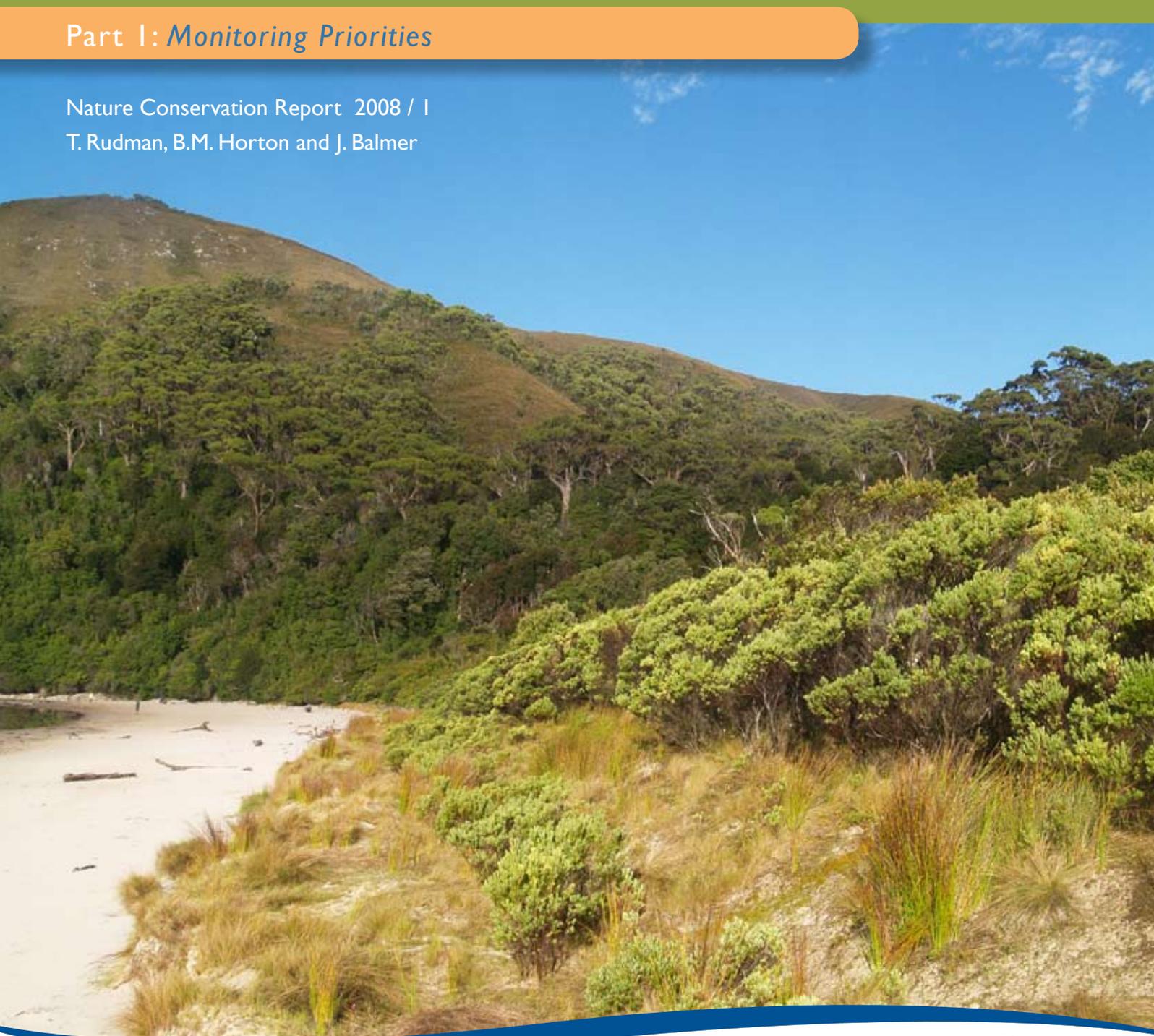


Monitoring Dry Coastal Vegetation in the Tasmanian Wilderness World Heritage Area

Part I: *Monitoring Priorities*

Nature Conservation Report 2008 / I
T. Rudman, B.M. Horton and J. Balmer



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in the Tasmanian Wilderness
World Heritage Area

Part 1 Monitoring Priorities
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EXECUTIVE SUMMARY

The coastline of the Tasmanian Wilderness World Heritage Area (TWWHA) is a globally significant near pristine coastline of very high conservation value. It is almost unique in presenting temperate coastal processes virtually undisturbed by human activities within the adjacent catchments or on the coast itself. World Heritage and nationally significant conservation values on the coast include: short coastal herbfield (marsupial lawn), dwarf littoral rainforest, coastal shrubland on rocky foreshores, beach sand and dune vegetation, rookery vegetation, coastal lagoons and other wetlands. Sixteen rare and one vulnerable vascular plant species within the TWWHA coastal environment are listed under the Tasmanian *Threatened Species Protection Act 1995*. (TSPA). This area is the best example remaining in the world of temperate coastal processes within a high-energy compartmentalised rocky and sandy coastline that hasn't been subject to major glacial actions. In particular the coastal sand ecosystem with its distinctive beach forms is of international conservation significance.

A major potential threat to the natural functioning of the coastal environment is the predicted change in sea levels, storm surges and wind that are associated with global warming. Though the coastal ecosystems have experienced past change in sea levels, the rate and magnitude of these changes may affect geomorphic processes and impact significantly on the abundance of some coastal species and communities.

This report assesses the potential impact of coastal retreat on the TWWHA dry coastal vegetation values. The ecosystems considered are those identified as vulnerable to sea level rise by Sharples (2006). Other interrelated impacts of climate change such as changing CO₂ levels, temperature and rainfall or altered fire regimes in coastal environments are not considered but are likely to also interact to affect conservation outcomes.

Coastal rainforest and coastal marsupial lawn communities are of high conservation value in the TWWHA and may be at risk. The impact of potentially greater fire risk will compound the risk faced by coastal rainforest to coastline changes. Coastal marsupial lawn is likely to persist in small transient sites however the large expanses of lawn may be lost. Some plant species that may be at risk include the threatened species *Veronica novae-hollandiae* and *Westringia brevifolia* var. *raleighii* and the restricted endemic shrub *Persoonia muelleri* subsp. *densifolia*. Determining the distribution of these species and how they are responding to coastal recession is a conservation priority. As our ability to predict risks is currently limited, there is a need to monitor the nature of the geomorphic changes occurring on the coast and the response of plant species and communities.

1 INTRODUCTION

This report is part 1 of a 2 part series on the dry coastal vegetation in the Tasmanian Wilderness World Heritage Area. This report assesses the risks associated with climate change induced coastal recession to dry coastal vegetation. The second volume, Monitoring Dry Coastal Vegetation in the Tasmanian Wilderness World Heritage Area. Part 2: Appraisal of Method (Horton *et al.* 2008), tests a method for dry coastal vegetation monitoring.

The Tasmanian Wilderness World Heritage Area (TWWHA) was first inscribed on the UNESCO World Heritage list in 1982 and now occupies a total area of 1.38 million hectares of western Tasmania. The TWWHA incorporates 755 km of coastline and a number of offshore islands (Sharples 2006). The coastal environment of the TWWHA includes many natural values including floristic and geomorphic values of high conservation significance (Balmer *et al.* 2004).

The coastal zone is one of the habitats considered to be at risk from global climate change due to sea level rise, increased storm events and tidal changes which may lead to increased rates and extent of erosion (IPCC 2007). The National Biodiversity and Climate Change Action Plan 2004–2007 (NRMCC 2004) sought national action to identify the long-term monitoring programs needed to assess the impacts of climate change on biodiversity over time and to evaluate the long-term effectiveness of adaptation strategies and actions. This included the action:

4.1.3 Undertake a risk assessment analysis to determine priority species and ecosystems for management response.

Coastal plant communities have been exposed to substantial and rapid rises in sea level in the post glacial period. However, the current coastal environment is very different in a few key areas. There is a substantial reduction and/or modification by man of coastal plant communities and there are considerable areas of the State where introduced weeds have largely displaced native vegetation (eg potential migration pathways or refugia are not available). Species or communities that are restricted in distribution (eg threatened species) may be at risk, particularly if there are compounding pressures on top of coastal recession (eg fire, weeds).

Recently there has been considerable beach erosion occurring on western and southern beaches of the TWWHA coastline (eg truncated Holocene dune paleosols). Understanding the rate and potential scale of coastal recession requires a detailed model for geomorphic process on vulnerable sections of coastline. This has not yet been done for the TWWHA coast. The implications of this are that our ability to effectively analyse risk to vegetation on the coastal zone is still limited.

This report makes a simple initial assessment of the vegetation values that may be at risk from coastal recession in areas assessed as potentially vulnerable to erosion by Sharples (2006). This in turn will inform the further research, monitoring and adaptive management.

2 THE CURRENT AND FUTURE CLIMATE OF THE TWWHA

The climate of the coastal areas of the TWWHA is described as a changeable maritime climate dominated by the passage of cold fronts associated with low pressure systems (Gentilli 1972). Strong winds occur around the coast, dominated by northwesterly winds reaching 40km/hr for more than 40% of the time at Maatsuyker Island (Bureau of Meteorology 2007). Rainfall in coastal areas within the TWWHA averages around 1230 mm per annum and temperatures with mean minimum temperature of 6.4°C in August and mean maximum of 17.2 °C in February (Bureau of Meteorology 2007).

The Southern Ocean region south of Australia is described as a very stormy environment with waves reaching greater than 5 m for 40% of the time (Bureau of Meteorology 1995). Swell and sea waves come mostly from the west to southwest and the tidal range is normally less than 2 m. Periodically, low air pressure systems and onshore winds can produce storm surges with large waves and swell (Cullen 1998) that may impact on beach dune systems and coastal vegetation.

Climate change will result in a number of global affects including changes in temperature, rainfall, wind direction and strength, sea temperature and sea level (Hughes 2003). General predictions have been made for Australia (CSIRO 2007) that are based on the IPCC (2007) report emission scenarios. These include a mean warming of 0.7°C to 1.0°C in coastal areas by 2030 with a greater divergence in predicted warming in the modelled scenarios beyond that period. In an earlier Tasmanian study the annual mean maximum temperature was predicted to change between -0.2 °C and +0.2 °C for the southwest, and between 0.3 C and 0.7 C for northwest Tasmania (McIntosh *et al.* 2005).

There is much uncertainty surrounding future changes in rainfall and evaporation, as it is more sensitive to local and regional conditions (CSIRO 2007, Hughes 2003). There are no climate stations on the SW Tasmanian coastline to assist in modelling the regions climate. Rainfall is likely to increase in seasonality in southern Tasmania. Summer and Spring rainfall is predicted to decrease, but little change may occur in annual rainfall (CSIRO 2007). McIntosh *et al.* (2005) predicted rainfall is likely to slightly increase in the southwestern half of the State with the greatest increase in rainfall occurring during July, August and September. However these predictions were based very few data points and are now being revised in a higher resolution study.

Average wind speed is expected to be affected by the southwards contraction of the westerlies that will result in winter and spring wind speeds increasing by 2-5%. Little change in annual average wind speed is predicted (CSIRO 2007). McIntosh *et al.* (2005) also predicted a strengthening of westerly winds across the State, especially in late winter and early spring. This is likely to increase the height of storm surges and Victorian models have shown a corresponding increased frequency of current 100 year storm tide levels with increased windiness (CSIRO 2007).

From 1961-2003, the rate of sea level rise was 1.8 mm per year, with a rise of 3 mm per year from 1993-2003. This rate of increase is an order of magnitude faster than the average rate of rise over the previous several thousand years (CSIRO 2007). There has been an increase in sea-level between 10-20 cm during the last century, with about 14 cm rise on the southeast Tasmanian coast (Sharples 2006). Church & White (2006) reported an increase in frequency of extreme sea level events post 1950 for the two localities in Australia that sufficient data was available.

The IPCC (Nicholls *et al.* 2007) prediction a sea-level rise of 18-59 cm by 2099 is based on modelling six climate scenarios but does not include the contribution from melting ice sheets which are poorly understood. Additional sea level rise from ice melting is possibly 10 to 20 cm but potentially substantially more if the ice sheet melting rates increase (CSIRO 2007). In Tasmania, the predicted southward extension of the warm East Australian Current will result in a sea level rise above that of the global background sea level rise.

However there are local drivers for sea level change which affect the application of global or national sea level models to the TWWHA coastline. Sea level rise relative to land will be less where land is uplifting. The coastal terraces south of Birches Inlet result from a rapid tectonic uplift in that area since the Pliocene (Houshold *et al.* in press). However the periodicity of uplift in that area is not at a frequency which is likely to ameliorated sea level rise this century.

3 TWWHA COASTAL VEGETATION AND FLORISTIC VALUES

3.1 Coastal vegetation of the TWWHA

The coast is a particularly dynamic environment in which disturbance is a major and natural phenomenon to which the plants are well adapted. The strong patterning and zonation of plant communities with respect to environmental gradients such as exposure to salt spray, tidal impacts and sand movement is a demonstration of the phenomenal interaction between plants and their environment. One of the particularly significant interactions is the relationship between beach grasses and dune formation.

Tasmanian coastal vegetation communities are diverse in composition and structure. Harris (1991) gives a general description of the main coastal vegetation communities within Tasmania and how they relate to coastal geomorphology. Kirkpatrick and Harris (1995) published an extensive survey of dry coastal plant communities throughout Tasmania. Vegetation communities were classified floristically as well as by species dominance. Thirty-eight floristic communities and 31 dominance communities were described.

At least 19 of the floristically defined dry coastal plant communities and 16 of those defined by dominance are known to occur in the TWWHA (Kirkpatrick and Harris 1995). However the south west Tasmanian coast line had less survey effort than other areas due to its relative inaccessibility and the communities they report do not include coastal forest or wetland vegetation. Floristically, community composition is diverse ranging from *Schoenus nitens* – *Cotula reptans* sedgelands to *Austrofestuca littoralis* grasslands to *Correa backhouseana* heath and *Atherosperma moschata* – *Eucryphia lucida* coastal rainforest (Kirkpatrick and Harris 1995, Harris and Kitchener 2005).

Vegetation communities within the TWWHA have been mapped as part of the WHA vegetation-mapping program from 1988 1:25,000 aerial photographs. This mapping has since been translated into the TASVEG classification to provide a standard State vegetation map. This scale of mapping does not identify the fine scale zonation in plant communities in the coastal zone.

3.2 Vegetation communities of conservation significance

The TWWHA contains a number of coastal vegetation communities that have high conservation value due to their unusual composition or restricted distribution and the presence of species of conservation significance. These communities are listed by Balmer *et al.* (2004) as short coastal herbfield (marsupial lawn), dwarf littoral rainforest, coastal shrubland and rocky foreshores, beach sand and dune vegetation, rookery vegetation and wetlands.

Short closed herbfield, also known as marsupial lawn, occurs along the coast within the TWWHA (Harris 1991, Kirkpatrick and Harris 1995). This community is notable by the absence of succulents and the dominance of matt forming sedges and forbs including *Leptinella longipes*, *Schoenus nitens* and *Plantago triantha*. It is also a major habitat for the restricted endemics *Ranunculus acaulis* and *Ammobium calyceroides* and the threatened species *Lachnagrostis scabra* subsp. *scabra*. This community is endemic to Tasmania and appears to have no close analogue outside Tasmania (Balmer *et al.* 2004). It occurs in situations where the water table is close to the surface in a variety of habitats. These include the margins of coastal lagoons, estuaries and creeks, dune swales, on the back of beaches above the strand line and on the leading edge of dunes above erosion scarps.

Coastal rainforest is identified as having significant conservation value as it is a rare community type in Australia that has its most extensive and best representation within the TWWHA (Balmer *et al.* 2004). This community type is described as having a dense canopy from 5-12 m with open understorey of ferns and/or sedges. Canopy dominants include *Atherosperma moschatum* or *Eucryphia lucida*. It is thought to be stable community not requiring disturbance for regeneration. It is often only separated from the littoral zone by a very narrow herbfield ecotone. The proximity of this vegetation to the ocean gives rise to the distinctive structure and floristics distinguishing it from rainforest more remote from coastal influence. It is distinguished by the presence of species such as large trees of *Leptecophylla juniperina*, *Persoonia muelleri*, the abundance of *Cenarrhenes nitida*, and species such as *Olearia argophylla* and *Zieria arborescens*. This distinctive rainforest is known to occur from Macquarie Harbour to South Cape Bay (Jarman, Kantvilas and Brown 1991). This community is habitat for tree form *Leptecophylla juniperina* subsp. *juniperina* and the rare species *Deyeuxia minor*.

Coastal shrubland and heath communities occur behind rocky shores and on coastal dunes within the TWWHA (Kirkpatrick and Harris 1995). These communities have particular world heritage significance where they are dominated by the Tasmanian endemic plants *Leptecophylla abietina*, *Westringia brevifolia*, *Ozothamnus costatifructus*, *O. reticulatus* and *Correa backhouseana* (Balmer *et al.* 2004). The rare species *Lepidium flexicaule* is also found within rock crevices on rocky shores (Threatened Species Unit 2003).

Native coastal grassland, often dominated by *Austrofestuca littoralis*, occurs on incipient dunes and dunes above the high tide mark on many beaches in the TWWHA. Native grasses play an important functional role in stabilisation and in many coastal environments, native grasses have been replaced by the introduced marram grass, *Ammophila arenaria* and sea spurge, *Euphorbia paralias* (Rudman 2003). This community is also habitat for the rare species *Lachnagrostis scabra* subsp. *scabra* and vulnerable species *Ranunculus acaulis* and has significant conservation value.

Rookeries found on offshore islands of the TWWHA, develop distinctive communities due to the high nutrient and disturbance regimes not present elsewhere. Two rare species, *Xerochrysum bicolor* and *Poa poiformis* var. *ramifer*, have been recorded on Maatsuyker Island (Balmer *et al.* 2004).

Wetland communities have significant value as they perform valuable functional roles within the coastal environment and provide essential habitat for many organisms including migratory birds (DPIWE 2004).

3.3 Plant species of conservation significance

Approximately 440 vascular plant species have been recorded in the coastal environment within Tasmania (Harris 1991) of which about 145 species are largely confined to the coastal environment (Balmer *et al.* 2004).

Within the TWWHA, 57 species, including 9 endemics, have the major proportion of their populations within the coastal region. At least 4 of the coastal endemic plant species have most of their population within the TWWHA (*Ammobium calyceroides*, *Leptecophylla abietina*, *Persoonia muelleri* subsp. *densifolia* and *Westringia brevifolia* var. *raleighii*) (Balmer *et al.* 2004) (Appendix 2).

Sixteen plant species within the TWWHA coastal environment are listed as rare under the Tasmanian *Threatened Species Protection Act 1995* and one species is listed as vulnerable (Balmer *et al.* 2004) (Appendix 3).

4 COASTLINE CHANGE PROCESSES

Much of the TWWHA coast is a high-energy coastal environment. Rocky shores predominate, consisting of cliffs and headlands, with sandy barrier systems (beaches) being the second longest shore type (Sharples 2003).

Cullen (1998) describes the geomorphology of the TWWHA barrier systems. These beaches are the product of a number of factors including geology, topography, shoreline position, the nature and supply of sediment, estuarine influences, the tidal regime and the amount of wind and wave energy. Sediment supply is likely to be low from streams and rivers draining the hinterland with reworked offshore and beach dune systems providing primary sediment source. Wind and wave energy largely determines the sediment transport in these systems.

Beaches can be defined by their morphology as either low energy reflective beaches, moderate energy beaches or high energy dissipative beaches (Cullen 1998). Beach and estuary morphology is dynamic and can respond to storm events or seasonal, short or long-term climatic changes. Erosion by wave action can be important during storm events and erosion by wind action can also occur (Cullen 1998).

It is likely that climate change will lead to a rise in sea-level, increased storm surges, changes in rainfall patterns, and wind characteristics that will impact on the TWWHA coastal geomorphology and processes (Sharples 2006). There is evidence along parts of the coastline that significant erosion and coastal recession is already occurring (eg. exposed paleosols on truncated foredunes). Sharples (2006) suggests a number of geomorphic effects as a result of climate change on coastal Tasmania. These are:

- increased flooding of low lying regions;
- erosion and landward recession of sandy shores;
- increased mobility of sand dunes;
- modification of muddy shores;
- erosion of clayey-gravelly shores;
- increased slumping of weathered bedrock shores;
- accelerated rock fall, and cliff collapse;
- and retreat and rising groundwater tables with the penetration of salt water into groundwater.

Geomorphic characteristics were used to assess the Tasmanian coast for its vulnerability to climate change induced effects. This assessment indicates that a significant proportion of the TWWHA coastline is susceptible to these impacts (Sharples 2006) (figure 1.). There are many complicating factors that place considerable uncertainty on the potential level of coastal retreat in the TWWHA. These are well described in IPCC (2007) that cites models for beach retreat that vary from 50-200 times sea level rise to an order of magnitude greater particularly in the vicinity of estuaries as a result of rising bed levels of bays. Increased frequency and or severity of storms is also considered a major factor in beach erosion rates (IPCC 2007) and changed swell direction may cause rotation of sandy shores.

The predicted changes in climate, sea-level rise and resultant geomorphic processes such as increased erosion, is likely to impact on the coastal floristic values of the TWWHA. Potential impacts due to erosion include both expansion or declines in the distribution of vegetation communities or species, altered species composition and replacement of species or communities by different/new species or communities. The resilience of individual communities and the coastal ecosystem is generally likely to be negatively impacted by climate change (IPCC 2007). Another factor to consider is the response of invasive species to climate change. These species could find the new disturbance conditions advantageous for invasion and expansion of

their populations. It is also possible they may facilitate the regeneration and succession of native vegetation on exposed dune systems (Heyligers 2006).

Some species and communities may also be affected by changes in temperature and rainfall (Hughes 2003) although in the context of the TWWHA this may be realised through changed fire regimes as well as environmental stress.

5 THREATS TO TWWHA COASTAL COMMUNITIES

Vegetation that is unable to withstand increased storm surge, inundation, eroding substrate and salt spray will be most effected by coastal recession, disrupting the current zonation of the coastal vegetation. For example, coastal rainforest is generally found behind shoreline shrubland and scrub communities. These shoreline communities buffer inland communities from salt spray, wind exposure and wave action. If shoreline vegetation is lost due to erosion or changing geomorphology, the coastal rainforest will become more exposed. Unless this community can either withstand the new conditions or retreat to a more protected area, it may diminish in extent or be locally eliminated.

Some vegetation may prefer disturbed environments and these species/communities may persist or even expand. Marsupial lawn, appears to colonise wet sands on the shoreline (eg creek outlets) where the disturbance level is high or adjacent to the leading edge of eroding dunes as the scrub canopy breaks down. This community may continue to persist as long as ecological processes that maintain the community, such as marsupial grazing and water seepage or a high water table, are unaffected. However the extent and demography of marsupial lawns may well be impacted in the short term. For example, the well developed marsupial lawn on the east side of Point Eric has been extensively eroded and is now confined to a much narrower strip under the tree canopy. Similarly, the extensive marsupial lawns surrounding Hannant Inlet are potentially at risk of degradation from progressive inundation.

The rate of coastal recession in vulnerable areas is likely to be site dependent and will dictate the capacity for plant community migration. The most drastic changes could occur quickly as non linear events, such as breaching of coastal sand barriers, substantially altering vegetation community distribution on the coast. Near coastal wetlands in the TWWHA have a low sediment input which limits the ability to lift lagoon base levels in response to rising sea levels. The penetration of sea water into coastal lagoons and estuaries is probable leading to increasing salinity of current brackish or freshwater wetlands.

Beach grasslands may be more prone to contraction as a result of sea level rise on beaches adjacent to a estuary or a large embayment that may act as a sand sink as base levels rise with rising sea level. Vegetation communities on spits such as at Prion Beach include extensive beach grasslands and well developed vegetation zonation may be at greater risk of erosion in response to sea level rise. Vegetation communities backing beaches on the west coast, exposed to the full force of storm surges are already dramatically undercut and eroding in the TWHA and adjacent areas.

The considerable uncertainty in sea level rise predictions (IPCC 2007) have a major bearing on the assessment of sea level and coastal recession related impacts on vegetation. Though the areas that are vulnerable to sea level change impacts have been identified (Sharples 2006), the local geomorphic mapping and modelling of processes is not available to predict the coastline changes to which the vegetation will be exposed. As a consequence only a preliminary assessment of potential risks to vegetation communities is attempted here.

Priority vegetation types occurring in the coastal zone were assessed subjectively for evidence of a capacity to adapt or avoid coastal recession processes and the implications of a significant recession of the coast on the vegetation type (Table 1). It is possible that for the period of sea

level rise there will be substantial loss of coastal sand binding grasslands, coastal rainforest on soft sediments may be lost, marsupial lawns may be reduced in extent and wetland salinity, floristics and distribution change.

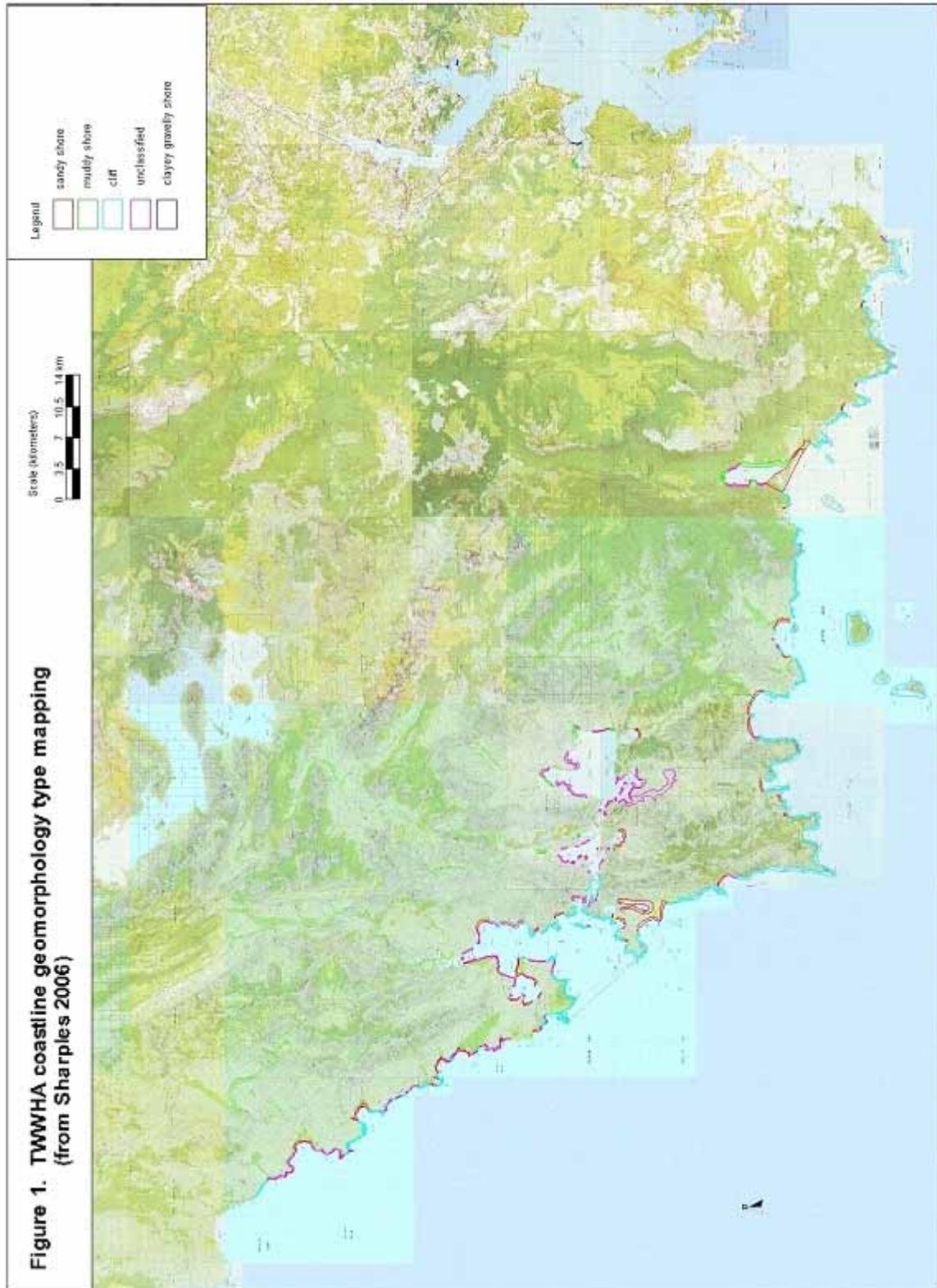


Table 1 Potential impact of coastline change on priority vegetation types in the TWWHA.

Priority Vegetation type	Capacity for adaptation or avoidance	Potential impact in the TWWHA
Short closed herbfield (marsupial lawn)	There is evidence of colonising by herbfield species in episodic eroding and depositional areas. Marsupial lawn formation on eroding dune scarp edges appears to be quite rapid.	Large tracts of mature herbfields are at risk from erosion. They are capable of re-establishing in suitable geomorphic situations but are likely to contract until erosional processes stabilise.
Dwarf littoral cool temperate rainforest	This forest is slow to establish and reach maturity. There are limited suitable environments in adjacent areas into which they may migrate but some sites occur above hard shorelines.	Rainforest in coastal dune situations may be reduced. Rainforest may persist in elevated sheltered headland sites.
Coastal shrubland and heath	These communities are likely to require 5 to 10 years to re-establish and resume a significant role in buffering inland communities from the effects of salt spray and wind exposure. The community is present in other lower risk sites above hard shorelines.	Local reduction in extent these are located behind sandy beaches they are at risk from undercutting and removal as sea levels rise.
Sand binding coastal grasslands	Grasslands are limited to a narrow ecological niche. They are capable of dispersing and establishing quickly but require suitable habitat to do so. Species occur only in this at risk environment	Substantial reduction of the area of sand binding grasslands particularly on more exposed beaches is likely. Only small areas of progradation were identified in Horton et al (2008).
Rookery vegetation	Largely above hard shorelines and at elevation.	There may be some seaward loss of rookery vegetation potentially counteracted by landward extension where the environment allows.
Wetlands	Wetland community migration is expected to be rapid if suitable habitat is available for creation of new wetlands with rising coastal water tables. Some wetlands may change salinity and floristics	Sea level rise and erosion may breach lagoon barriers causing loss of wetlands or conversion from freshwater to saline systems. Geomorphic situation will determine local expansion, contraction or creation of wetlands. Modelling is required to determine impacts.

Another aspect to consider is the compounding influence of other climate change associated impacts. Increased temperature, CO₂ levels and changed fire regimes may also affect floristic values. The absence of fire is known to be important for the development of rainforests, including coastal rainforests. Adverse changes in fire regimes may result in the burning of previously fire protected areas and coastal rainforest may be lost.

The impact of invasive species in eroding coastal environments has not been investigated in this project but weeds such as marram grass and sea spurge could have significant compounding consequences on the persistence of beach grassland communities within the TWWHA (Rudman 2003).

6 THREATENED SPECIES RISK ASSESSMENT

This risk assessment is based on the question; will rapid coastline change adversely affect the populations of threatened species in the TWWHA? It is based on a scenario of sea level rise and an associated long term coastal retreat trend. For example if the rate of coastal erosion is sufficiently high, communities at the forefront of the coastal zonation may be eliminated from a site along with associated threatened species. The uncertainty in the climate change scenarios and lack of local process knowledge affects the ability to undertake a detailed risk assessment at this stage.

A preliminary assessment of risks has been attempted based on observations made to date. Temperature and rainfall changes were not considered due to the small changes currently predicted and uncertainty in direction modelled by McIntosh *et al.* (2005). Sources of risk that were considered were based on the climate change scenario reported in McIntosh *et al.* (2005) and included sea level rise, change in swell direction, increased incidence of storm surges and increased windiness. The areas of impact considered were:

- coastal erosion of soft sediment shoreline leading to loss of foredunes;
- landward progression of lagoons and estuaries;
- lagoons opening up into bays;
- and changed depositional locations on or between beaches.

The species chosen for assessment were threatened species listed under the *TSPA 1995* and known to occur within the coastal zone of the TWWHA and a few restricted distribution endemic species. The risk assessment is based on the assessment matrix presented in Table 2 using the following classes for likelihood and consequence:

Likelihood classes:

Certain Existing data verifying population decline due to coastal erosion pressures.
 Likely Habitat reduction evident and species potentially susceptible to coastal erosion.
 Possible Habitat reduction may occur or species potentially susceptible to coastal erosion.
 Unlikely Habitat will persist.

Consequence classes:

Very high Nationally listed threatened species and moderate to major population exposure.
 High State listed (e or v) and moderate to major population exposure.
 Moderate State listed as r and moderate to major population exposure.
 Low Minor population exposure.

Table 2 Risk assessment matrix.

		Consequence			
		Very high	High	Moderate	Low
Likelihood	Certain	Extreme	Very High	High	Low
	Likely	Very High	High	Moderate	Low
	Possible	High	Moderate	Low	Low
	Unlikely	Low	Low	Low	Very Low

Persoonia muelleri subsp. *angustifolia* was excluded because the principal habitat for this species is not coastal. The coastal records identified by Orchard (1983) as *P. muelleri* subsp. *angustifolia* were described by him as appearing similar to *P. muelleri* subsp. *densifolia* in leaf shape. The endemic species *Persoonia muelleri* subsp. *densifolia*, although not listed, was included because it has a small population that is restricted to the south coast region.

The threatened species assessed to be most at risk is *Veronica novae-hollandiae* (Table 3). *Persoonia muelleri* subsp. *densifolia* is identified as being at moderate risk from climate change impacts (Table 3). The characteristics of these species are that a large proportion of their population is restricted to the littoral environment and/or the TWWHA and they are predicted to have a slow response to migration pressures or are subject to potential loss of large areas of suitable habitat. However a general lack of data on the distribution and dynamics of the populations of these species results in a high level of uncertainty attached to this basic risk assessment. Ultimately the extent and rate of coastal retreat will determine plant population responses. Though there has been recent rapid retreat, particularly on the west coast, the cyclic nature of past coastal erosion and lack of long term data makes long term predictions of rates of retreat difficult.

The extent of *Westringia brevifolia* var. *raleighii* in the TWWHA is uncertain with most records of *Westringia brevifolia* only identified to the species level. The location of the one record is imprecise, further survey is required to reduce the uncertainty of its risk assessment.

Species inhabiting the wetland or estuarine environments are assumed to be capable of rapid dispersal and clear migration paths are available in many circumstances. For example *Ranunculus acaulis* is a common coloniser in wet sites including incipient dunes and eroding foredune edges under scrub. It is likely to cope well with rapid coastal changes.

The potential for interacting impacts from changing temperature or rainfall on threatened plant species can only be assumed at this a stage from consideration of the current distribution of the species. Under the scenario of slightly warmer drier summers in SW Tasmania, those species that occur in warmer and drier regions of the State are demonstrably adaptable (Table 3, column 3). The species restricted to the south west such as *Persoonia muelleri* subsp. *densifolia* may be at further competitive risk under a changing climate. The relative competitive impacts between species resulting from changed CO₂ levels in the atmosphere and corresponding edaphic changes are unknown.

Table 3 TWWHA coastal threatened species risk assessment

Species	TSPA */ endemic	% pop in TWWHA	Extent of TWWHA habitat on coastal soft sediments	Situation	Likelihood	Consequence	Risk
<i>Comesperma defoliatum</i>	r	10-15	Minor. Present on coastal dunes. Primarily occurs inland in buttongrass/heath communities.	Dune habitat has recently reduced due to coastal erosion. Potential for longer term maintenance of erosion pressure with predicted sea level rise.	Likely	Low	Low
<i>Crassula moschata</i>	r, t	10-50	All. Incipient dunes, estuarine margins, poorly drained sands.	This is a vagrant species. The Tasmanian population is actively dispersing. Locally abundant, inhabiting eroding sites and highly dynamic beach environments.	Unlikely	Low to moderate	Low
<i>Deyeuxia densa</i>	r	minor	Minor. Heath, sedgeland and woodland.	Habitat extends inland from the littoral zone providing continuum of habitat. Likely to have adequate dispersal capacity.	Likely	Low	Low
<i>Deyeuxia minor</i>	r	minor	Minor. Limited known distribution	Forest habitat. Occurs on edges of littoral zone in lightly shaded areas.	Possible	Low	Low
<i>Lachnagrostis scabra</i> spp <i>scabra</i>	r	10-50	All. Wet seepage areas eg . back of beaches, herbfields, creek-lines and low fringing scrub	Potential for more populations in creek- line environments. Only a proportion of its population likely to be exposed to coastal climate change pressures and likely to have reasonable dispersal capability.	Possible	Moderate	Low
<i>Lachnagrostis robusta</i>	r	minor	All? Marsh and estuarine habitat Port Davey	Estuarine habitat likely to persist though progressive inland migration with rising sea levels. Some risk of conversion to new bays if spits are eroded.	Unlikely	Moderate	Low
<i>Lepidium flexicaule</i>	r endemic	10-50	Part. Habitat is rock crevices.	Maintenance of much of habitat likely under rising sea levels. Annual with likely reasonable dispersal ability.	Unlikely	Low - moderate	Low
<i>Lepilaena patentifolia</i>	r	10-50	All. The population occurs in near coastal habitat	Coastal lagoons and estuaries. Estuarine habitat likely to persist though potential for loss of some lagoons.	Unlikely	Low - moderate	Low

Species	TSPA ¹ /endemic ²	% pop TWWHA	Extent of TWWHA habitat on coastal soft sediments	Situation	Likelihood	Consequence	Risk
<i>Persoonia muelleri</i> subsp. <i>densifolia</i>	Not listed Restricted endemic	100	Majority? Littoral margin of coastal rainforest, coastal scrub along Sth Coast and Bathurst Harbour. Also in subalpine heath on Mt Council.	Majority of population exposed to coastal recession. Tolerates salt spray well however habitat eroding rapidly on some beaches. Probably relatively low capacity to respond to coastal recession.	Likely-	Moderate	Moderate
<i>Poa poiformis</i> var. <i>ramifer</i>	r	minor	All. Sand dunes and sandy rock crevices.	Dune grassland habitat has recently reduced due to coastal erosion. Potential for longer term reduction in habitat with predicted sea level rise. Matures rapidly, probably readily dispersing.	Likely	Low	Low
<i>Ranunculus acaulis</i>	r, t Restricted endemic	10-50	All. Incipient foredunes, leading edge of eroding dune scarps under coastal scrub	Locally abundant, inhabiting eroding sites and highly dynamic beach environments. Matures rapidly, probably readily dispersing.	Unlikely	Low	Very Low
<i>Veronica novae-hollandiae</i>	v	10-20	Majority. Herbfield, open grassy short shrubland and marsupial lawn from near high-tide to margins of coastal shrubland, on limestone by the Gordon River.	Localised and in low numbers with large proportion of population in areas susceptible to coastal recession.	Likely	High	High
<i>Westringia brevifolia</i> var. <i>raleighii</i>	r Restricted endemic	> 50	Uncertain. Unvouchered record in TWWHA in coastal scrub at South Cape Bay, majority outside TWWHA.	Main populations not at risk from coastal climate change impacts. In the TWWHA the location in relation to the coast is uncertain.	Possible	Moderate	Low

1. *Threatened Species Protection Act 1995* codes Categories: r – rare, v – vulnerable,

2. t - within Australia only occurs in Tasmania but also present outside Australia.

7 RECOMMENDATIONS

7.1 Species and communities recommended for monitoring

Future monitoring should target the broad range of habitats in the coastal zone in an overview to assess the type of habitat shifts that are occurring. Within this, communities of conservation value such as marsupial lawn and coastal rainforest should receive particular attention. These communities are unique, are often only found in small patches and are potentially sensitive to changed geomorphological processes and other climate change impacts. Coastal grasslands on beaches are under considerable pressure already in the TWWHA due to beach erosion and weed invasion, as they are elsewhere in Tasmania, and are a priority for monitoring as an early warning for major erosional or depositional change. Although coastal scrub and shrubland is common along the TWWHA coast, more data to characterise and separate variations of this community would be useful to aid monitoring.

Monitoring of individual species requires considerable resources and should be targeted carefully. The threatened species and restricted endemics considered most at risk from climate change impacts on the coast are:

- the herb *Veronica novae-hollandiae* that occurs rarely in the coastal grasslands, is distinctive but uncommon and inconspicuous;
- the tree *Persoonia muelleri* subsp. *densifolia* that is widely spaced but prominent along the littoral edge of coastal scrub and forest;
- the shrub *Westringia brevifolia* var. *raleighii* requires further survey.

Abundance data for these species is unlikely to be captured within general community level monitoring with sufficient power to estimate a significant change in their populations. Each of these species warrants a separate monitoring strategy since each occupies different habitat, have greatly different visibility and population densities.

7.2 Risk assessments

The dry coastal vegetation risk assessment may be improved development of:

- a model of the physical changes to the coastline in vulnerable areas to predict how habitats will be affected;
- improved demographic information for vegetation types/habitats and priority species in the coastal zone is required at a level of resolution finer than provided by the TASVEG mapping program;
- a higher resolution model of the climate changes predicted for the TWWHA and the modelling of plant and community responses for inclusion in the risk assessment;
- and including common coastal species. Other species not considered as threatened currently, could become so. Species such as *Stackhousia spathulata* occur in small localised populations on the Tasmanian coast. It has been observed in small numbers on vestiges of eroded foredunes on the west coast and may be vulnerable to the combination of coastal recession and weed invasion processes.

7.3 Management outputs

Understanding the natural processes along the TWWHA coastline may help to identify relative differences in the level of threat to landforms and associated vegetation species and communities on the coast. It is possible that areas of refugia may be identified where mitigation actions to enhance and maintain habitat will be important. For example these areas may be a high priority for management of fire or visitors to reduce adverse impacts. Conversely adaptive

management through the assisted translocation of priority species that are at the highest risk to new areas of habitat could be considered. *Ex situ* conservation programs are already in place through programs such as the Joint Tasmanian Millennium Seedbank (Royal Botanical Gardens Kew) and these may be an important component of the management of species most at risk.

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APPENDIX 1

Coastal endemic species

Tasmanian endemic species that occur within the TWWHA and are restricted to coastal habitats (from Balmer *et al* 2004).

Species	Family
<i>Ammobium calyceroides</i>	ASTERACEAE
<i>Ozothamnus bracteolatus</i>	ASTERACEAE
<i>Ozothamnus costatifructus</i>	ASTERACEAE
<i>Ozothamnus reticulatus</i>	ASTERACEAE
<i>Leptecophylla abietina</i>	EPACRIDACEAE
<i>Lepidium flexicaule</i>	BRASSICACEAE
<i>Persoonia muelleri</i> subsp. <i>densifolia</i>	PROTEACEAE
<i>Westringia brevifolia</i> var. <i>brevifolia</i>	LAMIACEAE
<i>Westringia brevifolia</i> var. <i>raleighii</i>	LAMIACEAE
<i>Billardiera longiflora</i> var. <i>ovalis</i>	PITTOSPORACEAE
<i>Prasophyllum concinnum</i>	ORCHIDACEAE
<i>Prasophyllum rostratum</i>	ORCHIDACEAE
<i>Specularantha aphylla</i>	ORCHIDACEAE

APPENDIX 2

Coastal Threatened Species

Plant species known to have at least part of their distribution on the TWWHA coast and listed under the *Tasmanian Threatened Species Protection Act 1995* (from Balmer *et al.* 2004).

Species	Family	Common Name	TSPA	% pop WHA	Endemic
<i>Comesperma defoliatum</i>	POLYGALACEAE	Leafless milkwort	r	10-15	
<i>Crassula moschata</i>	CRASSULACEAE	Musky crassula	r	10-50	t
<i>Deyeuxia densa</i>	POACEAE	Heath bent grass	r	minor	
<i>Deyeuxia minor</i>	POACEAE	Small bent grass	r	minor	
<i>Lachnagrostis scabra</i> subsp. <i>scabra</i>	POACEAE	Even blown grass	r	10-50	
<i>Lachnagrostis robusta</i>	POACEAE	Coast blown grass	r	minor	
<i>Lepidium flexicaule</i>	BRASSICACEAE	Springy peppergrass	r	10-50	t
<i>Lepilaena patentifolia</i>	ZANNICHELLIACEAE	Spreading water mat	r	10-50	
<i>Persoonia muelleri</i> subsp. <i>angustifolia</i>	PROTEACEAE	Narrow leaf geebung	r	10-50	endemic
<i>Poa poiformis</i> var. <i>ramifer</i>	POACEAE	Island purple grass	r	minor	
<i>Ranunculus acaulis</i>	RANNUNCULACEAE	Dune buttercup	r	10-50	t
<i>Veronica novae-hollandiae</i>	SCROPHULARIACEAE	New Holland speedwell	v	minor	
<i>Westringia brevifolia</i> var. <i>raleighii</i>	LAMIACEAE	Greater shortleaf westringia	r	> 50%	endemic

t – endemic to Tasmania within Australia, also present elsewhere in the world



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