline with densely grouped spikelets on the central stalk, and dark in colour.

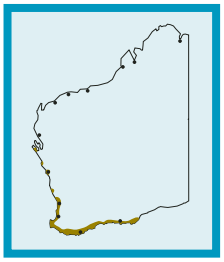
Waterlogging tolerant; suitable for lawns. Can be confused with couch Cynodon dactylon, a weed of similar form which has 2-7 digitate, purplish spikes of flowers, each 1-4cm long.

Flowering *All year*
Seeding *All year*
Propagation *Transplant rooted cuttings.*

GF Craig

Isolepis nodosa *[ex. Scirpus nodosus]* CYPERACEAE ●♦ *Knotted Club-rush*





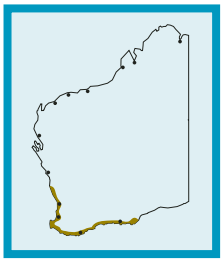
Perennial sedge, 0.5m tall, with rigid cylindrical stems and basal leaves reduced to a brown or reddish sheath. Flowerheads are dense, almost globular, to 2.5cm across, and borne just below the apex of the stem.

Very lime tolerant, waterlogging tolerant, prefers moist areas; very hardy.

Flowering *August-April*
Seeding *December-April*
Propagation *Division, transplants or seed (readily germinates). Plant at 0.5-1.5m intervals.*

GF Craig

Lepidosperma gladiatum CYPERACEAE ●♦ *Coastal Sword Sedge*



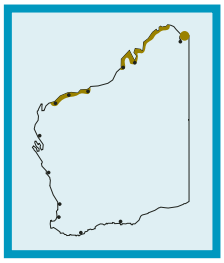
Robust sedge which forms broad clumps, 1.5m tall and 3m wide. Leaves are broad, flat and sword-like. The dense brown flower spikelets form a branched inflorescence, to 22cm long, at the top of the stems.

Lime tolerant; drought tender; waterlogging tolerant.

Flowering *November-May*
Seeding *December-March*
Propagation *Division or transplants. Plant at 0.5-1.5m intervals.*

GF Craig

Canavalia rosea PAPILIONACEAE ●♦ *Wild Jack Bean, Beach Bean*

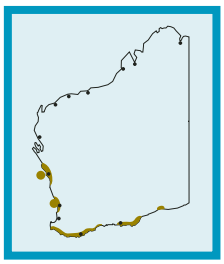



Spreading creeper with trailing stems, which may cover many square metres. Leaflets 3, thick, oval-shaped. Several pink to purple pea flowers are borne on erect racemes, to 30cm long, held above the foliage. Pods are thick, flat, woody and pale cream-brown when ripe.

Flowering *January-November*
Seeding *January-November*
Propagation *Scarified or untreated seed. Direct seed about one month before wet season at 10-20 grams per square metre.*

GF Craig/ Dept of Agriculture

Carpobrotus virescens AIZOACEAE ●♦ *Coastal Pigface*

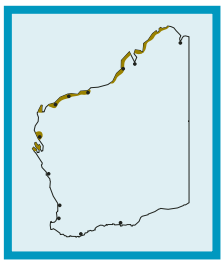
Creeper. Leaves are succulent, thick and triangular in cross-section. Attractive flowers have pink-purple petals which are white at the base. Distinguished from the introduced pigfaces *C. aequilaterus* which is not white at the base of the pink petals, and *C. edulis* which has yellow petals.

Readily attacked by aphid which causes degeneration of the plant.

Flowering *June-January*
Seeding *December-April*
Propagation *Direct transplant of rooted cuttings, division of layered stems or seed (wash flesh off seed as it inhibits germination, soak for 24 hours only). Cuttings 5-15cm long spaded into the ground and compressed have a good survival rate. Cuttings can be very slow growing. Plant at 1 metre or less intervals. Part shade or full sun.*

GF Craig

Ipomoea pes-caprae subsp. **brasiliensis** CONVOLVULACEAE ●♦ *Beach Morning Glory*

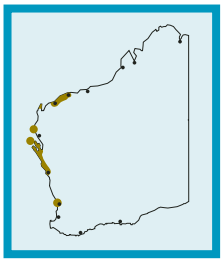



Climbing or creeping plant, to 5m across, with slender vigorous stems that root at the nodes. Leaves are large, broad and rounded. Flowers are large, deep pink to mauve-purple and trumpet-shaped. Fast growing.

Flowering *All year*
Seeding *All year*
Propagation *Direct transplant runners; scarified or hot-water-treated seed; or cuttings. Plant at 1 metre intervals. Requires irrigation to establish.*

T Tapper

Angianthus cunninghamii ASTERACEAE ●♦ *Coast Angianthus*

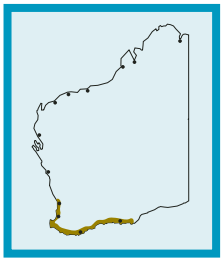


Much-branched, bushy shrub, 20-50cm high, covered with white woolly hairs on both stems and leaves. Leaves are linear, about 15mm long and rounded at the tip. Flower heads are cream to deep yellow, globular, 5mm across, terminal, and surrounded by short woolly leaves.

Flowering *October-March*
Seeding *February-August/ November-December*
Propagation *Seed or tip cuttings. Plant at 1.5m intervals.*

D Bellairs

Leucophyta brownii *[ex. Calocephalus brownii]* ASTERACEAE ●♦ *Silver Cushion Bush*



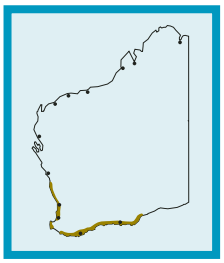
Low, rounded shrub, 20-70cm high, with a slender main stem and densely entangled, wiry, silvery-white branches. Leaves are small, silver and held close to the branches. Flower heads are 1cm across, globular, terminal, and creamy-coloured.

Hardy, survives very harsh conditions, full sun, tolerates alkaline soils and extended dry periods; good foliage contrast.

Flowering *All year*
Seeding *May-July (all year)*
Propagation *Seed. Plant at 30-50cm intervals.*

GF Craig

Pimelea ferruginea THYMELAEACEAE ♦ *Pink Rice Flower*



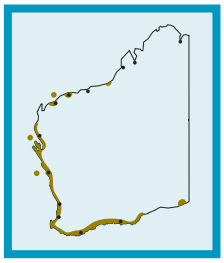
Low rounded shrub, 0.3-1m high. Leaves crowded, glossy and set in two pairs of opposite rows along the stems. Flowers are tubular-shaped, pale to rose pink and massed in dense, terminal, globular heads, 3-4cm across.

Low water requirement; attractive foliage, feature plant.

Flowering *August-February*
Seeding *December*
Propagation *Cuttings or seed (difficult to germinate). Plant at 1.5m intervals. Full sun or part shade.*

GF Craig

Scaevola crassifolia GOODENIACEAE ●♦ *Thick-leaved Fanflower*

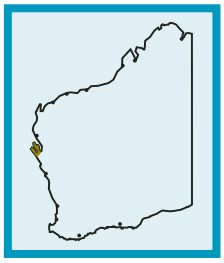
Low, spreading shrub, to 1m high and 3m wide. Leaves are thick, fleshy with serrated margins and usually have sticky stems. Flowers are in terminal spikes, blue or white with 5 fan-shaped lobes. Very hardy.

Flowering *July-February*
Seeding *December-April*
Propagation *Stem or leaf cuttings (easy), or smoked/ untreated seed. To collect seed, tip prune seed bearing stems or collect with vacuum cleaner after seed has fallen; seed germinates readily in compacted seed beds. Plant at 2m intervals. Full sun.*

Dept of Conservation and Land Management, WA Herbarium

9.4.2.2 Medium shrubs

Acacia amblyophylla MIMOSACEAE ● *Wattle*

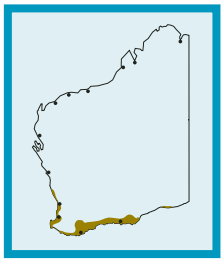
Bushy shrub or tree to 4m high, with a suckering habit. Phyllodes are 5-12cm long, 6-14mm wide, 1-nerved. Flower heads are globular, pale yellow and borne on stalks 3-6mm long in a raceme. Pods are 13cm long and 10mm wide. Seeds are black and encircled by a red stalk.

A species perhaps better regarded as a northern variant of *A. microbotrya* from which it is distinguished most reliably by its slightly broader pods.

Flowering *August-September*
Seeding *December-January*
Propagation *Scarified or hot-water-treated seed.*

BR Maslin/ Dept of Conservation and Land Management

Acacia cochlearis MIMOSACEAE ❒●✱ *Rigid Wattle*

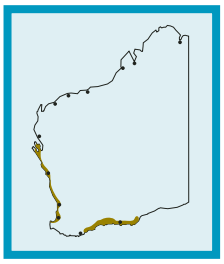
Erect to sprawling shrub, 0.5-3m high. Phyllodes are narrowly elliptic, 2-5cm long, 2-10mm wide, have 3 or 4 prominent nerves and a straight sharp point at the tip. Flowerheads are deep golden, globular and borne with 1-3 per axil. Pods are 3-4cm long, 3-5mm wide, straight and light brown. Seeds are mottled with a helmet-shaped aril below the apex.

Flowering *July-November*
Seeding *December-January*
Propagation *Scarified or hot-water-treated seed. Seed set rare, degree of flowering varies seasonally. Caution, plant may cause rash (blister similar to celery burn) to seed collectors. Plant at 1.5m intervals.*

Dept of Conservation and Land Management, WA Herbarium

Acacia rostellifera MIMOSACEAE ▼❐●

Summer-scented Wattle



Medium to tall shrub or tree, 2-6m tall and 2-5m wide, with a rampant suckering habit. Phyllodes are thin, linear-elliptic, 6-10cm long, 4-10mm wide, have a hooked apex and a prominent mid-nerve. Flowers are golden and occur in clusters of 2-9 globular heads. Pods break at the constrictions between the seeds. Seeds are dark brown with a prominent, twice-folded, orange or red aril.

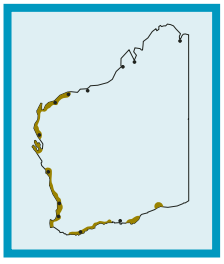
Acacia rostellifera may be confused with *A. xanthina* which has 2-nerved phyllodes and is restricted to limestone soils; or near Shark Bay, *A. ligulata* which has thick, linear phyllodes and seeds that are not partially sheathed by the aril. It is sometimes confused with *A. saligna,* with which it often grows in some coastal habitats, but the species have very different pods. Hardy.

Flowering *August-November*
Seeding *December-February*
Propagation *Scarified or hot-water-treated seed. Plant at 3-4m intervals. Full sun or part shade.*

BR Maslin/ Dept of Conservation and Land Management

Atriplex isatidea CHENOPODIACEAE ●

Coast Saltbush



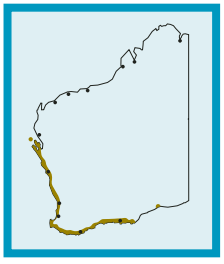
Medium shrub to 3m high, with scaly white branches and leaves. The thick, triangular leaves grow to 70mm long. Male flowers are borne in dense, globular clusters, 4mm across, in a spike. Female flowers are in terminal branched inflorescences. The fruit is enclosed in two broadly triangular bracts.

Flowering *March-June*
Seeding *March-June*
Propagation *Tip cuttings (strike readily) or seed (easy to harvest). Pre-treat seed by soaking for 1 to 24 hours only. Plant at 1.5m intervals. Part shade or full sun.*

B Madden

Olearia axillaris ASTERACEAE ●♦

Coastal Daisy Bush

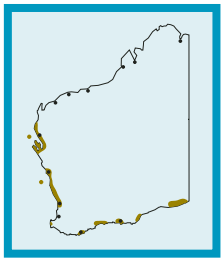


Medium, dense, rounded shrub, 1-2m tall. The silvery ornamental leaves, 12mm long and 2mm wide, are aromatic and covered in woolly hairs. Flowers are small and white. Adaptable, hardy, very lime tolerant.

Flowering *January-July/ September-December*
Seeding *January/ May-July (Perth)*
Propagation *Direct seeding, tip cuttings or seed. Collect seed by pruning stems when some seed falls with handling, beat prunings over seed traps then use prunings for brushing; pruned shrubs regenerate rapidly. Seed readily germinates; must be pricked out when very small and re-potted. Plant at 2-3m intervals.*

GF Craig

Nitraria billardierei ZYGOPHYLLACEAE ❒● *Nitre Bush, Wild Grape*

Rigid, spreading shrub, up to 3m high, with smaller branches sometimes spiny. Leaves are thick, fleshy, 1-4cm long and often yellowish. Flowers are small, white, with male and females borne on different plants. Ripe fruits are egg-shaped, fleshy, about 15mm long, reddish-purple or yellow and eaten by birds. Overruns disturbed saline soils.

Flowering *July-December*
Seeding *December-January (north); February-March (south)*
Propagation *Semi-hard wood cuttings or seed (hard to germinate). Wash flesh off seed before planting. Enhanced germination has been found in stones from emu faecal deposits.*

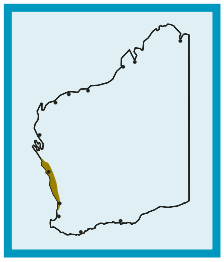
E Wittwer/ WSWA

9.4.3 Sheltered Dunes

These herbs, shrubs, mallees and trees are tertiary colonisers adapted to partially protected areas, including the landward side of the foredune, the first swale and secondary dune.

9.4.3.1 Perennial herbs and low shrubs

Acacia lasiocarpa var. **lasiocarpa** MIMOSACEAE ♦ *Panjang, Dune Moses*

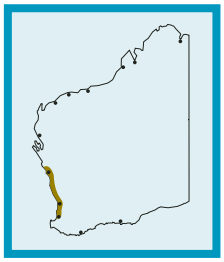
The coastal form is a low, compact shrub to 1m high, with few or no spines in the leaf axil. The bipinnate leaves have one or a pair of pinnae, each with 4-6 pairs of small leaflets which have their margins rolled backwards. Flowerheads are globular, bright yellow and borne on stalks to 12mm long. Pods are flat, up to 40mm long and 5mm wide.

Hardy, short-lived (<15 years).

Flowering *June-October*
Seeding *late November-January*
Propagation *Scarified or hot-water-treated seed. Collect seed by spreading a tarpaulin under the shrub and knock shrub gently with a stick. Plant at 40-cm intervals.*

E Wittwer/ WSWA

Conostylis candicans subsp. **calcicola** HAEMODORACEAE ♦ *Grey Cottonhead*

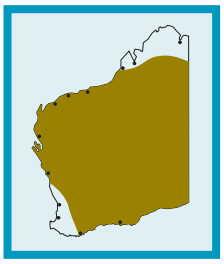



Perennial herb, 30-60cm high, to 90cm across with numerous stems. The strap-like leaves are covered in white to silvery-grey hairs. Flowers are woolly, golden yellow and clustered in heads of 10-20, on long stems. Low water requirement.

Flowering *August-November*
Seeding *November-early December*
Propagation *Smoked seed. Plant seedlings at 0.5m intervals. Full sun.*

GF Craig

Enchylaena tomentosa CHENOPODIACEAE ♦ *Barrier Saltbush, Ruby Saltbush*

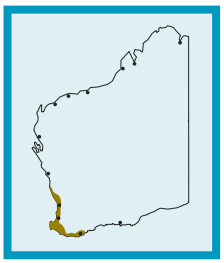


Low straggling or decumbent shrub, to 1m high and 1m wide. Leaves are 1-2cm long, almost cylindrical, succulent, greyish-green and sparsely to densely covered in soft fine hairs. Flowers are small and insignificant. Attractive, sweet, succulent, depressed-globular berries age from green through yellow to bright red-orange. Very drought tolerant.

Flowering *May-September, September-February*
Seeding *March-June*
Propagation *Seed or cuttings. Plant at 1m intervals. Full sun preferred.*

GF Craig/ Dept of Agriculture

Hardenbergia comptoniana PAPILIONACEAE ♦ *Native Wisteria*



Vigorous, twining shrub, climber or creeper that can spread to 6m across. Leaves are divided into 3-5 leaflets. Festoons of lightly fragrant, vivid, bluish-purple pea flowers are borne in long, dense racemes, up to 20cm long. Pods are cylindrical, up to 4cm long.

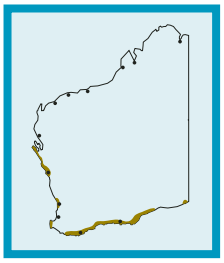
Fast growing, very hardy, low water requirement. Very aggressive tap root system.

Flowering *July-November*
Seeding *November-January*
Propagation *Direct seed (scarified or hot-water-treated) or cuttings. Pods burst and expel seed on hot days, so collect early and store in paper bag; seed germinates easily. Full sun or part shade.*

WF Walker/ Dept of Conservation and Land Management, WA Herbarium

Tetragonia implexicoma AIZOACEAE *Bower Spinach*

Prostrate or climbing perennial herb, 10-50cm high, to 2m wide, with long, trailing, weak branches. Leaves



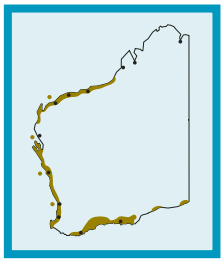
are slightly fleshy, to 5cm long, with various sizes clustered together. Flowers are mostly solitary, small, 6mm across, 4-petalled, yellow. Fruits are berry-like, 5-8mm across, succulent, green turning red then brown as they mature.

Related to the introduced *T. decumbens* (sea spinach), which is a more robust, succulent perennial with dry fruits, growing on foredunes.

Flowering *August-October (all year)*
Seeding *November-December*
Propagation *Seed or cuttings. Plant at 1-2m intervals. Prefers shade or part shade.*

J Stevens

Threlkeldia diffusa CHENOPODIACEAE ♦ *Coast Bonefruit*



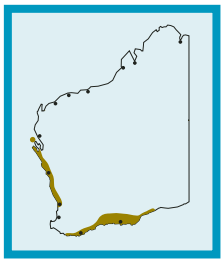
Much-branched prostrate to erect perennial, to 30cm high, with stems often red or red-green. Leaves are slender, near cylindrical, 5-30mm long, and succulent. Flowers are inconspicuous in the leaf axils. Fruits are hard and subglobular, green turning red, then black when dry and have the appearance of mouse faeces.

Flowering *October-November*
Seeding *January-April/ May-June*
Propagation *Smoked seed. Seed may readily germinate without pre-treatment, but can be slow to germinate – do not overwater.*

GF Craig/ Dept of Agriculture

Westringia dampieri LAMIACEAE ♦ *Coast Rosemary*

Dense shrub, 0.6-1m high. `Leaves are usually in whorls of 4, narrow, linear, margins rolled backwards towards the underside. Flowers are white with purple markings, have an erect 2-lobed upper lip and a lower, spreading 3-lobed lip. Nutlets are wrinkled.



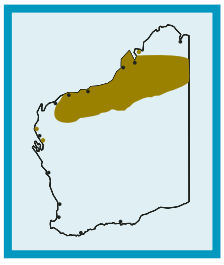
Flowering *June-January*
Seeding *December-January*
Propagation *Cuttings (easy) or seed. Plant at 1.5m intervals. Full sun or part shade.*

GF Craig

9.4.3.2 Medium shrubs

Acacia ampliceps MIMOSACEAE ▼❐ *Salt Wattle*

Spreading shrub or tree 2-9m high, occasionally prostrate. Phyllodes commonly pendulous, 7-25cm long, 7-30mm wide, light green, prominently 1-nerved. Flowerheads are large, globular, white to cream and borne in 2-11-headed racemes. Pods grow to 10cm long and 5-6mm wide, and break readily at the constrictions between the seeds. Seeds are brown to black with a scarlet aril.



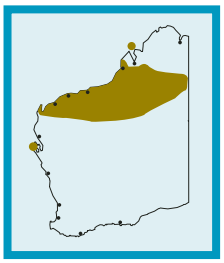
Hybridises with *A.bivenosa* in the Pilbara region.

Adaptable, fast-growing but short-lived (<15 years) species which can spread by root-suckering. Attractive tree when irrigated.

Flowering *April-September*
Seeding *September-October/ December-January*
Propagation *Scarified, hot-water-treated or untreated seed. Direct seed one month before wet season at 5 grams per square metre. Provenance selection required.*

BR Maslin/Dept of Conservation and Land Management

Acacia bivenosa MIMOSACEAE ❒● *Two-nerved Wattle, Cable Beach Wattle, Dune Wattle*



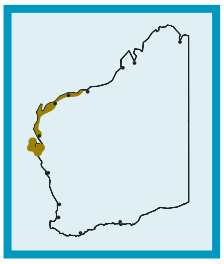
Dense shrub, 1-3m high. Phyllodes are oblong-elliptic, 2-5cm long and 6-25mm, with 2-nerves per face. Flowerheads are globular, deep golden and borne in 6-7-headed racemes. Pods are ± erect, to 8cm long, 5-9mm wide, light brown, dry and brittle. Seeds are dark brown with a red or orange aril.

A. bivenosa is readily distinguished from *A. xanthina* which has more elongate phyllodes and *A. didyma* which has wider pods. Short-lived (<15 years).

Flowering *April-November*
Seeding *September-December*
Propagation *Scarifed, hot-water-treated or untreated seed. Direct seed one month before wet season at 8-10 grams per square metre. Seed difficult to collect and process. Very variable in form, provenance selection required. Full sun or part shade.*

BR Maslin/ Dept of Conservation and Land Management

Acacia coriacea subsp. **coriacea** MIMOSACEAE ▼❒● *Wirewood, Dogwood*



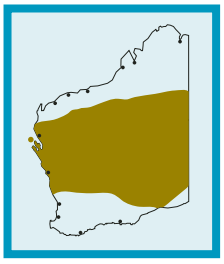
Bushy shrub or tree 1-3m high, occasionally semi-prostrate. Bark fibrous, hard. Phyllodes are erect, almost straight to very shallowly incurved, 12-22cm long, 1.5-10mm wide, silvery- or grey-green. Flowerheads are pale yellow or cream, globular and borne singly or in pairs. Pods are ± twisted and coiled before opening. Seeds are black with a large, bright orange aril.

Closely related subsp. *pendens* has a weeping habit and pendulous phyllodes that are shallowly to strongly recurved and 1.5-5mm wide. Subsp. *pendens* typically grows inland, but is known to grow on stable coastal dunes. Adaptable.

Flowering *June-July*
Seeding *October-December*
Propagation *Scarified or hot-water-treated seed. Provenance selection required.*

GF Craig/ Dept of Agriculture

Acacia ligulata MIMOSACEAE ❒● *Umbrella Bush, Dune Wattle*



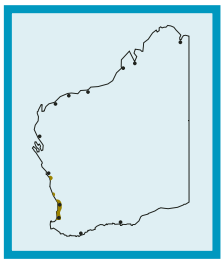
Dense shrub or tree, 2-3m high. Branchlets distinctly yellow-ribbed. Phyllodes are thick, linear, 3-7.5cm long and 4-14mm wide with a recurved to straight tip, 1-nerved. Flowerheads are globular, deep golden and borne in 2-4-headed racemes. Pods are up to 9m long, 5-9mm wide, thick, woody. Seeds are brown with a yellow-orange or red aril.

May hybridise with *A. bivenosa* which is distinguished by its 2-nerved phyllodes. Plants from Shark Bay resemble the closely related *A. rostellifera,* which at this location is characterised by short, <3.5cm, narrowly elliptic, thin phyllodes, and the aril which partially sheaths the end of the seed. *A. ligulata* also forms hybrids with *A. scleroperma* subsp. *sclerosperma.*

Flowering *May-October*
Seeding *October-December*
Propagation *Scarified or hot-water-treated seed. Confused taxonomy particularly in Shark Bay area, careful provenance selection required.*

BR Maslin/ Dept of Conservation and Land Management

Grevillea crithmifolia PROTEACEAE ●♦



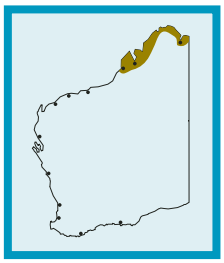
Dense shrub 0.6-2.5m high and 1m wide, or rarely prostrate. Branchlets are softly hairy. Leaves are light green, needle-like, 2cm long, and entire or divided into 2-5 segments. Flowers are pink in bud turning white and occur in short, dense clusters.

Fast growing; resprouts from basal suckers or lignotuber.

Flowering *June-November*
Seeding
Propagation *Cuttings or seed.*

BMJ Hussey

Grewia breviflora TILIACEAE ▼♦ *Bush Currant, Coffee Fruit*

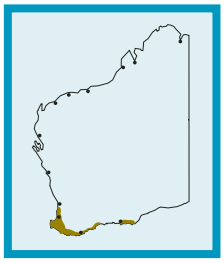


Deciduous shrub or tree, to 8m high and covered with minute star-like hairs. Leaves are ovate, sparsely to densely hairy, finely toothed on the margin, and have 3 prominent veins on the undersurface. Flowers are bright yellow or cream in 2-6 flowered clusters. Fruits are fleshy, globular, densely hairy at first becoming sparsely hairy, and green turning purplish-black with maturity.

Flowering *November-April*
Seeding *November-April*
Propagation *Seed*

BJ Carter/ Broome Botanical Society

Hibbertia cuneiformis DILLENIACEA ♦ *Cutleaf Hibbertia*

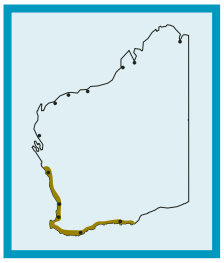


Compact, rounded shrub, 1-3m high and up to 2m wide. Leaves are dark, glossy, toothed and up to 4cm long. Flowers are large, 3cm across, open, yellow and crowded amongst the upper leaves. Fruits are orange. Demands a well-conditioned soil; companion plant to *Agonis flexuousa;* safe near sewers.

Flowering *January-March / June-November*
Seeding *December-January*
Propagation *Cuttings or scarified seed. Seed often insect damaged. Full sun or part shade.*

WF Walker/ Dept of Conservation and Land Management, WA Herbarium

Rhagodia baccata CHENOPODIACEAE ●♦ *Berry Saltbush*



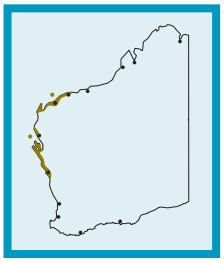
Spreading shrub to 2m high. Leaves narrowly elliptic, 1-4cm long. Flowers are borne in terminal, openly branching inflorescences. The depressed-globular berries are red when ripe.

Hardy, very salt tolerant; responds to pruning. Weed potential.

Flowering *February-May / October-December*
Seeding *February-March / April-May (Perth)*
Propagation *Tip cuttings or smoked seed (untreated seed can be successful). Dry berries in paper bag in sun, no need to wash, separate or clean flesh from berries; germination may be slow and irregular.*

T Tapper

Rhagodia preissii subsp. **obovata** CHENOPODIACEAE

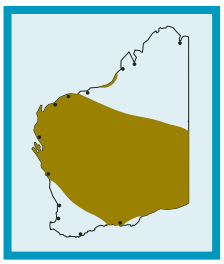


Shrub to 2m high. Leaves are broadest in the upper half, narrowed towards the base, 1.5-3cm long, leathery. Small flowers are borne on branched inflorescences, 5cm long. The depressed-globular berries, 3mm across, are red when ripe.

Flowering *May-August*
Seeding
Propagation *Cuttings*

GF Craig/ Dept of Agriculture

Scaevola spinescens GOODENIACEAE *Currant Bush, Maroon Bush*

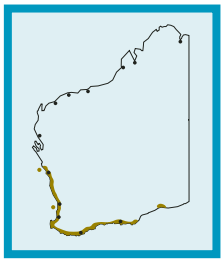


Rigid, spreading shrub to 2m high, the smallest branches often spiny. Leaves are thick, 9-35mm long, 1-6mm wide and clustered. Flowers are white or yellowish, split to base on one side and opened like a fan, bearded inside and softly hairy outside, solitary in leaf axils. Fruits are 5-8mm long, black or purplish.

Flowering *All year*
Seeding *All year*
Propagation *Stem or leaf cuttings (easy) or seed. Provenance selection required.*

GF Craig/ Dept of Agriculture

Spyridium globulosum RHAMNACEAE ❒●♦ *Basket Bush*

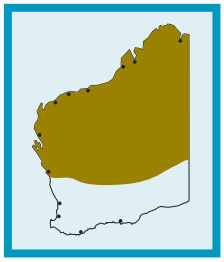



Compact, domed shrub, to 3m high. Leaves are elliptic, up to 50mm long, shiny and dark green on the upper surface, with the lower surface covered in short, woolly hairs. Dense flowerheads formed by small, white or cream flowers are surrounded by brown hairy bracts. Mature fruits split into 3 valves. Hardy.

Flowering *June-November*
Seeding *Late November-December (February)*
Propagation *Cuttings (easy) or smoked/ untreated seed (easiest). Seedlings are slow growing initially. Plant at 2.5m intervals. Full sun or part shade.*

GF Craig/ Dept of Agriculture

Trichodesma zeylanicum BORAGINACEAE ❒● *Camel Bush*

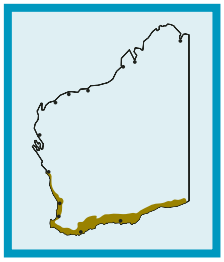
Erect, few-branched, woody annual or perennial to 2m high, covered in stiff hairs which may be highly irritant. Leaves lanceolate, 2-13cm long, bright green. Flowers pale to bright blue on long downwardly curving stalks.

Flowering *March-November*
Seeding *March-November*
Propagation *Cuttings or seed.*

GF Craig/ Dept of Agriculture

9.4.3.3 Tall shrubs

Acacia cyclops MIMOSACEAE ❒● *Red Eyed Wattle, Coastal Wattle*

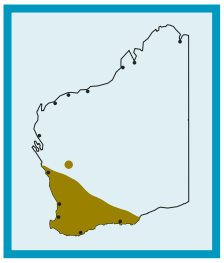
Domed shrub to small tree 1-6m high. Phyllodes are narrowly oblong to elliptic, 4-9.5cm long, 6-15mm wide, with 3 or 4 longitudinal nerves. Flowerheads are golden, globular and borne in pairs. Pods linear, slightly raised over seeds, to 15cm long, 7-15mm wide, persistent after seed-fall. Seeds dark brown to black with an enlarged orange to scarlet stalk encircling the seed in two folds.

Long-lived (> 40 years); seed-bearing branches used for rehabilitation brushing; weed potential; safe near sewers; low water requirement.

Flowering *September-May*
Seeding *November-January*
Propagation *Scarified, hot-water-treated or smoked seed. Plant at 3-4m intervals. Provenance selection east of Esperance good for amenity plantings.*

BR Maslin/ Dept of Conservation and Land Management

Acacia saligna MIMOSACEAE ❐● *Golden Wreath Wattle, Orange Wattle, Coojong*



Bushy shrub or tree, 2-6m high. Phyllodes often pendulous, variable in shape and size, linear to lanceolate, 7-25cm long, 4-20mm wide, often larger towards base of plant, with prominent midrib. Flowerheads globular, golden and borne with 2-10-heads per raceme. Pods are linear, flat, shallowly constricted between seeds, 8-12cm long, 4-6mm wide. Seeds are dark brown to black with a club-shaped aril.

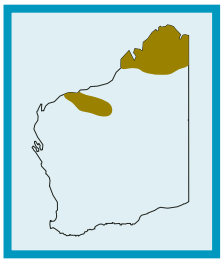
Acacia saligna is sometimes confused with *A. rostellifera* where they grow together in coastal habitats, but the pods and seeds are very different.

Hardy, fast-growing, short-lived (<10 years); susceptible to gall; eaten by kangaroos and rabbits; roots invasive, care needed near sewers; weed potential.

Flowering *July-November*
Seeding *December-early January*
Propagation *Scarified or hot-water-treated seed. Plant at 4m intervals. Coastal provenance selection required.*

BR Maslin/ Dept of Conservation and Land Management

Flueggea virosa subsp. **melanthesoides** EUPHORBIACEAE ● *Goowal, Snowball Bush*

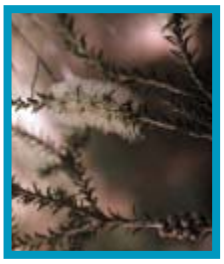
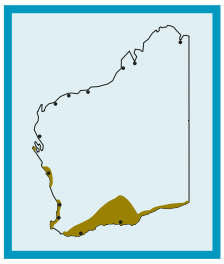


Small to tall spreading shrub or tree, 1-5m tall and 1-2m wide, with smooth bark. Leaves are oval, light green above and paler below, have distinct venation and pointed tips. Male and female flowers are borne on different plants. Flowers are tiny, cream and borne in clusters in leaf axils; male flowers fragrant; female flowers inconspicuous. Roundish fleshy berries are white when ripe.

Flowering *December-April*
Seeding *January-June*
Propagation *Seed.*

BJ Carter/ Broome Botanical Society

Melaleuca lanceolata MYRTACEAE ▼❐● *Rottnest Teatree, Moonah*

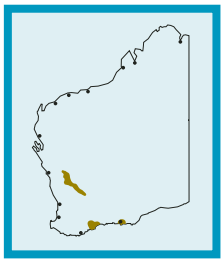
Large bushy shrub or medium tree, 3-10m high and 3-8m wide, with dark fibrous bark and a dense, low branching, rounded crown. Leaves are small, about 1cm long and 20mm wide, dull bluish green to olive green, held at a wide angle to the stem, and usually bent downwards. Flowers are clustered in large, 1-5cm long, brush-like spikes, white to pale yellow. Fruits are small, smooth, woody capsules interspersed along the stem.

Hardy, adaptable; tolerant of a wide range of soils and parent materials – limestone, sandstones, travertines, granites and shales; drought tolerant; salt tolerant; waterlogging tolerant. Roots invasive, care needed near sewers. Weed potential.

Flowering *January-September*
Seeding *All year*
Propagation *Seed or cuttings. Provenance selection important. Collect seed from older fruits lower down the stem. Plant at 5m intervals. Plants will branch at the base if planted singly; for future shade prune to single stem early on, or plant in higher densities (0.75-1m grid) to encourage straight growth. Needs full sun.*

GF Craig

Melaleuca nesophila MYRTACEAE ▼❐♦ *Mindiyed, Showy Honeymyrtle*

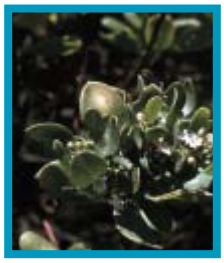
Handsome, dense, dome-shaped shrub or small tree, 2-6m tall and 2-7m wide, with branches at or near ground level, and greyish white papery bark. Leaves are leathery, dull, dark green, elliptic, 10-15mm long. Flowers are strongly scented, light mauve to purplish with yellow anthers, and clustered in terminal balls. Small, woody fruits are clustered into an ovoid head up to 2cm across.

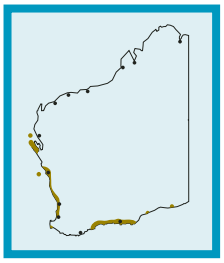
Hardy, fast-growing; appears adaptable to tropics; safe near sewers.

Flowering *August-January*
Seeding *All year*
Propagation *Seed or cuttings. Plant at 3m intervals.*

GF Craig

Myoporum insulare MYOPORACEAE ❒●♦ *Blueberry Tree, Boobialla*





Dense shrub, 1-7m tall and 2-8m wide. Leaves are thick, fleshy, bright green, up to 10cm long, shallowly toothed and crowded towards the ends of bare, heavily scarred branches. Flowers are small, white spotted with purple on the inside, tubular with 4 blunt, expanding lobes and clustered in the branch axils. Succulent berries, 6mm across, are greenish blue to purple.

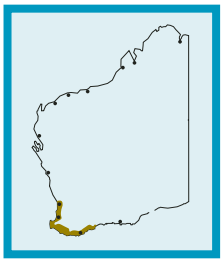
Fast growing, although it takes 15 years to reach average mature height (5 m). Very drought tolerant. Roots invasive, care needed near sewers. Narrow- and round-shaped leaf forms.

Flowering *May-February*
Seeding *September-February*
Propagation *Cuttings (easy), or smoked or scarified seed (hard to germinate). Seed frequently insect damaged; large purple galls often mistaken for fruit. Plant at 3-4m intervals. Full sun or part shade.*

GF Craig

9.4.3.4 Trees and mallees

Agonis flexuosa MYRTACEAE ▼❒●♦ *Peppermint*



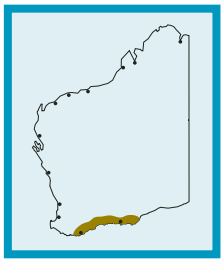
Spreading shrub or medium tree, 2-15m high and 2-15m wide, with dark fibrous bark, graceful pendant branches, and a rounded, rather dense crown. Leaves are lanceolate to linear, 8-13cm long, willow-like, have three main longitudinal veins and a strong peppermint fragrance. New growth is rich pink in colour. Numerous, small, honey-scented, 4-5 petalled white flowers grow in axillary, globular heads. Fruits form tightly packed globular heads of woody capsules.

Fast growing; waterlogging tolerant; ideal for parks, gardens and roadsides; dwarf cultivars available; demands a well conditioned soil, supplementary nutrients required in poor soils; low water requirement; roots invasive, care needed near sewers.

Flowering *August-December*
Seeding *January-April*
Propagation *Seed. Plant at 4m intervals.*

GF Craig/ Dept of Agriculture

Eucalyptus angulosa MYRTACEAE ▼❐♦ *Ridge-fruited Mallee*

Spreading mallee, 2-6m high and 3-8m wide, with erect, branching stems, with smooth, grey-brown to light bark peeling salmon pink beneath. Adult leaves are thick, leathery, lanceolate, glossy dark green, 5-14cm long, 1-3.5cm wide. Buds and fruits are strongly ribbed and borne in groups of 3 or 7. Flowers are creamy white to pale yellow. Fruits are cup-shaped to cylindrical, to 2 x 2 cm.

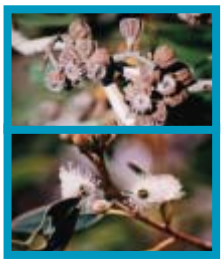
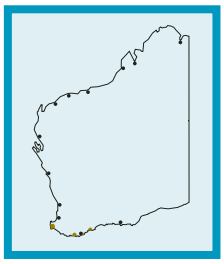
Closely related to *E. incrassata* which occurs further inland and is distinguished by being only slightly ribbed on the buds and fruits.

Long-lived (> 60 years); roots invasive, care needed near sewers.

Flowering *August-March*
Seeding *All year*
Propagation *Seed. Plant at 3-4m intervals.*

M French

Eucalyptus calcicola MYRTACEAE ▼❐♦ *Hamelin Bay Mallee, Boranup Mallee*

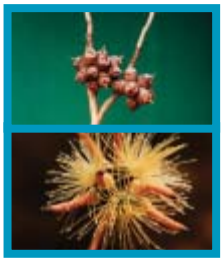
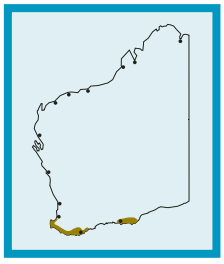



Mallee, 2-6m high, with smooth bark. Adult leaves are lanceolate, 6-10cm long, 1-3cm wide, slightly glossy, green, with numerous oil glands. Inflorescences are 7-flowered and borne on flattened stalks, 1-2cm long. Buds caps are strongly ribbed, conical; flowers are white. Fruits are ribbed, cupular, 1-1.5cm across, with 4 enclosed valves.

Flowering *May-June*
Seeding *All year*
Propagation *Seed*

M French

Eucalyptus cornuta MYRTACEAE ▼♦ *Yate*

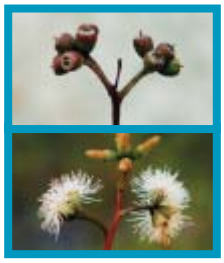
Small to tall, upright tree, 2-25m tall and 3-12m wide, with a rounded crown and dark rough bark forming a 'stocking' on the lower half of trunk with smooth grey bark above. Adult leaves lanceolate, glossy, dark bluish-green, 8-14cm long, 1-2.7cm wide. Buds are orange with a very long, horn-shaped cap, and borne in groups of 5-15. Flowers are pale yellow. Fruits are cup-shaped, about 1 x 1 cm, with 3 or 4 prominent valves joined at the tips.

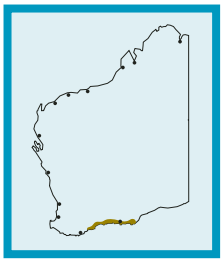
Fast growing, long-lived (> 50 years); grows only in damp places with no salinity; waterlogging tolerant; roots invasive, unsafe near sewers; drops limbs.

Flowering *July-November*
Seeding *All year*
Propagation *Seed.*

M French

Eucalyptus utilis Ms [ex. E. *platypus* var. *heterophylla*] MYRTACEAE ▼❐♦ *Coastal Moort*





Small tree (mallet), 3-8m tall and 3-8m wide, with a dense, rounded crown often to near ground level and smooth grey bark peeling pinkish grey or yellow-green beneath. Adult leaves are elliptical to broad-lanceolate, glossy, olive green to green, 4.5-9.5cm long, 1-3cm wide, and have numerous oil glands. Buds are ribbed at the base with horn-shaped caps, and borne in groups of 7 on a long, strap-like, pendulous stalk. Flowers are white to creamy yellow. Fruits are barrel-shaped to cylindrical, about 0.8 x 0.8 cm, with 4 or 5 enclosed valves.

Fast growing, adaptable, long-lived (> 40 years); waterlogging tolerant; roots invasive, care needed near sewers.

Flowering *September-January*
Seeding *All year*
Propagation *Seed. Full or filtered sun.*

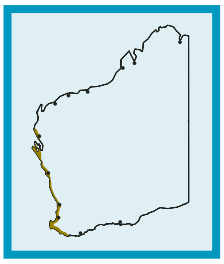
M French

9.4.4 Stable dunes

These herbs, shrubs, trees and mallees grow in protected, well stabilised and vegetated dune areas.

9.4.4.1 Perennial herbs and low shrubs

Acanthocarpus preissii DASYPOGONACEAE ●✷ *Prickle Lily*

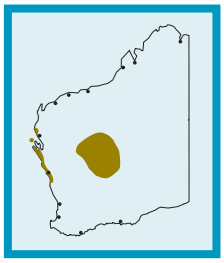


Grass-like herbaceous shrub, to 1m high, growing in a tangled mass of stems that are partially covered by leaf sheaths. Leaf blades are linear, to 5cm long, and have a needle-sharp tip. Flowers are white, sweetly scented and borne in axillary clusters. Fruits are spherical, covered in fine spines, turn yellow as they ripen, and contain 1-3 seeds.

Flowering *April-August*
Seeding *December-January*
Propagation *Smoked, scarified or hot-water-treated seed. Plant at 1.5m intervals. Dappled shade or part sun, can tolerate full sun providing root area has some protection; can withstand harsh pruning.*

GF Craig

Eremophila glabra subsp. **tomentosa** MYOPORACEAE ♦ *Tar Bush*

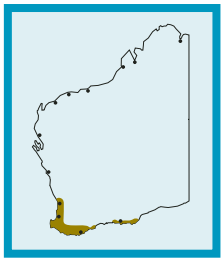
Prostrate, spreading shrub, 0.5m high and 2-3m wide in coastal areas, and up to 2m high further inland. Leaves are light green, covered in soft grey hairs, elliptical, 1.5-5cm long, 5-8mm wide. Flowers are greenish yellow to orange-red, tubular, with the lower lip curving backwards from the flower. Fruits are fleshy, subglobular, to 1cm long.

Very hardy. Low water requirement. Very variable in form, leaves and flower colour.

Flowering *April-October*
Seeding *September-January*
Propagation *Direct seed or cuttings (easy). Seed hard to germinate. Plant at 0.5-1m intervals. Dry, sunny position.*

GF Craig

Kennedia coccinea PAPILIONACEAE ♦ *Coral Vine*

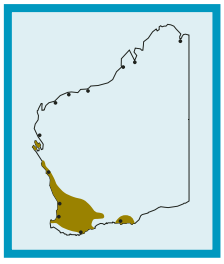



Prostrate, creeping or twining shrub, 0.2-2m high and 2-4m wide. Leaves have 3 rounded, blunt leaflets. Flowers are showy, coral pink or orange, with 4-20 forming dense clusters. Low water requirement.

Flowering *August-November*
Seeding *December-early January*
Propagation *Scarified or hot-water-treated seed. Plant at 2m intervals. Full sun or part shade.*

Dept of Conservation and Land Management, WA Herbarium

Kennedia prostrata PAPILIONACEAE ♦ *Running Postman, Scarlet Runner*

Vigorous, robust, annual or perennial, creeping groundcover, 0.1-1m high and 1-4m wide, with slender, twining, mat-forming stems, covered with silky white hairs. Leaves have 3 grey-green, broadly heart-shaped leaflets covered with silky hairs, often with wavy margins. Flowers are showy, scarlet, with 1-4 borne on short branches. Pods are hairy, brown, prominently veined, cylindrical, to 5cm long.

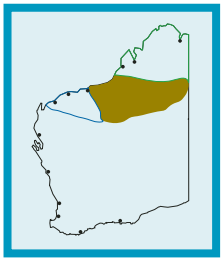
Fast growing, aggressive groundcover which can cover several square metres in one growing season; grows better where some nutrients available; establishes well after bushfires; low water requirement.

Flowering *April-November*
Seeding *November-December*
Propagation *Scarified or hot-water-treated seed. Plant at 1.5m intervals. Full sun or part shade.*

M Hislop

9.4.4.2 Medium shrubs

Acacia tumida MIMOSACEAE ❒● *Spear Wattle, Wongai*

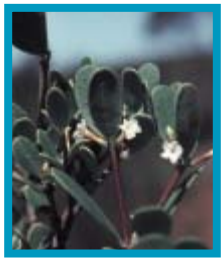
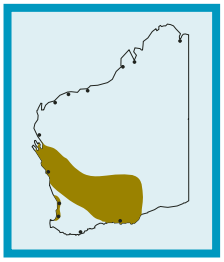
Shrub or tree, 1-15m tall. Phyllodes are sickle-shaped, 6-25cm long, 1-6cm wide, leathery, with numerous parallel, longitudinal nerves. Flowerheads are yellow to light golden spikes, 2-6cm long. Pods are narrowly oblong, sometimes constricted between and over the seeds, straight to curved and often twisted, 3-12cm long, 5-10mm wide, woody, longitudinally wrinkled. Seeds are black with a twice-folded, cream aril.

Variety *kulparn* ms (pictured) mainly differs from var. *tumida* by its low shrubby growth form to 2m high and its shorter (6-12 cm), nearly straight phyllodes, and resprouts from a lignotuber after fire; it occurs from Eighty Mile Beach to Dampier Archipelago. The 'typical' var. *tumida* is an openly branched tree or tall shrub, has long phyllodes (>12 cm), is killed by fire, and forms dense stands in some coastal areas.

Flowering *April-October*
Seeding *September-October*
Propagation *Scarified, hot-water-treated or untreated seed. Provenance selection required. Direct seed one month before wet season at 10 grams per square metre.*

BR Maslin/ Dept of Conservation and Land Management

Alyxia buxifolia APOCYNACEAE ♦ *Sea Box, Dysentry Bush, Hop Bush*

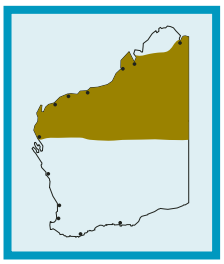



Erect, rigid or spreading shrub, 1-3m high. Leaves are opposite or in whorls of 3, dark green, thick, leathery, to 5cm long. Flowers are tubular, 1cm long, orange at the base with a small, star-like, white opening. Fruits are globular, to 8mm long, orange-red, solitary or linked together in pairs, ornamental. Fruits are red when ripe. Hardy.

Flowering *May-December (all year)*
Seeding *January-March*
Propagation *Scarified seed or cuttings (slow to strike). Seeds very slow to germinate (8 months); very slow growing. Plant at 1.5m intervals.*

Dept of Conservation and Land Management, WA Herbarium

Crotalaria cunninghamii PAPILIONACEAE ♦ *Green Birdflower*

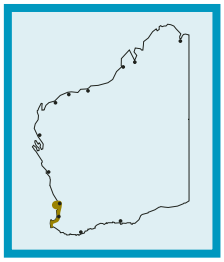
Erect shrub, 1-2m high and 0.5-2m wide, with soft, hairy, slender branches. Leaves are entire or rarely divided into 3 leaflets, ovate to elliptic, thick, hairy, light green. Bird-like pea flowers are yellow-green streaked with fine purple lines, borne in groups to 25cm long at the ends of branches. Pods are swollen, oblong, 30-45mm long, 10-12mm wide, hairy.

Fast growing; likes hot conditions; very drought tolerant.

Flowering *February-November*
Seeding *February-November*
Propagation *Scarified, hot-water-treated or untreated seed, or stem cuttings. Direct seed about one month before wet season. Full sun.*

GF Craig/ Dept of Agriculture

Diplolaena dampieri RUTACEAE ❒♦ *Dampier's Rose, Southern Diplolaena*

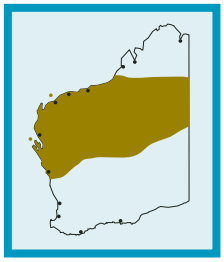


Bushy shrub, 0.5-2m high. Leaves are leathery, extremely aromatic, elliptic, to 4cm long, shiny on the upper surface and densely hairy beneath. Flowerheads are pendulous, have red-orange stamens which are surrounded at the base by grey, hairy bracts.

Flowering *July-November*
Seeding *November-January*
Propagation *Cuttings (easy), or smoked, scarified or hot-water-treated seed. Seeds are ejected over a short period; difficult to germinate. Plant at 1.5-3m intervals.*

G Keighery

Stylobasium spathulatum SURIANACEAE ❒ *Pebble Bush*

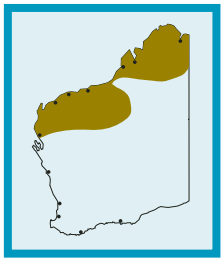


Erect shrub to 2.5m high. Leaves are generally hairy, 3cm long, 1cm wide and have indented tips. Flowers are small, yellow, with ten yellow-brown stamens protruding beyond the cup-like lobes. Fruits are pebble-like, less than 1cm across.

Flowering *May-October*
Seeding *November-January*
Propagation *Seed, soak in water overnight or longer before planting.*

D Bauer

Tephrosea rosea PAPILIONACEAE ♦ *Widji, Flinders River Poison*



Erect, weak shrub to 2m high. Leaflets are large, 2-3.5cm long, 5-11 pairs, silvery grey-green, silky hairy (especially beneath), up to 10 lateral veins. Flowers in pairs, dark pink, in terminal spikes up to 22cm long. Pods are linear, 25-30mm long, 3-4mm wide, silky hairy.

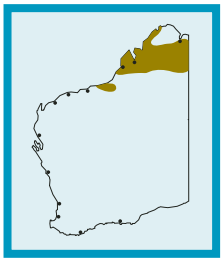
Flowering *February-October*
Seeding
Propagation *Seed. Provenance selection required. Full sun preferred.*

GF Craig/ Dept of Agriculture

9.4.4.3 Trees and mallees

Bauhinia cunninghamii [ex. *Lysiphyllum cunninghamii*] CAESALPINIACEAE ▼❐

Kimberley Bauhinia, Jigal Tree

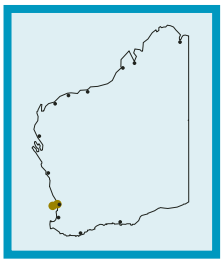
Semi-deciduous, dense shrub or tree 4-10m high and 2-5m wide, with rough, fissured, grey bark and pendulous branches. Young leaves are flushed red, then turn yellowish green. Adult leaves are bluish grey, and divided into two rounded leaflets (butterfly-shaped), 2-3cm long, 1-2.5cm wide. Flowers are nectar-rich, somewhat tubular, velvety pink with protruding red stamens. Pods are large, pendulous, flat, brittle, stiff, red when young, black when ripe.

Branches are used for constructing windbreaks.

Flowering *April-October*
Seeding *September-December*
Propagation *Direct seed about one month before wet season at 10-15 grams per square metre.*

T Tapper

Callitris preissii CUPRESSACEAE ▼❐♦ *Rottnest Island Pine*

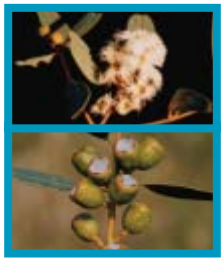
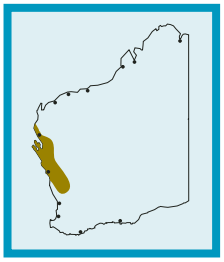
Shrub or compact, rather formal tree, 1-9m high, with an erect central stem of dark grey, fissured bark. Leaves are scale-like, joined to the branchlets for most of their length, in alternating whorls of 3, bronze or rich dark green. Clusters of 3 cylindrical male flowers occur at the ends of branchlets. Female flowers are small, solitary and globular. Depressed globular cones are usually more than 2cm across and slightly warty.

Hardy, long-lived, moderately fast growing; very drought tolerant; fire-sensitive; termite-resistant; roots invasive, care needed near sewers; low water requirement.

Flowering *January-December*
Seeding *All year*
Propagation *Smoked or untreated seed or cuttings. Seedlings, both wild and planted, are targeted by rabbits. Rabbits also like the plant roots.*

GF Craig

Eucalyptus eudesmioides MYRTACEAE ▼❐♦ *Malallie*

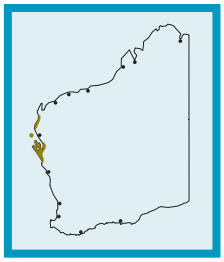
Small, bushy mallee or medium tree, 2-6m high and 2-6m wide, with variable bark. Adult leaves are + opposite, lanceolate, 4-10cm long, 0.6-2cm wide, dull light green or blue-green, have prominent side veins and numerous oil glands. Buds are small, oblong with yellow hemispherical bud caps, and borne in groups of 3. Flowers are white. Fruits are small, about 1cm long, cylindrical and slightly square in cross-section, with usually 3 valves.

Long-lived (> 50 years); intolerant of waterlogging.

Flowering *February-May*
Seeding *All year*
Propagation *Seed. Slow to establish*

M French

Eucalyptus fruticosa MYRTACEAE ❒

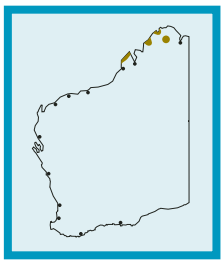



Sprawling mallee or shrub, 1.5-5m high, with smooth bark or + rough at base. A large number of juvenile leaves are retained in the crown. Inflorescences are usually densely clustered towards the ends of branches, often 7-flowered on stalks about 1cm long. Buds are small, about 6mm long, 3mm wide, with conical bud caps that are rounded at the tip and turn red near flowering. Flowers are white. Fruits are small, barrel-shaped, about 4mm across.

Flowering *January-May*
Seeding *All year*
Propagation *Seed. Slow to establish.*

M French

Pandanus spiralis var. **convexus** PANDANACEAE ▼❒♦✷ *Iidool, Common Screwpine*

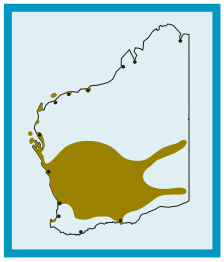



Tree-like, 3-10m tall. Leaves are very narrowly triangular, up to 2m long, with reddish-brown tipped scales along all or part of the midrib and on leaf margins. Male flowers are white. Fruits are red when ripe with about 24 globular segments.

Flowering *November*
Seeding *June*
Propagation *Transplant seedlings. Plant in clusters. Requires irrigation to establish.*

BJ Carter/ Broome Botanical Society

Pittosporum phylliraeoides PITTOSPORACEAE ▼♦ *Weeping Pittosporum*

Graceful tree or shrub, 3-8m high, with a smooth, slender grey trunk and weeping branches. Leaves are narrow, 2-8.5cm long, 5-15mm wide, leathery, light green with a hooked point. Small, fragrant, 5-petalled, white to creamy yellow, bell-shaped flowers occur singly or in short, terminal clusters. Berries are attractive, orange-red, have a strong orange fragrance and contain 4-24 sticky, red, irregularly-shaped seeds.

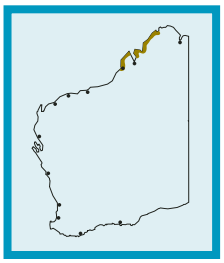
Hardy, adaptable; good street tree; waterlogging tolerant; fire tolerant; subject to scale attack which may cause severe defoliation; safe near sewers. Poisonous or irritating plant – the red seeds are poisonous and should be avoided.

Flowering *June-October / September-February*
Seeding
Propagation *Seed (wash flesh off seed as it inhibits germination) or cuttings. Full sun or part shade.*

GF Craig/ Dept of Agriculture

Terminalia latipes subsp. **Psilocarpa** [ex. T. ferdinandiana] COMBRETACEAE ▼♦

Gubinge, Billy Goat Plum

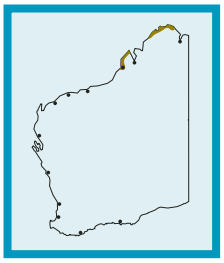


Deciduous spreading tree or shrub, 3-10m high, with orange-grey, flaky bark. Leaves are large, somewhat leathery, broadly elliptic to circular, 5-25cm long, 5-20cm wide, light green to yellow, with distinct veins and crowded towards the ends of branches. Fragrant cream flowers are borne on spikes, 10-20cm long, in leaf axils towards the ends of branches. Fruits are smooth, fleshy surrounding the stone, and yellow green when ripe. Immature fruits are prominently ridged and beaked.

Flowering *September-March*
Seeding *April-November*
Propagation *Seed. Plant at 4-5m intervals. Requires irrigation to establish.*

BJ Carter/ Broome Botanical Society

Terminalia petiolaris COMBRETACEAE ▼❐♦ *Marool, Blackberry Tree*



Semi-deciduous tree, to 10m high, with dark, fissured bark. Leaves are green, turning purplish-red before falling, broadly ovate, with a long stalk. Flowers are creamy white and borne in long spikes. Fruits are smooth, beaked, fleshy surrounding the stone, green turning maroon to purplish-black when ripe.

Extremely wind tolerant, capable of withstanding cyclones.

Flowering *October-May*
Seeding *April-December*
Propagation *Seed. Plant at 4-5m intervals. Requires irrigation to establish.*

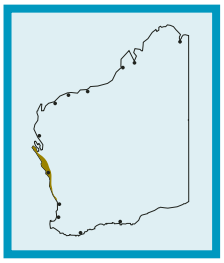
BJ Carter/ Broome Botanical Society

9.4.5 Limestone outcrops

These shrubs and mallees are suitable for growing on highly alkaline, shallow soils typical of limestone outcrops, in areas exposed to salt spray and windblast. Many of these plants will also grow on limestone ridges, and sheltered and stable dunes.

9.4.5.1 Low shrubs

Acacia idiomorpha MIMOSACEAE ♦✱ *Wattle*

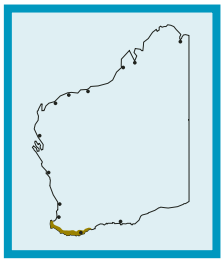


Spreading, sprawling shrub, to 1m high and 1-2m wide, with hairy branchlets and spiny stipules. Phyllodes are hairy, obliquely-oval, 5-25mm long, 3-14mm wide, usually 1-nerved, sharply pointed at the tip, and have wavy margins. Flowerheads are globular, golden, 1 or 2 per axil. Pods are narrowly oblong, often curved, to 6cm long, 4-5mm wide, wavy, densely hairy. Seeds are light grey or brown, often mottled.

Flowering *June-August*
Seeding *October-January*
Propagation *Scarified or hot-water-treated seed. Plant at 40cm intervals.*

D Bauer

Hibbertia grossulariifolia DILLENIACEAE *Gooseberry-leaved Guinea Flower*

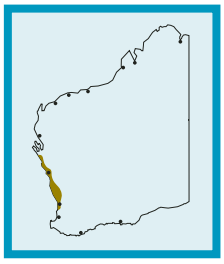


Prostrate, trailing perennial, 1-2.5m wide, with softly hairy, reddish young stems. Leaves are hairy, lobed, ovate, 2-3.5cm long, 1-2cm wide, light green becoming darker with age, and have wavy margins with prominent, blunt teeth. Flowers are bright yellow.

Flowering *August-December*
Seeding
Propagation *Cuttings or seed.*

WSWA Albany

Nemcia reticulata *[ex. Oxylobium reticulatum]* PAPILIONACEAE

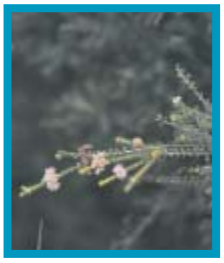


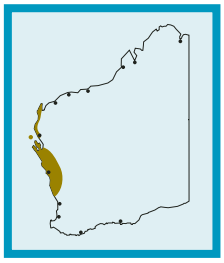
Rigid sometimes spreading shrub, to 0.5m high, with slender branches. Leaves are opposite, oblong, 30-70mm long, 4-8mm wide (coastal variants are broad and flat, while further inland leaves are narrow and folded), with a notched apex, and a conspicuous network of veins. The pea flower is small, yellow with red to purple markings. Pods are 9-11mm long and hairy. Non poisonous.

Flowering *May-November*
Seeding *October-December*
Propagation *Scarified, hot-water-treated or smoked seed. Plant at 2m intervals.*

M Hislop

Thryptomene baeckeacea MYRTACEAE ♦





Spreading to prostrate shrub, to 1.2m high and 2m wide, with long, arching branches. Leaves are tiny, 1-2mm long, overlapping and triangular in cross-section; the arrangement on young branches resembling the skeleton of a small fish. Flowers are dainty, white, pink or purple.

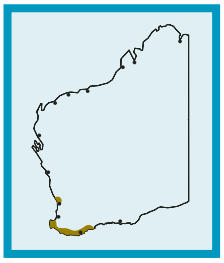
Susceptible to dieback disease *(Phytophthora).*

Flowering *March-October*
Seeding
Propagation *Cuttings or seed.*

D Bauer

9.4.5.2 Medium shrubs

Acacia littorea MIMOSACEAE ●♦✱ *Wattle*

Dense shrub 1-2m high, with prominently ribbed branchlets. Phyllodes are rather crowded, triangular, with a prominent gland at the top angle, 7-17mm long, 5-15mm wide, midrib near lower margin, sharply pointed. Flowerheads are globular, pale yellow, mostly single on stalks 6-12mm long. Pods are linear, curved, to 6cm long, 3mm wide, blackish, with thick, yellowish margins. Seeds are shiny brown.

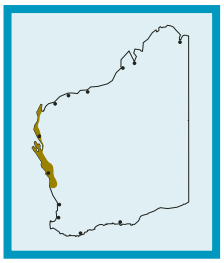
Closely related to *A. truncata,* which mainly occurs north of Bunbury and flowers in winter to early spring.

Adaptable, short-lived (<15 years).

Flowering *August-November*
Seeding *October-January*
Propagation *Scarified or hot-water-treated seed.*

BR Maslin/ Dept of Conservation and Land Management

Acacia spathulifolia MIMOSACEAE ❒♦ *Spoon Leaf Wattle*

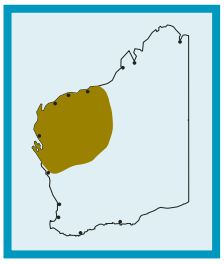
Dense, spreading shrub, 0.5-3m high. Phyllodes horizontally flattened, narrowly oblong, 1-2cm long, 1.5-4.5mm wide, rounded at the tip, thick, fleshy, green to yellow-green, with distinct, yellow marginal nerves. Flowerheads are globular, golden, showy, mostly single on stalks 5-15mm long. Pods are narrowly oblong, slightly raised over and slightly constricted between seeds, to 4cm long, 4-4.5mm wide. Seeds are shiny, dark brown, with a white aril.

Short-lived (< 15 years); often grows in dense stands.

Flowering *June-October*
Seeding *October-December*
Propagation *Scarified or hot-water-treated seed.*

BR Maslin/ Dept of Conservation and Land Management

Acacia sclerosperma subsp. **sclerosperma** MIMOSACEAE ❒● *Limestone Wattle*

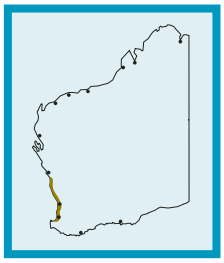
Dense, rounded shrub or tree, to 4m high and 4m wide. Phyllodes are narrowly linear, cylindrical to flat, 4-14cm long, 1-4mm wide, often with a hooked tip. Flowerheads are globular, golden, buds bright green and borne on 2-5-headed racemes. Pods are bead-like, 6-12cm long, 1-2cm wide, woody, golden brown. Seeds are dark brown to black with a red aril.

Distinguished from *A. ampliceps, A. bivenosa* and *A. ligulata* by its large, woody pods and large seeds; it is known to hybridise with these species. Adaptable; good coloniser.

Flowering *April-October*
Seeding *October-December*
Propagation *Scarified or hot-water-treated seed.*

GF Craig/ Dept of Agriculture

Acacia truncata *[ex. A.cuneata]* MIMOSACEAE ♦ *Cut Leaf Wattle, West Coast Wattle*

Dense shrub, 0.5-2.5m high. Phyllodes are oblong-triangular, 9-25mm long, 5-13mm wide, with a prominent gland on the top angle, midrib ± central, scarcely sharp-pointed. Flowerheads are globular, pale yellow, usually single on stalks 10-18mm long, (to 25mm long in fruit). Pods are linear, curved, to 6.5cm long, 2-4mm wide, blackish, with thick, yellowish margins. Seeds are shiny brown.

Closely related to A. littorea, which grows mainly south of Bunbury and flowers late spring to early summer.

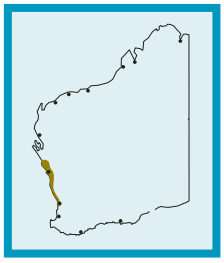
Short-lived (<15 years); calcareous dunes; low water requirement.

Flowering *June-September*
Seeding *November-December*
Propagation *Scarified, hot-water-treated or smoked seed. Plant at 2m intervals. Full sun.*

BR Maslin/ Dept of Conservation and Land Management

Acacia xanthina MIMOSACEAE ▼❐♦● *White-stemmed Wattle*

Large spreading, domed shrub, 2-4m high and 3-5m wide, with straggly branches covered in a whitish coating. Phyllodes are bright bluish-green, thin, narrowly elliptic 6-10cm long, 1-2cm wide, with usually two longitudinal nerves. Flowerheads are globular, golden, and borne in clusters of 3-9 heads. Pods are bead-like, to 11cm long, 5-7mm wide. Seeds are dull, black with a cream aril.

Plants near Kalbarri are atypical in their linear-elliptic, consistently 1-nerved phyllodes to 13cm long.

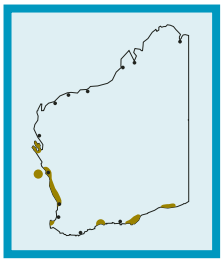
Closely related to *A. rostellifera* which occurs on sand dunes whereas *A. xanthina* occurs on limestone ridges; *A. rostellifera* is distinguished by its branchlets which are not covered in a whitish coating, and seed with a red or orange aril.

Fast growing; very drought tolerant; prune severely to induce suckering.

Flowering *August-October*
Seeding *November-December*
Propagation *Direct seed scarified or hot-water-treated seed, or seedlings. Variable seed set. Plant at 3m intervals.*

BR Maslin/ Dept of Conservation and Land Management

Atriplex cinerea CHENOPODIACEAE ●♦ *Grey Saltbush*

Prostrate or erect shrub, 0.3-2m high and 2-8m wide. Leaves are grey-green, with a sheen on both surfaces, up to 2cm long. Male flowers are borne in dense terminal clusters. Female flowers are borne in clusters in leaf axils near the tops of branches. Hard, roughly triangular or diamond-shaped fruiting bracts, 2-6mm long and wide, each contain a single seed, and are joined towards the base with a smooth or warty appendage on the surface.

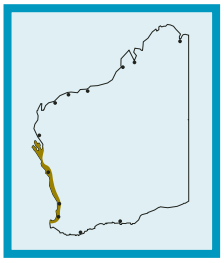
Hardy, fast growing; very drought tolerant; ornamental foliage; safe near sewers.

Flowering *September-March*
Seeding *March-June*
Propagation *Seed or cuttings. Plant at 1.5m intervals. Full sun.*

GF Craig/ Dept of Agriculture

Dodonaea aptera SAPINDACEAE ♦ *Coast Hop Bush*

Erect to spreading shrub, 0.5-3m high, with sticky branches and leaves. Leaves are flat, broadest in the upper half, about 2cm long and 1cm wide, with a rounded, sometimes indented tip. Buds are globular in terminal clusters. Fruit capsules are small, about 5mm across, 4-angled, and light to pink-brown when mature.

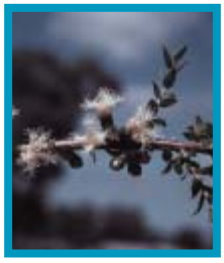
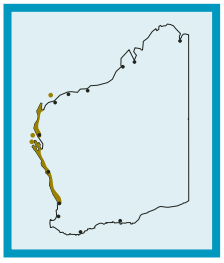
Interesting foliage.

Flowering *April-July*
Seeding *August-January*
Propagation *Smoked seed. Plant at 1-3m intervals. Tolerates shade.*

G Keighery

Melaleuca cardiophylla MYRTACEAE ✷ *Tangling Melaleuca*

Spreading, dense, prickly, shrub, 0.3-3m high and 1-3m wide, with many slender, interwoven, tangling branches. Leaves are many nerved, often stem-clasping, usually less than 1cm long, and prickly. Flowers are borne in small clusters along the branches, and have white or cream staminal bundles, usually less than 1cm long. Fruits are small, woody capsules.

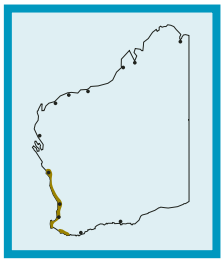



The variety *longistaminea,* has staminal bundles about 2cm long and grows on sands associated with limestone between Kalbarri and Jurien Bay.

Flowering *August-February*
Seeding *All year*
Propagation *Seed or cuttings. Plant at 1m intervals. Prefers shelter from wind.*

Dept of Conservation and Land Management, WA Herbarium

Melaleuca systena *[ex. M. acerosa]* MYRTACEAE ❒♦ *Coastal Honeymyrtle*

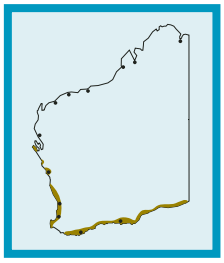



Dense, sprawling shrub, 0.5-3.5m high and 1-5m wide, with an erect, branching main stem, and a rounded crown. Leaves are fine, very narrow, 8-12mm long, silky-hairy when young, eventually hairless. Flowers are white, cream or yellow in terminal, globular heads. Fruits are urn-shaped. Hardy.

Flowering *February-March/August-December*
Seeding *All year*
Propagation *Seed or cuttings. Full sun.*

GF Craig

Templetonia retusa PAPILIONACEAE ❒♦ *Cockies' Tongues, Bullock Bush*

Erect, occasionally prostrate, rigid shrub, 1-2.5m high and 1-3m wide, with spreading branches. Leaves are grey-green, broad, leathery, egg-shaped or oblong to wedge-shaped, to 5cm long, with blunt 2-lobed ends. Flowers are large, very showy, scarlet (or occasionally yellow), to 4cm long, and arranged in small, terminal or axillary clusters. Pods are flat, oblong, to 8cm long, and black when ripe.

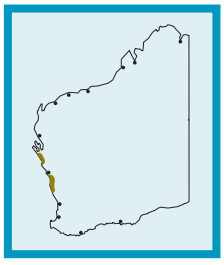
Fast growing; underground rootstocks allow regrowth after fire; plants harbour ticks; safe near sewers.

Flowering *April-November*
Seeding *November-December*
Propagation *Scarified, hot-water-treated or smoked seed. Seed is often insect damaged. Plant at 1.5m intervals. Full sun or part shade; prefers wind-protected areas and lime soils.*

T Tapper

9.4.5.3 Tall shrubs, trees and mallees

Eucalyptus erythrocorys MYRTACEAE ♦ *Illyarrie*

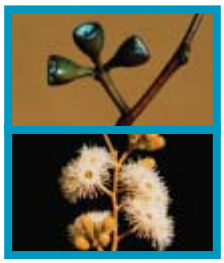
Tree, 3-8m high, with smooth bark. Adult leaves are opposite, 11-18cm long, 1.5-3cm wide, dark green with numerous oil glands. Buds are borne in clusters of 3 on stout, flattened stalks; bud caps are spectacular, bright red, 4-lobed with radial ribs. Flowers are yellow. Fruits are somewhat cuboid, strongly ribbed, to 4cm long and 5cm wide, with 4 raised curved sides, and 4 enclosed valves.

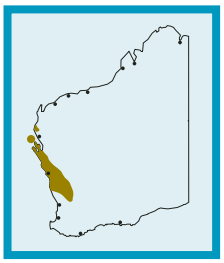
A low form, 0.5m high, forms a dense ground cover on the Zuytdorp Cliffs.

Flowering *February-April*
Seeding *All year*
Propagation *Seed. Provenance selection required.*

M French

Eucalyptus obtusiflora MYRTACEAE ▼❐ *Dongara Mallee*





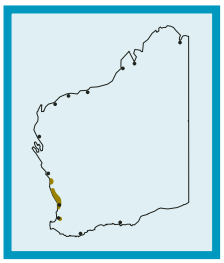
Mallee or rarely small tree, 1-8m high and 2-8m wide, with single or multiple stems, and smooth bark often hanging in ribbons; the tree form has rough bark for the basal 1 m. Adult leaves are narrow to broadly lanceolate, moderately thick, dull, light green to grey-green, to 15cm long and 3cm wide, with numerous oil glands. Inflorescences are 7- or 9-flowered, cream or white, and borne on stalks 8-17mm long. Buds are ovoid or cylindrical with flattened or hemispherical, ribbed caps, often reddish at maturity. Fruits are cup-shaped to cylindrical, to 12mm long and 9mm wide.

Tolerant of hard pruning; coppicing habit.

Flowering *December-May*
Seeding *All year*
Propagation *Seed. Slow to establish.*

M French

Eucalyptus petrensis MYRTACEAE ▼❐♦ *Limestone Mallee*

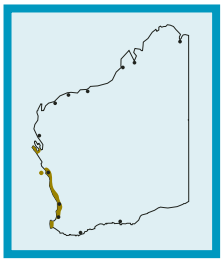


Straggly mallee, 1.5-4m high with smooth bark. Buds are creamy and borne in clusters of 7-11 on short, erect stalks; flowers are creamy white. Fruits are flattened-globose with persistent, fragile style remnants exserted from the centre.

Flowering *October-July*
Seeding *November-February*
Propagation *Seed. Plant at 3-4m intervals.*

M French

Melaleuca huegelii MYRTACEAE ❐♦ *Chenille Honeymyrtle*



Medium to large, upright shrub or small tree, 1-8m high and 2-6m wide, with rough grey bark and twisted branches. Leaves are triangular, 3-10mm long, crowded, usually overlapping. The very long, honey-scented, terminal, creamy white brush-like flowers are purplish-pink in bud. New leaf growth protrudes from the ends of the spikes. Woody capsules are held in dense clusters, up to 10cm long, along the stem.

Very drought tolerant, very lime tolerant; roots invasive, care needed near sewers.

Flowering *September-January*
Seeding *All year*
Propagation *Seed or cuttings. Collect seed from older fruits lower on stem. Plant at 2m intervals. Requires wind-protected sites.*

E Wittwer/ WSWA

9.5 AMENITY SPECIES

The majority of native species suitable for shade and shelter usually need some protection from windblast, such as sheltered embayments and in the lee of dunes, to reach their full potential. In less protected environments, many species will develop a wind-pruned, shrubby form.

A list of shrubs and trees that can provide shade and/or shelter in coastal environments is given below. They are suitable as street trees, and for parks and gardens. Notated species are not suitable in car parks as they drop sap or berries which mark vehicles. The previous section should be referred to for detailed descriptions, distributions and illustrations of ticked species. Other species which are suitable for sand-binding/stabilising, ornamental purposes or for people control, are tabulated for each region in Appendix 5.

Figure 9-5

Agonis flexuosa (Peppermint) form attractive shade trees in the South-West [Photo: GF Craig]

Figure 9-6

Eucalyptus utilis ms (Coastal Moort) provides shade and an effective windbreak. [Photo: GF Craig]

Figure 9-7

Acacia coriacea subsp. *coriacea* (right) and subsp. *pendens* (left) are attractive street trees in Karratha. [Photo: BR Maslin/ Dept of Conservation and Land Management]

Figure 9-8

Callitris preissii (Rottnest Island Pine) is a hardy, rather formal tree and is very drought tolerant. [Photo: GF Craig]

Table 9-2 Amenity species for the coastal zone

Species marked with an asterisk are described in detail in the previous section.

Desc.	Species	Common Name	Growth Form	Use		Pilbara Kimberley	Gascoyne	Central West Coast	SW Capes	South Coast	Notes
*	*Acacia ampliceps*	Saltwater Wattle	medium-tall shrub or small tree	▼	❒	x	x				1
*	*Acacia bivenosa*	Two-nerved Wattle Cable Beach Wattle Dune Wattle	medium shrub		❒	x	x				1
*	*Acacia cochlearis*	Rigid Wattle	medium shrub		❒			x	x	x	
	Acacia colei var. *colei*	Candelabra Wattle Cole's Wattle Soap Wattle	medium-tall shrub		❒	x					
*	*Acacia coriacea* subsp. *coriacea*	Wirewood Dogwood	medium shrub or small gnarled tree	▼	❒	x	x				
	Acacia coriacea subsp. *pendens*	Wattle	medium shrub	▼	❒	x					
*	*Acacia cyclops*	Red Eyed Wattle Coastal Wattle	tall shrub or small tree		❒			x	x	x	2
	Acacia didyma	Wattle	medium-tall shrub or small tree		❒		x				
*	*Acacia ligulata*	Umbrella Bush Dune Wattle	medium-tall shrub or small tree		❒		x	x			
*	*Acacia rostellifera*	Summer-scented Wattle	medium-tall shrub or small tree	▼	❒			x		x	
*	*Acacia saligna*	Golden Wreath Wattle Orange Wattle Coojong	tall shrub or small tree		❒			x	x	x	1,5
	Acacia sclerosperma subsp. *glaucescens*	Wattle	medium shrub		❒		x				
*	*Acacia sclerosperma* subsp. *sclerosperma*	Limestone Wattle	medium-tall shrub or tree		❒	x	x				
*	*Acacia spathulifolia*	Spoon Leaf Wattle	medium shrub		❒			x	x		1
*	*Acacia tumida*	Spear Wattle Wongai	medium shrub or tall tree		❒	x					
*	*Acacia xanthina*	White-stemmed Wattle	medium-tall shrub	▼	❒			x			
	Adenanthos sericeus	Coastal Woollybush	medium-tall shrub		❒					x	
*	*Agonis flexuosa*	Peppermint	medium tree	▼	❒			x	x		5

Table 9-2 Amenity species for the coastal zone (continued)

Desc.	Species	Common Name	Growth Form	Use	Pilbara Kimberley	Gascoyne	Central West Coast	SW Capes	South Coast	Notes
	Allocasuarina lehmanniana	Dune Sheoak	tall shrub	▼ ❒			x		x	
*	*Bauhinia cunninghamii* [ex. *Lysiphyllum cunninghamii]*	Kimberley Bauhinia Jigal Tree	medium-tall tree or shrub	▼ ❒	x					
	Banksia prionotes	Acorn Banksia	tall shrub or medium tree	▼			x			
	Beyeria viscosa	Pinkwood	medium shrub	❒				x		
	Brachychiton acuminatus	Pilbara Kurrajong	medium tree	▼ ❒	x					
	Callitris drummondii	Drummond's Cypress Pine	medium shrub or small tree	▼ ❒					x	
*	*Callitris preissii*	Rottnest Island Pine	medium tree	▼ ❒			x			5
	Chamelaucium uncinatum	Geraldton Wax	tall shrub	❒			x			
	Clerodendrum tomentosum	Woolly Clerodendrum	medium-tall shrub or medium tree	▼	x					
*	*Diplolaena dampieri*	Dampier's Rose Southern Diplolaena	medium shrub	❒			x	x		
	Dryandra sessilis var. *cygnorum*	Parrot Bush	tall shrub	❒			x			
*	*Eucalyptus angulosa*	Ridge-fruited Mallee	mallee	▼ ❒					x	2
*	*Eucalyptus calcicola*	Hamelin Bay Mallee Boranup Mallee	mallee	▼ ❒				x	x	
	Eucalyptus conferruminata	Bald Island Marlock	medium tree or mallee	▼ ❒				x	x	
	Eucalyptus conglobata	Port Lincoln Mallee	mallee	▼ ❒					x	
*	*Eucalyptus cornuta*	Yate	small–tall tree	▼				x	x	3,5
	Eucalyptus decipiens subsp. *decipiens*	Redheart Moit	medium tree	▼ ❒			x			
	Eucalyptus dolichocera		mallee	❒		x	x			2
*	*Eucalyptus eudesmioides*	Malallie	mallee or medium tree	▼ ❒		x	x			

Table 9-2 Amenity species for the coastal zone (continued)

Desc.	Species	Common Name	Growth Form	Use	Pilbara Kimberley	Gascoyne	Central West Coast	SW Capes	South Coast	Notes
	Eucalyptus ficifolia	Red Flowering Gum	small tree	▼ ❒				x		
	Eucalyptus foecunda subsp. *Coolimba* pn		mallee	❒			x			
	Eucalyptus foecunda subsp. *foecunda*	Fremantle Mallee Coastal Dune Mallee	mallee	❒			x			
*	*Eucalyptus fruticosa*		mallee	❒		x	x			
	Eucalyptus gomphocephala	Tuart tall tree		▼ ❒			x			3
	Eucalyptus goniantha subsp. *notactites*		mallee	▼ ❒					x	
*	*Eucalyptus obtusiflora*	Dongara Mallee	mallee	▼ ❒		x	x			
	Eucalyptus oraria	Ooragmandee	medium tree	▼ ❒		x	x			
*	*Eucalyptus petrensis*	Limestone Mallee	mallee	▼ ❒				x		2
	Eucalyptus prominens		mallee	❒		x				2
	Eucalyptus uncinata	Hook-leaved Mallee	mallee	❒					x	2
	Eucalyptus unita subsp. *telenotia* ms		mallee	❒				x		2
	Eucalyptus unita subsp. *unita* ms		mallee	❒					x	2
*	*Eucalyptus utilis* ms [ex. *E. platypus* var. *heterophylla]*	Coastal Moort	small-medium tree (mallet)	▼ ❒					x	2,5
	Eucalyptus zopherophloia	Blackbutt Mallee	mallee	▼ ❒			x			
*	*Flueggea virosa* subsp. *melanthesoides*	Goowal Snowball Bush	medium shrub	❒	x					
*	*Grewia breviflora*	Bush Currant Coffee Fruit	medium-tall shrub	❒	x					
	Hakea trifurcata	Two-leaf Hakea	medium-tall shrub	❒			x	x	x	
	Hakea oleifolia	Olive-leaved Hakea	tall shrub or medium tree	❒				x		
*	*Melaleuca lanceolata*	Rottnest Teatree Moonah	tall shrub or medium tree	▼ ❒			x	x	x	2,5

Table 9-2 Amenity species for the coastal zone (continued)

Desc.	Species	Common Name	Growth Form	Use	Pilbara Kimberley	Gascoyne	Central West Coast	SW Capes	South Coast	Notes
*	*Melaleuca huegelii*	Chenille Honeymyrtle	tall shrub	❐		x	x	x		5
*	*Melaleuca nesophila*	Mindiyed Showy Honeymyrtle	tall shrub	▼ ❐					x	
*	*Melaleuca systena* [ex. M. *acerosa]*	Coastal Honeymyrtle	medium shrub	❐			x	x		
	Myoporum acuminatum	Native Myrtle Boobialla	medium shrub	❐		x	x			
*	*Myoporum insulare*	Blueberry Tree Boobialla	tall shrub	❐		x	x		x	5
*	*Nitraria billardierei*	Nitre Bush Wild Grape	medium shrub	❐		x	x		x	
*	*Pandanus spiralis* var. *convexus*	Iidool Common Screwpine	small-medium tree	▼ ❐	x					
*	*Pittosporum phylliraeoides*	Weeping Pittosporum	small-medium tree	▼	x	x	x			
*	*Spyridium globulosum*	Basket Bush	medium shrub	❐			x	x	x	
*	*Stylobasium spathulatum*	Pebble Bush	medium shrub	❐	x	x	x			
*	*Templetonia retusa*	Cockies' Tongues Bullock Bush	medium shrub	❐			x	x	x	
*	*Terminalia latipes* subsp. *psilocarpa* [ex. *T. ferdinandiana]*	Gubinge Billy Goat Plum	medium tree or tall shrub – deciduous	▼	x					
*	*Terminalia petiolaris*	Marool Blackberry Tree	medium tree	▼ ❐	x					?4
*	*Trichodesma zeylanicum*	Camel Bush	medium shrub	❐	x	x	x			

Growth Form

medium shrub	1-3m tall
tall shrub	3-6m tall
small tree	<5m tall
medium tree	5-15m tall
tall tree	> 15m tall

Notes

1 – short-lived (<15 years)
2 – best grown in groves, single plants blow over in strong winds
3 – tree to 40m tall, suitable for parks, tendency to drop branches
4 – not suitable for carparks, drops sticky sap or fruits which mark vehicles
5 – invasive roots, care needed near sewers

9.6 SPECIES TO AVOID PLANTING

The species listed in table 9-3 should not be planted as they are not native to Western Australia. In the past, they may have been recommended for coastal planting as they are colourful, fast-growing or have sand-binding abilities.

Table 9-3 Species to avoid planting

Species marked with an asterisk are described in detail in section 8: Weeds and Weed Management.

Desc.	Species	Common Name	Growth Form
*	*Ammophila arenaria*	Marram Grass	grass
*	*Cenchrus ciliaris*	Buffel Grass	grass
	Cenchrus setigerus	Birdwood Grass	grass
*	*Ehrharta villosa*	Pyp Grass	grass
	Paspalum vaginatum	Saltwater Couch	grass
	Secale cereale	Cereal Rye	grass
		Triticale	grass
	Thinopyrum distichum	Sea Wheat	grass
*	*Aerva javanica*	Kapok Bush	herb
	Arctotheca populifolia	Dune Arctotheca	herb
	Arctotis stoechadifolia	Swanbourne Daisy	herb
*	*Cakile maritima*	Sea Rocket	herb
	Carpobrotus aequilaterus	Angular Pigface	herb
	Carpobrotus edulis	Hottentot Fig, Pigface	herb
*	*Euphorbia paralias*	Sea Spurge	herb
*	*Mesembryanthemum crystallinum*	Iceplant	herb
*	*Pelargonium capitatum*	Rose Pelargonium	herb
	Tetragonia decumbens	Sea Spinach	herb
*	*Trachyandra divaricata*	Dune Onion Weed	herb
	Nerium oleander#	Oleander#	shrub
	Araucaria heterophylla	Norfolk Island Pine	tree
	Casuarina equisetifolia#	Horse-tail Sheoak#	tree
	Lagunaria Patersonia	Norfolk Island Hibiscus	tree
*	*Tamarix aphylla*#	Tamarix, Athol Tree#	tree

Notes: # – dropped leaves will mark vehicles

Figure 9-9

Norfolk Island Pine has been planted in the south-west for shade. [Photo: GF Craig]

Figure 9-10

Horse-tail Sheoak an eastern Australian species has spread from sites where it has been planted in WA. [Photo: GF Craig]

10. CASE STUDIES

CONTENTS

FIGURES

10.1 COASTAL PARK MANAGEMENT, MINYIRR BROOME

In 1997, a partnership was established between Rubibi, an organisation representing the land, heritage and development interests of Broome's Aboriginal people, and the Shire of Broome. The aim was to care for coastal country adjoining Cable Beach and Roebuck Bay, an area under increased human impact from the rapid growth of tourism and residential development. The coastal area includes beach, water and natural bushland.

Initiated by Rubibi for the benefit of the whole community, the Minyirr Park project has focused on effective partnerships with diverse groups and agencies such as the Shire, Ministry of Justice, Environs Kimberley, the Department of Conservation and Land Management, Broome Bird Observatory, Coastwest/Coastcare, Broome Botanical Society, TAFE and local business as well the wider community. Rubibi's other objective was to seek opportunities for training and employment of Aboriginal people.

Firstly, a joint Shire Coastal Park Management Committee was established with five Rubibi representatives and five Shire-nominated representatives. A Management Plan was developed that established the community's goals for the Park. They were:

- to protect and promote Aboriginal culture and heritage
- to maintain the environmental integrity of the coastal areas
- to provide opportunities for recreational activities that are consistent with the above goals.

Rubibi had volunteers but needed a culturally aware supervisor on-site and a project officer to co-ordinate it all. Coastwest/Coastcare funded a part-time project officer to kick-start the first stage of the project, and the Shire committed funds for materials and tools and a landcare officer ten hours a week. The Kimberley Land Council gave in-kind support by managing the grants and contractors. Negotiations with the Prison secured a work team of offenders for three days a week. With the support of Skillshare Derby, and funding for a Work for the Dole project, the coastal work got underway. Local businesses, community groups and the public generously contributed donations and labour and we established *Friends of Minyirr Park* who provide valuable in-kind support. Each year there is a struggle to secure grants to fund the 2 part-time on-site supervisors, the coastal project officer, a leased vehicle to tow the trailer with tools and equipment and to transport the community team to remote coastal sites. In 2002, a Greencorps team of young local conservation volunteers commenced work and training in Minyirr Park.

Raising awareness of Indigenous culture is a top priority for Rubibi and this happens through guided cultural walks, newsletters, talking to groups, special events in the Park, monthly meetings with the Shire and partnering with Aboriginal tourism interests.

Traditional Owners, who have the right to 'speak for country', offer guided cultural walks and tell the stories, taking small groups including school children around the coast. Minyirr Park has hosted Reconciliation Walks, Clean Up days, annual Coastcare events, cultural performances for the Shinju Matsuri Festival, National Tree Day Family Fun and provided cultural stories for the Community Directory, interpretative shelters and plaques for the Historical Society etc.

Minyirr Park also keenly encourages and fosters coastal research. This year there are three international groups working on the coast in Broome, one studying wader birds and their habitat, another human impacts on Cable Beach and the third is a British University team working with local high school students to study invertebrate macrofauna. New volunteers, workers or consultants are made welcome and receive a cultural orientation and ongoing support from Aboriginal people in the project.

The project has developed more than 22 kilometres of low-key self-guiding walk trails that direct pedestrians to the beach or through the bush away from sensitive cultural and environmental areas. The project team has constructed numerous shade shelters, blocked off vehicle access, collected native seeds and rehabilitated degraded areas, protected dunes with sand fences and board walks, and developed and/or

implemented policies to guide activities in the coastal areas such as vehicle use on beaches and commercial activities. Project members have supervised young people on community work orders, performed on-the-job supervision for TAFE landcare traineeships, gathered and documented traditional knowledge about the plants, fought wild fires in the Park, designed logos and instigated community monitoring of the coast.

The strength of Minyirr Park is its natural and cultural environment attracting volunteers from all walks of life and offering them something special – a chance to really 'feel' country and their place in it. Many people have volunteered their time including an architect (design of shelters), retired visitors (typing), geologist (PowerPoint presentation on our coastal processes), environmental science graduate (plants and photos), Work for the Dole participant (writes for the newsletter), unemployed musician (boils the billy, entertains the work team at breaks and the visitors from the aged care hostel), offenders (doing community work and being accepted and appreciated as part of the community). It is definitely a team effort!

Figure 10-1


Figure 10-2

Figures 10-1 and 10-2 Working on Minyirr Park, Broome.

Aboriginal people take an active involvement in every aspect from planning and management to the day-to-day work on site. Having Traditional Owners as supervisors and guides provides a presence on the coast that helps to educate users rather than needing to 'enforce' laws. Minyirr Park has provided visible benefits for both tourists and residents and fostered cross cultural awareness and respect.

Project Tips

- Don't go it alone – it's a big coast. Develop partnerships!
- Never give up, look for alternative strategies.
- Start small and do it well – build on success.
- Only establish what you can maintain with existing resources.
- Encourage research on the coast and ensure Indigenous people get the results.
- Hold regular meetings on-site and invite partners and land managers to view the work.

10.2 STABILISATION, REHABILITATION AND ACCESS CONTROL, 40 MILE BEACH (GNOOREA POINT), ROEBOURNE

Uncontrolled camping and four-wheel drive access continues to damage dunes and threaten turtle-nesting areas at 40 Mile Beach (Gnoorea Point). Gnoorea is a popular remote fishing and camping destination for north-west visitors and locals, with in excess of 40 'long-term' campsites occurring during the winter months. Recreational activities include four-wheel driving, boating, snorkelling, beachcombing and exploring this varied coastal environment.

The area 45km south-west of Karratha was targeted by the Shire of Roebourne which co-ordinated work on dune stabilisation and rehabilitation, rationalisation of 4WD tracks, formalisation of camping areas and pedestrian access, finished off by the erection of fences and signs. The main activities were signage, matting and revegetation (direct seeding) to stabilise sensitive foredunes. Other issues which needed to be dealt with

were the inappropriate disposal of sanitary and domestic waste, the removal of vegetation for fires, litter, the removal of shells and coral, damage to station fencing, and localised overfishing.

Unnecessary vehicle tracks were ripped, re-seeded and rationalised (blocked by bollards). Controlling access points for vehicles and pedestrians was seen as the key to controlling damage to the fragile coastal environment. Pedestrian access points were also delineated to prevent further degradation.

Figure 10-3

Stabilising dunes using matting.

Local environmental group, the Nickol Bay Naturalists Club, participated by providing preliminary advice during the consultative period at the beginning of the project.

The project provided training in coastal rehabilitation was for long-term unemployed people through the involvement of Skillshare / Jobs Australia and the Roebourne Workers Aboriginal Corporation (CDEP).

As the area is Unallocated Crown Land with several native title claimants, consultation was required with traditional owners before works could begin. Under the Aboriginal Affairs Planning Authority Act (1972), section 16 clearance was required by the Department of Indigenous Affairs, for which the Shire of Roebourne had to employ consultants. Aboriginal consultation affected timing and costs of the project, an issue the Shire urges others to take into consideration when dealing with proposals of this nature.

The main obstacle since project completion has been acceptance by users of the area, with ongoing vandalism directed towards signs and bollards, and 4WD vehicles on the beach. Constant inspection and replacement of signs and bollards is required to maintain the site.

Other recommendations of the *Gnoorea Coastal Management Plan* are yet to be implemented.

Project Tips

- Ensure that consultants who prepare management plans also provide detailed plans that can be quantified and costed.
- Clearly budget for Aboriginal surveys and inspections.
- Consult extensively with the community members who use the project area and ensure their comments are consistent with the objectives of the proposal.

10.3 DUNE REHABILITATION OF KEMPTON STREET FORESHORE, GERALDTON

When boxthorn and other weeds infested the coastal foredune and the native vegetation was being disturbed by people walking and driving across to the beach, Bluff Point residents took action.

They formed the Friends of Bluff Point Foreshore to restore the dunes, remove the worst of the weeds, and then revegetate and preserve their local beach by providing access paths.

In February 2000, the Friends completed their Kempton Street Foreshore Project, which was funded by Coastwest/Coastcare, but they have applied for further funding to assist in their continuing care for this part of the northern Geraldton coast by weeding, propagating and planting local species.

The size of the task was reflected in the size of the tool used to remove the boxthorn – a bulldozer. Regular follow-up treatments were far from mechanical. They involved the community walking the dunes and

tagging the 'boxies' which would then be sprayed. Only five boxthorn plants were found in 2001, an indication of the group's success in only three years.

Ice plant started to spread, carried by machinery from the adjacent grassed area when the path was graded, but this was hand pulled by passing residents and school groups, filling three skip bins.

New weeds began to take over. Geraldton carnation weed *(Euphorbia terracina)* was hand pulled for two seasons but, because it is toxic, alternative methods are being tried. Herbicides are being applied at different stages of growth of the weeds.

Herbicide control and the Bradley method are being tried on the spreading Buffel *(Cenchrus ciliaris)* grass and Fountain grass *(Pennisetum setaceum)* but broadleaf annual weeds such as bearded crown still need attention.

Revegetation was undertaken in conjunction with weeding to avoid leaving bare ground. Ground-covering plants proved the most effective at excluding weeds.

Plants were grown from seed or cuttings *(Atriplex spp)* in commercial and home nurseries and at TAFE. Spinifex longifolius seed heads have been direct seeded by burying them close to the surface in the dune sand. The list of successfully regenerated species is increasing.

Preserving the revegetated dunes was enhanced by providing access paths to the beach. Previously, people were walking and driving across the dune to reach the beach and launch boats, destroying native vegetation on the way.

A new gravel pathway was constructed to direct pedestrians and to separate grassed areas from the dunes. Most pedestrians now keep to the made paths and the gravel provides a weed buffer.

Figure 10-4

Working at Kempton Street Foreshore, Geraldton.

Areas of dense vegetation have increased and the extent of weed invasion has been reduced. All that is required is weed monitoring and control at the right time of year, and to keep propagating plants to fill any gaps.

The main obstacle was timing. Delay in path construction caused a year's delay in planting and allowed a lot more weeds to invade, as did the delay in announcement of the successful Coastwest/Coastcare grant.

The Friends of Bluff Point joined forces with the City of Geraldton to oversee the project. There was lots of practical help from TAFE Land Management students who propagated in their nursery and transplanted successful cuttings to the site.

St Lawrence School planted *Spinifex* seed heads, mulched young plants and pulled ice plant weeds. Local residents held regular monthly and weekly busy bees to weed and plant.

Figure 10-5

Kempton Street Foreshore project sign promoting the community's work.

Bluff Pointers

- Don't weed a greater area than you have plants available. Bare ground invites erosion or more weeds.
- Experiment with different methods of weed control. Don't put all your energy into a new method until you have tried it on a small scale.
- Grow only local species. Others become weeds or look sick and eventually die.
- Don't stifle enthusiasm – let people do their own bit. More than one method can be successful.
- Communicate with the authorities for advice and to ensure that your efforts are not in conflict with their plans.
- Keep a diary so you can plan what needs doing when in the following year.

10.4 ACCESS MANAGEMENT AND REHABILITATION, LANCELIN BACK BEACH

People walking on the dunes, and high winds buffeting the backbeach at Lancelin caused blowouts and erosion at this popular surfing, swimming and fishing spot.

The main path to the beach was aligned with the incoming wind and was continuing to widen. Access into the dunes for views of the surf led to significant blowouts.

The area was continuing to worsen and an aerial photograph clearly showed the extent of dune erosion that was occurring.

Off-road vehicles were being driven through the wetland swale behind the dunes to take people fishing at the beach further south of the car park. The area was becoming denuded of vegetation and numerous tracks were forming.

The Shire of Gingin, the Lancelin Chamber of Commerce and local schools stepped in with a project to restore the environment.

The path to the beach was realigned for better wind protection and easier access from the car park. It was aligned at a north-west angle at the beach entrance, kept three metres wide and at a suitable gradient to allow wheelchair access as far as the lookout beside the beach entrance.

This lookout was erected by a contractor to allow people to watch the surf without needing to walk up into the dunes.

The contractor used earthmoving machinery to create a berm in front of the main blowout and the southern beach entrance for added wind protection. This was done rather than re-contouring the dune by pushing the sand at the top of the dune back into the blowout.

Berms were brushed with branches from nearby pine plantations to help stabilise them. Machinery was useful for transporting the large amount of brushing on to the site.

Three-strand wire and post fencing was erected along the pathway and frontal dunes to prevent further access into the dunes.

Off-road access was formalised with the closure of all informal entrances but one. This track was formalised to discourage use of the sensitive wetland areas and allow continued access to the beach further south. It also helps to separate vehicles from families and other beach goers.

Extensive planting was carried out over two seasons to help revegetate the dunes. In the winter of 2000, two full planting days were carried out by Lancelin Primary School and Gingin Senior High. A follow-up planting day was held in July 2001 to compensate for the plants that did not survive the summer.

Species used were locally endemic, although not all were propagated from seed collected locally. Spinifex seed heads were collected locally and buried in the sand blow. Many have successfully sprouted.

Figure 10-6

Planting at Lancelin Back Beach.

Figure 10-7

Planting at Lancelin Back Beach.

An unusual grass has been found at the site, possible a hybrid species of Seawheat and *Spinifex longifolius* which might have been used to rehabilitate the site many years ago.

A high level of community support was generated for the project, despite many of the locals being uneasy at first about the changes taking place. They were supportive once they realised the works were needed to improve access and protect the dune environment.

Local students were extremely enthusiastic but, in their excitement, some seedlings were not planted deep enough or were trodden on. There was a low success rate in some areas of the dunes which should be rectified by follow-up planting.

Quotes from dune re-contouring experts were too high, so a dune rehabilitation contractor was used instead. He had a great deal of local experience and used his own machinery.

The blowout is now slowly rehabilitating though it will require careful supervision of the growth of seedlings.

A great deal of sand is accreting around the lookout that was constructed in such a way that it can be lifted to prevent it being buried. Apart from this, the project is low maintenance due to the construction of berms and a well-designed pathway.

Good planning helped the project to run smoothly. Detailed site plans were drawn up of the lookout and walkways. On the advice of the contractor, the alignment changed once the project began.

Project Tips

- It's great to involve school kids—they can learn a lot from planting. However, before they begin they need to be told about being careful not to tread on plants, to plant the seedlings deep enough, and about the reasons for planting.
- A talk to children about 'clever coastal plants' can help them understand how well adapted coastal plants are to their environment (such as white hairs on Olearia to reflect sunlight and heat), and help increase their appreciation of how fragile plants are.
- Kids can get over-excited about being out of the classroom and run all over the dunes. If local community volunteers can take kids in smaller groups of five or six, this can help keep them in one place with better supervision.
- Consultation with as many local people and experts as possible ensures better on-ground outcomes.
- Big events, such as large-scale planting days, can work well to attract local attention, media and support to your project.

10.5 4WD MANAGEMENT AND REHABILITATION, TIMS THICKET MANDURAH

Uncontrolled access to the dunes by four-wheel drives, trail bikes and dune buggies over many years led to large-scale dune erosion at Tims Thicket, south of Mandurah.

Earthworks to close breaches in the foredunes, formalising some 4WD tracks and the closure of others, and huge amounts of brush spreading helped the rehabilitation process in readiness for seeding and planting.

Unfortunately the Bouvard Coastcare Group experienced problems with vandals who removed brush for fires, and drove through blocked off access tracks and areas where seedlings had been planted.

Figure 10-8

4WD management and rehabilitation Tims Thicket, Mandurah.

Figure 10-9

Access control at Tims Thicket, Mandurah.

Tracks were initially closed with sand bunds[1] or by covering in brush. When four-wheel drivers still managed to break through, the most effective method of track closure proved to be placing a boulder within a sand bund.

The Bouvard Coastal Group has made great progress despite such setbacks, working in conjunction with the City of Mandurah through the Mandurah Coastcare Co-ordinating Committee.

Signs erected to keep people off vegetation frequently need replacing after vandalism. Other ongoing maintenance, including replacing brush and replanting areas, is carried out by the Group and the City.

As part of the project, a purpose-built trailer was developed to transport large amounts of brush to the site. This allows the collection and spreading of brush on an ongoing basis rather than at one fixed time as is the case using brush bales that require heavy machinery to move them.

Volunteers collected brush and spread it on illegal access tracks and rehabilitation sites, though some was spread by machine. Many other groups have helped with seeding and planting, including Fredrick Irwin Primary School, Scouts and Venturers.

Plant species that have survived the best are Spinifex *(S. longifolius and S. hirsutus),* Pigface *(Carpobrotus virescens)* and Knotted Club Rush *(Isolepsis nodosa).* Other indigenous coastal plants have a moderate to poor success rate in such an exposed site. Sea Rocket *(Cakile maritima)* and Coastal Daisy *(Olearia axillaris)* will naturally re-establish amongst the brush or along furrows.

[1] Sand bunds are mounds of sand placed on tracks to physically block them off to traffic.

Several members of the Bouvard Coastcare group are Volunteer Rangers with the City of Mandurah. Volunteer Rangers can issue infringement notices which are then followed up by Council Rangers. This has greatly increased the visual presence on the beach and general community awareness of the types of activities allowed.

Community awareness of the project and its value is vital to the success of the project. The Bouvard Coastcare Group conducts regular letter drops to surrounding households, has regular articles in the local newspapers, advertises public planting days and involves other local community groups such as Scouts and schools in rehabilitation work.

Tips from Tims Thicket

- Brush areas before planting—plants have a very poor survival rate if the area is not brushed first.
- The involvement of the local management agency with your group is invaluable. (The Department of Conservation and Land Management is an active member of the group and the City of Mandurah is also closely involved.)
- Keeping minutes of meetings is an important part of the effective running of the group and any Coastcare projects. It helps the group keep on track with all the tasks required.
- Steel signs are longer lasting as vandals cannot burn them.
- Several smaller signs are more effective than one large sign to keep people off the area being rehabilitated.

10.6 REHABILITATION OF RABBIT HILL, YALLINGUP

The landscape scar on Rabbit Hill at Yallingup beach had been an eyesore for many years as a result of 4WDs. More recently, the illegal use of sand boards has exacerbated the problem.

Having successfully worked on many other conservation projects in the area, the Yallingup Land Conservation District Committee took on the job of rehabilitating the site in conjunction with the Department of Conservation and Land Management, Shire of Busselton and Busselton TAFE.

Because of the vast size of the affected area, the group developed a new approach to collecting, sorting, transporting and spreading brush and tree loppings.

Brush was sorted, stacked and baled at the local tip using native green waste according to the following process:

- preparing the cradle (placing wire in the cradle to bind the brush)
- sorting of native brush from weed species
- stacking native green waste onto a brush baler
- compacting the bale as it fills 4 or 5 times
- baling of the brush with wire
- trimming the ends of the bale.

The group constructed an access track to the top of the blowout to transport brush and other rehabilitation materials. Brush was transported to the top of the blowout using an excavator which was also used for spreading brush. The use of an excavator with a thumb allowed for more precise picking up and spreading of brush.

This brushing process enabled vast areas of eroded coastal blowout to be stablised and rehabilitated. Using traditional techniques of hand carting brush up the dune, covering the same areas would have taken many years of back-breaking work.

Brush baler at Yallingup tip

Dimensions:	Max 5m long, 2.5m wide, 1.8m tall. Frame is adjustable
Cost of baler:	Around $500
Size of bale:	Around 23m^3 if baler full. (= Around 3 to 3.5 tonnes) (Around 250 – 300 m^3 covers 1ha)
Labour cost to produce bale:	$250 – $275
Machine to transport:	Truck with Hyab to lift brush bales on and off

Once brushing was complete, and with the onset of winter, schools and other organisations assisted with the planting. These were Lynwood High School, Mc Killop College Busselton Senior High School, Busselton Scout Troop and Busselton TAFE. Plants were a mix of cuttings from the site and seedlings grown by Busselton TAFE.

The beach at the toe of the foredune was fenced with assistance from Curtin University and signage was installed to deter pedestrian access.

The Yallingup Land Conservation District Committee continues to monitor the site, which was completed in 2000. Brushing and planting in the area has halted the spread of the blowout, with a 75% plant survival rate over a two-year period, and successful natural regeneration at the site.

Very few beach users access the foredune now the area is fenced, and sand boarding no longer occurs there.

Figure 10-10

Aerial showing area prior to project commencement.

Figure 10-11

Bale of sorted brush about to be transported from the local tip to the site (approximately 6 km).

Figure 10-12

One of the bales of sorted brushing prior to spreading.

Project Tips

- Involving local schools, TAFE or a scout group in planting and brushing can increase community ownership of the project.
- Field days are useful at the start to learn coastal rehabilitation techniques.
- Don't be afraid to use an excavator to cut an access track to the site or to move sand to rebuild dunes. An access track is essential to get materials to the site in large quantities, and can be closed and rehabilitated at a later stage.
- Fencing is essential to keep people off the rehabilitated areas.
- It is best to allow collection of green waste at only one site where there is enough room for hand-sorting. Ideally, this should be far enough away from the eyes of the public that it is not regarded as a rubbish-dumping site.
- Make sure the contractor separating the brush has a good knowledge of the types of plants that may become weeds in a coastal environment.
- Monitor the site for weeds, vandalism and plant survival.
- Signage is important as it informs the public about the purpose of the project and why it is important to restrict access. It also serves to promote a coastal conservation ethic amongst beach users.
- Frogmatting is a sand stabliser that is made up of two layers of biodegradable mesh with a layer of straw sandwiched between. Whilst useful for limited wind affected areas such as accessways, it is not suitable for wide expanses of dune as:
  - a hole must be cut into the plastic mesh before planting
  - it does not allow for natural regeneration from self-sown seed
  - the straw between the plastic mesh layers degrades after around two years
  - the mesh layers do not easily biodegrade and can result in rolls of plastic mesh polluting the environment.

10.7 ACCESS MANAGEMENT AND COASTAL REHABILITATION, GRACETOWN

When nine people lost their lives in a cliff collapse near Gracetown in September 1996, the local community and people throughout the State were in shock.

The Gracetown Progress Association set out to rehabilitate the site of the cliff tragedy and heal the community's wounds.

As the project developed, it expanded to include the surrounding cliff area at South Point, which had become badly degraded.

Stage one of the project involved developing a master plan for coastal rehabilitation at South Point including landscaping, trail construction, brush collection, plant propagation and planting.

The next stage is continuing the brushing and planting and involves a school education program.

As part of this rehabilitation work, the Gracetown Progress Association established a community nursery, now based at Margaret River, to grow indigenous plants for the area. Seed collection and plant propagation continue to be part of the project.

Dune construction was carried out by a contractor.

Brush collection was facilitated by making a brush bale, which allowed brush to be collected and transported to the site in large quantities.

Figure 10-13

Gracetown Progress Association members discuss plant propagation at the community nursery.

Construction of an access track has allowed the transport of brush bales to the rehabilitation site where brush has been laid mechanically and by hand. A system of walk trails has been constructed.

Gracetown Progress Association is thrilled by the success of the project which achieved its objectives and drew the community together.

It ignited the community to work to rehabilitate a glorious part of the coast and the Association says that regardless of future funding, the project has begun something that will never die. Members found the change in attitude towards doing something constructive was rewarding and likely to become even more meaningful as the adults work towards educating the younger generation.

A rehabilitation plan is in place.

The community has developed extensive expertise in seed collection and plant propagation and the nursery is now well established.

A close working relationship has been established between the Department of Conservation and Land Management and the Association, resulting in increased awareness and knowledge of issues. The community has realised what a huge job the Department of Conservation and Land Management has in regard to coastal management and this has brought them closer together to achieve a common goal.

An effective method to collect, bale and spread brush has been developed. Brush for bales is sourced from green waste at either the Margaret River waste disposal site or local Department for Conservation and Land Management office. This green waste is sorted to ensure no weed species are used in the bales. Balers are of a metal frame construction and can hold approximately 10 cubic metres of brush. Section 7: *Stabilisation and Rehabilitation* provides details of the brush baler.

Fencing and signs are generally adhered to, and ongoing maintenance is undertaken by the Association and the Department of Conservation and Land Management.

One of the obstacles was trying to involve absentee landowners in the rehabilitation. The Association is considering planning busy bees well in advance to coincide with long weekends and holidays.

Capturing the Community

- Short stints of 2-3 hours attract more volunteers than day-long working sessions.

10.8 PLANNING AND RESERVE MANAGEMENT, CHEYNE BAY, WELLSTEAD

An outstanding large coastal reserve had an equally big list of problems to address when the Wellstead LCDC decided to create a management plan and tackle environmental issues.

It was a community-driven project to develop a holistic approach to managing a series of largely unvested reserves adjoining Cheyne Bay, on the southern coast.

Environmental issues included access, dieback, fire management, flora and fauna, pest species, management of camping, rubbish management and education.

Figure 10-14

Figures 10-14 and 10-15 The Wellstead area subject to planning and management by the local community. [Photos: Mike Moir]

Starting in 1998, the group set to work on an initial survey of the coastal reserves. Based on the information gathered in that document, a management plan was developed with extensive consultation and workshops between key stakeholders: the community, the Department of Conservation and Land Management, City of Albany, Bush Fires Board, the Department of Agriculture and the Department of Land Administration.

The group used a community questionnaire and produced a draft map of changed vehicle access for the reserves to stimulate community input into the planning process.

The Wellstead community worked on environmentally sustainable access, fire management, management of pests to preserve indigenous fauna, rehabilitation of an old rubbish site, installation of signs, dieback mapping, a fauna trapping program, vegetation mapping and interpretation.

Aerial photos and maps were prepared, rubbish removal working bees were carried out and signs prepared and erected to encourage visitors to take out their rubbish.

Figure 10-15

The Boat Harbour site has been of recent interest for the group and, with community and Department of Local Government funding assistance, a compost toilet has been erected to take pressure off a popular camping site. Bollarding was erected around a camping area and a barbeque, donated by the community, was installed. A large rubbish bin has also been placed at the Boat Harbour and Pallinup Estuary main exit, which will be emptied by the community.

A fire management plan was initiated and carefully controlled burns have commenced. Surveys of the coastal heath recovery after the controlled fires are to be carried out by the community.

Interpretive signs are being erected with information about the area, encouraging visitors to assist the community in their efforts to preserve the coastal reserves.

The *S.T.S. Leeuwin* sailing ship visits this coast twice each year and the community provides displays, talks and guided walks.

Greencorps teams have assisted the community in trail preparation and sign erection throughout the project.

Two members represent the Wellstead community on the South Coast Management Group—the regional body for coastal issues in the South Coast. The importance of linking up the Cheyne Bay project with overall planning and management of the South Coast is recognised.

The results were outstanding and the project achieved its objectives, but over a long time frame because of the holistic approach involving planning and works, the involvement of many agencies and extensive community consultation. This project has also generated enthusiasm for other initiatives to improve the state of the environment and to provide improved visitor experiences, such as the installation of the compost toilet and day-use barbecue facility at Boat Harbour.

Initially the Wellstead LCDC might have under-estimated the size of the project. The main obstacles were getting government agency commitments, though the group did find the Department of Conservation and Land Management very helpful. The Department of Agriculture has also played a crucial part in their fox control program along this section of coast. Wet weather also caused delays as work at such times would promote the risk of spreading dieback.

As it was a large project to manage, it placed a heavy load on one individual.

The lack of a designated management presence was also a problem. The project was on Department of Land Administration (DOLA) land, and DOLA does not have management capability or a local presence.

Wellstead Wisdom

- Be patient when working with government agencies.
- Make sure there is a steering committee to share the project management on large projects.
- Make sure all relevant agencies are represented on the steering committee and are involved in the project as much as possible.
- Deal with one person from each agency and get them to own the project by bringing them on-site and getting them involved with the community.

11. USEFUL CONTACTS

CONTENTS

11.1 ADVISORS/CO-ORDINATORS

Facilitate coastal management in Western Australia through financial and technical assistance to land managers and community groups.

WA State Coastwest and Coastcare Co-ordinator
Western Austalian Planning Commission
Phone: (08) 9264 7777
Fax: (08) 9264 7566
email: corporate@wapc.wa.gov.au

Pilbara Kimberley Coastcare Facilitator
Shire of Wyndham-East Kimberley to Shire of Ashburton; Cocos-Keeling and Christmas Islands
c/- Pilbara Development Commission
Phone: (08) 9185 0193
Fax: (08) 9185 0189

Batavia Gascoyne Coastcare Facilitator
Shire of Exmouth to Shire of Geraldton
c/- Department of Fisheries, Geraldton
Phone: (08) 9921 6800
Fax: (08) 9921 3617

Metro Central Coast Coastcare Facilitator
(Shire of Irwin to City of Rockingham; Rottnest Island)
c/- Western Australian Local Government Association
Phone: (08) 9213 2065
Fax: (08) 9322 2611

Peel South-West Coastcare Facilitator
City of Mandurah to Shire of Manjimup
c/- Department of Conservation and Land Management, Bunbury
Phone: (08) 9725 5931
Fax: (08) 9725 4351

South Coast Coastcare Facilitator
Shire of Denmark to Shire of Dundas
c/- Department of Conservation and Land Management, Albany
Phone: (08) 9842 4500
Fax: (08) 9841 3329

11.2 INDIGENOUS LAND MANAGEMENT FACILITATORS

Assist Indigenous groups to access Natural Heritage Trust funding

Kimberley Land Management Facilitator
c/- Kimberley Land Council
Land and Sea Unit
PO Box 2145 BROOME, WA 6725
(08) 9193 6199

Central WA Land Management Facilitator
c/- CAPAC
PO Box 343 WICKHAM, WA 6720
(08) 9187 0330

South-West Land Management Facilitator
c/- WA Aboriginal Lands Trust
PO Box 7770 Cloisters Square PERTH, WA 6850
(08) 9235 8111

11.3 STATE GOVERNMENT AGENCIES

Aboriginal Sites Department, WA Museum
Preservation of places and objects used by or traditional to Australian Aborigines
(08) 9427 2700
www.museum.wa.gov.au

Department of Agriculture
Advice and information regarding environmentally sustainable agriculture
(08) 9368 3333
www.agric.wa.gov.au

Department of Conservation and Land Management
Conservation of WA wildlife and management of vested lands and waters
(08) 9334 0333
www.calm.wa.gov.au

Department of Environment
Environmental protection, maintenance of waterways, enhancement of the quality of the environment

Waters and Rivers
(08) 9278 0300
www.wrc.wa.gov.au

Environmental Protection
(08) 9222 7000
www.environ.wa.gov.au

Department of Fisheries
Fisheries policy and management
(08) 9482 7333
www.fish.wa.gov.au

Department of Indigenous Affairs
Information on Aboriginal sites, and assists and advises on their protection and management
(08) 9235 8000
www.dia.wa.gov.au

Department of Industry and Resources
Advances the responsible development of industry and geological resources for the benefit of Western Australians
[Formed through the merger of the Department of Minerals and Petroleum Resources and the industry and trade functions of the Department of Industry and Technology]
(08) 9222 3333
www.doir.wa.gov.au

Department of Land Administration
Administers and maintains a survey and land information framework for Western Australia, including aerial photography
(08) 9273 7373
www.dola.wa.gov.au

Department of Local Government and Regional Development
Providing support and advice to organisations involved in the development of Western Australia
(08) 9222 0511
www.dlgrd.wa.gov.au

Department for Planning and Infrastructure
Land use, transport, and coastal planning, including ports, marine and harbours
(08) 9264 7777
www.wapc.wa.gov.au and www.dpi.wa.gov.au

Heritage Council
Advisory body on heritage matters
(08) 9221 4177
www.heritage.wa.gov.au

Rottnest Island Authority
Planning and management of Rottnest Island
www.rottnest.wa.gov.au

Water Corporation
Manages wastewater disposal and drainage, groundwater abstraction
(08) 9420 2420
www.watercorporation.com.au

11.4 LOCAL GOVERNMENT AGENCIES

Western Australian Local Government Association
Representative body for local government in Western Australia
(08) 9321 5055
www.walga.asn.au

11.5 COMMONWEALTH AGENCIES

Aboriginal and Torres Strait Islander Commission
(08) 9220 3211
www.atsic.gov.au

Environment Australia
(02) 6274 7777
www.ea.gov.au

11.6 NON-GOVERNMENT ORGANISATIONS

Australian Marine Conservation Society (WA)
(08) 9420 7209
amcs@iinet.net.au

Conservation Council
(08) 9420 7266
www.conservationwa.asn.au

Greening Australia (WA)
(08) 9335 8933
www.greeningaustralia-wa.org

Marine and Coastal Community Network
(08) 9420 7206
mccnwa@ozemail.com.au

National Trust of Australia
(08) 9321 6088
www.ntwa.com.au

World Wide Fund for Nature – Marine and Coastal
(08) 9387 6444
www.wwf.org.au

11.7 INDIGENOUS RERPRESENTATIVE BODIES

Kimberley Land Council
(08) 9193 6199 Broome
(08) 9168 2298 Kununurra
(08) 9193 1118 Derby

Pilbara Native Title Service
(08) 9144 2866 Karratha
(08) 9172 5433 Port Hedland

Yamatji Land and Sea Council
(08) 9964 5645 Geraldton

South West Land and Sea Council
(08) 9222 6000 Perth

Goldfields Land and Sea Council
(08) 9091 1661 Kalgoorlie

Aboriginal Legal Service
1800 019 900

Regional offices are based in Kununurra, Derby, Fitzroy Crossing, Halls Creek, Broome, South Hedland, Newman, Roebourne, Carnarvon, Geraldton, Meekatharra, Kalgoorlie, Laverton, Northam, Bunbury and Albany.

11.8 COASTAL COMMUNITY GROUPS

Community groups that are active coastal planning and management are listed by local government area. Please contact the relevant Regional Coastcare Facilitator or local government authority for contact details for individual groups.

Shire of Wyndham–East Kimberley

Christmas Is. District High School	Annual marine debris survey and coastal cleanups

Shire of Derby–West Kimberley

Derby Revitalisation Committee	Creek stabilisation and revegetation around Derby wharf

Shire of Broome

Environs Kimberley	Benthic surveys at Roebuck Bay and 80 Mile Beach, protection of migratory birds, lobbying, and community education. Focus on sustainable development and integration of environmental and cultural objectives into land use planning
Goolarabooloo-Millibinyarri Aboriginal Corporation	Work on the Lurujarri Dreaming Trail, including cross-cultural education, revegetation, signage, track rationalisation, indigenous management, cultural heritage and interpretation, trails and information shelters
Goombaragin Aboriginal Corporation	Coastal clean-ups

Mundud and Mudjarl Co-operatives	Turtle protection, vehicle management and protection of wader bird habitats at Carnot Bay
Anna Plains Station	Fencing and protection of migratory wader bird habitat at 80 Mile Beach
Broome Coastal Landcare Group	Coastal revegetation and education
Broome Bird Observatory	Community education through signage, pamphlets, and boardwalk construction
Rubibi Land Heritage and Development Council	Indigenous management, cultural heritage and interpretation, walking trails and information shelters at Cable Beach, Broome
Bardi Aborigines Association	Coastal revegetation, erosion control and signage in and around One Arm Point
Town of Port Hedland	
Port Hedland Coastal Planning and Management Working Group	Education, planning and community consultation activities for coastal projects within the Town of Port Hedland
Shire of Roebourne	
Nickol Bay Naturalist Club	Crocodile, mangrove and cultural interpretation at Port Hedland and Cape Keraudren, turtle monitoring/tagging, coastal clean-ups around the Dampier Archipelago
Dampier Preservation Association	Weed control in Dampier Archipelago, turtle tagging
Point Samson Community Association	Community education, reef protection, construction of a walking trail and signage
Mamabulanjin Aboriginal Corporation	Visitor education, eco-tourism, coastal clean-ups, interpretative signage and beach shelters around the Dampier Peninsula
Marapikurrinya Aboriginal Corporation	Revegetation, cross-cultural education and track rationalisation
Shire of Ashburton	
Urala Station	Protection and rehabilitation of the coastal environs of Urala Station
Onslow Employment Project	Development of a coastal boardwalk and signage around Onslow, in conjunction with the Shire of Ashburton
Shire of Exmouth	
Cape Conservation Group	Community education and lobbying
Cape Boardriders Club	Dune rehabilitation and construction of infrastructure to manage boardriders
Shire of Carnarvon	
Norwest Boardriders Club	Dune rehabilitation and construction of infrastructure to manage boardriders along the Carnarvon coast
Ningaloo Reef Outback Coast Association	Coastal rehabilitation and construction of infrastructure to manage tourists and pastoral activities along the Carnarvon – Coral Bay coast
Coral Bay Progress Association	Dune rehabilitation and construction of infrastructure to manage tourists

Shire of Northampton	
Horrocks Beach Progress Association	Coastal rehabilitation
Friends of the Abrolhos	Community education, lobbying, visitor management, island rehabilitation and coastal clean-ups
Port Gregory Progress Association	Dune rehabilitation
Kalbarri Boardriders Club	Dune rehabilitation and construction of infrastructure to manage boardriders
Kalbarri Townscape Committee	Coastal planning
City of Geraldton	
Friends of Bluff Point Foreshore	Coastal rehabilitation, education and coastal clean-ups at Bluff Point, Geraldton. Have links to local primary schools
Sunset Beach Coast Care	Dune rehabilitation, maintenance of recreational area and coastal clean-ups at Sunset Beach, Geraldton
Geraldton Community Nursery	Seedling propagation for rehabilitation projects in coastal and other areas
Shire Of Greenough	
Greenough Rivermouth Progress Association	Coastal clean-ups and rehabilitation work at Cape Burney, Greenough
Drummond Cove Progress Association	Coastal rehabilitation work at Drummond Cove, Greenough
Shire of Irwin	
Dongara Townscape Committee Dongara-Denison Lions Club	Irwin River estuary rehabilitation, including removal of invasive weed, seed collection and propagation of local coastal species
Shire of Coorow	
Cervantes Chamber of Commerce	Coastal rehabilitation including replanting and access management
Greenhead Townscape Committee	Coastal rehabilitation, seed collection and propagation, and access management, Dynamite Bay
Shire of Dandaragan	
Jurien Bay Tourism and Progress Association	Coastal rehabilitation of the Jurien foreshore
Shire of Gingin	
Guilderton Community Association	Moore River estuary education and interpretation
Friends of Lancelin Island	Island habitat management and seabird protection and monitoring

City of Wanneroo	
Quinns Rocks Environment Group	Community education and weed removal projects around Quinns
Yanchep/Two Rocks Board Riders and Coastcare Inc.	Coastal rehabilitation of 'The Spot' surf break between Two Rocks and Yanchep
Mindarie Keys Coastcare Group	Weed eradication and replanting projects
City of Joondalup	
Friends of Marmion Marine Park	Marine and coastal community education and research in and around the Marmion Marine Park
Joondalup Community Coastcare Forum	Coastal rehabilitation, education, art, lobbying and information sharing forum for coastal groups within the Joondalup area
Burns Ratepayers Residents and Community Recreation Association Inc	Lobbying, education and weed removal
City of Stirling	
Stirling Coastcare Group	Education, coastal monitoring and clean-ups around Scarborough, Brighton and Trigg beaches
Town of Cambridge	
Cambridge Coastcare Association	Coastal rehabilitation, including replanting and weed control, and education around City Beach/Floreat
City of Nedlands	
Friends of Allan Park	Rehabilitation, replanting and education regarding near-coastal bushland, Swanbourne
Town of Cottesloe	
Cottesloe Coastcare Association	Coastal rehabilitation and stabilisation of Cottesloe foreshore, community education and protection of Cottesloe reef
City of Fremantle	
Friends of East Fremantle Foreshore	Swan River estuary foreshore rehabilitation and stabilisation
Friends of Manning Lake Park	Replanting, access control and weed management of coastal wetland
South Beach Coastcare	Marine monitoring and education, coastal rehabilitation
City of Rockingham	
Rockingham Regional Environment Centre /Coastal and Marine Management Office	Lobbying, education, weed removal and replanting of Rockingham islands and coastline. Focused on Shoalwater Islands Marine Park and Lake Richmond. Working towards establishment of a marine monitoring program
Golden Bay Coastcare	Coastal rehabilitation – replanting, fencing, clean-ups in the Singleton/Golden Bay area. Maintains links to the Singleton Primary School

City of Mandurah	
Bouvard Coastcare Group	Coastal rehabilitation around Bouvard, Whitehills, Tims Thicket and Melros
Falcon Coastcare group	Brushing and planting along the Falcon foreshore
Comet Central Coastcare	Brushing, fencing and signage around Comet Bay
Southern Estuary Progress Association	Protection and restoration of fragile foreshore areas of the Peel Estuary
Shire of Waroona	
Preston Beach Coastcare Group	Planning and coastal rehabilitation of foredunes at Preston beach, and preparation of a coastal management plan for the area
Shire of HarveyMyalup/Binningup Community Association	Coastal rehabilitation and management
City of Bunbury	
Bunbury Community School	Coastal rehabilitation at Koombana Bay and Maidens Coastal Reserve
Leschenault Community Nursery	Weed eradication, replanting and fencing in and around the estuary
Shire of Capel	
Bunbury Cathedral Grammar School	Marine monitoring, Dalyellup Beach
Capel LCDC	Survey work, fencing and rehabilitation of a coastal reserve at the mouth of the Capel River
Shire of Busselton	
Wonnerup Progress Association	Rehabilitation, management and planning of the Wonnerup foreshore
West Busselton Primary School	Snorkel trail development, marine and coastal monitoring
Busselton Senior High School	Protection and rehabilitation of an estuarine wetland, 'Adopt a Beach'
Dunsborough Coastcare Group	Foreshore management, weed mapping and weed control along the Dunsborough foreshore
Eagle Bay Residents Association	Coastal rehabilitation at Eagle Bay
Friends of the Cape to Cape Track	Establishment and maintenance of the Cape to Cape walking track (Cape Leeuwin to Cape Augusta) in conjunction with CALM
Meelup Regional Park Management Committee	Coastal access and rehabilitation within the Meelup Regional Park
Yallingup LCDC	Extensive coastal rehabilitation at Rabbits blowout, Yallingup
Yallingup Residents Association	Coastal management, Three Bears and Moses Rock

Shire of Augusta–Margaret River	
Christian Surfers, Margaret River	Coastal access and rehabilitation, Guillotine Beach
Redgate Coastcare	Coastal rehabilitation at Redgate Beach and Prevelly
Gracetown Progress Association	Management of Gracetown cliffs and limestone headland at South Point. Includes masterplanning, rehabilitation works, installation of infrastructure and community nursery establishment
Karridale Electors Association	Rehabilitation of a rocky exposed limestone headland at Cape Hamelin
Leeuwin Conservation Group	Coastal rehabilitation at Boodjidup beach and Kilcarnup, and establishment at a community nursery
Lions Club of Leeuwin	Construction of a disabled fishing platform at Dead Finish
Lower Blackwood LCDC	Planning and dune rehabilitation between Cape Hamelin and Turner Brook, and establishment of an indigenous nursery
Prevelly Wilderness Progress Association	Rehabilitation, walk trail and lookout construction, Gnarabup
Shire of Manjimup	
Lower Donnelly River Environment Group	Walk trail construction, Donnelly River Beach to Lake Jasper
Manjimup LCDC	4WD education, D'Entrecasteaux National Park
Windy Harbour Advisory Group	Coastal rehabilitation
Walpole Nornalup National Parks Association	Coastal rehabilitation at Blue Holes Beach
South Coast Management Group	Regional forum for resolution of coastal and marine issues relevant to the South Coast.
Shire of Manjimup	
Walpole/Nornalup National Park Association	Fauna and flora surveys, rehabilitation education
Peaceful Bay Progress Association	Coastal rehabilitation
Parrys Beach Voluntary Management Group	Management of informal camping area, and user education
Shire of Denmark	
Denmark Agricultural College	Marine survey of near-shore reefs
Wilson Inlet Restoration Group	Rehabilitation of the Wilson Inlet sandbar
Denmark Boating and Angling Club	Off-road vehicle track management in the Boat Harbour/Quarram Nature Reserve
City of Albany	
Albany Bush Rangers	Coastal monitoring and rehabilitation at Middleton Beach
Albany Bush Carers Group	Large scale weeding projects

Youngs Siding Progress Association	Planning and rehabilitation works in the Lowlands Beach area
Elleker Progress Association	Planning and rehabilitation works in the Sand Patch to Mutton Bird Beach area
Southern Edge Arts	Education through performing arts productions
Parents and Friends of Great Southern Grammar	Transplanting of seagrasses in Oyster Harbour
South Coast Progress Association	Weed removal and coastal management works, Princess Royal Harbour
CoastForce	Management of informal camping area at Boat Harbour/Pallinup River and user education
Wellstead Progress Association	Management of informal camping area at Cape Riche and Cheyne Island and user education
Shire of Jerramungup	
Bremer Bay Dive Club	Reef and fish monitoring in nearshore areas, snorkel trail construction
Jerramungup Coastcare Committee	Forum for nominated community group representatives to discuss and provide advice about environmental issues relevant to the Shire of Jerrmungup
Shire of Ravensthorpe	
Hopetoun Progress Association	Landscape planning for Hopetoun foreshore
Shire of Esperance	
Esperance Coastcare Group	Snorkel trail at Woody Island. Dune rehabilitation work at Wylie Cove and Wharton Beach
Bay of Isles Aboriginal Community	Coastal rehabilitation and construction of management infrastructure around Esperance and Middle Island. Boxthorn removal on Cull Island
Local Environmental Action Forum	Lobby and assist land management agencies with environmental issues of community concern. Shearwater viewing platform on Woody Island
Natural Resources and Environmental Advisory Committee	Forum for nominated community group representatives to discuss and provide advice about environmental issues relevant to the Shire of Esperance
Shire of Dundas	
Birds Australia	A national body which manages and co-ordinates the Eyre Bird Observatory. This includes education about birds, and works to support coastal birds

11.9 REGIONAL HERBARIUMS

The Community Regional Herbarium Volunteer Program was initiated by the Western Australian Herbarium and Greening Australia in 1996. Today there are 75 regional herbaria from Kununurra to Esperance, 21 of which are located on the coast.

These herbaria are responsible for collecting local plant samples and relaying them to the State Herbarium.

Geraldton: The Residency 321 Marine Tce GERALDTON WA 6531	Julie Firth Sally Vigilante	9938 1628 9938 1016
Rockingham: Rockingham Regional Environment Centre Safety Bay Rd ROCKINGHAM WA 6969	Elizabeth Rippey	9386 7694
Bunbury: CALM Office Cnr Dodson and Nth Boyanup Rds BUNBURY WA 6231	Shirley Fisher	9791 5915
Albany CALM Office Rear 120 Albany Hwy ALBANY WA 6330	Corralie Hortin	9842 4500
Esperance CALM Office 92 Dempster St ESPERANCE WA 6450	Coral Turley	9071 2339

11.10 PEAK REGIONAL GROUPS

South Coast Management Group
C/- South Coast Regional Facilitator
(08) 9842 4500

South Coast Regional Planning Team (SCRIPT)
(08) 9892 8512

Peel South-West Coastal Management Group
C/- Peel South-West Coastal Facilitator
(08) 9725 5931

South West Catchment Council (SWCC)
(08) 9271 0696

Swan Catchment Council (SCC)
(08) 9374 3333

Central Coastal Planning Coordination Committee

Batavia Coast Planning Coordination Committee

Northern Agricultural Catchment Council (NACC)
(08) 9954 3354

Rangelands NRM Coordination Group
(08) 9455 5455

WALGA - Coastal Management Advisory Group
C/- Western Australian Local Government Association
(08) 9321 5055
www.walga.asn.au

Natural Resource Management Council
(08) 9368 3164

12. REFERENCES AND FURTHER READING

CONTENTS

12.1 COASTAL ENVIRONMENT

Bascom W. (1980) *Waves and Beaches,* Anchor Doubleday, New York

Bureau of Meteorology (1995) *The Storm Spotters Handbook,* Australian Government Publishing Service, Canberra

Bureau of Meteorology (1975) *Manual of Meteorology: Part 1: General Meteorology* Australian Government Publishing Service, Canberra

Bruun P. (1983) Review of conditions for uses of the Bruun Rule of erosion. *Coastal Engineering* 7: 77-89

Carter R.W.G. (1988) *Coastal Environments: An Introduction to the Physical Ecological and Cultural Systems of Coastlines,* Academic Press, London

Carter R.W.G. and Woodroffe C.D. (editors) (1996) *Coastal Evolution: Late Quaternary Shoreline Morphodynamics,* Cambridge University Press, UK

Crowder B. (1995) *The Wonders of Weather,* Bureau of Meteorology, Australian Government Publishing Service, Canberra

Davies J.L. (1980) *Geographical Variation in Coastal Development,* Second Edition, Longman, London

Dutton G. (1985) *Sun, Sea, Surf and Sand – The Myth of the Beach,* Oxford University Press, Melbourne

Hart B.T. and Grant A. (editors) (1993) *Interactions between Sediments and Water,* CSIRO, Australia

Harris P.T., Baker E.K. and Cole A.R. (1991) *The Indian Ocean – Western Australia.* In Harris P.T. (editor) *Physical Sedimentology of the Australian Continental Shelf,* Ocean Sciences Institute Report No. 51, The University of Sydney, Sydney

Hegge B., Eliot I. and Hsu J. (1996) Sheltered sandy beaches of Southwestern Australia. *Journal of Coastal Research,* 12: 748-760

Hsu S.A. (1988) *Coastal Meteorology,* Academic Press, London

Intergovernmental Panel on Climate Change (IPCC) (2001) *Third Assessment Report of the Intergovernmental Panel on Climate Change Working Group,* UNEP, January 2001

Komar P.D. (1998) *Beach Processes and Sedimentation,* Second Edition, Prentice-Hall, Englewood Cliffs, New Jersey

Komar P.D. (1996) The budget of littoral sediments: concepts and applications. *Shore and Beach,* 64: 18-26

Laughlin G.P. (1990) *The Complete Book of Australian Maritime Weather,* W.Gibson, Brookvale

Laughlin G.P. (1997) *The User's Guide to the Australian Coast.* New Holland, Sydney

Manuel M., McElroy B. and Smith R. (1995) *Coastal Conflicts.* Cambridge University Press, Cambridge

Masselink G. and Short A.D. (1993) The effect of tide range on beach morphodynamics and morphology: A conceptual beach model. *Journal of Coastal Research,* 9: 785-800

Masselink G. and Pattiaratchi C.B. (1998) Morphological evolution of beach cusps and associated swash circulation patterns. *Marine Geology,* 146: 93-113

May P., Waterman P. and Eliot I. (1998) *Responding to Rising Seas and Climate Change: A Guide for Coastal Areas,* Department of Environment, Commonwealth of Australia, Canberra

New South Wales Government (1992) *Estuaries Management Manual,* Government Printer, Sydney

Nordstrom K.F. (1992) *Estuarine Beaches: An Introduction to the Physical and Human Factors Affecting Use and Management of Beaches in Estuaries, Lagoons, Bays and Fjords.* Elsevier Applied Science, Amsterdam

Nordstrom K.F. and Roman C.T. (1995) *Estuarine Shores: Evolution, Environments and Human Alterations,* Wiley, Chichester

Pugh D.T. (1987) *Tides, Surges and Mean Sea-level,* John Wiley and Sons, Chichester

Radok R. (1976) *Australia's Coast,* Rigby, Adelaide

Raymond R. and Morrison R. (1979) *Australia: The Greatest Island,* Lansdowne Press, Sydney

Sanderson P.G. and Eliot I. (1996) Shoreline salients, cuspate forelands and tombolos on the coast of Western Australia. *Journal of Coastal Research,* 12: 761-773

Semeniuk V., Searle D.J. and Woods P.J. (1988) The sedimentology and stratigraphy of a cuspate foreland, southwestern Australia. *Journal of Coastal Research,* 4: 551-564

Short A.D. (Editor) (1999) *Handbook of Beach and Shoreface Morphodynamics,* John Wiley and Sons, Chichester

Short A.D. and Hogan C.L. (1994) Rip currents and beach hazards, their impact on public safety and implications for coastal management. In C.W. Finkl Jnr (editor), *Journal of Coastal Research,* Special Issue No. 12: 197-210

Silvester R. and Hsu J.R-C. (1993) *Coastal Stabilisation: Innovative Concepts,* Prentice-Hall, Englewood Cliffs, New Jersey

Thom B.G. (1984) *Coastal Geomorphology in Australia,* Academic Press, Sydney

Underwood A.J. and Chapman M.G. (1995) *Coastal Marine Ecology of Temperate Australia,* UNSW Press, Sydney

Viles H. and Spencer T. (1995) *Coastal Problems: Geomorphology, Ecology and Society at the Coast,* Edward Arnold, London

Walsh K.J.E., Betts H., Church J., McInnes K., Pittock A.B., Jackett D.R. and McDougall T.J. (in press) Using sea level rise projections in urban planning in Australia. *Journal of Coastal Research*

Warren M. (1994) *Atlas of Australian Surfing,* Angus and Robertson, Sydney

Wright L.D. and Short A.D. (1984) Morphodynamic variability of surf zones and beaches: A synthesis. *Marine Geology,* 56: 93-118

12.2 COASTAL MANAGEMENT GUIDES

Coastcare (1999) *Coastal Rehabilitation Workshop Course Notes,* Coastcare Training Program

Department for Environment and Heritage (2001) *Coastcare Community Handbook* [CD Rom]

Department of Agriculture (1992) *Coastal Rehabilitation Manual.* Oma V.P.M., Clayton C.M., Broun J.B. and Keating C.D.M

Department of Conservation and Land Management (2001) *Community Monitoring Manual,* Como, WA

Department of Conservation and Land Management (1990) *Dune Access Erosion Control and Management Techniques for Control of Recreational Vehicles,* Ewing Consulting Engineers and Lovegrove I.C.

Department of Conservation and Land Management (undated) *Visitor Interpretation Manual* [available at www.naturebase.net]

Department of Conservation and Land Management (undated) *Public Participation Manual* Como, WA

Department of Conservation and Land Management (undated) *VISTAT Booklet* [visitor statistics booklet] Como, WA

Department of Conservation and Land Management (undated) *Recreation Management and Planning Manual,* Como, WA

Department for Conservation and Land Management (undated) *Signage Manual,* Como, WA

Department of Land and Water Conservation (2001) *Coastal Dune Management: A manual of coastal dune management and rehabilitation techniques,* NSW Department of Land and Water Conservation, October 2001

Department of Planning and Urban Development (1990) *Townscape Guide.* Chapter 15: Coastal Considerations

Harvey N. and Caton B (2003) *Coastal Management in Australia*, Oxford University Press

Kay R. and Alder J. (1999) *Coastal Planning and Management,* E. and F. N. Spon

National Landcare Program (undated) *Setting Up For Success – a guide for designing, managing and evaluating projects*

Northern Territory Conservation Commission (undated) *Soil Conservation Manual*

NSW National Parks (undated) *Boardwalk Guidelines*

Soil Conservation Services of NSW (1990) *Coastal Dune Management: A manual of coastal dune management and rehabilitation techniques,* Soil Conservation Service of NSW

South Metropolitan College of TAFE (1999) *Coastal Rehabilitation Techniques; Course notes,* Delivered in Busselton WA June 1999

12.3 COASTAL PLANNING

City of Albany (1999) *Nanarup Beach Management Plan,* Price M., Giles D. and Davies J., December 1999

Department of Planning and Urban Development (1992) *Hopetoun: Foreshore Management Plan for public comment,* March 1992

Shire of Dandaragan (1999) *Coastal Plan incorporating Structure Plan and Design Guidelines for Coastal Development and Management for the Shire of Dandaragan : Final Report,* Landvision Pty Ltd in association with Elliot I., Priskin J., Environs Consulting and Evangelisti and Associates

Western Australian Planning Commission (2003) *Coastal Planning Program: Status of Coastal Planning in Western Australia 2002/03* Report, May 2003

Western Australian Planning Commission (1996) *Central Coast Regional Strategy: a strategy to guide land use in the next decade,* September 1996

12.4 COASTAL POLICY / STRUCTURAL ARRANGEMENTS

Department for Planning and Infrastructure (2003) *Coasts WA: Better integration – the Western Australian Government's Response to the Coastal Taskforce Report*, April 2003

Department for Planning and Infrastructure (2002) *Report of the Ministerial Taskforce Investigating the Structural Arrangements for Coastal Planning and Management in Western Australia:* for public comment, May 2002

Donaldson B., Eliot I.G. and Kay R.C. (1995) *Review of Coastal Management in Western Australia: A Report to the Minister for Planning,* Coastal Management Review Committee, Perth, Western Australia

Western Australian Planning Commission (2001) *Coastal Zone Management Policy for Western Australia,* January 2001, Government of Western Australia

Western Australian Planning Commission (2003) *Statement of Planning Policy No.2.6: State Coastal Planning Policy,* Government of Western Australia

12.5 COMMUNITY PARTICIPATION

Coastcare (1999) *Coastcare Communication Kit,* Sponsored by Pioneer

Department for Conservation and Land Management (undated) *Public Participation Manual*

Institute for Science and Technology Policy (1994) *Community Participation in Practice: Workshop Checklist* Sarkissian W. and Walsh K.

Institute for Science and Technology Policy (1988) *Community Participation in Practice: The Community Participation Handbook: Resources for Public Involvement in the Planning Process,* 2nd edition, edited by Sarkissian W. and Perlgut D. with Ballard E. and Walsh K.

Marine Education Society of Australia (1997) *Field Activities for Coastal and Marine Environments: Report series 10,* Oliver J., Department of Environment, Sport and Territories

Patrick S. (1997) *How to Create a Local Herbarium,* Department of Conservation and Land Management and Land for Wildlife

12.6 EVALUATION

Dart J., Pethram R.J. and Shaw W. (1998) *Review of Evaluation in Agricultural Extension* Rural Industries Research and Development Corporation Pub No. 98/136

Foddy W. (1996) *Constructing Questions.* Melbourne, Cambridge University Press

Ministry for the Environment (1999) *Matauranga Take Taiao / Environmental Education: A guide for programme providers. How to develop, implement and evaluate strategies and programmes.* Ministry for the Environment, New Zealand; Sustainable Management Fund

Patton M.Q. (1997) *Utilisation Focused Evaluation,* Third Edition, Sage Publications

12.7 FIRE PLANNING

Emergency Management Australia (2002) *Planning Safer Communities – Land Use Planning for Natural Hazards*, Commonwealth of Australia

Western Australian Planning Commission (2001) *Planning for Bushfire Protection*

Western Australian Planning Commission (2001) *Development Control Policy 3.7 Fire Planning*

12.8 FUNDING

Department of Local Government (2000) *Directory of Financial Assistance – funding available to local governments in Western Australia 1999-2000,* Government of Western Australia

Ministry for Planning (1999) *Coastcare Hints for Applicants* [Guide for WA applicants to supplement National Coastcare guidelines] [unpublished]

TAFE *Coastal Planning Short Course Notes*

12.9 INDIGENOUS INVOLVEMENT

Australian Local Government Association (April 2002) *Working with Native Title. Linking Native Title and Council processes.* 2nd Edition.

Department of Indigenous Affairs (undated) *Fact Sheets.*

Department of Conservation and Land Management (1999) *Kimberley Tourism Manual,* CALM, Kensington, Perth WA.

Edmunds M. and Smith D. (2000) *Guide to Mediation and Agreement Making.* National Native Title Tribunal.

Kimberley Land Council (1998), *The Kimberley – Our Place Our Future.* Conference Report. KLC 1998.

Lurrijarri Council and Royal Melbourne Institute of Technology (November 1993), *Draft Management Plan for the Lurrijarri Heritage Trail Broome, Western Australia.* Lurrijarri Council Goolarabooloo Broome.

Plumptre T. and Graham J. (1999) *Governance and Good Governance: International and Aboriginal Perspectives,* Institute on Governance, unpublished paper appearing on www.iog.ca, Ottawa, Canada.

Shire of Broome (1999) *Coastal Park Management Plan – Broome Western Australia.* Broome Shire Council. April 1999.

Switzer M. (1998) at the National Coast to Coast Conference Perth WA May 1998 quoted in *Shire of Broome Coastal Park Management Plan Broome* Western Australia – April 1999. Broome Shire Council WA.

The Sydney Coastal Councils Group (1998) *Sydney Regional Coastal Management Strategy.* Sydney Coastal Councils Group, Chatswood NSW.

United Nations (1992) Recognising and Strengthening the Role of Indigenous People and their Communities Policy. *Agenda 21* (Chapter 26.1). International conference on Environment and Development 1992.

Wensing E. (January 2002) *Issues Paper No. 4 – Indigenous Land Use Agreements (ILUAs) Involving Local Government.* Australian Local Government Association Canberra.

Western Australia Aboriginal Native Title Working Group (undated) *Reaching Agreement: A better approach to native title in Western Australia.*

Western Australian Museum Department of Aboriginal Sites (May 1989) *A Management Report for the Lurijarri Heritage Trail, Broome, Western Australia.* WA Museum.

Wunambal Gaambera Aboriginal Corporation (January 2001) *Land of Wandjina and Wunggurr. Ngauwudu Management Plan.* KLC Land + Sea Unit Broome.

12.10 WEEDS AND WEED MANAGEMENT

Bradley J. (1988) *Bringing Back the Bush- the Bradley method of bush regeneration,* Landsdown Press

Carr C.W., Yugovic J.V. and Robinson K.E. (1992) *Environmental Weed Invasions in Victoria: Conservation and Management Implications* Department of Conservation and Environment and Ecological Horticulture Pty Ltd

Department of Agriculture Western Australia (1999) *State Weed Plan,* Western Australian Department of Agriculture

Department of Conservation and Land Management (1999) *Environmental Weeds Strategy for Western Australia*

Department of Land and Water Resources (1998) *Attack of the Killer Weeds,* Coastcare, NSW

Dixon B. and Keighery G. (1995) *Weeds and their Control in Managing Perth's Bushlands,* Greening Western Australia

Horlock J. (1998) *Coastal Weed Treatments Handbook,* Greening Australia, Victoria, CoastAction/Coastcare, Vic.

Hussey B.M.J., Keighery G.J., Cousens R.D., Dodd J. and Lloyd S.G. (1997) *Western Weeds: a guide to the weeds of Western Australia,* Plant Protection Society of WA

Moore J. (2000) *HerbiGuide: the pesticide expert on disk* [Contact for more information John Moore 08 98 444 064]

Scheltema M. and Harris J. (1995) *Managing Perth's Bushland,* Greening Western Australia

12.11 REVEGETATION, CONSERVATION AND BIODIVERSITY

APACE (1997) *Revegetation Catalogues,* The Appropriate Technology Development Group Inc

Burgman M.A. and Lindenmeyer D.B. (1998) *Conservation Biology for the Australian Environment,* Surrey Beatty and Sons

Cochrane A. (2002) *Seed Notes for Western Australia,* Perth Branch of the Wildflower Society of Western Australia (Inc.)

Cole H., Carter D. and Clay B. (2000) *Native Flora of the Cape Naturaliste Region*

Craig G.F. (1983) *Pilbara Coastal Flora,* Department of Agriculture

Craig G.F. (1995) *Native Plants of the Ravensthorpe Region,* Ravensthorpe Wildflower Show Inc

Department of Conservation and Land Management (1996) *Broome and Beyond: Plants and people of the Dampier Peninsula, Kimberley, Western Australia,* Keneally K.F., Edinger D.C. and Willing T.

Doran J.C. and Turnbull J.W. (2000) *Australian Trees and Shrubs: species for land rehabilitation and farm planting in the tropics,* Australian Centre for International Agricultural Research

Esperance Wildflower Society Inc (1997) *Wildflowers of Esperance Vols 1-3*

Forests Department (1977) *Planning your Garden to Conserve Water,* Edmiston R.J. and Beggs B.J.

Hussey B.M.J. and Wallace K.J. (1993) *Managing your Bushland: A guide for Western Australian landowners,* Department of Conservation and Land Management, Como, WA

Kwinana, Rockingham and Mandurah Branch of the Western Australian Naturalist's Club (1988) *A Guide to the Flora and Fauna of the Rockingham Offshore Islands and Cape Peron*

Mortlock W. and the Australian Tree Seed Centre (1999) *Guidelines: Native seed storage for revegetation; Basic methods for drying, extraction and cleaning of native plant seed; Native seed collection methods* FloraBank

Mortlock W (1999) *Model Code of Practice for community-based collectors and suppliers of native plant seed,* FloraBank

Paczkowska G. and Chapman A.R. (2000) *The Western Australian Flora: A descriptive catalogue,* Wildflower Society of WA, WA Herbarium, CALM and Botanic Gardens and Parks Authority

Powell R. and Emberson J. (1996) *Growing Locals: Gardening with local plants in Perth,* Western Australian Naturalist's Club

Rippey E. and Rowland B. (1995) *Plants of the Perth Coast and Islands,* University of Western Australia Press

Robin Road Software (2001) REX: *Revegetation Expert System,* Robin Software, Agriculture WA, Department of Conservation and Land Management and Greening WA, PCWare, [revision, in prep.]

Seabrook J. (1987) *Seeds of the Future: How to establish a native plant seed orchard and revolutionise revegetation,* Greening Western Australia

Semeniuk V., Keneally K.F. and Wilson P.G. (1978) *Mangroves of Western Australia,* Handbook No.12, Western Australian Naturalist's Club

Smith G.G. (1985) *A guide to the coastal flora of South-Western Australia,* Western Australian Naturalist's Club

Tyler J.P. (1990) *Revegetation with Pilbara seed,* Dampier Salt (Operations) Pty Ltd

Tyler J.P. (1988) *The Dampier Salt Guide to Pilbara Plants for the Garden,* Dampier Salt (Operations) Pty Ltd

Wrigley J.W. and Fagg M. (1996) *Australian Native Plants: Propagation, cultivation and use in landscaping,* Reed

Yencken D. and Wilkinson D. (2000) *Resetting the Compass: Australia's journey towards sustainability* CSIRO Publishing

12.12 PLANT IDENTIFICATION

Anon. (1997) *Wildflowers of Esperance.* Vols 1-3. Esperance Wildflower Society Inc.

APACE (1997) *Revegetation Catalogues.* The Appropriate Technology Development Group Inc., Perth.

Cole H.D., Carter and Clay B, (2000) *Native Flora of the Cape Naturaliste Region,* Perth

Craig G.F. (1983) *Pilbara Coastal Flora,* Western Australian Department of Agriculture, Perth.

Craig G.F. (1995) *Native Plants of the Ravensthorpe Region,* Ravensthorpe Wildflower Show Inc.

Keneally K.F., Choules D., Edinger and Willing T. (1996) *Broome and Beyond: Plants and People of the Dampier Peninsula, Kimberley,* Western Australia, Department of Conservation and Land Management, Perth.

Kwinana, Rockingham and Mandurah Branch of the Western Australian Naturalist's Club (1988) *A Guide to the Flora and Fauna of the Rockingham Offshore Islands and Cape Peron.*

Paczkowska G. and Chapman A.R. (2000) *The Western Australian Flora: A descriptive catalogue,* Wildflower Society of WA, WA Herbarium, CALM and Botanic Gardens and Parks Authority

Powell R. and Emberson J. (1996) Growing Locals: Gardening with Local Plants in Perth, Western Australian Naturalist's Club, Perth

Rippey E. and Rowland B. (1995) *Plants of the Perth Coast and Islands,* University of Western Australia Press

Robin Road Software [2001] *REX: Revegetation Expert System.* Robin Software, Agriculture WA, Department of Conservation and Land Management, and Greening WA. PCWare, Sydney. [revision, in prep.]

Semeniuk V., Keneally K.F. and Wilson P.G. (1978) *Mangroves of Western Australia.* Handbook No. 12. Western Australian Naturalist's Club, Perth

Smith G.G. (1985) *A Guide to the Coastal Flora of South-Western Australia,* Western Australian Naturalist's Club, Perth

Tyler J.P. (1990) *Revegetation with Pilbara Seed,* Dampier Salt (Operations) Pty Ltd, Karratha

Tyler J.P. (1988) *The Dampier Salt Guide to Pilbara Plants for the Garden.* Dampier Salt (Operations) Pty Ltd, Karratha

Wrigley J.W. and Fagg M. (1996) *Australian Native Plants: Propagation, Cultivation and Use in Landscaping,* Reed

Wheeler J., Marchant N. and Lewington M. (2002) *Flora of the South West (Bunbury, Augusta, Denmark) Volume 1 and 2,* Australian Biological Resources Study and Western Australian Herbarium

12.13 VEHICLE MANAGEMENT

Department of Local Government (1978) *Control of Vehicles (Off-road areas) Act – An Explanation*

12.14 USEFUL WEB REFERENCES

www.wa.gov.au
The Government of Western Australia
Lists all Government Agencies

www.planning.wa.gov.au
Western Australian Planning Commission
Coastal management and planning, Coastal Data Centre

www.dpi.wa.gov.au
Department for Planning and Infrastructure
Coastal management and planning, Coastal Data Centre

www.ea.gov.au
Environment Australia
Commonwealth Coastcare Website, Australia's World Heritage Areas, Ramsar sites, Manuals and Reports

www.env.qld.gov.au/environment/science/coasts/
Environmental Protection Agency Queensland
Coastal Dune Management

www.dnr.qld.gov.au
Department of Natural Resources Queensland
Vegetation and Weed Fact Sheet series

www.agric.wa.gov.au
Department of Agriculture
State Weed Strategy

www.weeds.org.au
Weeds Australia
National Weeds Strategy

www.marine.csiro.au
CSIRO Marine

www.members.iinet.net.au/~ewan/
Environmental Weeds Action Network

www.dnr.qld.gov.au
Queensland Department of Natural Resources:
Declared plants fact sheets

www.mesa.edu.au
Marine Education Society of Australasia

www.amcs.org.au
Australian Marine Conservation Society

www.reefwatch.asn.au
Reef Monitoring Program

www.surfrider.org.au
Surfrider Foundation
Protection and Enhancement of Australian Oceans

www.mccn.org.au
Marine and Coastal Community Network

www.coastal.crc.org.au
Coastal CRC
A Decision making Tool for Coastal Management

www.nre.vic.gov.au/coasts/coastkit/cstsite.htm
The Government of Victoria
The Coast Kit: Coastal Resource Information Kit

www.env.qld.gov.au/environment/science/coasts/bc.html
The Government of Queensland
A Series of Notes on Coastal Dune Management

www.wwf.org.au/tsn/
Threatened Species Network

www.coastalmanagement.com
Coastal Management Internet Organisation
Coastal Management Web Searches

www.florabank.org.au
Flora Bank Online

www.environment.gov.za
South African Coastal Management Centre

www.bom.gov.au
Bureau of Meteorology
Climate and Weather Data

www.slp.wa.gov.au
State Law Publisher
List of Western Australian Legislation

www.science.murdoch.edu.au/centres/others/mangrove/
WA mangrove database

accretion	build up of sediment
aeolian	sediments which have been transported by winds
aff.	affinity, resembling or closely related
annual	a plant grown from seed that completes its life cycle in one season
aril	an appendage growing near the point of attachment of the seed
axil	the point of the upper angle formed between the axis of a stem and any part (usually a leaf) arising from it
bar	a bank of sand, gravel or other unconsolidated material built up on the sea floor in shallow water
beaked	bearing a narrow or prolonged tip
berm	nearly horizontal part of the beach formed by the deposition of sediment by wave action
bipinnate	twice pinnate, the paired pinnae being again divided
biodiversity	the variety of plants and animals living within an ecosystem
biomass	a quantitative estimate of the entire amount of living organisms in a particular habitat
blowout	bare sandy hollows formed by wind and wave erosion of sand dunes
bract	leaflike structure at base of a flower or inflorescence
breakers	waves breaking on a shore or over a reef
bund	mounds of sand placed on tracks to physically block them off to vehicle traffic
calyx	the collective term for all the sepals of a flower; the outer whorl of a flower
climate	weather information for an area collected over space and time
coastal processes	the combined natural processes such as weather, tides, sea level and waves, that impact on coastal environments
community capacity building	development work that may involve training as well as providing resources, to strengthen the ability of community groups and organisations to build structures, systems and skills that enable them to participate fully in decisions affecting their community and to take community action
country	refers to the cultural or spiritual place of origin of an Indigenous person. When Indigenous people talk of *'my country'* they are referring to their clan or tribal area. Their membership of that clan country was given at birth and remains even if they move away and live on other 'country'
creeper	growing along the surface of the ground and producing roots, usually at the nodes

cultural heritage	knowledge, places and things including those made or changed by humans, that have aesthetic, historic, scientific, social or spiritual significance or other special value for future generations as well as the present community. *(Australian Heritage Commission 1991)*
cuspate foredune	a seaward protrusion in a beach produced by the accumulation of sediment at a zone of convergence or in the lee of an off shore obstacle
custodian	a person who cares for and protects an area of great sensitivity, such as a sacred site, food source or valued habitat. A custodian is not an 'owner' but rather a site 'protector' or 'carer' who lives locally and is responsible for the ritual maintenance and protection of a specific site or area. Most importantly, the custodian is responsible to a wider group of people who also have strong connections to the area, even though they may live at a distance from the site
deciduous	not evergreen, leaves fall off the tree
decumbent	reclining on the ground, but with the tip ascending
digitate	lobed or divided from a common point like the fingers of a hand
empowerment	the process by which people can effect and gain control over their own lives while learning to participate democratically in the life of the community. Empowerment not only conveys a psychological sense of control, but is also concerned with the actual social influence, political power and the rights of all individuals and communities." *Environments for Health Vic State Govt 2000.*
environmental weed	an environmental or bushland weed is a plant growing in bushland that is not part of the original species composition for that site
erosion	the loss of sediment
escarpment	a steep slope or long cliff that results from erosion or faulting
estuary	a partly enclosed coast water body in which waters derived from terrestrial and marine sources are mixed
evaluation	the collection of information about aspects of a project or action to determine its success
foredune	first dune on the landward edge of the beach
future act	a proposed activity or development on land and/or waters that may affect native title by extinguishing (removing) it or creating interests that are inconsistent with the existence or exercise of native title. Examples of future acts include the granting of mining or exploration rights.
geomorphology	the formation and evolution of landforms
groyne	a shore protection structure built to trap littoral drift or retard erosion of the shore
harden off	acclimatise a plant to harder conditions

headland	land, usually high and with a sheer drop, extending out into a body of water – a promontory
high water mark	the intersection of the mean high water with the shore
holocene	strata younger than 10,000 years, the time when sea level began to rise (also called recent or modern)
Indigenous Land Use Agreement (ILUA)	a voluntary agreement about the use and management of an area of land or waters made between one or more native title groups and others (such as miners, pastoralists, governments). A registered agreement is legally binding on the people who are party to the agreement, and all native title holders for that area
Indigenous peoples	Australians who identify as belonging to Aboriginal and Torres Strait Islander groups and who are recognised by their communities as belonging to those groups
inflorescence	the arrangement of flowers on the stem; a flower cluster
intertidal	the section of the coast between high and low tide marks
lanceolate	lance-shaped; much longer than wide, with the widest point below the middle
land manager	the public or private body with legal responsibility for management of an area
land tenure	defines land ownership or vesting, and establishes the purpose and intended use of a parcel of land
lignotuber	a woody swelling just below ground level which can produce new roots and shoots after disturbance such as fire, e.g. mallee root
linear	long and narrow with more or less parallel sides
littoral	of or pertaining to the shore, especially of the sea
littoral drift	littoral sediment movement under the influence of waves and currents
local provenance	plants that grow within the same recognised botanical province and which may not differ genetically
longshore	parallel to the shoreline
mallee	a shrubby eucalypt with several stems arising from an underground lignotuber
mallet	small to medium sized tree with usually steep branching form and a conspicuously dense terminal crown; often occurring in pure stands
mangrove	intertidal, salt-tolerant seed-bearing plants
mean	the average value in a series of data
microclimate	the climate of a small, particular place within an area, as contrasted with the climate of the entire area

modal value	the value occurring most frequently in a series of data
ms	manuscript name, the proposed name for a species yet to be formally described
Native Title	the term used by the High Court to recognise the communal, group or individual rights of Aboriginal and Torres Strait Islander people in relation to their pre-existing and continuing connection with land or waters according to their traditional laws and customs. These rights may be rights of ownership, possession and use of traditional country and are recognised under Australian law
Native Title Representative Body	a regional organisation recognised by the Commonwealth Minister for Aboriginal and Torres Strait Islander Affairs and funded by the Aboriginal and Torres Strait Islander Commission (ATSIC) to represent Indigenous Australians in native title issues in a particular region
National Native Title Tribunal	the independent body established under the *Native Title Act 1993* to assist people to resolve native title issues. The Tribunal provides administrative support to deal with native title applications. It works closely with communities across Australia to help resolve land issues and make agreements that recognise everyone's rights and interests in land and waters
naturalised plant	a plant that is able to complete its entire lifecycle in an environment to which it is not indigenous (usually a weed)
near shore	the section of the coast from the backshore to the beginning of the offshore zone
nodes	position on the stem where leaves or branches originate
noxious weed	a weed that has been declared harmful by statute law and requires compulsory eradication
ovate	egg-shaped in outline and attached at the broad end
perennial	a plant that lives for more than two years
petal	a segment of the inner whorl (corolla) of the flower, usually coloured or white
phyllodes	leaf stalk modified into the shape of a leaf and functioning as a true leaf
pinnae	leaflets of a pinnate leaf
pinnate	compound leaf with leaflets arranged on opposite sides of an elongated axis
pn	phrase name, given to a putative new species yet to be formally described
promontory	a high ridge of land or rock jutting out into a body of water; a headland
propagate	to give rise to a new plant

propagule	a structure with the capacity to give rise to a new plant, for example a seed, a spore, or a part of the vegetative body capable of independent growth if detached from the parent
prostrate	lying flat on the ground
protocol	respectfully following the customs and lores of the people or community you are working with and communicating in a way that is relevant to them.
provenance	location where seed is collected
raceme	unbranched, elongated inflorescence with stalked flowers maturing from the bottom upwards
recurved	curved backward
rhizome	underground stem that grows horizontally
rip	a strong, narrow seaward flow of water from the surf
saltwater people	a term used to describe Indigenous people who were born in the coastal country and are culturally linked to the coast
secondary dune	generic term for dunes occurring inland of the foredune which are progressively more protected from coastal processes; generally vegetated with low shrubs
sedimentary coast	coast formed by the deposition of sediment
sedge	plant resembling a coarse grass growing together in a mass
seed lot	an apportionment of seed
sepal	a segment of the calyx
shoreline	line that forms the boundary between the land and the water, often taken as mean high water mark
shrub	a woody plant with several stems
species	a group of plants with similar genetic constitution
spike	unbranched, elongated inflorescence with stalkless flowers maturing from the bottom upwards
spikelet	the ultimate flower cluster of grasses and sedges
stipule	one pair of leaflike appendages found at the base of some leaf stalks
subaerial	above sea level on a beach, between mean low water mark and the lower limit of vegetation
subsp.	subspecies, a form of a species having a distinctive identity and occupying a particular habitat or region
sucker	a shoot originating from below the ground

surf	the wave activity in the area between the shoreline and the outermost limit of breakers
stakeholder	a Public or private body with an interest (stake) in decisions and actions pertaining to an event or area
swale	hollow between dune ridges
swash	rush of water on the beach following the breaking of a wave
swell	wind waves that have travelled some distance from their area of generation, and have regular shape
tertiary dune	generic term for well protected dunes, not greatly exposed to salt-laden winds; vegetated with shrubs and trees
topography	the configuration of a surface, including its relief, the position of its roads, streams etc.
traditional owner	an Indigenous person with cultural connections to a specific area or tract of land or waters (regardless of historical or current land tenure), arising from Indigenous law and customs observed by the relevant land-owning group
tree	a large woody plant, usually with a single main stem or trunk
tsunami	long period wave caused by water displacement due to an underwater disturbance such as earthquake or volcanic eruption
tussock	clump of grasses or sedges
wave	a ridge, deformation, or undulation of the surface of a liquid
weather	the term used to describe conditions of temperature, humidity and wind conditions at any place and time
wind shear	a change in wind direction and speed between slightly different altitudes, especially a sudden downdraft. It creates drag on the water's surface.
whorl	a ring-like arrangement of similar parts arising from a common point or node

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