A REVIEW OF THE FLORISTIC VALUES OF THE

TASMANIAN WILDERNESS WORLD HERITAGE AREA

wilderness

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J. Balmer, J. Whinam, J. Kelman, J.B. Kirkpatrick and E. Lazarus

DEPARTMENT OF PRIMARY INDUSTRIES, WATER AND ENVIRONMENT

Tasmania

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J. Balmer, J. Whinam, J. Kelman, J.B. Kirkpatrick & E. Lazarus

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Front Cover Photograph: Alpine bolster heath (1050 metres) at Mt Anne. Stunted *Nothofagus cunninghamii* is shrouded in mist with *Richea pandanifolia* scattered throughout and *Astelia alpina* in the foreground.
Photograph taken by Grant Dixon

Back Cover Photograph: *Nothofagus gunnii* leaf with fossil imprint in deposits dating from 35-40 million years ago:
Photograph taken by Greg Jordan

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1. Definitions

Acronyms

ACT	Australian Capital Territory
BP	Before present (years)
BCNAA	Bibliographic Checklist of Non-marine Algae in Australia (Day et al. 1995).
CBD	Convention on Biological Diversity
Ck	creek
DASETT	Department of the Arts, Sport, the Environment, Tourism and Territories
DEH	Department of the Environment and Heritage
DIWA	Directory of Important Wetlands in Australia (Environment Australia 2001)
DPIWE	Department of Primary Industries, Water and Environment
EA	Environment Australia
EPBC Act 1999	[Australian] Environment and Protection and Biodiversity Conservation Act 1999
GBMWHA	Greater Blue Mountain World Heritage Area
ha	hectares
HEC	Hydro-Electric Commission
IUCN	The World Conservation Union [previously known as the International Union for the Conservation of Nature]
ka	thousand years ago
km	kilometres
m	metres
Ma	million years ago
NPWS	National Parks and Wildlife Service
NSW	New South Wales
Rd	road
RFA	[Tasmanian] Regional Forest Agreement [1997]
RPDC	Resource Planning and Development Commission [Act 1997]
TPLUC	Tasmania Public Land Use Commission
TSP Act 1995	[Tasmanian] Threatened Species Protection Act 1995
TWWHA	Tasmanian Wilderness World Heritage Area
UNESCO	United Nations Educational, Scientific and Cultural Organization

Glossary

alpine vegetation: usually taken to be that found above the climatic treeline (see treeline).

anaerobic: pertaining to life or biological processes that occur in the absence of oxygen.

aquatic herbfields: areas dominated by aquatic herbaceous plants (see forb and herbfield).

biodiversity: defined by the Convention on Biological Diversity (CBD) as 'the variability among living organisms from which all sources including inter alia, terrestrial, marine and other aquatic ecosystems and the complexes of which they are part; this includes diversity within species, between species and of ecosystems themselves'.

biome: a large ecological region characterised by similar vegetation and climate (such as the deserts, tundra, etc.) and including all living organisms in it.

biotic: pertaining to life or living organisms.

bog: a low nutrient, acid peatland.

bolster heath/cushion plant: woody or herbaceous plant with many closely packed, erect stems forming a raised mat above ground level.

buttongrass moorland: communities dominated by *Gymnoschoenus sphaerocephalus* and/or other sedges, found in perhumid oligotrophic environments from lowland to subalpine regions.

caespitose: growing in dense clumps or tufts.

chemocline: often a vertical gradient of changing chemical composition within a body of water from anoxic salt water at the bottom to oxygenated fresh water at the surface associated with other biotic changes.

chrysophyceae: the yellow-green algae having flagella of unequal length.

cirque: a deep, steep-walled half bowl-like hollow on the side of a mountain caused by glacial erosion.

climax vegetation : is vegetation that has reached equilibrium with the environment and does not require disturbance to regenerate. It is the culmination of a series of successional changes in plant community development over time (see succession).

colloids: very small, finely divided solids (particles that do not dissolve) that remain dispersed in a liquid for a long time because of their small size and electrical charge.

conifer/Gymnospermae: plants that predate flowering plants in evolution; plants having naked seeds not enclosed in an ovary (cones).

crepuscular: active primarily in dim light, around the hours of dawn and dusk.

desmids: tiny, free-floating, photosynthetic organisms in aquatic systems (see phytoplankton).

dinoflagellates: a unicellular microscopic plankton characterised by two flagella. They are divided into two groups: 'naked' with a thin cell wall and 'armoured' with a theca made of thick plates. Some species are toxic.

disjunct: separated or disjoined populations of organisms. Populations are said to be disjunct when they are geographically isolated from their main range.

dolerite: a medium grained intrusive igneous rock that has the same chemical and mineralogical composition as extrusive basalt and plutonic gabbro.

dystrophic: water that is low in nutrients and highly coloured with dissolved humic organic material.

edaphic: all soil factors affecting plant growth including pH, hydrology, nutrients etc.

endemism: the restriction of a taxon to an area to which it is exclusive, so that it is not found outside the bounds of that region. In the context of this report, unless otherwise prefaced, an endemic is a species restricted to the state of Tasmania (excluding Macquarie Island).

eucalypt: when used in the wider Australian context is a general term that includes several genera closely related to the genus *Eucalyptus* e.g. *Angophora*.

eutrophic: high primary productivity waters that are rich in plant nutrients (nitrates and phosphates).

exotic species: a plant or animal species that is not native to a geographic area or ecosystem. Because of the lack of natural pests once they are placed in a new location, many exotics reproduce prolifically and can invade native species habitats.

fen: peat ecosystems where water and nutrients inflow from the surrounding catchment.

fibric peat: poorly decomposed peat (having more than two-thirds fibre by volume) with large amounts of well-preserved fibre that is readily identifiable.

fjaeldmark: high altitude plant community containing few scattered ground-hugging or prostrate plants that grow on bare stony ground in places of extreme wind exposure.

forb: a dicotyledonous plant with a soft stem, rather than a permanent woody stem, that is not grass or grass-like.

Geological timescale: see table 2.2.

geomorphic: pertaining to those processes that affect the form or shape of the surface of the earth.

Gondwana: the ancient super continent comprising Antarctica, Australia, New Zealand, India, South America and South Africa.

graminoids: grass-like flowering plants.

green window lakes: a lake with clear fresh-water, which allows light to penetrate in the green spectrum.

herbfields: vegetation which is dominated by herbaceous (non-woody) plant species. These communities can be found in lowland to alpine areas and often comprise succulent, sedge and wetland species.

humic: highly decomposed organic material with a large organic carbon content.

humified: organic material converted to humus.

hydrology: the study of the waters of the earth, especially with relation to the effects of precipitation and evaporation upon the occurrence and character of water in streams, lakes, on or below the land surface.

karst: a type of topography that results from dissolution and collapse of carbonate rocks such as limestone and dolomite and characterised by closed depressions or sinkholes, caves, and underground drainage.

lentic wetlands: still water bodies such as lagoons, lakes and pools together with the vegetation associated with the margins of these water bodies (Kirkpatrick & Harris 1999).

limnology: the study of the physical, chemical, meteorological and biological aspects of fresh water.

listed species: species on the schedules of the Tasmanian *Threatened Species Protection Act 1995* and/or the Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999*.

lotic wetlands: flowing water systems such as streams and rivers together with the riparian vegetation associated with these waters (Kirkpatrick & Harris 1999).

macrophyte: large aquatic plants.

marsupial lawn: closely cropped herbs, grasses and graminoids grazed by marsupials.

mature forest: for the purposes of this report is forest that is more than about 110 years in age.

meromictic: lakes that are permanently stratified due to the periodic penetration of estuarine waters.

meromixis: the process of stratification (see meromictic)

mixed forest: for the purposes of this report refers to eucalypt dominated forest with a rainforest understorey (Gilbert 1959).

mono-typic: a genus or a family containing a single species.

montane: a high elevation region occurring below the subalpine area. In Tasmania this is generally between 600–800 metres.

Natural Heritage: In accordance with Article 2 of the [World Heritage Area] Convention, the following is considered as 'natural heritage':

-'natural features consisting of physical and biological formations or groups of such formations, which are of outstanding universal value from the aesthetic or scientific point of view;

-geological and physiographical formations and precisely delineated areas which constitute the habitat of threatened species of animals and plants of outstanding universal value from the point of view of science or conservation;

-natural sites or precisely delineated natural areas of outstanding universal value from the point of view of science, conservation or natural beauty.'

niche: the place of an organism within its environment and community (affecting its survival as a species).

non-vascular: organisms without a system for transporting water and nutrients (algae, lichens, fungi, mosses).

obligate: restricted to a particular condition of life, as an obligate seeder, a plant that can only reproduce by seed.

old-growth: ecologically mature forest where the effects of disturbances are negligible.

oligotrophic: a body of water low in nutrients and in productivity.

ombrotrophic: a terrestrial or wetland area in which the only significant source of nutrients is from the rain, a characteristic of acid bogs.

oxidation: the chemical process of oxygen combining with an element or compound (e.g. the oxidation of iron to form rust). Oxidation is part of the process by which many organisms derive energy from their food.

palaeoecological: the ecology of geologically ancient ecosystems.

pathogen: a disease-causing organism.

peatland: an area dominated by soils that have an organic content of more than 30%, usually forming in poorly drained areas.

perhumid: pertaining to moist, temperate environments.

permafrost: a layer of soil at varying depths below the surface in which the temperature has remained below freezing continuously from a few to several thousand years.

phytoflagellates: photosynthetic free-living protozoan with whip-like appendages that enable mobility.

phytoplankton: tiny, free-floating, photosynthetic organisms in aquatic systems. They include diatoms, desmids and dinoflagellates.

plankton: tiny, free-floating plant (phytoplankton) and animal (zooplankton) organisms that are found in aquatic ecosystems.

pyrogenic: very flammable, fire promoting.

red window lakes: a lake with brown, tannin-stained water, which precludes light of the red spectrum.

RFA: unless otherwise stated refers to the Tasmanian State and Commonwealth Government Regional Forest Agreement that was signed on 8 October 1997.

rhizomatous: producing, possessing or resembling rhizomes.

rhizomes: a root-like stem which is prostrate, grows partly or wholly underground, and can root from the stem nodes. Sometimes called 'rootstock'.

ria: a river valley flooded by the sea.

riparian: pertaining to rivers, or dwelling on the bank of a river or other body of water.

sapric muck peat: highly decomposed peat, having less than one-sixth by volume of organic soil material as recognisable plant tissue.

scleromorphic: hard, with a large amount of fibrous material.

sclerophyll/scleromorphic: a Greek word meaning 'hard-leaved' (sclero = hard; phyllon = leaf) (Hale et al. 1995). This term is applied to plants that have developed hard, thick, small or leathery leaves with a thick cuticle, sunken stomata and low transpiration rates.

scrub: is defined by Specht (1970) as vegetation between 2 and 8 m tall with a projective foliage cover of more than 30%.

sedge: for the purposes of this report refers to plants of the family Cyperaceae, which often grow in wet places. Examples include *Carex* sp.

sedgeland: vegetation dominated by plants in the families Cyperaceae, Restionaceae or other hard leaved graminoids.

short herbfield: herbfield dominated by graminoid or herbaceous species shorter than 4 cm in height (Kirkpatrick 1997); short alpine herbfields occur within the alpine zone.

sinkhole: a depression in a karst area, commonly with a circular pattern. The drainage is subterranean and sinkholes are commonly funnel shaped.

species richness: the number of species occurring within a given area.

***Sphagnum* peatland:** an area greater than 1000 m^2, where *Sphagnum* moss covers no less than 30% of the peatland.

string ponds: string bogs or staircase ponds are pools of water formed within dams of vegetation and peat, in a sequence up a gentle slope.

subspecies: a grouping of organisms that differ from other members of their species by colour, size or various morphological features.

succession: the gradual and orderly process of change in an ecosystem brought about by the progressive replacement of one community by another until a stable climax is established.

swamp: a type of wetland that is dominated by woody vegetation and that does not accumulate appreciable peat deposits. Swamps may be freshwater or saltwater, tidal or nontidal.

tall herbfield: herbfield dominated by graminoid or herbaceous species taller than 4 cm in height. Tall alpine herbfields occur within the alpine zone and include alpine sedgelands (Kirkpatrick 1997).

tall forest: dominated by trees greater than 30 m in height (Specht 1970). Note that mapped areas of tall forest in Tasmania are those greater than 35 m in height (Hickey 1987).

taxa: the plural of taxon (see taxon).

taxon: a classification category for a group of organisms.

tree height classes: Davies (1988) – Forestry Tasmania mapping height classes.

tall >34 m

very tall >41 m

immensely tall >55 m

treeline: the upper slope treeline, or climatic treeline, is the point at which trees are unable to grow because the mean summer temperature is too low to support tree growth. A bottom slope treeline, or **inverted treeline,** is where trees are absent from the valley bottom because of frost, waterlogging or environmental factors other than mean summer temperature.

tussock: a large clump or tuft, usually of a perennial herb, especially grasses.

Tyler's line: the approximately east–west boundary line adopted to define the division of rotifer communities across Tasmania that partitions Tasmania into two zones differing significantly in a range of factors including water chemistry, rainfall and geology (Shiel et al. 1989).

vascular plant: any plant with a system for transporting water and nutrients (seed plants, ferns and fern allies).

very tall trees: greater than 50 m (Ashton 1987). When referring to mapped areas of very tall forest in Tasmania, the forest is greater than 41 m (Hickey 1987).

wet sclerophyll: vegetation dominated by *Eucalyptus* with an understorey characterised by a dense layer of mesophytic (broad-leaved) shrubs (Beadle & Costin 1952). It is a term often used instead of tall-open forest to avoid the confusion arising from height classes.

wetland marginal herbfields: short or tall herbfields on the margins of water bodies such as rivers or lakes.

wetlands: areas of shallow water that are usually flooded for at least part of the year and contain aquatic herbs, sedges and/or rushes. Wetlands may be natural or artificial, permanent or temporary, static or flowing, and can be fresh, brackish or salty.

woodland: tree dominated vegetation in which the canopy layer has a projective foliage cover of between 10 and 30% (Specht 1970).

Table 1.1: Geological timetable

(source: Haq and Van Eysinga 1994)

Era	Period	Epoch	Ma
Cenozoic 0–66 Ma	Quaternary 0–1.7 Ma	Holocene	0–0.1
		Pleistocene	0.1–1.7
	Tertiary 1.7–66 Ma	Pliocene	1.7–5.3
		Miocene	5.3–24
		Oligocene	24–36
		Eocene	36–55
		Palaeocene	55–66
Mesozoic 66–250 Ma	Cretaceous 66–140 Ma	Late Cretaceous	66–97.5
		(Campanian	71.5–83)
		Early Cretaceous	97.5–140
	Jurassic 140–210 Ma	Late Jurassic	140–160
		Middle Jurassic	160–184
		Early Jurassic	184–210
	Triassic 210–250 Ma	Late Triassic	210–230
		Middle Triassic	230–243
		Early Triassic	243–250
Palaeozoic 250–590 Ma	Permian 250–290 Ma	Late Permian	250–270
		Early Permian	270–290
	Carboniferous		290–360
	Devonian		360–410
	Silurian		410–440
	Ordovician		440–500
	Cambrian		500–590
Cryptozoic	Precambrian		>590 Ma

2. Introduction

The Tasmanian Wilderness World Heritage Area (TWWHA) is located within the Australasian biotic realm, one of the world's eight realms (Udvardy 1975). Both Australia and New Zealand are well known for their rich and distinctive flora, a feature resulting in part from their isolation from other continental landmasses. Tasmania is one of Australia's hotspots of botanical diversity and endemism at the large regional scale (Crisp et al. 2001). Throughout recent geological history Tasmania has been an occasional island off southeastern Australia and lies at the latitude 42° south, directly in the path of the roaring forties. Tasmania's southerly position, variable topography and soil fertility have given rise to its highly diverse and significant vegetation (Jackson 1965, Jackson 1999a). There is a strong gradient in precipitation and soil fertility from the southwest to the northeast of Tasmania. In the west, soils are poor and rainfall reaches in excess of 4000 mm per annum. In the east rainfall may be less than 400 mm per annum and the soils are often more fertile.

The TWWHA is located in southwest and central Tasmania and was first inscribed on the UNESCO World Heritage list in 1982 (Tasmanian Government and the Australian Heritage Commission 1981). In 1989 an expanded area of 1.38 million ha was successfully nominated (DASETT 1989) (Fig. 3.1). To qualify for World Heritage listing it is necessary that the nominated site meets one of a number of either natural or cultural criteria and satisfies various conditions of integrity. The World Heritage convention is only for sites that are deemed to be of outstanding universal value. Although the most recent changes to the natural diversity criteria has given representativeness more importance, representativeness is still not a criterion in itself. Thus, while the TWWHA comprises more than 20% of the Australasian biogeographical province 'Tasmania' (Udvardy 1975) this in itself is not sufficient for qualification as World Heritage. It is the outstanding values present within the TWWHA that have led to its listing, and it is these qualities that are the subject of this report.

The TWWHA is unusual among World Heritage sites in being able to satisfy both natural and cultural criteria. Its value resides within, and is protected by, its essentially wilderness nature where the direct impacts of western industrial and agricultural practices are restricted to a few isolated locations on its borders. The extensive glacial landscape and various karst features throughout the region provide values meeting the first of the natural criteria (detailed in Sharples 2003). The TWWHA is a showcase of natural on-going ecological and biological processes, best displayed by the presence of all stages of vegetation succession that meet the second of the natural criteria. The third criterion is met by the presence of magnificent natural scenery and superlative natural phenomena exemplified by the world's tallest flowering forests. The TWWHA contains significant areas of natural habitat renowned for their plant diversity, species of ancient origins, high degree of endemism and the presence of many species of natural rarity. These qualities enable it to meet the fourth natural criterion.

The fauna values of the TWWHA are detailed in Driessen and Mallick (2003) and Mallick and Driessen (in press). An impressive assembly of Aboriginal sites that includes Pleistocene cave art has justified acceptance as World Heritage against cultural criteria (DASETT 1989).

The 1999 TWWHA Management Plan identified the need to review the values of the region to confirm previously nominated World Heritage values and to identify new values. The nomination document is regularly referred to in the process of assessing the impact of proposed developments within and adjacent to the TWWHA. A document detailing the current values and threats is an essential management tool for the region. Since the production of the 1989 nomination document for the TWWHA, scientific knowledge has increased and there have been changes to the criteria against which significance is assessed. Twenty-one areas adjacent to the TWWHA have been added to the reserve network and are currently under consideration for inclusion in the TWWHA. These are currently managed under the 1999 TWWHA Management Plan.

The documentation of significant floristic values and themes here has largely been restricted to those found that meet the World Heritage listing criteria or those recognised as nationally important. A report is still required to catalogue the floristic resources of this important region and to describe the flora values of state and regional significance. This document would highlight the broad themes and identify superlative features of the Tasmanian flora.

In examining the question of whether significant flora values represented within the TWWHA meet the required conditions of integrity for World Heritage listing, other Tasmanian areas with these significant values are documented and compared. Threats to the condition and integrity of flora values within the TWWHA are also discussed if they are of critical management concern.

The flora values of the TWWHA are described for each of the region's main ecosystems since many of the nationally and internationally important themes fit relatively well within these headings. Six broad ecosystem groups are recognised: rainforest; sclerophyll communities (forest, woodland and scrub); alpine and subalpine treeless vegetation; buttongrass moorland; coastal communities; and wetland communities. All of these floristic associations have unique features and values of both national and international significance, which highlight the unusual and outstanding nature of the TWWHA vegetation. Separate sections on the biogeographical origins of the TWWHA flora and its floristic diversity have been added because these topics cross ecosystem boundaries and are issues of such underlying importance to the World Heritage Area listing criteria.

The references for this report are included together with an extensive bibliography of the literature relevant to the TWWHA flora. A table listing the floristic values under each of the IUCN natural criteria is placed at the end of the document.

To assist the reader and to avoid repetition, the current World Heritage criteria are provided on a book mark attached to this report. They are reproduced below in full, together with a summary of the conditions of integrity that must be met for the region to qualify as World Heritage.

Figure 2.1: Map of the Tasmanian Wilderness World Heritage Area.

Natural Heritage Criteria and Conditions of Integrity

44. a. A natural heritage property … which is submitted for inclusion in the World Heritage List will be considered to be of outstanding universal value for the purposes of the Convention when the Committee finds that it meets one or more of the following criteria and fulfils the conditions of integrity set out below. Sites nominated should therefore:

(i) be outstanding examples representing major stages of earth's history, including the record of life, significant on-going geological processes in the development of landforms, or significant geomorphic or physiographic features; or

(ii) be outstanding examples representing significant on-going ecological and biological processes in the evolution and development of terrestrial, fresh water, coastal and marine ecosystems and communities of plants and animals; or

(iii) contain superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance; or

(iv) contain the most important and significant natural habitats for in-situ conservation of biological diversity, including those containing threatened species of outstanding universal value from the point of view of science or conservation;

(v) AND

(vi) **b.** also fulfil the following conditions of integrity:

(vii) The sites described in 44(a)(i) should contain all or most of the key interrelated and interdependent elements in their natural relationships; …

(viii) The sites described in 44(a)(ii) should have sufficient size and contain the necessary elements to demonstrate the key aspects of processes that are essential for the long-term conservation of the ecosystems and the biological diversity they contain; …

(ix) The sites described in 44(a)(iii) should be of outstanding aesthetic value and include areas that are essential for maintaining the beauty of the site; …

(x) The sites described in paragraph 44(a)(iv) should contain habitats for maintaining the most diverse fauna and flora characteristic of the biog[eog]raphic province and ecosystems under consideration; …

(xi) … sites should … have a management plan

(xii) … sites should have adequate long-term legislative, regulatory, institutional or traditional protection. The boundaries of that site should reflect the spatial requirements of habitats, species, processes or phenomena that provide the basis for its nomination for inscription on the World Heritage List. The boundaries should include sufficient areas immediately adjacent to the area of outstanding universal value in order to protect the site's heritage values from direct effects of human encroachment and impacts of resource use outside of the nominated area. …

(xiii) … should be the most important sites for the conservation of biological diversity. … Only those sites which are the most biologically diverse are likely to meet criterion (iv) of paragraph 44(a).

(xiv) SOURCE: 'Operational Guidelines' for the Implementation of the World Heritage Convention. D. Criteria for the inclusion of natural properties in the World Heritage List paragraph nos 43–45 (UNESCO 2002).

3. Primitive Flora and Refugia

The TWWHA contains many relict and ancient taxa including Tasmanian endemics, many with population strongholds in the TWWHA. This primitive flora contributes to the areas listing under natural criterion (iv). The DNA of some primitive plant species of the TWWHA provide evidence for the evolution of plants and are consequently of international significance. Fossils form an important sub-theme of national and global importance (TPUCK 1997). The most significant pollen site identified in the TWWHA is that of the Darwin Crater, which is of international significance because it is the longest continuous pollen record in Australia (Sharples 2003). The most significant Cainozoic macrofossil sites in the TWWHA are Coal Head, Macquarie Harbour (Rowell et al. 2001) and the Mersey/Cathedral site, both of which are of national significance.

The montane rainforests and coniferous heaths of the TWWHA are internationally significant because of their richness in primitive taxa and affinity to the ancient flora of Gondwana. Genera of national or international significance for their primitive values, with some of their best populations within the TWWHA, include: *Agastachys, Archeria, Athrotaxis, Bellendena, Campynema, Dicksonia, Eucryphia, Lagarostrobos, Lomatia, Microcachrys, Microstrobos, Nothofagus, Orites, Phyllocladus, Podocarpus, Prionotes, Telopea* and *Tetracarpaea* (see Table 3.1).

The conifers in the TWWHA provide a nationally significant dendrochronological record, important for Holocene climatic reconstructions in the southern hemisphere (Cook et al. 2000). They are also nationally important as examples of species of extreme longevity exhibiting evolutionary stasis.

Background

This section identifies primitive taxa of significance, important fossil sites and significant plant refugia. Macrofossils and primitive taxa assist in the study of evolution and give insights into the origin of species. They also provide useful information about the climates in which the extant flora evolved, and may assist with predictions of plant responses to current climate change (Read and Hill 1989, Arroyo et al. 1996). Tasmania has some of the best records of the Early Tertiary period in the world (Jordan and Hill 1998). The break of Tasmania and Australia from Antarctica/South America was complete by the middle Eocene. Only a few fossil deposits in Tasmania predate this time. Fossil plants present in late Eocene and early Oligocene rocks are more abundant. Plant genera with representatives in this fossil flora may well have had a Gondwanan origin and are certainly of importance as primitive taxa demonstrating the nature of evolution. It must be emphasised that the flora species present in Tasmania's modern flora are not the same as those present more than 60 million years ago.

Most plants have undergone considerable evolutionary change, but some retain traits that link them to the genera and families that were present in Tasmanian vegetation and elsewhere in ancient times.

Justification

The Australian theme 'origin and development of biota and landforms as a result of Gondwana plate tectonics and more recent stability and long isolation' is of world significance. It has three sub-themes relevant to the TWWHA flora and fossil flora (TPLUC 1997a). These are 'fossils', 'refugia & relicts', and 'rainforest'. Past nomination documents have identified elements of the Tasmanian flora that have significance on the basis of representing stages in the earth's evolutionary history (DASETT 1989).

For example, the coniferous genera of *Athrotaxis, Lagarostrobos* and *Microcachrys* are identified as possessing links to Gondwana, providing living examples of ancient vegetation types.

The disjunct distributions of primitive flora are also considered to be of global significance as evidence in support of the theory of continental drift.

Macrofossil sites

The palaeobotanical macrofossil is particularly important in the determination of the possible origins and evolution of flora. The presence of Cainozoic sediments containing macrofossils also provides a rare opportunity to compare the past *in situ* vegetation with the present.

The TPLUC (1997) advised that the best expression of fossils in Australia is the fossil mammal sites at Riversleigh and Naracoorte. Jordon and Hill (1998) reported that several Cenozoic fossil plant sites of international significance exist outside the boundaries of the TWWHA, several in close proximity. Although no international significance is attached to macrofossil sites within the TWWHA, two sites of national significance (Coal Head and Mersey/Cathedral) are present.

The Coal Head site at Macquarie Harbour has been dated up to 88 +/- 12 ka. It is one of only two sites in the southern hemisphere containing Pleistocene fossil forests that predate the last glacial episode, and is of national significance (Rowell et al. 2001). The other site of national significance is the Mersey/Cathedral site, which is a Late–Middle Pleistocene site with well preserved macrofossils of conifers and other species that suggest colder climates than now (Jordan and Hill 1998). Relatively few sites of this age exist in Australia.

The type locality for the extinct *Banksia kingii* is adjacent to the TWWHA at Melaleuca Inlet and has been destroyed by mining. *Banksia kingii* is the most recent known extinction of a plant species in Australia (apart from post-European extinctions) and is one of only two tree extinctions recorded in the late Pleistocene in the world (Jordan and Hill 1998). This is also the site where the fossil leaf of *Lomatia tasmanica* has been found. The fossil contributes evidence for the age of the oldest known plant clone (Jordan et al. 1991, Lynch et al. 1998).

Microfossil sites

Nationally and globally significant microfossil (pollen) sites exist in Tasmania (TPLUC 1997a). Lake sediments are well represented within the TWWHA, although most alpine lake sites only provide records of the Holocene.

The most significant microfossil site in Tasmania is the Darwin Crater (Colhoun & Van de Geer 1988, Colhoun & Van de Geer 1998). The Darwin Crater provides significant fine-scaled information about the late Pleistocene and Holocene in Tasmania (documenting the last five glacial cycles) and is the longest continuous pollen record in Australia (Heusser & Van der Geer 1994, Colhoun & Van de Geer 1998, E. Colhoun pers. comm. Oct 2003). It provides data for interpreting the arrival of early people in the region as well as the glacial history of Tasmania (Jackson 1999b). International significance is justified on the basis of these attributes. Another Australian site of comparable significance is Lake George (ACT). It also includes a pollen record that demonstrates a major shift in vegetation from fire sensitive to fire adapted Acacia communities coinciding with an increase in charcoal levels (Singh and Geissler 1985). This site provides information on vegetation changes over the last three to four glacial cycles but, unlike the Darwin Crater, is not continuous and is not as precisely dated.

The Chatham Rise provides a comparable pollen core in its continuity and age. It contains evidence of four glacial cycles and the associated changes in the New Zealand Pleistocene flora (Huesser & Van de Geer 1994) but it is from a marine site and therefore does not contain as good a record of land plants. No terrestrial sites of such continuity and length from New Zealand, southern Chile or South Africa have been located.

Primitive taxa

The genera listed in Table 3.1 include taxa of global and national conservation significance because of their evolutionary links with taxa that formed the vegetation of the ancient super continent Gondwana. The TWWHA is a stronghold for many of these taxa. The primitive floras of both South America and New Zealand also contribute to the understanding of the earth's evolutionary history, and share many plant families and some genera with Tasmania and other areas of Australia.

Podocarpaceae is a very ancient southern hemisphere gymnosperm family which dominated Gondwana during the Mesozoic period nearly 200 million years ago. Western Tasmania is one of the most significant regions for this family, with five genera, two of which are found nowhere else in the world. A distinct Southern Gondwanan flora dominated by *Nothofagus,* araucarian and podocarp trees was present by the late Cretaceous period and has modern analogues.

Some of New Zealand's rainforests have the closest affinities with this ancient association, the best examples occurring in the Te Wahipounamu (southwest New Zealand WHA) where 14 podocarp species, including 10 trees, remain extant (IUCN 1990, Pole 1993). Chile has five podocarp species in four genera represented in its flora. Three commonly occur with *Nothofagus* (*Podocarpus*, *Prumnopitys* and *Saxegothaea*) while the fourth, *Fitzroya*, dominates upland habitats but is now rare.

Podocarp-dominated communities in Tasmania today include the riparian rainforests dominated by Huon pine (*Lagarostrobos franklinii*), the thamnic and implicate rainforests rich in celery top pine (*Phyllocladus aspleniifolius*) and the montane coniferous heaths (*Microcachrys tetragona*, *Microstrobos niphophilus*, and *Podocarpus lawrencei*).

Podocarp-dominated vegetation is extremely rare on the Australian mainland. While Podocarps do remain in South Africa, the genus *Nothofagus* has become extinct. There is strong DNA evidence of the extreme antiquity of some genera that are endemic to Tasmania and are best represented in the TWWHA. The two species of *Athrotaxis* are the only living members of the tribe Athrotaxeae in Cupressaceae that diverged before the *Sequoia* group of genera (Gadek et al. 2000). Because there are Jurassic fossils of the latter group of conifers, the genus *Athrotaxis* is at least 150 million years old. Given that the other basal groups of Cupressaceae are all in the northern hemisphere, it is possible that *Athrotaxis* represents a Pangean relict. It is one of the best candidates for this status in the southern hemisphere.

Bellendena montana is the basal member of the major southern hemisphere family, Proteaceae (Hoot and Douglas 1998). That is, this species is the only surviving member of the taxa that first diverged from the rest of the Proteaceae. This event happened by the Early Cretaceous (at least 80 million years ago). The Proteaceae genera *Agastachys* (monospecific genus endemic to Tasmania) and *Symphionema* (restricted to the Blue Mountains, NSW) are the basal group for the subfamily Proteoideae (Hoot & Douglas 1998, Barker et al. 2002). The Proteoideae include all but one of South Africa's rich Proteaceae, as well as those of New Caledonia, Madagascan and many Australian species. This implies that *Agastachys* and *Sympionema* diverged before the split between South African and Australian Proteaceae.

The Tasmanian endemic, *Tetracarpaea tasmanica*, is the only living member of the family Tetracarpaeaceae (although it is sometimes placed in Escalloniaceae). This family is more basal than the family Haloragaceae, which has fossils extending back to the Paleocene, implying that *Tetracarpaea* is at least as old (Savolainen et al. 2000).

The nearest relative of the Tasmanian endemic monospecific genus *Prionotes* is the Chilean genus *Lebetanthus* (the only member of Epacridaceae in South America). These two taxa are the basal group of the southern hemisphere family, Epacridaceae (Crayn et al. 1998). *Archeria* (now restricted to central and western Tasmania and New Zealand rainforest) is the second basal group in this family (Crayn et al. 1998). The wood structure of *Archeria* provides further evidence for this genus being primitive (Lens et al. 2003).

The genus *Campynema* is the earliest member of the monocot order, Liliales, diverging about 81 million years ago (Chase et al. 1995a, Bremer 2000, Rudall et al. 2000, Peterson & Givnish 2002). The only species of this genus, *Campynema lineare,* is now endemic to Tasmania and has its stronghold within the TWWHA.

The Chilean rainforests possess a rich flora including many primitive taxa (Arroyo et al. 1996). Of particular note is the presence of ancient genera with no extant relatives in Tasmania, including *Gormotega* and *Trochodendron*. Some Chilean species possess traits that show a resemblance to ancestral Tasmania flora.

For example, the fossil Cunoniaceae flora of Tasmania include many with compound leaves and serrate margins – features still displayed in some extant species of Chile and rarely in those of Tasmania (Barnes & Jordan 2000, Barnes & Rozefelds 2000, Barnes et al. 2001). Although *Eucryphia* is of ancient lineage, the other two Cunoniaceae genera in Tasmania, *Anodopetalum* and *Bauera,* evolved in the Pleistocene (Barnes et al. 2001).

The Tasmanian ferns include representatives of a number of ancient families and genera (table 3.1). Osmundaceae is the basal family representing a transition between eusporangiate and leptosporangiate ferns (Armstrong undated). The family dates as far back as the Devonian. Fossils of the family dating back to the early Cretaceous have been found in Victoria (Martin 1994). This family is now only represented by about 20 extant species in the world including the primitive tree fern, *Todea barbara,* which occurs in New Zealand and Australia (Garrett 1996).

Tasmanian woody genera, with disjunct southern hemisphere distributions suggesting ancient origins, include *Aristotelia*, *Discaria*, *Eucryphia**, *Gaultheria*, *Gunnera*, *Lagarostrobos**, *Lomatia**, *Muehlenbeckia*, *Nothofagus**, *Phyllocladus**, *Podocarpus** and *Pseudopanax* (*indicates genera with early fossil evidence within Tasmania). Long distance dispersal may also explain these distributions.

Genera with their closest taxonomic affinities to South American genera include *Prionotes* (closely related to *Lebetanthus*) and *Tasmannia* (closely related to the genus *Drimys*). Tasmania's one member of the ancient plant family Monimiaceae (order Laurales) is *Atherosperma moschatum*. *Atherosperma* is a mono-specific genus of southeastern Australia with a population stronghold in the TWWHA. It is of considerable scientific interest, as it has been thought to represent an evolutionary stage in the development of flowering plants, and is related to the New Caledonian species *Nemuaron* and the Chilean genus *Laureliopsis* (Schodde 1969, Schodde 1970, Shapcott 1993, Arroyo et al. 1996). Long distance dispersal is now considered to have contributed to the radiation of these related genera (Hill and Orchard 1999, Renner et al. 2000).

Tasmania's primitive southern hemisphere flora, best exemplified by the montane rainforests and coniferous heaths, exceeds those of other southern hemisphere continents, with the presence of such superlative examples of primitiveness as *Athrotaxis* and the most evolutionary diverse podocarp flora.

There are few woody plant genera within the montane rainforests without some evidence of primitive lineage. The Tasmanian Proteaceae flora, which occupies a diverse array of habitats from alpine areas to the lowlands, including rainforest and buttongrass moorlands, are more primitive and scientifically interesting than those of Chile. The Tasmanian fern flora includes more ancient taxa than that of Chile, including representatives of the primitive families Osmundaceae (*Todea barbara*), Dicksoniaceae and Cyatheaceae.

Dendrochronology and species longevity

Dendrochronology is the study and correlation of tree rings for the purpose of dating events or climatic changes in the recent past. Some of the conifers of Tasmania have proven to be very important species for dendrochronological research (LaMarche 1979). The slow growth and longevity of species such as *Athrotaxis cupressoides*, *Athrotaxis selaginoides*, *Phyllocladus aspleniifolius* and *Lagarostrobos franklinii* provide a discernible record of climate changes in the life of the individual. Comparison between similarly aged individuals can be used to infer patterns in climatic events. Tree ring studies have been conducted at a range of sites within the TWWHA including the Walls of Jerusalem, Cradle Mountain–Lake St Clair National Park, the Central Plateau and Frenchmans Cap.

Chile also has long-lived conifers of significance for dendrochronology, such as *Fitzroya cupressoides*, with a longevity of 3600 years (Lara & Villalba 1993). By comparison the oldest individual *Lagarostrobos franklinii* known is from a fossil tree dated at 3462 years (Carder 1994).

Longevity of such magnitude (more than 1000 years) is globally unusual. The TWWHA has populations of species with extreme longevity including *Athrotaxis cupressoides*, *A. selaginoides* and *Lagarostrobos franklinii* that have national significance as long-lived species exhibiting evolutionary stasis.

Glacial refugia

The TWWHA provides excellent examples of glacial refugia and can be ranked as nationally significant in the presentation of this global World Heritage theme. It is likely that areas with extant glaciations can present this theme more graphically, although in terms of evolution and lasting impacts over time, the TWWHA provides an outstanding representative example.

Kirkpatrick and Fowler (1998) identify the critical glacial refugia as those that occur at the extremes of climatic fluctuations characteristic of the Holocene. In Tasmania glacial refugia have been identified using the fossil record in combination with current endemic species distributions (Kirkpatrick & Fowler 1998). The glacial refugia identified within the TWWHA include: the riparian rainforest tracts in the lower Gordon River catchment, the lower New River area, and inland valleys below 200–300 m in the interior of the Southwest National Park (Kirkpatrick & Fowler 1998).

Eastern Tasmanian species with isolated distributions in the Port Davey, Louisa Bay and Maatsuyker Island regions (e.g. *Eucalyptus tenuiramis, Eucalyptus globulus*) suggest that this area was a glacial refugia (Williams & Marsden-Smedley 2000, Lynch & Balmer 2004).

Alpine vegetation previously covered much of the TWWHA. Evidence for the past extent of alpine vegetation may be indicated by the presence of typically alpine species in the lowland buttongrass plains of far southwest Tasmania, particularly in the vicinity of Melaleuca/Bathurst Harbour. There are many refugial sites for alpine vegetation in the western and southern mountains.

The distribution of distinctive genotypes provides further evidence for glacial refugia. The recent Pleistocene evolution of the subspecies and morphotypes within *Eucryphia* and *Tasmannia* provide examples (Barnes & Jordan 2000).

Integrity

Although a number of macrofossil sites are located close to the TWWHA, they fall within other reserves, with few significant fossil sites incorporated within the TWWHA boundaries.

The fossil site at Coal Head, Macquarie Harbour, was attributed very high national significance (Jordon & Hill 1998). The Mersey/Cathedral site warrants national significance since fossil plant sites are unusual and of great value in the interpretation of past stages in the earth's evolutionary history. However the Melaleuca Inlet site is on a mining lease immediately adjacent to the TWWHA with the sediments in a poor state of preservation (Jordon & Hill 1998). Jordon and Hill (1998) list five fossil sites outside the TWWHA as having international significance: Little Rapid River, Regatta Point, Lea River, Cethana and Monpeelyata.

Tasmania probably has the richest supply of lakes and peatlands in Australia for palynological research. The TWWHA contains a large proportion of these including sites of both national and international significance (Darwin Crater). However because of the glacial history of Tasmania, most sites only data back to the last glacial.

Some significant examples remain just outside the area including one microfossil site of great national significance at Lake Selina on the West Coast Range. This site has a record dating from the Last Interglacial to the present and is the best record of its kind in Australia (Professor Eric Colhoun pers. comm).

The absence of many of the most important Tasmanian fossil sites within the TWWHA, prevents the fossil sites of the area being ascribed World Heritage significance under natural criterion (i) as it fails to meet the first of the conditions of integrity.

Most primitive genera are restricted to fire sensitive rainforest and alpine habitats. Fire and global climate change may be a threat to the long-term conservation of some of these species. These factors also threaten the integrity of plant distributions resulting from glacial refugia. Fire threatens the potential value of the long-lived conifers and other species of value in the interpretation of past climates through the use of dendrochronology. The current management plan incorporates aims to exclude fire from sensitive communities.

Some of the best Australian expressions of both 'refugia', 'relict' and 'rainforest' themes were considered by TPLUC (1997a) to be within the TWWHA. They placed the Tasmanian examples among several other Australian rainforest sites of international significance. They note also that the Mt Dundas–Mt Read rainforests, adjacent to the TWWHA, are exemplary.

Key Gondwanan genera are Nothofagus and the coniferous genera Athrotaxis, Phyllocladus, Lagarostrobos, Microstrobos and Microcachrys. To satisfy the conditions of integrity, the region must have a boundary that encompasses the taxonomic range of the species, provide habitat of sufficient area to enable natural evolutionary and ecological processes to continue and provide the best examples of that species or process (Table 3.1). The assessment of whether the boundary is sufficient to satisfy conditions of integrity is to some extent subjective. Only 10,970 ha of *Nothofagus gunnii* remain extant in Tasmania, of which nearly 70% is within the TWWHA, satisfying the condition of integrity (Robertson & Duncan 1991). The largest stands, and arguably therefore the most superlative examples, of the species are currently outside the TWWHA boundary on Mt Murchison, Mt Dundas and the Tyndall Range. However, these stands are not in secure reserves and are subject to mineral exploration.

Nothofagus cunninghamii is a widespread dominant of Tasmanian and Victorian cool temperate rainforest. Data from the National Forest Inventory of Australia program show that 201,000 ha (34%) of the rainforest in Tasmania is protected by the TWWHA (Bureau of Rural Sciences 2003).[1] The new reserves provide an additional 4596 ha of this forest. Montane, implicate and thamnic rainforests are well represented within the TWWHA. While some examples of higher altitude callidendrous forests are also well represented, the best and most superlative examples of lowland tall callidendrous rainforests are likely to be the Savage River rainforests outside the TWWHA boundaries (TPLUC 1997a).

Of the 33,670 ha of live *Athrotaxis selaginoides* vegetation remaining, about 60% is within the TWWHA (Brown 1988). The largest and most extensive stands of this species occur within the TWWHA. An additional 50 ha of *A. selaginoides* forest occurs within the newly proclaimed reserves adjoining the TWWHA.

The majority of the population and best expressions of *Athrotaxis cupressoides* and the alpine conifers, with the exception of *Microstrobos niphophilus*, are within the TWWHA. Superb examples of these species also occur outside the TWWHA boundary within the Mt Field National Park. Small and scattered populations of *Microstrobos niphophilus* occur within the TWWHA, but the best population is in the Mt Field National Park.

Fire sensitive elements of the primitive flora, particularly the conifers, have been reduced in extent by fire.

Fire management planning and fire suppression has prioritised the protection of these values within the TWWHA. This coupled with the extent of habitats supporting this primitive flora ensure that the conditions of integrity are met for World Heritage listing.

Using dendrochronology, some taxa with ancient origins have provided detailed information about the Holocene climate since de-glaciation and are of regional, national and, in some instances, global significance. The Huon pine stand at Lake Johnson on Mt Read is arguably the site of greatest significance so far found for dendrochronological studies in Tasmania. It may well be the best of such sites in the southern hemisphere. It is adjacent to the TWWHA. The Huon pine population at this site consists of a single male plant gamete that has spread and reproduced vegetatively for at least 10,000 years (Shapcott et al. 1995, Anker et al. 2001). The combination of such a high elevation site in which plant growth responds strongly to temperature variation, combined with the large number of trees both dead and alive with exactly the same genetic material, makes the site of immense value to Holocene temperature studies.

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[1] Data from TVMP (2005) suggests more than 300,000 ha of rainforest occurs in the TWWHA.

Table 3.1: Tasmanian genera with evidence for ancient Tasmanian ancestry.

Family	Genus	Species extant in TWWHA	End.	Genus age and evidence type	Ref	Sig.	Int
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Cunoniaceae /Eucryphiaceae	*Eucryphia*	*lucida* *milliganii*	E E	Early Eocene MF	C94 H91a B01	N N	M H
Cupressaceae	*Athrotaxis*	*selaginoides* *cupressoides*	EG	Jurassic DNA Early Eocene MF	G00 M94 T65	I I	H H
Cupressaceae	*Diselma*	*archeri*	EG	Not distinguishable in fossil record but presumed to have ancient origins because of taxonomic relationships	H99	N	H
Cyatheaceae	*Cyathea*	*australis*		Early Tertiary P	M94	N	L
Dicksoniaceae	*Dicksonia*	*antarctica*		MF of family late Jurassic, P for genus early Cretaceous	G96 C94	N	M
Fagaceae	*Nothofagus*	*cunninghamii* *gunnii*	 E	Paleocene P, Early Eocene MF	H84 H87 C91 H91b	N I	M H
Epacridaceae	*Archeria*	*eriocarpa* *hirtella* *serpyllifolia*	E E E	DNA evidence as second most primitive member of family, P of this family in the late Cretaceous	C98 De94 M94	N N N	M M M
Epacridaceae	*Prionotes*	*cerinthoides*	EG	DNA evidence as most primitive member of family, P of this family in the late Cretaceous	C98 De94 M94	I	H
Escalloniaceae	*Tetracarpaea*	*tasmanica*	EG	Paleocene DNA	S00	I	H
Gleicheniaceae	*Gleichenia*	*abscida* *alpina* *dicarpa* *microphylla*	E	Cretaceous P, Oligocene- early Miocene MF	C91 C94	N	H L L L
Gleicheniaceae	*Sticherus*	*lobatus* *tenera* *urceolatus*		Oligocene- early Miocene MF	C91 C94		L M L
Hymenophyllaceae	*Hymenophyllum*	*australe* *cupressiforme* *flabellatum* *marginatum* *peltatum* *rarum*		Oligocene- early Miocene MF	C91		M L M M M L
Isoetaceae	*Isoetes*	*gunnii* *humilior* *muelleri* sp. *nov* Maxwell R	E E E	Oligocene- early Miocene MF	H87	N N N	M M L H
Liliaceae	*Campynema*	*lineare*	EG	Late Cretaceous DNA	P02	I	H
Osmundaceae	*Todea*	*barbara*		MF of family Cretaceous in Gippsland, Victoria.	D094	N	L
Podocarpaceae	*Lagarostrobos*	*franklinii*	E	Early Eocene P, Podocarpaceae Pollen similar to *Lagarostrobos* widespread 90 mya. The family dates back 200 my	W89 C94	N	M
Podocarpaceae	*Microcachrys*	*tetragona*	EG	Early Eocene P	C94	I	H
Podocarpaceae	*Microstrobos*	*niphophilus*	E	Early Eocene MF	C94	I	M
Podocarpaceae	*Phyllocladus*	*aspleniifolius*	E	Tertiary P,	H89b	N	M

Family	Genus	Species extant in TWWHA	End.	Genus age and evidence type	Ref	Sig.	Int
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
				Early Eocene MF	C94		
Podocarpaceae	*Podocarpus*	*lawrencei*		Early Eocene MF	C94, T65	N	L
Polypodiaceae	*Microsorum*	*pustulatum*		Oligocene- early Miocene MF	C91		L
Proteaceae	*Agastachys*	*odorata*	EG	Late Paleocene P, Early Pleistocene MF	J75 M94	N	M
Proteaceae	*Banksia*	*marginata*		Late Oligocene–early Miocene MF	C91		M
Proteaceae	*Bellendena*	*montana*	EG	Paleocene DNA	HD98	I	M
Proteaceae	*Cenarrhenes*	*nitida*	EG	Possible Middle to Late Eocene MF	P92 C94	I	M
Proteaceae	*Lomatia*	*tinctoria* *tasmanica* *polymorpha*	E E E	Early Oligocene MF	C94	N N N	L H M
Proteaceae	*Orites*	*acicularis* *diversifolia* *milliganii* *revoluta*	E E E E	Cretaceous P, early Oligocene MF	M94 C97 B94	N N N N	M M M M
Proteaceae	*Telopea*	*truncata*	E	Late Paleocene MF	M94	N	M
Psilotaceae	*Tmesipteris*	*elongata* *oblonga*		Oligocene-early Miocene MF	C91		L L
Schizaeaceae	*Schizaea*	*fistulosa*		Oligocene-early Miocene MF	C91		M

(1, 2, 3) Taxa are listed in alphabetic order according to family, genus and species. Only taxa with ancient fossil records within Tasmania and/or species with ancient ancestry now restricted to Tasmania are listed in this table.

(3) Only extant species with populations in the TWWHA are listed.

(4) Tasmanian endemicity: E = species endemic to Tasmania, EG = genus endemic to Tasmania.

(5) The epoch in which the earliest fossil evidence for the genus appearing in Tasmania is listed.
DNA = evidence from phylogenetic studies using DNA analysis, MF = macrofossil, P = microfossil evidence from either pollen or spores.

(6) References to the data source for evidence of genus age:

B00 = Barnes and Rozefields 2000
B01 = Barnes et al. 2001
B94 = Blackburn and Sluiter 1994
C91 = Carpenter 1991
C94 = Carpenter et al. 1994
C97 = Carpenter and Jordan 1997
C98 = Crayn et al. 1998
De94 = Dettmann (1994)
D094 = Douglas (1994)
G00 = Gadek et al. 2000
G96 = Garrett 1996
H84 = Hill 1984
H87 = Hill 1987
H89b = Hill 1989b
H91a = Hill 1991a
H91b = Hill 1991b
H94 = Hill 1994
HD98 = Hoot and Douglas 1998
J75 = Johnson and Briggs 1975
M94 = MacPhail et al. 1994
P02 = Peterson and Givnish 2002
P92 = Pole 1992
S00 = Savolainen et al. 2000
T65 = Townrow 1965ab and 1967
W89 = Wells and Hill 1989ab

(7) The level of significance of the TWWHA populations of primitive plant species in presenting the Global World Heritage Theme of Gondwana.
I = International significance (species providing the best example of the genus in the world).
N = National significance (Tasmanian endemic species of primitive genera, or species with primitive traits of a particularly ancient genus).

(8) Integrity of the TWWHA in capturing the extent and variation of the species:
H = high integrity (all components of the morphological variation in the extant species and a large proportion and the best examples of the population are included in the TWWHA);
M = moderate integrity (a substantial part of the population included in the TWWHA together with the best examples).
L = low integrity (only a small portion of the population is included and the best examples are excluded from the TWWHA).

4. Alpine and treeless subalpine ecosystems

The Tasmanian alpine vegetation is globally unusual because it is dominated by scleromorphic shrubs that have evolved in an ancient landscape with low nutrient soils in a maritime climate. Scleromorphic life forms of particular note are the bolsters which have their richest development within the TWWHA, providing a superb example of convergent evolution and demonstrating on-going natural and evolutionary processes of world significance, thereby meeting natural criterion (ii).

The TWWHA alpine and subalpine region is a richly varying mosaic of distinctively contrasting colours, textures, smells and sounds. The landscape varies in character with dramatic extremes in weather, shrouded in mist at one moment, crystal clear the next. This region meets natural criterion (iii) in that it has universally outstanding natural aesthetic value.

The Tasmanian alpine ecosystem is distinguished by high vascular plant diversity and endemic richness (70% of the vascular plants on some western mountaintops are endemic). There are five alpine plant species listed as threatened under national legislation (*EPBC Act 1999*) and a further 33 plant species listed as threatened under the Tasmanian *TSP Act 1995* (see Appendix 1). The high species diversity, endemic richness and presence of threatened flora and fauna ensure the alpine vegetation of the TWWHA meets natural criterion (iv).

Background

Tasmania has more than half of Australia's alpine and treeless subalpine vegetation, most of which is within the TWWHA (Balmer & Whinam 1991, Costin et al. 2000). Two per cent (136,600 ha) of Tasmania is alpine or subalpine treeless vegetation (Table 4.1, Figure 4.1). Nearly two thirds (61%) of this is within the TWWHA. Much of this region occurs below the climatic treeline but has substantial treeless areas due to the elimination of trees by poor edaphic conditions, cold air drainage and frost (Kirkpatrick 1982). Such areas, which are characterised by inverted treelines and treeless vegetation, are structurally and floristically similar to adjoining alpine areas that they are discussed together here. Tasmanian alpine vegetation contains three distinctive regional floras –eastern, central and western (Kirkpatrick 1982) – all well represented in the TWWHA. The vegetation of the eastern Tasmanian mountains has the closest affinities with both the mainland and New Zealand alpine floras. A number of eastern mountains lie outside the TWWHA. The western and central alpine areas are mostly within the TWWHA and have been identified as having global significance (Kirkpatrick 1982, 1986a, 1989, 1994b, 1997).

Justification

Comparative assessment within the biome

'Mountains' are one of the world's 14 biomes (Udvardy 1982) and a theme of World Heritage significance (Thorsell & Hamilton 2002). The TWWHA, although certainly mountainous, has relatively low relief in comparison with some other regions. Nevertheless, it qualifies as a World Heritage mountain area by meeting the minimum criterion set for this theme (greater than 10,000 ha, at least one mountain greater than 1500 m and meeting at least one of the natural criteria for World Heritage listing). Of the 55 inscribed World Heritage sites representing this biome in 2002 the TWWHA was one of only 11 sites meeting all four natural criteria and one of 10 meeting both natural and cultural criteria (Thorsell & Hamilton 2002).

Both the 1981 and 1988 nomination documents asserted that the alpine areas of the TWWHA qualify for World Heritage listing in their own right. This claim rests primarily on the distinctive nature of the Australian alpine region in a global context. Wardle (1989) places the high mountain ecosystems of the world into 11 groups, including the Australasian mountains group.

There is little floristic or structural similarity between the temperate Gondwanan mountains (which include the Australasian mountains) and the temperate continental or oceanic mountains of the northern hemisphere, and hence they do not compete for WHA qualification. Wardle (1989) describes the southern hemisphere mountain systems as divergent and diverse in contrast to the homogeneity of the northern hemisphere mountain vegetation. Kirkpatrick (1994b, 2003) agrees and goes on to discriminate between the Australian mountains and others of the temperate southern hemisphere, including New Zealand. He concludes that the Australian mountains are distinct from almost all others by virtue of being uniquely placed in an ancient weathered landscape with a maritime climate.

Within the context of 'continental isolation', a story of the origins and development of the Australian continent, one of the Australian themes identified by the World Heritage Expert Panel as having outstanding universal value is 'Evolution of landforms, species and ecosystems under conditions of stress' (TPLUC 1997a). The sub-theme 'alpine' was identified because 'Australia has outstanding examples of globally unusual alpine vegetation that has developed in response to maritime conditions and poor soils' (TPLUC 1997a). This sub-theme was acknowledged by TPLUC (1997) to be best expressed within the TWWHA.

The highly scleromorphic nature of the TWWHA alpine vegetation contrasts markedly with that of most other alpine regions of the world, including the Australian Alps, which are principally herb and grass dominated. The maritime climate of Tasmania is associated with a lack of persistent snow-lie in winter and snow that falls at any time of the year. This has led to a landscape exposed to the extremes of ice-bearing winds and frosts (Kirkpatrick 1983, Kirkpatrick et al. 1994a). These conditions, combined with shallow, rocky and nutrient poor soils (a product of repeated glaciation and ancient geology), has resulted in alpine vegetation that is largely dominated by scleromorphic shrubs, hard-leaved graminoids and cushion (bolster) plants. A densely compacted cushion formed by hard leaved shrubs or herbs is a plant form largely restricted to the southern hemisphere.

The bolster heaths or cushion communities of TWWHA exhibit a globally exceptional level of endemism and diversity. In Tasmania there are eight families of cushion shrubs containing 10 species, of which six are endemic. There are also seven endemic cushion-forming hard-leaved sedge species associated with bolster heaths (Kirkpatrick 1997). High endemicity in cushion plant communities is characteristic of these communities in other regions in which they occur (New Zealand, South America and New Guinea) (Gibson & Hope 1986, Gibson 1989).

Table 4.1: Area in hectares of alpine & treeless subalpine vegetation types in Tasmania and the TWWHA (source: TVMP 2005).

Vegetation type	TWWHA	Tasmania	% In TWWHA
highland grassland[2]	14,900	22,839	65%
alpine sedgeland & herbfield	19,943	37,085	54%
bolster heath	2909	3083	94%
coniferous heath	5735	6210	92%
deciduous heath[3]	1953	2117	92%
alpine heath	37,692	65,271	58%
total alpine	**83,132**	**136,605**	**61%**

Cushion plants provide habitat for the endemic and threatened cushion plant moth, *Nemotyla oribates*, probably the most alpine-adapted of the vast Australian gelechioid fauna (Nielsen et al. 1992). *Nemotyla* appears to be an isolated, endemic genus, being the only known Australian representative of the family Symmocidae (Edwards & McQuillan 1998). The current fragmented range suggests a formerly more extensive range, possibly reflecting climatic fluctuations within its alpine habitat over the last 20,000 years (Nielson et al. 1992).

The western mountain alpine areas, where shrub-dominated vegetation is most prominent, have up to 70% Tasmanian endemism at the species level. This contrasts strongly with the more grassy and herbaceous alpine floras of the eastern mountains where Tasmanian endemism is much lower.

[2] Highland grassland includes vegetation ranging from montane to alpine grasslands.
[3] Deciduous heath is *Nothofagus gunnii* dominated vegetation without an emergent stratum of *Athrotaxis* or other trees.

Figure 4.1: Distribution of Tasmanian alpine and subalpine treeless vegetation types in the TWWHA (source TVMP 2005).

Terrestrial alpine vegetation provides habitat for a number of fauna groups, which while not threatened, are of scientific interest. There are three endemic alpine skinks, the southern snow skink *Niveoscincus microlepidotus*, the northern snow skink *Niveoscincus greeni,* and the mountain skink *Niveoscincus orocryptus.* These three skinks inhabit arguably the most challenging environment of any Australian reptile, yet they can be seen in great numbers on many mountain peaks and are largely restricted to the TWWHA (Kirkpatrick et al. 1993, Bryant & Jackson 1999). There are also four endemic grasshopper genera, three of which are monotypic, and all with Gondwanan ancestry, *Russalpia, Truganinia, Tasmaniacris* and *Tasmanalpina* in the TWWHA (Mallick & Driessen in press). A remarkable species of Australian sawfly (Hymenoptera: Symphyta) has also been found in the alpine areas of the TWWHA. The females are flightless, the only member of the family Pergidae to exhibit this characteristic. The species is also globally unusual in that both sexes are active in total darkness (Naumann 1997).

Another globally unusual feature of the Tasmanian alpine zone is the absence of a distinctive and abrupt treeline between the subalpine and true alpine zones (Kirkpatrick 1982). With increased altitude woody vegetation typically becomes progressively shorter without any sharp transition in species or shrub height to mark the point of the climatic treeline. Fjaeldmark vegetation occurs at the extreme of the environmental gradient for exposure to wind, frost heave and insolation and is rare in Tasmania and Australia (Lynch & Kirkpatrick 1995, Kirkpatrick et al. 2002a). Major areas of fjaeldmark within the TWWHA are found on the Boomerang and the Southern Ranges (Kirkpatrick and Harwood 1980, Lynch and Kirkpatrick 1995, Kirkpatrick et al. 2002a). Other small areas of fjaeldmark occur in the Cradle Mountain area (Kirkpatrick & Balmer 1991), and at Rocky Hill, Pyramid Mountain (Kirkpatrick 1984b), Eastern Arthurs, Western Arthurs, Denison Range Mt Murchison and Dome Hill (Kirkpatrick & Whinam 1988).

This vegetation is often associated with unusual geomorphic processes in which plants are an important element in the interactive relationship and permafrost does not play a part. The unexpectedly high species diversity and dominance by prostrate woody shrub species distinguishes the fjaeldmarks of the TWWHA from others elsewhere in the world, where herbaceous species and non-vascular plants are typically the dominant lifeforms. The roots of these woody species are often connected to the leaves by many metres of trunk creeping along the ground, a testimony to the great age of many of the slow growing occupants of this vegetation. The geomorphic features, the dominance by woody species coupled with the diversity and high number of endemic species present in the vegetation make all examples of this community a significant conservation priority at all scales, possibly meeting WHA criteria (ii) and (iv) in their own right.

Alpine sedgeland occurs in areas of waterlogged peat soils dominated by species of hard-leaved graminoids. The eastern and central mountain alpine sedgelands are typically dominated by species widely distributed in the Australasian alpine regions (*Astelia alpina, Baloskion australe, Empodisma minus* and *Carpha alpina*) while the western alpine sedgelands are dominated by endemic Tasmanian species (*Milligania* species, *Isophysis tasmanica* and *Carpha curvata*). This vegetation type has a very limited distribution on mainland Australia. The Tasmanian examples are greater in extent, diversity and condition. They appear not to have an analogue elsewhere in the world (Kirkpatrick 1997). Most of the diversity and the best expressions of this vegetation in Australasia (particularly the endemic dominated communities) are to be found within the TWWHA and they are of international significance.

The moss froglet *Bryobatrachus nimbus* is a specialist of mossy habitats contained within alpine sedgeland and rainforest. It is is the only representative of this endemic genus and is restricted to southern parts of the TWWHA (Bryant & Jackson 1999).

This species has fully terrestrial embryonic and larval development, a life history which does not occur in any of the most closely related species of *Crinia* (Rounsevell et al. 1994, Littlejohn 2003)).

Comparative assessment within the biogeographic realm of Australasia

Floristically the alpine floras of the Gondwanan mountains are very similar at the family and generic level, with no families and few genera confined to one country or continent. The alpine floras of Australia, New Zealand and South America have very little in common at the species level. More than 80% of Australia's including Tasmania's alpine species are restricted to Australia while New Zealand's alpine flora has an endemism of 93% (Mark & Adams 1986).

New Zealand's mountain landscape is much younger than that of Australia, being a product of recent uplift and volcanic activity. This, combined with the presence of active glaciation, has given rise to vegetation with structure, floristics and ecology that has little in common with its ancient Australian counterparts. Similarly, the glacial history, isolation and ancient origins of Tasmania have combined to make the Tasmanian alpine flora distinct from the rest of the Australasian alpine flora.

Only eight of Tasmania's alpine species are not found within the TWWHA and only three of these are endemics. Forty-two percent of the 402 alpine species found in the TWWHA are Tasmanian endemics (see Table 10.2 and Appendices 2 and 3).

Nearly half are shared with the Australian mainland, 15% are shared with New Zealand, while only 4% have a wider distribution. Floristically, the most similar alpine vegetation to that of Tasmania is found in the Australian Alps (Kirkpatrick 1982, 1986a). Coniferous heaths have the highest concentration of endemic flora, followed by the bolster heaths and other alpine heaths.

Tasmania has a greater number of alpine recognised plant communities than the Australian Alps, with most of this variation present within the TWWHA. The variable climate, topography, geology and edaphic conditions give rise to a wider range of environmental conditions within Tasmania than within the Australian Alps (Kirkpatrick & Bridle 1998, 1999). A diversity of environments and disturbance histories is reflected by the wide range of vegetation formations in the TWWHA: deciduous heath; coniferous heath; bolster heath; alpine heath; fjaeldmark; fen; bog; tall alpine herbfield, short alpine herbfield; alpine sedgeland; alpine tussock grasslands (Kirkpatrick & Bridle 1999). All except one of the 43 Tasmanian alpine communities identified by Kirkpatrick (1986a) are found within the TWWHA (Kirkpatrick 1994a).

Western and southern Tasmanian mountains, largely in the TWWHA, have species with a mean geographic range lower than those of the Australian mainland and eastern Tasmania (Kirkpatrick 2002). Although local endemism is highest in the Snowy Mountains and the Bogong High Plains on the Australian mainland, the Central Plateau and the Southern Ranges in TWWHA also have a very high concentration of local endemics (Kirkpatrick 2002). Few mountains have species or subspecies confined to them. Taxa restricted to one alpine island are most numerous in the Snowy Mountains, followed by the Central Plateau (TWWHA). The only other alpine habitat islands that have endemic taxa are the Bogong High Plains, the Southern Range (TWWHA), Mt Counsel (TWWHA), Mt Field, Mt Wellington and Ben Lomond (Kirkpatrick 2002).

The diversity of Tasmanian alpine conifers (seven species from six genera and two families) is unusual for Australia, as only one alpine conifer occurs on the mainland, *Podocarpus lawrencei* (Costin et al. 2000). New Zealand also has a less diverse coniferous flora with only three alpine gymnosperms, all of which belong to Podocarpaceae (Mark & Adams 1986). Tasmanian coniferous heath structure is comparable to the northern hemisphere *Juniperus* heaths (Kirkpatrick 1997). Alpine coniferous heath and deciduous heath are of national significance.

Four vascular plants of alpine areas within the TWWHA are listed under national legislation: three are vulnerable, *Oreoporanthera petalifera*, *Hymenochilus pratensis* (listed as *Pterostylis pratensis*), *Colobanthus curtisiae*; and one, *Sagina diemensis,* is critically endangered. The liverwort *Pseudocephalozia paludicola* is also listed under the *EPBC Act* 1999 as vulnerable. A further 33 species are listed under the Tasmanian *TSP Act 1995,* including one lichen, *Cetraria islandica.* All but two of these threatened species are listed as rare with only *Rhytidosporum inconspicuum* listed as endangered and *Microstrobos niphophilus* as vulnerable (Appendix 1). Of these 37 threatened species, 11 are confined to the TWWHA and 18 are well represented within the TWWHA (Appendix 1).

The number of primitive taxa and Gondwanan relicts in the alpine flora of Tasmania exceeds that of the Australian Alps. Alpine communities that are particularly rich in relict Gondwanan species include coniferous heath, deciduous beech and some associations of alpine heath (*Nothofagus* and *Eucryphia*-dominated) (see section 3 'Primitive flora and refugia').

Tasmania has only 10 species almost entirely confined to areas above the climatic treeline (alpine obligates). Of these, nine are found in the TWWHA: *Phyllachne colensoi, Dracophyllum minimum, Carpha rodwayi, Gaultheria depressa, Milligania lindoniana, Aciphylla procumbens, Celmisia saxifraga, Cheesemania radicata* and *Oreomyrrhis sessiliflora* (Balmer 1991a). A much greater number of plant species restricted to areas above the climatic treeline occur on the Australian Alps and in New Zealand.

This probably reflects Tasmania's greatly fluctuating climate where like today alpine areas occupy only small islands leading to the extinction of species restricted to such environments.

Snow patch communities are of national significance because of the extreme rarity within Australia of places with the prolonged snow. These areas are associated with the development of short alpine herbfields. The vegetation is very restricted in the TWWHA but contains a diverse range of species. The best expressions of this vegetation formation in the TWWHA are at Mt Anne, Cradle Mountain, Mt Rufus and the Du Cane Range. Similar and better examples are found on the mainland of Australia and New Zealand (Kirkpatrick 1997).

In comparing the two regions in terms of exceptional aesthetic beauty, Kirkpatrick (1994b) considered the TWWHA more pleasing to the eye in at least three measures. It had a more pleasing juxtaposition of water and land, a wilderness landscape of such size as to be unrivalled in its natural aesthetic qualities, and a terrain with more dramatic relief and towering features (although this relative relief is nationally outstanding, it falls short of international importance). While many aspects of the Australian landscape may only be appreciated through certain cultural filters, the TWWHA alpine landscape has a far more universal appeal.

It does not have the traditionally appealing qualities of other high mountain systems such as grand vertical relief with towering snow-capped mountains above rolling-meadows of wildflowers and grasses. Instead it has a more subtly provocative appeal to those that get to know it. Black coloured pools and lakes reflect jagged quartzite crags in still moments while at other times the wind scours the slopes and stunts plant growth. The gentle slopes and saddles are carpeted in a multicoloured mosaic of hard-leaved cushion plants. Wilderness photographers inspired by the aesthetic qualities of the TWWHA alpine zone have been internationally recognised, with Peter Dombrovskis elected to the Photographic Hall of Fame, alongside Ansell Adams.

Contribution of alpine vegetation to other themes of universal significance

Glaciation is another theme of the TWWHA listing and is given more attention in Sharples (2003). The current TWWHA alpine flora evolved in, or endured, major climatic upheavals during the Pleistocene. During the glacial maxima much of the current land area of southwest and central Tasmania was either under ice or was alpine with only small relict patches of montane forest in the more lowland valleys (Kirkpatrick 1997, Kirkpatrick & Fowler 1998). Although the alpine areas have contracted to a fraction of their former extent (Figure 4.2), the large area of treeless vegetation in montane and subalpine areas has enabled the persistence of a rich alpine flora.

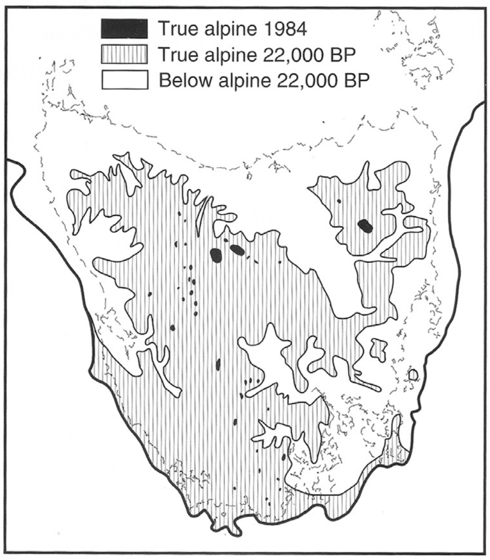

Figure 4.2: Area of alpine zone at the height of the last glaciation in Tasmania.

(source: Kirkpatrick 1986b)

Wetlands are another of the world's 14 biomes and another World Heritage theme that intersects with both the mountain biome and glaciation themes. The glacial history of the TWWHA has produced a landscape rich in wetland types, all occupied by aquatic herbfields, some with margins of specialised wetland marginal herbfields (Kirkpatrick & Harwood 1983ab). About 100 of Tasmania's alpine plants (25%) occupy aquatic herbfields, marginal herbfields, fens and bogs within the TWWHA. One third of these alpine wetland plants are endemic. Wetlands are described in more detail in section 8, 'Wetland ecosystems'.

Grasslands are another of the world's biomes, and the one most under-represented in the protected area networks globally (Henwood 1998). They are of considerable conservation importance in Australia, being the most endangered ecosystem on the continent (McDougall & Kirkpatrick 1994). The montane and alpine elements of the Australian grasslands are less threatened and degraded than their lowland counterparts (Kirkpatrick & Duncan 1987). Despite this, the montane and alpine grasslands of the TWWHA are of great national importance for the protection of this ecosystem and are essential to the representative reserve system. They provide habitat for more than one third of the Tasmanian alpine flora including 11 state listed and two nationally listed threatened plant species. Some montane grasslands within the TWWHA provide habitat for the threatened fauna species, the ptunarra brown butterfly (*Oreixenica ptunarra*, Mallick & Driessen in press).

While they do not represent the most superlative example of this ecosystem in a global context, they are a representative and significant component of the Tasmanian alpine ecosystem, and contribute to the integrity of the listing. More nationally significant and internationally superlative examples of Australian alpine and montane grassland and herbfields are located in the Australian Alps.

Another theme of significance in the context of the TWWHA is that of karst ecosystems. A number of small karst outcrops occur within the alpine region of the TWWHA, providing contrasting vegetation to the surrounding region. Of national significance is the tower karst of North East Ridge, Mt Anne.

This area is dominated by the vulnerable prostrate herb species *Oreoporanthera petalifera*, which is entirely confined to these craggy outcrops. Associated with it is a small population of the critically endangered herb *Sagina diemensis*, which has been discovered in only one other location – the Weld River Arch.

Outcrops of limestone or dolomite at Tim Shea, Mt Ronald Cross and Mt Gell support a distinctive flora that includes the threatened plant *Veronica plebeian*, normally found in wet sclerophyll forest in the north of the state, and *Taraxacum aristum*, a threatened native dandelion.

Both species are listed as rare (*TSP Act 1995*). The alkaline grassland occupies an immense sinkhole on Mt Gell. This sinkhole is a spectacular and unusual feature of the TWWHA (Gilfedder 1989, Smith & Gilfedder 1993, Kirkpatrick 1997).

Integrity

To satisfy listing under criterion (iv) the alpine areas of the TWWHA must be shown to be the most diverse of their kind and the best examples of their type.

Tasmania's western and central alpine vegetation is well represented in the TWWHA. The Central Plateau and the Walls of Jerusalem National Park provide highly representative examples of the eastern alpine flora. Only three regions of particular significance to the presentation of the Tasmanian alpine and subalpine flora are missing from the listed area.

The first is the West Coast Range, which contains superlative examples of western alpine vegetation with alpine associations rich in endemics and Gondwanan relicts (Kirkpatrick 1977a, 1984a) underlain by rock types poorly represented within the TWWHA (including granite). The national importance of these areas is recognised by their listing on the Register of the National Estate.

Another notable omission from the listed area is Mt Field National Park. Its high relief provides habitat for alpine obligates and its environmental diversity provides habitats for a large range of coniferous communities and bolster heaths. The most abundant population of the vulnerable ancient endemic conifer *Microstrobos niphophilus* is within this reserve. This area has the most internationally superlative example of string ponds in which hard cushion shrubs form vegetation dams (Kirkpatrick & Gibson 1984, Gibson & Kirkpatrick 1985a,1992). Areas of prolonged snow-lie give rise to snow patch communities of national significance (Gibson & Kirkpatrick 1985b) and provide habitat for the rare species *Plantago glacialis.* Mt Field National Park is also the stronghold for the *Euphrasia gibbsiae* subsp. *pulvinestris,* which is listed in Tasmania as rare. It is also the only known location for the endemic sedge species *Carex barbata* (Curtis and Morris 1994).

The third omission from the listed area is the montane grasslands adjacent to the Cradle Mountain region – the Vale of Belvoir/Middlesex Plains area. Kirkpatrick et al. (1991a) note that it is one of the highest priority areas for reservation in the state for the protection of the remaining poorly reserved and rare dicotyledons. It provides habitat for at least four poorly reserved or rare plants including the nationally listed *Leucochrysum albicans* subsp. *albicans* var. *tricolor, Rhodanthe anthemoides, Rhytidosporum alpinum* and *Stackhousia pulvinaris*, all listed under the TSPA 1995. The Vale of Belvoir is a karst landscape with nationally superlative examples of herbfields and grasslands. The area's national importance was recognised with its listing on the Register of the National Estate in 1984 for its high altitude native grassland vegetation (specifically *Poa labillardierei–Veronica gracilis* grassland). This area possibly has its greatest World Heritage significance in providing an insight into the nature of the dolomite-floored valleys in western Tasmania during the height of the last glacial (Kirkpatrick 1994b).

Most of the Tasmanian alpine vegetation is comparatively pristine. The greatest threat to the integrity of alpine vegetation in the TWWHA is fire, followed by recreational impacts (Whinam et al. 1994, Whinam & Chilcott 1999) and climatic changes associated with global warming. Historic burning and grazing practices led to the degradation of some highland grasslands but this has ceased and the vegetation is now recovering (Bridle et al. 2001). Some areas of the alpine vegetation have been burnt but large areas remain in good condition.

The current management plan aims to actively manage to exclude fire from sensitive communities. It also recognises the damage to alpine vegetation caused by recreational use. The potential impacts of global warming are being studied at several locations including the long-term ecological research site, Warra, which is registered on the international register of LTER sites around the world (Brown et al. 2001, Doran et al. 2003).

Although definitive trends towards warming have not yet been detected in the Tasmanian climatic records it is predicted that conditions may become both warmer and drier (Kirkpatrick et al. 2002a, Bridle et al. 2003)

Despite the omissions described above, the TWWHA does include a superlative range of Tasmanian alpine diversity. It also includes the best examples of most of the key elements of this ecosystem. The TWWHA therefore meets the conditions of integrity for World Heritage listing of its alpine areas.

5. Temperate rainforest

Tasmania represents a major centre of distribution for cool temperate *Nothofagus* rainforest in the world. The significance of Tasmania's cool temperate rainforests was successfully argued in the nominations for the inscription of the TWWHA on the World Heritage Register, in 1982 and 1989.

Rainforests occur in perhumid Tasmania where exogenous disturbance may be absent for more than 500 years, and are part of a universally outstanding process of forest dynamics (see section 6, 'Sclerophyll communities'). The biological and successional processes evident in this vegetation fulfil natural criterion (ii).

Dark tannin-stained rivers snake their way below shrouds of ancient rainforest that cloak deep valleys. This primeval landscape is of outstanding universal beauty and meets natural criterion (iii). National significance is ascribed to the autumnal displays of montane deciduous beech communities.

Tasmania's cool temperate rainforests provide habitat for primitive relict genera of flora and fauna flora (see section 3), habitat for the critically endangered plant *Lomatia tasmanica* (*EPBC Act 1999*) and nine other threatened plant taxa (*TSP Act 1995,* see Appendix 1). They are also rich in non-vascular species and exhibit high levels of endemism among seed plants, especially woody species. Previous nominations asserted that the TWWHA rainforests were the best of their type in the world and satisfied natural criterion (iv), but in fact the Chilean cool temperate rainforests exceed them in diversity, antiquity and endemism. The TWWHA rainforests are the best example of their type in Australia for the protection of biodiversity. They represent a distinct facies that warrants international recognition as one of a trilogy of sites (along with Chile and New Zealand) presenting the *Nothofagus* cool temperate rainforests of the world.

Background

Tasmanian cool temperate rainforest may be defined as vegetation dominated by species of *Nothofagus, Eucryphia, Anodopetalum, Atherosperma, Athrotaxis, Lagarostrobos, Phyllocladus* or *Diselma* and others that do not depend on exogenous disturbance for its perpetuation *(sensu* Jarman and Brown 1983). Rainforest in Tasmania varies from tall forest with a closed canopy and sparse to absent understorey (callidendrous), forest with a closed canopy and a distinct shrub understorey (thamnic) to low tangled forest or scrub with an open canopy (implicate). Other rainforest types that have been distinguished are gallery rainforest, dwarf littoral rainforest and montane communities (Jarman et al. 1984, 1991).

Justification

Cool temperate rainforests occur mainly in moist coastal regions of the temperate zone (between latitudes 32 and 60 degrees) of both hemispheres. The rainforests of the northern and southern hemisphere have little in common. Those in the north are principally dominated by conifers with a few dominated by the northern beech (*Fagus spp*). In the southern hemisphere, cool temperate rainforests are principally dominated by the southern beech, *Nothofagus*. Such forests occur in southeastern Australia, southern New Zealand and southern South America (Chile/Argentina).

Figure 5.1: Distribution of Tasmanian rainforest and associated scrub vegetation types in the TWWHA (source TVMP 2005).

Comparative assessment within Australia.

Cool temperate rainforests are confined to eastern Australia. Rainforest is naturally rare in Victoria, with only 16,000 ha remaining (Bureau of Rural Sciences 2003). A substantial part of this small area of rainforest is dominated by *Nothofagus* or *Atherosperma*. In NSW there are 486,000 ha of rainforest but the majority of it is subtropical with an Indo-Malayan rather than a Gondwanan flora. The temperate forests occur in relict patches at high altitude. The best of these rainforests have been inscribed on the World Heritage List as the 'Central Eastern Rainforest Reserves'. These forests include remnant patches of *Nothofagus moorei* temperate rainforest, with considerable conservation importance because of its primitive flora (see section 3, 'Primitive flora and refugia'). Nevertheless, this area was listed principally for its subtropical rainforest values which were recognised as distinct from both the cool temperate forests of the TWWHA and the tropical rainforests of the 'Wet Tropics of Queensland' WHA (IUCN 1988). The TWWHA is acknowledged as containing the best example of cool temperate rainforest in Australia by virtue of its extent, condition, the interspersed distribution with sclerophyllous vegetation, the structural diversity and highly Tasmanian endemic woody flora (TPLUC 1997a).

Comparative assessment within the biome

The largest undisturbed region of temperate rainforest remaining in New Zealand is that of the southwest, where more than two million hectares of cool temperate rainforest are protected under the World Heritage Convention. This region, the *Te Wahipounamu* South West WHA, is currently the only other World Heritage site listed in part for its cool temperate rainforest biodiversity values. Four *Nothofagus* species dominate much of the rainforest, which contains over 220 vascular plant species (most endemic to New Zealand) including some endemic genera. There are also 14 Podocarpaceae species (10 forest species) within the listed area that are considered of world significance by providing modern examples of the ancient forest flora of the Mesozoic era (Hutching & Potton 1987). The New Zealand temperate rainforests are more diverse and extensive than those of the TWWHA. While this region is mostly pristine, introduced browsing mammals including possums and deer impact on some of the WHA as well as on temperate rainforests in other areas of New Zealand.

The temperate forests of Chile have more biodiversity than those of both New Zealand and Tasmania, with some 443 species of vascular species. One third of Chile's 82 woody forest plant genera are endemic (Arroyo et al. 1996). These forests provide habitat for a number of woody species threatened with extinction (Armesto et al. 1995) and are one of the highest priorities for temperate forest conservation in the southern hemisphere (Neira et al. 2002). IUCN has identified central Chile as one of the world's 25 'hot spots' for biodiversity conservation (Smith & Jakubowska 2000, Neira et al. 2002).

Chile's cool temperate rainforests are not uniformly species rich. The most species rich rainforests are the Valdivian rainforests of the coastal region and lowlands between 41° and 43° south, a region that escaped glaciation during the Pleistocene and which combines relative warmth with high rainfall in an equitable climate (Veblen et al. 1983). The Valdivian forests contain most of Chile's temperate forest diversity with 423 vascular plant species, while the forests further south – the North Patagonian forests and the Magellanic forests – have 149 and 102 vascular plant species respectively (Arroyo et al. 1996).

The past practices of forest clearance by burning for settlement and farming has reduced rainforest to remnants in the northern part of its distribution. More recently, conversion of native forests to exotic pine plantations has been extensive, particularly in the accessible Valdivian forests where the reserve system is least adequate (Veblen et al. 1983, Neira et al. 2002). These factors reduce the potential for World Heritage listing in the most species rich areas of Chile's rainforests. Smith and Jakubowska (2000) reported four sites in Chile with potential for World Heritage listing on the basis of their forest biodiversity but only one of these reserves is in Valdivian rainforest (Table 5.1).[4]

Table 5.1: Potential WHA sites in Chile

Site	Area x 1000 ha	Forest Type
Bernardo O'Higgins NP	1761	Magellanic
Laguna San Rafael NP/biosphere reserve	1350	Northern Patagonian, Subalpine deciduous
Las Guaitecas National Reserve	1098	Northern Patagonian
Chiloé NP	43	Valdivian

[4] Note that Chile's Torres del Paine NP (184,414 ha), a biosphere reserve, is a significant mountain site nominated for WHA listing. It has some areas of *Nothofagus* rainforest but is better recognised for its Patagonian Steppe vegetation. The adjoining Los Glaciers NP WHA in Argentina has similar vegetation but the rainforest has been impacted by wildfire (Erize et al. 1993, UNEP 2004).

Tasmania has about 747,000 ha of rainforest of which 308,000 ha (41%) occur in the TWWHA (TVMP 2005)[5]. Both the total extent and the reserved area of rainforest are much less than that of New Zealand or Chile's North Patagonian or Magellanic rainforests. The TWWHA rainforests compare favourably to the Valdivian rainforests in terms of integrity and extent.

By comparison with the New Zealand and Chilean Valdivian rainforests, Tasmania's are low in vascular plant species diversity. They are comparable with the diversity of Chile's North Patagonian rainforests and certainly richer than the Magellanic forests. Tasmania's rainforests have 154 vascular species (with another 30 species regularly occuring but probably adventive). Of the 67 woody species in 43 genera of woody plants, 51 species (76%) and nine genera (21%) are Tasmanian endemic. Close to 60% of all the seed plant species of rainforests are Tasmanian endemic (Jarman et al. 1984, Buchanan 2003). There are two *Nothofagus* species and nine conifers (four in Cupressaceae and five in Podocarpaceae) in the Tasmanian rainforests. Only one of the 51 fern species of the Tasmanian rainforests is a Tasmanian endemic (Garrett 1996, Jarman et al. 1984).

Tasmanian temperate rainforests are floristically rich in non-vascular species, which outnumber the vascular taxa about 6:1. There are more than 220 species of bryophytes, 360 species of lichens and an unknown but greater number of fungi (Jarman & Kantvilas 1995). The levels of Tasmanian endemism are much lower in the cryptogamic flora than the vascular flora since they have excellent long distance dispersal capability. Nevertheless, there is a notable Tasmanian endemic component within this rainforest flora. It would seem likely, however, that comparable or richer regionally endemic non-vascular flora occurs in the NZ and Chilean rainforests (Smith 1987, Arroyo et al. 1996).

The rainforests are repositories of 'living fossils', including fauna of outstanding biogeographic and taxonomic importance. For example, rainforest litter provides habitat for an endemic mono-specific genus of pseudoscorpion *Anysrius chamberlini* collected from Frodshams Pass within the TWWHA (Harvey 1998). The species is extremely similar to the genus *Syarinus* from the northern Hemisphere (USA, southern Canada and northern Europe). The species has a highly disjunct (vicarious) distribution suggesting a Pangean distribution. Other examples include the hairy cicada (*Tettigarcta*), mandibulate moths (*Sabatinca*), and velvet worms (*Peripatus*) (Mallick & Driessen in press). Rainforests are also an arena for endemic radiation in many insects such as stag beetles (*Lissotes*) and moss beetles (*Pedilophorus*). Talitrid amphipods have undergone extraordinary adaptive radiation in Tasmanian forests with the result that Tasmanian wet forests are a world centre of diversity for this group (Mallick & Driessen in press).

The crown of the Tasmanian endemic plant species *Richea pandanifolia* provides food for the larvae of the giant Tasmanian pandani moth (*Proditrix nielseni*). It is the largest moth in the super family Yponombutoidea and is the only record of this genus in Australia (Mallick & Driessen in press).

The only nationally listed threatened plant species in Tasmanian rainforests is *Lomatia tasmanica* (listed as critically endangered and described below). This species and nine other threatened plant taxa are listed on the *TSP Act 1995* lists. One is listed as a vulnerable species (*Microstrobos niphophilus*, which occurs in montane rainforests and alpine coniferous heaths). The other species are all listed as rare and include two lichens known only from a montane pencil pine forest (see Appendix 1). Greater numbers of rare and threatened flora are known in the Chilean rainforests.

In terms of aesthetics, the montane communities of deciduous beech (*Nothofagus gunnii)* have less spectacular autumn displays compared with those of their relatives in South America, while weather-sculptured conifers are better expressed in the northern hemisphere. However, both these rainforest communities are of national aesthetic significance, as shown by the number of published photographs of both these rainforest communities by Australian and Tasmanian photographers.

The dark tannin-stained rivers framed by cool temperate rainforest have been identified as universally significant in terms of their aesthetics (see section 8, 'Wetland ecosystems'). The rainforests form part of outstandingly beautiful mountain landscapes, characterised by the mosaic of colour and form of different vegetation types. The experience of peering up through the mixed green colours of a closed canopy of rainforest to view tall eucalypts towering overhead is also visually superlative. The aroma of these forests is memorably distinct with fragrant oils from the sassafras and eucalypts mingling in the damp, still, cool air. The ground is spongy underfoot being composed of decomposing duff overlain by mossy carpets sprinkled with leaf litter. Each aspect adding dimensions to the sensory experience of this forest.

While its international importance might be questioned in comparison to Chile's temperate rainforests, the Tasmanian cool temperate rainforests are nevertheless a significant global refugium for plant genera of Gondwanan origin (see section 3, 'Primitive flora and refugia').

[5] This figure includes scrub and montane rainforest communities. Note also the Bureau of Rural Sciences (2003) report 598,000 ha of rainforest in Tasmania of which 325,000 ha occur in the TWWHA.

'The *Nothofagus* rainforests constitute a primeval vegetation type in Australia which is being gradually replaced by the "Australian element" … flora. … Tasmania has custodial responsibility for maintaining Australia's last remaining large areas of cool temperate rainforest' (Tasmanian Government and the Australian Heritage Commission 1981).

Thus Tasmania's rainforests may not be the 'best of the best' of the world's cool temperate *Nothofagus* rainforest. However they are internationally significant as one of only three large natural regions (including *Te Wahipounamu*, Chile), which each represent a unique evolutionary outcome from a common ancestral *Nothofagus* forest, thereby having World Heritage significance (IUCN 1990).

Other universally significant themes present within the rainforest vegetation

The ecological successional processes culminating in the development of cool temperate rainforest[6] was recognised as being an internationally outstanding example of on-going natural process in both the 1981 and 1989 listing statements for the TWWHA (see section 6, 'Sclerophyll communities'). The successional processes within the Tasmanian vegetation and within rainforest are distinct from those in other analogous regions. In New Zealand the significant successional processes identified for the *Te Wahipounamu* WHA relate to plant succession after glacial retreat. Presumably, similar processes are evident in the Argentine Los Glaciers NP WHA, while in Chile significant successional processes have been described following volcanic disturbance and landslips (Veblen et al. 1983).

Additional values of the Tasmanian rainforests

Lomatia tasmanica

This critically endangered species (*EPBC Act 1999*) is endemic to Tasmania and is restricted to a single population occupying riparian areas in rainforest, mixed forest and scrub in southern Tasmania. Genetic studies have shown that the entire 'population' of *Lomatia tasmanica* is a single clone. Root suckering and coppice sustain the population because the plant is a sterile triploid (Brown & Gray 1985, Lynch et al. 1998, Lynch & Balmer 2004). Fossil evidence from Melaleuca Inlet (10 km from the existing population) suggests that this clonal population has been in existence for more than 43,600 years, making it the world's oldest known plant clone (Jordon et al. 1991, Lynch et al. 1998) and giving this species international value in its own right.

Montane rainforests

Most montane rainforests are species rich in comparison with their lowland counterparts. They are rich in primitive plant species as well as endemics. There is a range of communities within this rainforest type, with the coniferous forests identified as priority communities for conservation under the RFA (1997) and described briefly below.

King Billy Pine montane forest/woodland

The long-lived (1000+ years) fire sensitive endemic conifer, *Athrotaxis selaginoides,* dominates small areas of rainforest from mid altitude forests to alpine heaths. Montane King Billy pine forests have been identified as a priority community for conservation under the Tasmanian RFA (1997) because of their sensitivity to fire, restricted distribution, richness in Tasmanian endemics, and primitive and relict species. The TWWHA protects 49% (11,217 ha) of Tasmania's remaining King Billy pine forest. A small part (846 ha) of this vegetation in the TWWHA has an understorey of deciduous beech (*Nothofagus gunnii*). A further 5700 ha of King Billy dominated scrub and heathland also occurs in the TWWHA. This tree species is known to live longer than 1000 years.

Pencil pine montane forests and woodland

About 24,300 ha of montane woodland and forest vegetation is dominated by pencil pine (*Athrotaxis cupressoides*). Some of this (4160 ha) includes deciduous beech (*Nothofagus gunnii*) in the understorey. The most extensive of these forests and woodlands are located on the Central Plateau and most (97%) are in the TWWHA (Table 5.2). Like King Billy pine, pencil pine is a long-lived conifer that does not regenerate after fire. Large populations of pencil pine have been killed by wildfire in the last 100 years. There has also been a general regeneration failure observed on the Central Plateau, which may be caused by grazing pressure from introduced rabbits and native wallabies (Cullen & Kirkpatrick 1988a). This species has a lifespan in excess of 1000 years and short-term regeneration problems are not considered to threaten the conservation of the species in the long term. The forest type has been identified as a priority conservation community under the Tasmanian RFA (1997) because of its vulnerability to threatening processes and its restricted distribution.

As for the King Billy pine montane vegetation, pencil pine forests and woodlands are nationally significant because of their richness in endemics, and primitive and relict species.

[6] * See endnote (page 30) for a more detailed account of succession in rainforest.

Table 5.2: Area in hectares of rainforest vegetation within Tasmanian and the TWWHA. (source TVMP 2005)

Rainforest (rf) type	TWWHA	Tasmania	% in the TWWHA
pencil pine	23,667	24,279	97%
King Billy (KB) pine	16939	28,932	59%
dead KB rf scrub	6959	8587	81%
montane	16,120	18,978	85%
Other rf[7]	242,654	664,919	36%
Total	307,703	747,183	41%

Huon pine rainforests and floodbank forest

Huon pine (*Lagarostrobos franklinii*) rainforest is usually found along river banks, flood plains and the margins of lakes in western Tasmania. It can occur from sea level to 850 m altitude. The total area of Huon pine forest does not exceed 9000 ha (RPDC 2002) but the area of vegetation including scrub containing Huon pines may be as much as 14,000 ha (Peterson 1990). Two thirds of this is within the TWWHA. The largest stand of Huon pine (Davey River) is within the TWWHA.

A small part of the Huon pine rainforest includes vegetation with *Acradenia franklinii* within the understorey. This primitive endemic angiosperm is highly restricted to just a few catchments and to a narrow riparian habitat.

Mature rainforest provides habitat for a great abundance and diversity of non-vascular species (Duncan et al. 1993, Jarman & Kantvilas 1995a). In a study of a single old Huon pine tree, 74 lichen species (including two rare endemics) and 40 species of bryophyte were recorded (Jarman & Kantvilas 1995b).

Huon pine is of scientific importance for dendrochronological studies. It is the longest lived tree in Australia – trees over 3000 years old have been dated – making it one of the longest lived organisms on Earth. Its frequent pattern of vegetative regeneration makes it a species very slow to evolve and change. The longest-lived tree species known is the Californian bristle cone pine. The known oldest tree of this species has been estimated to be older than 4789 years (Benders-Hyde 2000), while the Chilean rainforest species *Fitzroya cupressoides* is known to attain ages of more than 3600 years (Lara & Villaba 1993).

[7] TVMP (2005) has not consistently mapped Huon pine either within or outside the TWWHA and so separate figures for Huon pine rainforest and scrub have not been provided here. Littoral rainforest is not included in these figures but is included under coastal vegetation.

Integrity

The TWWHA contains some of the largest intact tracts of cool temperate rainforest remaining in Australia. In terms of the major structural rainforest types, the TWWHA provides superlative examples of the Tasmanian endemic-rich, implicate, thamnic and montane rainforest communities. The best examples and largest tracts of tall callidendrous rainforest occur outside the TWWHA in the Savage River area (the 'Tarkine') of northwest Tasmania. This rainforest supports some non-vascular flora not common elsewhere for example the endangered and endemic lichen *Menegazzia minuta* is entirely restricted to northwestern rainforests (Grgurinovic 1992, Brown et al. 1994, Lazarus et al. 2003).

The TPLUC (1997) identified that the Mt Dundas–Mt Read area (adjacent to the TWWHA) is a particularly significant refuge for temperate rainforest with the richest assemblage of temperate rainforest species known from any area in Australia. This assemblage includes many primitive relict species with strong Gondwanan affinities. This area has significant populations of all the species that define Tasmanian temperate rainforest.

Rainforest south of Macquarie Harbour was also identified by TPLUC (1997) as warranting further investigation of its inclusion to enhance the sub-theme of the landscape elements of rainforest.

Rainforest is most at threat from fire. One third of King Billy pine populations have been eliminated by fire in just one period of 100 years (Brown 1988). Large populations of other conifers and deciduous beech have also been lost from the TWWHA by fire. Attitudes to fire have changed. The region currently has a fuel-stove-only policy and a fire management plan that includes protection of the fire sensitive vegetation communities as one of its highest priorities.

Disturbance increases the rate of infection by the native pathogen, myrtle-wilt, but unless the gaps associated with dying trees are invaded by exotic species or exotic diseases there is no real risk to the integrity or long-term conservation of the community. Weeds are currently rare in this vegetation and an active weed eradication program in areas with roads will maintain its integrity.

* **A note on successional processes in rainforest**. The process of succession from sclerophyll forests to rainforests is slow (up to 500 years). Rainforest is not achieved until the disturbance requiring plant species have died out leaving only the plants able to grow and regenerate without catastrophic disturbance. The importance of the rainforest element within the community increases over time until the sclerophyll species in the understorey are replaced and a mixed forest is formed (110 years). In some highland situations, the increasing dominance of rainforest in the understorey may lead to the premature demise of the eucalypt over-storey (Ellis 1971). Any major disturbance events, especially fire, advantage the prolific and fast growing sclerophyllous species to the disadvantage of rainforest species provided a seed source is present. Some rainforest conifers and *Nothofagus gunnii* are particularly sensitive to fire and may be eliminated permanently from a site by a single fire (Kirkpatrick & Dickinson 1984). Interestingly, some types of rainforest, such as those dominated by *Athrotaxis* species, can have their range within forest extended by land slips or other localised exogenous disturbance (Cullen 1991, Cullen & Kirkpatrick 1988b).

Fires are rarely able to burn rainforest vegetation. Rainforests are composed of species that decompose rapidly, are not highly flammable and do not transfer fire readily. Wind speed is greatly reduced within a rainforest and the microclimate is generally cool and moist relative to the external weather. Rainforests occupy topographic locations protected from fire or regions in which fires are rare. Hence, although the vegetation landscape is dynamic, the dynamism is extremely slow. For example, there is good evidence that King Billy pine is replacing pencil pine in a rainforest on Mt Read, a succession that could take more than one thousand years.

Nothofagus cunninghamii is the most widespread dominant of Tasmanian rainforests, yet this species is not the most shade tolerant climax species (Read 1985a). Rather it occupies its dominant position by sheer size, fast growth and successful seed germination in the gaps created by tree fall or death (Read 1985b).

Kantvilas (1990) has documented succession in lichen communities within rainforest, a process observable on individual trees as they age. As many as 20 crustose lichen species may be the first colonisers of newly grown twigs. As the twig grows and it's bark fissures grey foliose lichens begin to dominate. Several other stages follow as the trees grows and ages until on an old mature trees as many as 76 species may occupy a single tree (Jarman and Kantvilas 1995).

6. Sclerophyll communities

The sclerophyll vegetation of the TWWHA meets three of the four natural criteria necessary for inscription on the World Heritage register. Natural criterion (ii) is met by the on-going natural processes of succession within the vegetation. These progress from the pyrogenic fire sere communities of buttongrass moorland through sclerophyll scrub, forests, mixed forest to climax cool temperate rainforest. The region provides the world's most superlative examples of mixed eucalypt forest, a stage in the succession from wet sclerophyll forest to climax rainforest (Helsham et al. 1988[8], Wells & Hickey 1999).

In the 1988 nomination for World Heritage listing of the Western Tasmanian Wilderness, sclerophyll communities were considered to be of World Heritage significance in relation to on-going speciation within the *Eucalyptus* genus. It is now recognised that better examples of hybridisation and introgression occur elsewhere and that speciation in *Eucalyptus* is better presented in the Greater Blue Mountains Area which has a far greater number of *Eucalyptus* species present in the listed area (NSW NPWS and EA 2000, UNESCO 2003).

Tall eucalypt forests provide the world's best examples of distinctive evolutionary features that enable the dominant sclerophyll trees to survive in areas where the climatic climax vegetation is rainforest (Helsham et al. 1988). These traits together lead to the 'hot fire paradox' and include exceptional growth rates, flammability, and phenomenal height (Helsham et al. 1988). The TWWHA contains larges areas of tall eucalypt forests in a wilderness setting. These evolutionary traits are of World Heritage significance.

Natural criterion (iii) is met by the TWWHA tall open-forest communities, which provide visually majestic examples of mixed forest with eucalypts towering up to 86 m above a rainforest understorey. This extreme height is reached by several species. The eucalypt species with the greatest recorded height is *Eucalyptus regnans*, which has been recorded to heights of over 100 m in Victoria and is the world's tallest flowering plant (Mifsud 2003).

Wet sclerophyll forests are unique to Australia (Ashton 1981a). This ecosystem type includes 'mixed forest', the best examples within a wilderness context are those found within the TWWHA. These forests have the greatest species richness and highest levels of endemism of any mixed forest in Australia. Together these factors enable them to meet natural criterion (iv). Overall the TWWHA sclerophyll vegetation is an important habitat for at least 92 Tasmanian endemic plant species including 17 endemic eucalypts, with several major genetic clines recognised between species (Williams & Potts 1996). This vegetation supports 12 threatened plant species and several threatened fauna (*TSP Act 1995*).

[8] The minority report by Commissioner Hitchcock found in favour of tall forests having World Heritage Value.

Background

The Australian continent is remarkable for the diversity and dominance of scleromorphic vegetation. The scleromorphic vegetation within the TWWHA ranges from heathland to tall forests. Within the TWWHA there is a continuum between heathland and sedgeland. The sedgeland heaths and heathy sedgelands of the TWWHA are referred to as buttongrass moorland and are described in detail in section 7, 'Buttongrass moorland'. Scrub is an integral part of the dynamic vegetation successional sequence within the TWWHA, however other aspects of its significance are not known. Scrub, while occupying large tracts within the TWWHA (110,300 ha, see Figure 7.1), has not been the focus of a statewide survey and classification and is therefore not discussed here.

This section focuses on the identification of significant values within eucalypt-dominated forests and woodlands of the TWWHA (390,300 ha, see Table 6.1 and Figure 6.1). The most significant components of this vegetation are the tall mixed forests and montane woodlands.

Justification

Cool temperate forests cover less than eight million square kilometres between latitudes 32 and 60 degrees. Those of the northern hemisphere are largely deciduous or coniferous forests and most have been heavily modified, with virgin forests now restricted to remnant pockets (Thorsell & Sigatty 1997). Within the southern hemisphere, temperate forests are more commonly sclerophyllous with the greatest extent occurring in Australia (Ovington and Pryor 1983). The Australian sclerophyll forests, which include tall open-forests, are unusual in being almost exclusively dominated by eucalypts (Ashton 1981a). This is a taxon with phenomenal species diversity being represented in Australia by about 700 endemic species. Twelve eucalypt species have a distribution that extends beyond Australia of which only two are not found in Australia. The genus gives Australia a distinctive smell and character. It is a keystone taxon in Australia's vegetation ecology.

The floristic, structural and ecological distinctiveness of the Australian sclerophyll forests in a global context make it unnecessary to provide a formal comparison of the Tasmanian sclerophyll forests with regions outside Australia.

Table 6.1: Area in hectares of sclerophyll vegetation types within Tasmania and the TWWHA. (source TVMP 2005)

Vegetation type	TWWHA	Tasmania	% In TWWHA
Wet ash forest[9]	90,304	767,397	12%
All other wet eucalypt forest types[10]	23514	55846	42%
E. nitida forest[11]	174,848	295,373	59%
TWWHA dry forest types[12]	18,337	714,076	3%
Subalpine woodland[13]	83,292	155,259	54%
Acacia forest[14]	1109	72,496	2%
Tea-tree forest	48,183	63,211	76%
other dry forest types[15]	0	775,915	0%
total	439,587	2,899,573	

Comparative assessment within the biogeographic realm of Australia

Both 'scleromorphy' and 'eucalypt dominated vegetation' are recognised as sub-themes within the universally significant Australian theme 'evolution of landforms, species and ecosystems under conditions of stress' (TPLUC 1997a).

There are now six universally significant forest sites listed as World Heritage within Australia. These include the TWWHA, which is in a separate biogeographical province to the other sites. Four of the sites, Greater Blue Mountains Area (GBM), Central Eastern Rainforest Reserves, Wet Tropics and Fraser Island, are in the eastern sclerophyll biogeographic province. The sixth site is Kakadu, which has the least in common with the TWWHA.

In addition to the forest sites now inscribed on the World Heritage list, several other Australian regions have superlative examples of eucalypt dominated vegetation. Of particular note are the *Eucalyptus diversicolor* (karri) forests of south-west Western Australia, the eucalypt forests of the Central Highlands in Victoria and the montane forests and woodlands of the Australian Alps.

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9 Ash forests are those dominated *by Eucalyptus delegatensis, E. obliqua* and *E. regnans.*
10 Excluding *Eucalyptus nitida* and ash forest types.
11 Includes both wet and dry forest types.
12 *Eucalyptus dalyrmpleana, E. delegatensis, E. obliqua, E. ovata, E. rodwa*yi and *E. tenuiramis* dominated dry forest and woodland.
13 Woodland dominated by *Eucalyptus coccifera, E. gunnii* and *E. pauciflora.*
14 Includes *Acacia dealbata* forest and *A. melanoxylon* forest on slopes.
15 Includes all Tasmanian dry eucalypt and non-eucalypt forest types not present within the TWWHA.

Despite the presence of these phenomenal examples, in 1997 TPLUC advised that the TWWHA and Kakadu National Park provide the world's best examples of the sub-theme 'eucalypt dominated vegetation'.

They also suggested that the TWWHA should be included in any serial nomination of Australian sites demonstrating the sub-theme 'eucalypt dominated vegetation'. Their recommendation was undoubtably based on the presence of the most extensive and superlative examples of tall open eucalypt forest with a rainforest understorey in a wilderness setting ('mixed forest', Gilbert 1959).

Most wet sclerophyll vegetation in temperate Australia is structurally classified as tall open-forest, from here on referred to as 'tall forest' (Specht 1970). Although not all tall forest is wet sclerophyll vegetation, it is the component that is relevant here. These forests consist of a sclerophyllous tree dominated canopy over an understorey of mesophyllous shrubs, trees or rainforest and often exceed 41 m in height. The greatest remaining extent of tall forest is in NSW (3.7 million ha), followed by Victoria (2.2 million ha) and Tasmania (0.84 million ha, Bureau of Rural Sciences 2003)[16]. Table 6.1 gives the extents of different sclerophyllous forest and woodland types within the TWWHA and Tasmania.

Tasmania's tall forest as a whole are not as diverse or scientifically important as other regions in terms of plant community richness, vascular plant species richness or in the richness of the sclerophyllous flora. The GBM, the Wet Tropics and the Central Eastern Rainforest Reserves include 86, 85 and 81 species of *Eucalyptus* respectively, compared with only 20 species in the TWWHA. The only threatened eucalypt taxa in the TWWHA is *Eucalyptus radiata* subsp. *robertsonii*, listed as rare (*TSP Act 1995*), and the most restricted eucalypt in the TWWHA is *E. archeri* (Briggs & Leigh 1988), but even this is now considered to be greater than 100 km (Williams & Potts 1996).

The TWWHA tall forest flora includes 385 of Tasmania's 496 wet forest vascular plant species (Table 10.2 in section 10). About a quarter of these plants are also considered to be rainforest species (*sensu* Jarman & Brown 1983). Sclerophylly is not well developed since the understoreys are mesophyllous. Table 6.2 shows the representation of the most important Australian sclerophyllous families in the Tasmanian wet forest flora. The TWWHA flora includes 78 species (121 for Tasmania) and is low compared with the GBM and the Wet Tropics, which have 481 and 934 species in these families respectively (NSW NPWS and EA 2000). The TWWHA has only 158 species in these families across all habitat types. Tasmania's forests are also species poor in comparison with the karri forests of south-west WA, which occur in one of Australia's richest botanical provinces.

Table 6.2**:** Number of species in important Australian sclerophyllous families in Tasmanian wet forest and the TWWHA.

Sclerophyll families	**TWWHA wet forest**	**Tas. wet forest**	**TWWHA all habitats**
Epacridaceae	26	37	61
Fabaceae	9	16	19
Goodeniaceae	2	4	5
Mimosaceae	3	8	7
Myrtaceae	23	35	33
Proteaceae	12	14	20
Rutaceae	3	7	13

While the TWWHA includes at least 31 wet and 15 dry eucalypt forest communities and a number of grassy woodlands, this diversity of communities is exceeded by the GBM (56 communities of eucalypt forest and woodlands).

Eucalypt trees are architecturally unusual among the world's trees, having a very sparse open canopy, which allows 40 to 60% of sunlight to reach the understorey (Nunez 1985, Blakers 1987, Helsham et al. 1988). The consequence of this in high rainfall regions is the development of dense understorey vegetation beneath which eucalypt seedlings are unable to regenerate due to insufficient light. Fire or other catastrophic disturbance is required to clear the understorey so that the eucalypts can regenerate (Ashton 1981ab). It is probable that the phenomenal canopy height achieved by eucalypt species in wet forests has evolved in response to the need not only to avoid competition for light from understorey species (Ashton 1981b, Helsham 1988) but to protect their seed capsules from the heat emitted from the understorey when it burns. The separation of the understorey from the canopy often results in the two strata burning separately. The capsules provide sufficient insulation to protect seeds from canopy fires because these fires, while intense, have a short residence time of only a few seconds (Mutch 1970, Ashton 1987).

Traits that promote fire spread and intensity include decorticating bark, leaves and limbs that are extremely slow to decompose when shed and highly volatile oils in the leaves. The hot fire paradox is that the evolution of these traits has led to fires of such intensity that the canopy trees are often killed at the same time as the understorey is cleared (Mutch 1970, Ashton 1981a). While destroying the vegetation, the fire provides an ash bed for the next generation of eucalypts that have evolved a phenomenally fast seedling growth rate due to competition for light (Jackson 1968).

[16] TVMP (2005) estimate that there is an area of 1.07 million ha of wet eucalypt forest and woodland in Tasmania of which 26% is in the TWWHA.

The best expression of these evolutionary characteristics were considered by Hitchcock to be tall eucalypt forests (greater than 41 m in height) with a tall rainforest understorey in the high rainfall regions of Tasmania.

The species of dominant trees best representing the hot fire paradox were considered to be *Eucalyptus regnans* and *E. delegatensis* since they are the most fire sensitive (Ashton 1981a, Helsham et al. 1988).

Tasmania currently has the tallest trees in Australia. The world's tallest recorded flowering plant is *Eucalyptus regnans,* reaching heights of greater than 110 m in Victoria last century (Ashton 1981b). Most of Victoria's tall forests were burnt in 1939 creating extensive areas of single-age regrowth forest (Ashton 1987). At present, the tallest known Australian tree is in the Andromeda stand in the Styx Valley of Tasmania, outside the TWWHA. It is recorded as 96 m in height (Misfud 2003, Giant Trees Consultative Committee 2004). The Andromeda stand is the state's tallest, with seven of the Tasmania's 10 tallest trees occurring within.

The tallest tree in Victoria is currently measured as 91.6 m, which is taller than any so far recorded within the TWWHA. As Victoria's regrowth forests become mature it is likely that taller trees will emerge. The tallest tree in Victoria is part of a very tall stand of *Eucalyptus regnans* known as 'the Big Ash' in the Wallaby Creek Catchment of Kinglake National Park located in the Victorian Central Highlands. This site demonstrates the phenomenal potential of eucalypt forest productivity. The stand is about 100 ha and includes at least 26 trees greater than 85 m in height (Mifsud 2003). It is part of an extensive catchment area of undisturbed old-growth forest protected from logging in part because of its importance as a water catchment area. It includes *Eucalyptus regnans* and *E. obliqua-E. regnans* wet sclerophyll and mixed forest communities.

While the TWWHA does not currently have the tallest individual trees in Australia it does include a large extent of very tall forest. The tallest trees species present within the area are *Eucalyptus regnans* and *E. obliqua.* One *E. regnans* tree reaches 86 m in the remote Upper Coles River Valley (Kostaglou 2000, Hickey et al. 2000). Another region of the TWWHA with immensely tall trees is the Beech Creek–Councel River area, which is dominated by *E. obliqua* and *E. delegatensis* with at least one tree reaching up to 86 m and another 10 trees known to be greater than 75 m). There are six trees recorded from near Wayatinah that are taller than 75 m (Forestry Tasmania's Giant tree register, September 2004, GTCC 2004). Towering old growth giants such as these have been the subject of media attention for more than a decade and have inspired photographic interest from both nationally and internationally renowned photographers. The superlative height and elegant architecture of these flowering trees is phenomenal on a world scale.

These plants are of interest to science, providing an evolutionary example of gigantism which reflects an extreme in ecological adaptation. They are iconic, inspiring human wonder at the ingenuity and beauty of nature. An aesthetic description of tall eucalypt forest over rainforest is provided in section 5, 'Temperate rainforest'.

The significance of the TWWHA tall forests rests not on the presence of individually tall trees, although it does have some very good examples, but on the extent of very tall forests with rainforest understoreys located within a large wilderness region. The greatest extent of temperate mixed forest in Australia is in Tasmania (more than 168,000 ha, TVMP 2005), with comparatively small, isolated patches occurring in Victoria and NSW (Wells and Hickey 1999, Bureau of Rural Sciences 2003). A large proportion (82%) of Tasmania's reserved mixed forest occurs in the TWWHA, which protects the full range and diversity of this ecosystem in Tasmania (137,000 ha, TVMP 2005).

The largest extent of subalpine forests and woodlands on the Australian mainland occur in the Victorian Alps and Kosciusko National Park. Kirkpatrick (1994b) suggested that the most superlative feature of the Alps region was the catena of eucalypt-dominated forest and woodland, which extends from 100 m above sea level to the treeline. The extent and diversity of the subalpine woodlands of the TWWHA are similar to the Australian Alps but have greater integrity. Cattle grazing in the Victorian Alps has led to the degradation of some woodland bogs and fens (Wahren et al. 1999) and the presence of weeds (*Salix cinerea,* Whinam et al. 2003b; *Juncus effusus,* McMorran 2002). Commercial horse-riding and feral horses have also resulted in degradation to parts of the Australian Alps, including some woodland areas (Walsh et al. 1986, Vollbon 1990).

The dominance of open crowned evergreen angiosperms in the upper slope treeline is unique to Australia. The Tasmanian endemic *Eucalyptus coccifera* dominates this treeline in Tasmania, while *Eucalyptus niphophila* occupies this niche on the Australian mainland. Another eight eucalypts are present within the montane and subalpine forests and woodlands of the TWWHA, of which only *E. pauciflora* is not a Tasmanian endemic (Kirkpatrick & Gilfedder 1999).

The natural succession from moorland through sclerophyll forests to rainforests is considered an internationally significant example of seral succession (Evans 1975, Noble and Slatyer 1981). Evidence of the successional dynamics is provided by the spatial arrangement of each of the vegetation types in the landscape.

The moorlands occupy the most fire prone regions and have fire histories of the greatest fire frequencies, while at the other extreme rainforests tend to occupy areas topographically protected from fires such as slopes with southeastern aspects, river valleys and gullies.

The western Tasmanian vegetation successional sequence has a greater number of physiognomically and floristically distinct stages than any other known example of secondary succession through relay floristics (Noble & Slatyer 1981).

The TWWHA provides a large natural area (1.38 million ha) in which these processes can occur. The elements of the successional process within the scleromorphic flora have their best representation within the TWWHA. The area includes all stages in the successional process, but notably buttongrass moorlands, mixed forests and cool temperate rainforest have their greatest extent and best expression in the TWWHA.

The process takes place in a 'perhumid' climate within a region dominated by extreme infertility. It is unusually complex and involves feedback between edaphic factors (oxygenation, hydrology and nutrients), vegetation and fire, across five structurally and floristically distinctive seral vegetation stages – buttongrass moorland, scrub, wet eucalypt forest, mixed forest and rainforest (either angiosperm or conifer dominated). The global importance of Tasmania's successional processes is acknowledged with the establishment of the Warra long-term ecological monitoring site, which has an altitudinal transect from the lowland flats outside the TWWHA up to the top (1300 m) of Mt Weld (Brown 1998, Brown et al. 2001, Doran et al. 2003).

As the TWWHA provides the best examples of mixed forest montane and subalpine woodlands, their unique flora and threatened species are consequently of international significance. Only one species within these sclerophyll floras, *Lomatia tasmanica,* a riparian species present in mixed forest, is listed on the national schedule for the *EPBC Act 1999.* It is listed as critically endangered (see section 5, 'Temperate rainforest'). Eleven other threatened vascular plant species are listed under the *TSP Act 1995,* all as rare: *Acacia mucronata* subsp. *dependens, Australina pusilla* subsp. *muelleri, Centaurium spicatum, Deyeuxia benthamiana, Eucalyptus radiata* subsp. *robertsonii, Persoonia gunnii* var. *oblanceolata, Senecio velleioides, Thismia rodwayi, Veronica plebeia, Viola hederacea* subsp. *curtisiae* and the riparian and wetland species *Baumea gunnii.*

Dry forests and subalpine forests and woodlands of the TWWHA also support at least two threatened species. *Westringia angustifolia* and *Viola hederacea* subsp. *curtisiae* are listed as rare on the *TSP Act 1995*. The number of threatened species supported by the sclerophyll forests and woodlands of the TWWHA is very low in comparison to those occurring the Greater Blue Mountains Area (127 taxa) (NSW NPWS and EA 1998).

The TWWHA sclerophyllous flora is distinctly different from other World Heritage sites in Australia, having low similarity scores to these other sites (NSW NPWS and EA 2000). In part this may be attributed to a relatively high proportion of endemic species, particularly in the subalpine forests and woodlands (which includes alpine species) and the wet forest flora (which includes rainforest species). In terms of endemicity, the wet sclerophyll flora recorded in the TWWHA comprises 88 species endemic to Tasmania (25% of the wet forest flora of the TWWHA). The total number of endemics for all sclerophyllous forests is likely to be higher and may well be similar to that recorded for the GBM, which has 114 endemic plant species (NSW NPWS and EA 1998, 2000).

The TWWHA, and Tasmania in general, have relatively low species richness in the genus *Eucalyptus*. Nevertheless, eucalypts of Tasmania show a high proportion of endemism. Of the 29 Tasmanian eucalypts 17 are restricted to the state. In the TWWHA, 20 of the Tasmanian eucalypts can be found naturally: *Eucalyptus amygdalina*, E. archeri**[s]*, E. brookeriana, E. coccifera**[s]*, E. dalrympleana, E. delegatensis* subsp. *tasmanica**[s]*, E. globulus, E. gunnii**[s]*, E. johnstonii*, E. nitida*, E. obliqua, E. ovata, E. pauciflora*[s]*, E. regnans, E. robertsonii subsp. radiata*, E. rodwayi*, E. subcrenulata**[s]*, E. tenuiramis*, E. vernicosa**[s] and *E. viminalis* (*denotes taxonomic endemism, [s] denotes a montane and subalpine species). Fifty-four eucalypts out of a total of 91 within the GBM are not found in other World Heritage sites, while five are shared with the TWWHA (NSW NPWS and EA 2000).

Many of the TWWHA eucalypt species regularly hybridise, and clinal variation is observable for several of the closely related species. The two alpine white gums, *Eucalyptus gunnii* and *E. archeri,* form a species cline that is the subject of on-going research into evolutionary processes (Potts et al. 2001). They are two of the most frost tolerant species of eucalypt and are therefore superlative examples of the evolution of a scleromorphic species in response to stress. These species are also of national cultural significance as they provided the only known source of alcoholic beverage for the Tasmanian Aborigines (Cosgrove 1984).

The yellow gum complex incorporates *Eucalyptus vernicosa, E. subcrenulata* and *E. johnstonii*, which Jackson (1960ab) observed to vary across a continuum. The complete spectrum of variation for this complex occurs on a single mountain, Mount Arrowsmith, in the TWWHA. These three species are endemic to Tasmania and, while they are all closely related, there is significant variation in their morphology (McGowen 2000, McGowen et al. 2001).

Surprisingly, recent DNA analysis has shown that this cline is a result of morphological convergence over time associated with at least two different gene pools (McGowen et al. 2001).

Eucalyptus globulus is commercially grown in numerous countries globally and is one of the most intensively studied forest tree species in the world (Potts and Reid 2003).

Traits associated with long isolated populations of this species, such as the stand that occurs at Settlement Point, Port Davey, in the TWWHA, are therefore of great scientific and commercial interest. Conservation of this gene pool is of international importance.

In addition to supporting endemic and threatened plant species the sclerophyll habitats of the TWWHA are also important breeding and foraging habitat for several endemic or threatened fauna. These include the threatened marsupial *Dasyurus maculatus* (spotted-tail quoll) and all five of Tasmania's endemic mammals (Driessen & Mallick 2003). Invertebrates include the threatened southern hairy red snail (*Austrochloritis victoriae*), the threatened giant velvet worm (*Tasmanipatus barretti*) and representatives from the primitive moth family Hepialidae, many being endemic (Bryant & Jackson 1999). Several threatened raptors, wedge-tail eagle (*Aquila audax*), grey goshawk (*Accipiter novaehollan*diae), as well as the masked owl (*Tyto novaehollandiae*) occur in the TWWHA. *Eucalyptus nitida* sclerophyll forests provide breeding habitat for the endangered orange-bellied parrot (*Neophema chrysogaster)* the rarest parrot in the world. The vulnerable swift parrot *Lathamus discolor* feeds in the wet blue gum forests of the TWWHA as it migrates from their breeding habitat in eastern Tasmania to their winter habitat on the Australian mainland. A total of nine of Tasmania's 11 endemic bird species are also found within the sclerophyll habitats of the TWWHA (Driessen & Mallick 2003).

Integrity

Sclerophyll forests and woodlands account for more than 32 % (0.44 million ha) of the TWWHA (TVMP 2005). Tall (>34 m) and very tall forests (>41 m) are well reserved in the TWWHA, which has about 127,614 ha of the Tasmanian tall forests (Forestry Tasmania SWIFT map data 1988, Balmer unpublished).

The tall forests of the TWWHA form part of one of the most pristine temperate forests in the world. Their reservation within a substantial area of wilderness is significant as it allows the natural regeneration and associated successional processes to continue in a largely uninterrupted manner. The addition of the Beech and Cook Creek areas as well as several other forest areas into National Parks at the boundary of the TWWHA has improved the integrity of tall forest values. In all 10,510 ha of additional sclerophyllous forest together with 9575 ha of other vegetation has been reserved on the TWWHA boundary (see Table 6.3).

About 2240 ha (less than 5%) of tall *Eucalyptus regnans* forest in Tasmania occurs within the TWWHA (Species SWIFT mapping 1987, TVMP 2005). Other tall tree species have greater areas represented within the TWWHA (23% of *E. delegatensis* wet forest*,* 6% of *E. obliqua* wet forest*,* 67% of *E. nitida* wet forest and 42% of other wet forest)(TVMP 2005).

Most tall forests with immensely tall trees (> 75 m in height) occur outside the TWWHA boundaries with only four tall forest areas known within the TWWHA and one other area in a National Park (the Growling Swallet stand in Mt Field National Park). Tall forest areas with superlatively tall trees near the TWWHA include: the Styx Valley, Councel Creek, Manning Rd and Lower Coles Valley (Giant Tree Register, Forestry Tasmania). Tree heights change with time and the presence of forests in the TWWHA with the potential to produce such tall trees is considered to be the important factor.

In general, the sclerophyll communities are relatively robust in comparison to rainforests and alpine areas. Nevertheless, inappropriate fire frequency, especially the complete cessation of burning, is perhaps the greatest threat to the integrity of sclerophyllous communities (Brown 1996). Dieback in eucalypt trees of the TWWHA is widespread but is likely to be natural in most instances. The ecology and causes of eucalypt dieback within the TWWHA is not well understood but in some areas may relate to drought or competition as rainforest species become dominant in the understorey (Ellis 1964, Ellis 1981, Old 2000). The implications for management of this vegetation require further study.

Table 6.3: Area (ha) of forest types within RFA reserves adjacent to the TWWHA.

Location	*Acacia dealbata* forest	*Athrotaxis selaginoides*	*E. coccifera*	*E. delegatensis* dry forest	*E. delegatensis* wet forest	*E. nitida* dry forest	*E. nitida* wet forest	*E. obliqua* dry forest	*E. obliqua* wet forest	*E. pauciflora* forest not on dolerite	*E. regnans* wet forest	*E. subcrenulata* wet forest	Huon pine	Non-forest	Short rainforest	Tall rainforest	Grand total
Beech Ck - Counsel R				270	1760				7					320	615	951	3924
Blakes Opening			10		13	42		64	2461		3		1	631	351	140	3715
Catamaran						24	108	7	33					218			390
Cook Rivulet			134	13	63				6					54	64		335
Counsel R				45	5									86			135
D'Entre-casteaux R						34	46	304	306					749	8		1447
Devils gullet	41		66	6	112									76			301
Dove R		8		24	10									110	163	5	319
East Cockle Ck						86	73	561	811					629	15		2174
East Picton					10			10	305					77		3	405
Farmhouse Ck		28				45	65		31					149	16		334
Hartz Hole				34	116			33	337		96			281	279	35	1212
Hastings						27		23	23					11	2		86
Hastings Cave		14						2	365					15	674	87	1156
Little Florentine R				74	85			19	17			9		426	165	24	819
Mersey Valley 1& 2					12												12
Mersey Valley 2					48									36		12	96
Navarre Plains			4	155	57					24				514	5		760
Nelson														53			53
Nelson Falls														272			272
Styx R				110	46		1	8	104		163			158	148	279	1017
Tiger Range				75	240			43	103		42			65	182	372	1123
Total	41	50	214	806	2578	258	294	1075	4908	24	303	9	1	4929	2688	1908	20,085

Figure 6.1: Distribution of sclerophyll forest and woodland vegetation types occuring in the TWWHA (source TVMP 2005). (Note mapping categories not occurring in the TWWHA have been excluded from this map).

7. Buttongrass moorland

Buttongrass moorlands have been recognised as containing values of international significance that meet all four of the natural criteria required for inscription on the World Heritage register.

Criterion (i) is met through the development and on-going accumulation of significant peatlands. This is a complex process that involves the combination of floristic, geomorphic and climatic variables (see Sharples 2003 for further detail).

The process of vegetation succession and the impacts of fire in the Australian environment are exemplified in the buttongrass moorlands. Many species provide superb illustration of the development of scleromorphy in response to the stress of high fire frequency and low nutrients. Hence this vegetation meets natural criterion (ii).

Australia's extensive plains and vast buttongrass peatlands are largely undisturbed by development and their pristine nature and unique floristic characteristics make them an unmatched phenomenon, meeting natural criterion (iii).

Buttongrass moorlands provide habitat for a number of fauna and flora species not found outside this vegetation formation, as well as taxa of ancient origins. They are rich in endemic species and include one vascular plant species listed nationally as vulnerable, *Centrolepis pedderensis* (*EPBC Act 1999*), and a further seven species that are listed on the state schedules (*TSP Act 1995*). No close analogue for this vegetation formation occurs outside Australia. Within Australia this ecosystem has its best expression in the TWWHA and it thereby meets natural criterion (iv).

Background

Buttongrass moorlands are communities dominated by the large rosette tussock sedge, *Gymnoschoenus sphaerocephalus* (buttongrass) which is 50 cm or more in height and diameter and may reach heights of nearly two metres. The terms 'tussock sedgeland', 'hummock sedgeland', 'heathy-sedgeland' and 'wet heathland' have also been applied to this vegetation (Jarman et al. 1988a).

Decomposition is slow in buttongrass moorlands because of the cool maritime climate, the high rainfall and the anaerobic, strongly acid conditions that result from waterlogging. These factors inhibit oxidation and consequently act as a partial preservative of dead organic matter (Brady 1990). This, in combination with the low-nutrient availability of ancient Precambrian rocks upon which a scleromorphic flora has developed, has given rise to a unique peatland type (see Sharples 2003 for further details).

The vast majority of the world's peatland ecosystems occur in the northern hemisphere where the most common peat forming plant is *Sphagnum* moss (Gore 1983ab). Unlike these systems, the major peat forming plants in Tasmania are sedges from the families Restionaceae and Cyperaceae.

The typical sapric muck peats found in buttongrass moorlands are probably generated from the partial decomposition of roots of scleromorphic graminoids. In situations where more shrubs are present a more fibric peat develops from the partial decomposition of wood. The highly humified state of most buttongrass peats is probably caused by the periodic summer droughts, which may allow an acceleration of decomposition.

Buttongrass communities have been classified by Jarman et al. (1988a) on the basis of floristic composition and structure, topography and climatic variables.

The two main types – eastern moor and blanket moor – reflect the gradient in climate, topography and floristics from the west to the east of the state.

Justification

Comparative assessment within the biome

The peatland systems of Tasmanian buttongrass moorlands are distinct from the more extensive blanket bogs of the northern hemisphere, which are formed primarily from *Sphagnum* moss. However in ombrotrophic situations in the northern hemisphere the tussock forming sedge genus *Eriophorum* (Cyperaceae) may become dominant in blanket bogs in the absence of *Sphagnum* (Firbas 1931 cited in Ingram 1983). Such vegetation was not described for the temperate zone within Gore (1983b) but is important in more northerly latitudes with permafrost. *Eriophorum* dominated hummock sedgeland within the temperate zone is not well documented in the published literature and so a comparative assessment is difficult.

There do not appear to be any hummock sedgelands comparable with those of the Australian buttongrass moorlands elsewhere in the Southern Hemisphere. New Zealand does have some peatlands formed from *Empodisma* (Restionaceae), a species of importance within the Tasmanian peatlands, but they are not dominated by a hummock sedge. A greater diversity of species contributes to peat formation in the Tasmanian moorlands, which are more extensive and have greater integrity than those of New Zealand (Campbell 1983).

The largest temperate peatland complex in the southern hemisphere is that of Tierra del Fuego and southern Chile, termed 'Magellanic tundra', which covers over 2000 km^2. This peatland complex has a diverse structural composition but the major peatland types are *Sphagnum magellanica*, ombrotrophic bogs and montane bogs dominated by cushions and herbs. The sedge dominated blanket bogs of the lowland coastal region include associations dominated by *Schoenus antarcticus* (magellanic bunch sedge, Cyperaceae) or *Marsippospermum grandiflorum* (Juncaceae). These species, while caespitose, are much more diminutive than the sedge dominants of the Tasmanian moorlands. The peat soils underlying the South American bogs are eutrophic, structurally distinct and do not include extensive areas of black sapric muck peats of the Tasmanian ecosystem. The Magellanic tundra occurs within a glaciated landscape in which soils regularly freeze in winter (Pisano 1983).

Comparative assessment within Australia

Buttongrass moorlands occur in isolated poorly drained boggy valley plains in Victoria and New South Wales but have their greatest extent and diversity in Tasmania. On the Australian mainland buttongrass moorlands are largely restricted to drainage lines and flats and do not form the extensive blanket bogs that occur in western Tasmania.

The ecological significance of Tasmanian buttongrass moorlands

In western Tasmania they may dominate the landscape, extending from valley plains up slopes to mountain plateaus and ridge tops. Buttongrass moorland abruptly changes to alpine moorland on many mountains in southwest Tasmania (Kirkpatrick & Brown 1987), this boundary being related to a frequent inversion layer (Kirkpatrick et al. 1996).

The Tasmanian buttongrass flora provides examples of scleromorphic plants and communities that have evolved in association with extreme nutrient stress, waterlogging and fire. The moorlands are highly pyrogenic and may burn at any time of year after only two rain-free days. The moorland may be the most flammable vegetation type in the world, burning at higher fuel moisture levels than any other community for which these data have been recorded (Marsden-Smedley et al. 1999).

Species occurring in buttongrass moorlands have physiological adaptations to the dual stresses of waterlogged anaerobic nutrient-poor soils and frequent fire (e.g. the ability to reabsorb phosphorus from leaves, rhizomatous habit and vegetative regeneration). Buttongrass itself has the lowest recorded phosphorus levels in its foliage of any plant species for which this datum is available (MacLean 1978, Bowman et al. 1986).

Both fire frequency and time since fire are significant factors in the determination of floristics and structure in buttongrass moorland vegetation (Brown & Podger 1982a, Brown et al. 2002). The study by Jarman et al. (1988a) revealed that some buttongrass moorland communities appear to be successional stages, but the successional dynamics within buttongrass moorland vegetation remain poorly understood. Buttongrass moorland vegetation occurs within a mosaic of scrub and forest communities with moorland occupying the most frequently burnt areas.

Buttongrass moorlands are the first stage in the successional sequence towards rainforest and, together with other parts of this landscape, meet natural criterion (ii) being an on-going natural process of international significance (see section 6, 'Sclerophyll communities').

Extensive tracts of both eastern and western buttongrass moorland occur within the TWWHA.

The buttongrass moorland landscape is characterised by undulating hills clothed by blanket peats, which form a memorable vista. The folded quartzitic topography is accentuated by slanting rays of sunshine and shadow. Extensive buttongrass moorlands dominate the landscape of the TWWHA. The aesthetics of buttongrass moorlands meet natural criterion (iii).

Buttongrass moorlands contain a diverse flora with more than 206 species typical of moorlands of which at least 195 are in the TWWHA. There are several species that are entirely confined to Tasmanian blanket moorland communities and are well represented within the TWWHA. They include *Epacris corymbiflora, Euchiton poliochlorus, Gaimardia amblyphylla, Haemodorum distichophyllum, Hydatella filamentosa, Isoetes* sp. *nova* 'Maxwell River', *Milligania johnstonii, Oreobolus tholicarpus, Oschatzia saxifraga, Schoenus biglumis* and *Winifredia sola.* There is also a relatively high level of endemism exhibited, with 38% of species within blanket moor being Tasmanian endemic and 17% in eastern moor (Balmer unpublished data, Jarman et al. 1988a).

Some moorland species are from families that have disjunct Southern Hemisphere distributions suggestive of ancient origins including Cunoniaceae, Haemodoraceae, Proteaceae, Restionaceae, Rutaceae and Stylidiaceae. Of these only Cunoniaceae and Proteaceae have fossil evidence to support their presence in Tasmania from ancient times (see section 3, 'Primitive flora and refugia'). However, the diversity of most of these groups is greater in the wetlands and wet heaths of Western Australia and South Africa than it is in the Tasmanian buttongrass moorlands.

The buttongrass flora includes several threatened species. Only one species, *Centrolepis pedderensis*, is listed nationally as vulnerable. This species and *Rhytidosporum inconspicuum* are listed as endangered on the state schedule (*TSP Act 1995*) while six other threatened species are listed as rare (*Ambuchanania leucobryoides, Comesperma defoliatum*, *Euchiton poliochlorus, Isoetes* sp. *nova* 'Maxwell River', *Milligania johnstonii,* and *Persoonia moscalii*).

Buttongrass moorland is the stronghold of the ground parrot, *Pezoporus wallicus*, one of only four ground-nesting parrots in the world.

The endangered orange-bellied parrot *Neophema chrysogaster*, feeds in buttongrass moorlands within southwest Tasmania during summer (Brown 1993, Driessen & Mallick 2003).

Few mammals in Tasmania are restricted to buttongrass moorlands but the broad-toothed mouse (*Mastcomys fuscus*) has its greatest populations in buttongrass moorlands of the TWWHA (Driessen 2002). Likewise the swamp *Antechinus minimus* is common in buttongrass moorlands of the TWWHA but on the Australian mainland it is restricted to coastal habitats that are threatened by human activities.

The lack of analogues for buttongrass moorlands outside Australia, combined with the high level of endemism and species diversity of those within the TWWHA, enables this vegetation to meet natural criterion (iv) for WHA listing.

Significant features of the buttongrass moorland ecosystem

Alkaline pans

Alkaline pans are sparsely vegetated depressions associated with outcropping limestone or dolomite, that have a medium to high pH. These pans form scattered habitat islands within the predominantly acidic peatlands. The pH may range from 3.5 on the buttongrass moorland peat soil to 9.0 on the exposed gravel of the pan over a distance of less than one metre. Strong patterning in the vegetation is associated with this pH gradient.

Alkaline pans have a species mix distinct from the adjacent buttongrass moorland (Brown et al. 1982a). These unusual formations are rare (less than 620 ha) and almost entirely confined to the TWWHA (Table 7.1). They occur in the Hardwood, Olga, Giblin and Maxwell river valleys (Brown 1993). Alkaline pans provide environmental niches for rare and endemic species, such as *Milligania johnstonii and Isoetes* sp. *nova* 'Maxwell River' and at least two other undescribed species (*Uncinia sp. nova and Chionogentias* sp. *nova*) which are rarely found outside this habitat (Jarman et al. 1988a, Brown 1993).

Alkaline pans are the product of on-going successional processes and possess highly distinct vegetation communities which reflect the dynamic interaction of fire, erosional processes and vegetation (Brown et al. 1982a). The alkaline pans within the TWWHA are therefore of international significance in their own right meeting both natural criteria (ii) and (iv) for World Heritage listing.

Table 7.1: Area in hectares of buttongrass moorland, heath and scrub vegetation in Tasmania and the TWWHA (source TVMP 2005).

Vegetation type	TWWHA	Tasmania	% In TWWHA
alkaline pans	577	616	94%
buttongrass moorland	344,626	551,183	63%
heath and scrub[17]	110,218	320,561	34%
subalpine heath & scrub	8,679	16,759	52%
highland grassy sedgeland and rushland[18]	6,942	20, 076	35%
Total	**471,042**	**909,195**	**52%**

Peat mounds

Interactions between the biotic communities, hydrology and climate have created unique peat mounds in a few restricted locations of southwest Tasmania (see geoconservation values). The best examples of peat mounds (several metres in depth and up to 30 m in diameter) are recorded from the Louisa Plains within the TWWHA and just outside the TWWHA at Melaleuca (Macphail et al. 1999). The peat mounds are unique in the southern hemisphere and possibly unique to the Holocene, and as such are of international scientific significance (Macphail et al. 1999).

Fauna-Vegetation Interaction

The buttongrass moorland peatland soils are highly anaerobic with the water table at the soil surface or above for substantial periods of the year. Many of the plant species of this vegetation display adaptive features which assist them to survive in this environment. An important and dynamic factor in buttongrass moorland ecology is the presence of the globally unique peat burrowing crayfish (*Parastacoides*). The burrows created by this animal increase the oxygen availability for plant roots. The roots concentrate around the tunnels where they are browsed by the crayfish. The burrows also carry water from the subsoil to the surface, or occasionally the reverse (Brown 1993). On average there is one burrow entrance for every square metre of buttongrass moorland and the surface area of the burrows exceeds that of the ground (Richardson 1983). One of the impacts of the bioturbation in this ecosystem is the transfer of gravels up the peat profile.

The burrows and pools in buttongrass moorlands are a significant habitat for many primitive and endemic invertebrates. These include the pholoteros (Lake 1977), two syncarid crustaceans, *Allanaspides hickmani* (listed as rare on the *TPS Act 1995*) and *A. helonomus, and* the rare dragonfly *Synthemiopsis gomphomacromioides* (Mallick & Driessen in press).

Interactions with the aquatic systems

The tannin from buttongrass moorlands species stains waterways a dark colour, significantly affecting their biodiversity. The unique conditions in Bathurst Harbour are a direct consequence of the buttongrass moorlands (see section 8 'Wetland ecosystems').

Integrity

Buttongrass moorlands cover 0.55 million ha of Tasmania; the largest wilderness tracts of this vegetation occur in the TWWHA. Buttongrass moorland covers 24%, (335,000 ha) of the TWWHA (TVMP 2005). There are another 110,000 ha of associated wet heathlands and scrub communities (Table 7.1, Figure 7.1).

Soil loss caused by erosion following fire may lead to a reduction in vegetation cover and height. Buttongrass moorlands are highly susceptible to the plant pathogen *Phytophthora cinnamomi.* Some large areas of buttongrass moorlands are being structurally and floristically altered because of infection by this pathogen *Phytophthora cinnamomi* (Tim Rudman, unpublished data, Parks and Wildlife Service 2004). Management programs are in place to limit the human induced spread of the pathogen, however further spread of disease is inevitable in infected valleys. While the short term impacts of disease within buttongrass moorlands have been dramatic it is likely that over the long term plants will develop better genetic resistance to the pathogen.

Up to now the weather data for the TWWHA have not provided evidence of a systematic shift in recent climate. However, predictions of global climate change have direct implications for peat formation processes through changes in precipitation and temperature, and indirect implications through changes in fire regimes (Bridle et al. 2003).

[17] *Leptospermum-Melaleuca* swamp forest is included in Table 8.1. Lowland sedgey heath and riparian scrub are excluded from this unit since their extent in the TWWHA is less than 50 ha.

[18] This includes grassy communities dominated by *Lepidosperma filiforme* in which *Gymnoschoenus* is rare or absent but excludes *Diplarrena latifolia* rushland for which only 9 ha is mapped in the TWWHA.

Figure 7.1: Distribution of Tasmanian heath, scrub and moorland communities in the TWWHA. (source TVMP 2005).

8. Wetland ecosystems

The TWWHA wetlands range from the humic oligotrophic waters of the southwestern regions (meromictic levee lakes of the Gordon River, coastal lagoons, the tannin-stained river systems of many montane humic lakes and the Bathurst Harbour/Port Davey marine system), to the clear freshwater systems of the eastern boundary and central highland 'lake country' (Tyler 1992, Fulton & Tyler 1993, Ponder et al. 1993, Vyerman 1995, Vyerman et al. 1996). Among these predominantly pristine wetlands are internationally significant examples of various wetland types (notably the meromictic lakes of the Gordon River and the estuarine system of the Bathurst Harbour/Port Davey Ria), which meet natural criterion (ii). Other wetland types (such as coastal lagoons, green-window lakes, and karst wetlands) are of national significance.

The phenomenal beauty and aesthetic importance of some of the wetlands within the Tasmanian TWWHA justifies listing under natural criterion (iii). Two wetland types are of particular note. One is the extensive dark tannin-stained waterways of Bathurst Harbour/Port Davey, mirroring the steep and craggy quartzite mountain ranges that frame them. The other is the dark dystrophic waters framed by riparian rainforest.

Wetlands provide habitat for numerous fauna and flora of conservation signficance. One wetland plant species, *Centrolepis pedderensis*, is listed nationally as vulnerable while the riparian species *Lomatia tasmanica* is listed nationally as critically endangered (*EPBC Act 1999*). At least 23 other vascular plant species occupying wetland and/or riparian habitats within the TWWHA are listed on the state schedule as rare (*TSP Act 1995*) (Appendix 1). Freshwater algae species in the wetlands of the TWWHA include *Batrachospermum antiquum, B diatyches*, *Chrysonephele palustris*, *Dinosphaera palustris*, all nationally vulnerable Tasmanian endemic species, and *Batrachospermum debile* as nationally rare (Day et al. 1995).

Background

The term 'wetlands' is applied in its broadest sense to include:

(i) permanent water bodies (marine or freshwater aquatic systems such as estuaries, harbours, lakes and rivers)

(ii) habitats subjected to temporary inundation (flood plains or transitional zones between aquatic and terrestrial habitats such as the margins of the coast, lakes or streams)

(iii) peatlands–moorlands, bogs, swamp forests, alpine meadows (buttongrass moorlands are described in section 7 'Buttongrass moorlands').

There have been few surveys to describe or document the values of the TWWHA wetlands. Three major limnological provinces have been recognised for the freshwater lentic* wetlands of the TWWHA (Tyler 1992).

These are: deep green window lakes* in the north and east of the TWWHA; the dim crepuscular red window lakes* of the upland areas of southwest Tasmania; and coastal and other dystrophic* red window lakes of lowland southwest Tasmania.

The TWWHA lotic* environment is characterised by stream and river systems with high precipitation, and consequently high flows with relatively little flow variability (Hughes 1987a, 1987b, 1990).

Justification

The TWWHA wetlands comprise a number of distinctive types. The Pleistocene glacial lakes in the high rainfall regions of the Central Plateau and southwest Tasmanian mountains are unique in an Australian context (Tyler 1974).

The dystrophic rivers and lakes of lowland southwest Tasmania are also unique nationally, being derived from the extensive southwest peatlands in a cool climate with high rainfall.

Such limnological properties are probably widespread in the northern hemisphere peatland regions and in the southern hemisphere they have analogues in *Te Wahipounamu*, South West New Zealand WHA, Tierra del Fuego and Chile where blanket bogs also occur. New Zealand and probably Chile also have tannin-stained dystrophic fjords that provide habitat for deep water organisms in shallow situations (O'Donnell 1987). Nevertheless, this characteristic is best expressed in the shallow flooded river valley of Bathurst Harbour/Port Davey, which supports a diverse and unique biota (Edgar 1989, Edgar et al. 1999).

Despite the importance of the wetlands for their unusual limnology, the TWWHA wetlands are generally low in bird abundance and diversity and none have been listed as Ramsar sites to date.

Diversity and endemism

While the wetland communities of the TWWHA have a richer diversity of herbs and other vascular species in comparison to the dry terrestrial habitats within the region (Ponder et al. 1993), they do not exceed the richness of other temperate wetlands. For example, within temperate Australia, southwest Western Australia has probably the greatest wetland diversity (Gibson et al. 1994, Dixon et al. 1999, Lane et al. 2001). Similarly, internationally outstanding temperate wetlands exist in Chile and Tierra del Fuego (Pisano 1983).

The wetlands of the TWWHA are important for a number of endemic and threatened vascular species including two listed as endangered on the state schedule and nationally as vulnerable (*Centrolepis pedderensis*) and critically endangered (*Lomatia tasmanica*). Another 23 species are listed as rare under the Tasmanian *Threatened Species Protection Act 1995*. The wetland vegetation contains more than 58 Tasmanian endemic vascular plant species.

The cold rivers and streams of the TWWHA are typified by highly endemic aquatic invertebrate fauna, including many insect groups with Gondwanic origins (eg dragonflies, chironomid midges, stoneflies, caddisflies).

Threatened and endemic fish largely restricted to the TWWHA include the Pedder galaxias (*Galaxias pedderensis*) Clarence galaxias (*Galaxias johnstoni*), the swamp galaxias (*Galaxias parvus*) and the western paragalaxias (*Paragalaxias julianus*). The freshwater crustacean groups include the archaic and endemic family Anaspidaceae, as well as Parastacidae and Phreatoicoidae which are also of zoogeographic significance. The endemic Tasmanian redspot dragonfly, *Archipetalia auriculata* is of ancient Gondwanan origins and is the only representative of its genus. It is restricted to moorland areas within the TWWHA.

Sphagnum peatlands generally exhibit a moderately high level of endemism, particularly in the shrub and herb flora (Whinam et al. 1989, 2001a).

Freshwater algae and other plankton are diverse and unusual (Bowling et al. 1993, Fulton & Tyler 1993, Tyler 1996ab, Croome et al. 1998 and Walsh et al. 2004). The dystrophic conditions within the western lakes, rivers and streams, especially the meromictic lakes and coastal lagoons of the TWWHA, provide habitat for a distinctive freshwater algae flora (Fulton & Tyler 1993). However, the alpine lakes and rivers associated with dolerite mountains have greater species richness and most species are widespread.

Marine systems

Bathurst Harbour/Port Davey (including Payne Bay) is a type of marine ecosystem that is rare in the world and is of international conservation significance (Edgar 1989, Edgar et al. 1999). This harbour has highly stratified waters with a surface layer of highly humic, tannin-rich fresh water, and deep areas occupied by saline water separated from the open sea by shallower areas. During summer months the waters of Bathurst Harbour are very low in dissolved oxygen. Nitrates and other nutrients are also among the lowest reported anywhere in the world (Edgar & Cresswell 1991).

The organic colloids and tannins that stain the waterways of the southwest river systems and harbours are derived from the peat soils that underlie the buttongrass moorlands and scrubs that dominate the landscape. In Port Davey there is a distinctive tannin gradient, with tannin declining with distance from the entrance to the Bathurst Channel and the Davey River. Because various species that would otherwise dominate are absent because of low light conditions, the community floristics and structure are quite distinct from macrophytic communities elsewhere (Barrett et al. 1998).

Edgar et al. (1999) also identified New River Lagoon as being of critical conservation importance in Tasmania. It provides another example of an estuary similar to Bathurst Harbour/Port Davey and is of national significance.

Coastal lagoons

The limnology and importance of coastal lagoons are described by Bowling et al. (1993) with particular reference to a number of significant lagoons within the TWWHA. Tasmania's coastal lagoons provide a habitat for a very rich flora of freshwater algae and particularly favour phytoflagellates, desmids and dinoflagellates.

The only coastal lagoons within the TWWHA to be included on the Directory of Important Wetlands of Australia (DIWA) are the South East Cape lagoons (Environment Australia 2001). These have been listed for their significant biota. Of particular value is the presence of phytoplankton species such as the Tasmanian endemic mono-specific dinoflagellate genus *Thecadiniopsis tasmanica* and the Australian endemic chrysophyte species *Mallomonas sabulosa*, for which these lagoons are the type locality. *Mallomonas grossa* has a disjunct bipolar distribution and within Australia is restricted to Tasmania. Two Tasmanian endemic species of Heliozoans – *Pinaciophora columna* and *P. tasmanica* – also occur in these lagoons (Tyler 1986a, Croome 1987ab, Croome & Tyler 1996ab, Croome et al. 1998 and Walsh et al. 2004).

Gordon River lakes

Tyler et al. (2001) eloquently state the case for the international significance of the three meromictic lakes on the Gordon river lakes (L. Morrison, L. Fidler) and Sulphide pool (see also Tyler & Vyverman 1995).

The lakes have been well documented with more than 30 publications describing their characteristics. There are less than 150 meromictic lakes known worldwide and only four others in Australia. Two of the Gordon River meromictic lakes are considered among the most shallow of such lakes in the world (Tyler & Vyverman 1995).

All three lakes provide excellent examples of the process of terrestrialisation, as they are being slowly infilled by the encroachment of herbfield (Tallis 1973). These provide internationally significant examples of on-going processes in the development of freshwater bodies (Mulvaney 1983, Tyler et al. 2001).

The lakes have an unusual and significant chemocline underlying the limnological importance of the lakes, in addition to their biological significance.

The meromictic lakes harbour more than 89 phytoplankton species with an unusual diversity of silica-scaled Chrysophyceae with 16 (50%) of the Australian species, the richest array of these species seen anywhere in Australia. Algal species are typically of cosmopolitan distribution but some, such as *Mallomonas tasmanica,* are restricted to Tasmania. These lakes are the type locality for both *Mallomonas morrisonensis and M. tasmanica* (Croome & Tyler 1983ab, 1984b). *Pinaciophora columna,* a Tasmanian endemic Heliozoan, occurs in Sulphide pool (Croome 1987ab).

Other dystrophic red window lakes

Tyler (1987) considered the southwest lakes to be a limnological showcase because they provide classic examples of red window lakes. Many contain the Australian endemic golden algae species, *Dinobryon unguentariforme* (Croome et al. 1988, Tyler 1992). Lakes on the Denison Range provide habitat for the Tasmanian endemic dinoflagellate *Thecadiniopsis tasmanica* (Croome et al. 1987). The Tasmanian endemic freshwater red algae species, *Batrachospermum diatyches,* was first discovered in Lake Pedder prior to its flooding but has been found more recently in both humic and intermediate type lakes within the TWWHA (Entwisle 1992, 1993). It is considered to be nationally vulnerable (Day et al. 1995).

The Golden Cloud Swamp at Lake St. Clair is intermediate between an oligotrophic and eutrophic wetland system. This is the only known location of *Chrysonephele palustris*, a species which displays both 'animal-like and plant-like nutritional characteristics and appears to be mid-way between two evolutionary classes of algae' (Pipes et al. 1989, Fulton & Tyler 1993).

Endemicity in diatoms and in some other micro-algal groups is peculiar to the Australasian region and is particularly evident in the Tasmanian oligotrophic and dystrophic wetland flora (Sabbe et al. 2001).

Clarence Lagoon is intermediate in its chemical and optical properties between the dystrophic lakes and the green window lakes of the TWWHA and is listed on the DIWA for its biological values.

The Lake Surprise wetland on the Frankland range is an example of a glacial cirque lake that has been included on the DIWA for its biotic values. A similar glacial lake further along the same range, aptly named Sanctuary Lake, is currently the only known location of the semi aquatic cushion sedge *Centrolepis pedderensis.*

Green window glacial lakes

Green window lakes are more diverse in their plankton biota but have fewer endemics than the red window lakes. Nevertheless, significant green window lakes within the TWWHA include Lake Kay, west of Liawenee, which is part of an extensive lagoon complex. It is a deflation basin and has been listed on DIWA for its rare flora communities and unusual geomorphology. The rare communities present include vegetation dominated by species of *Chara* and *Myriophyllum.*

Good examples of deep green window lakes are provided on the Mt Picton massif and South Picton range. 'The whole massif is a classic and impressive example of lake formation by corrie glaciation.' (Tyler 1987) In addition, North Lake on Mt Picton contains the only Australian locality for the vulnerable dinoflagellate species *Dinosphaera palustris* (Ling et al. 1989).

Karst wetlands

Lake Timk and Lake Sydney are examples of permanent lakes drained by sink holes. The significance of Lake Sydney has been recognised by its listing on the Directory of Important Wetlands in Australia (DIWA, Environment Australia 2001). The area was listed because of its unusual hydrology, ecology and surrounding coniferous rainforest vegetation.

Another karst wetland type is the internationally unique alkaline pans of the TWWHA. These are discussed in section 7, 'Buttongrass moorlands'.

Lotic wetlands

Old River has provided the only known location of the newly described *Batrachospermum antiquum*, while a stream on Mt Rugby provided the first known location of *B. debile*, both of which are listed nationally as vulnerable and rare respectively (Day et al. 1995, Entwisle & Nairn 2004).

Swamp forests and riparian scrub

There is a pristine but dark grandeur about the tannin stained rivers fringed by riparian scrub, rainforest and swamp forests dominated by Tasmanian endemics such as *Acradenia frankliniae, Lagarostrobos franklinii* and *Leptospermum riparium*. From the limestone cliffs above these rivers are hanging gardens of the endemic lily *Milligania longifolia* and herbs such as *Oreomyrrhis gunnii*. The uniqueness of these river systems justifies their listing under natural criterion (iii).

Within the TWWHA, swamp forest is known to occur behind the levee banks along the Gordon River and around Macquarie Harbour. It is floristically distinct, dominated by the endemic species *Lagarostrobos franklinii* and *Acradenia frankliniae*, and is of national significance. The *Leptospermum nitidum* and *Melaleuca squarrosa* swamp forest vegetation is more widespread on flood plains associated within buttongrass moorland vegetation. These cover nearly 3400 ha within the TWWHA (Table 8.1, Figure 8.1).

Table 8.1: Extent of Wetland vegetation types in Tasmania and the TWWHA[19]. (source TVMP 2005).

	TWWHA	Tasmania	% In TWWHA
water & sea	71,399	217,900	33%
Leptospermum swamp forest	3,393	14,031	24%
Sphagnum peatland	2,488	3,114	80%

Sphagnum peatlands

About 80% (2488 ha) of Tasmanian *Sphagnum* peatlands occur within the TWWHA (Table 8.1, Figure 8.1). Two *Sphagnum* peatlands in the TWWHA are listed as nationally important wetlands.

They occur at Mt Rufus (considered to be an outstanding example of snowpatch *Sphagnum*) and Shadow Lake in Cradle Mountain–Lake St Clair National Park There are several other nationally outstanding and representative examples of *Sphagnum* peatlands within the TWWHA. These include the largest ombrotrophic bog in Tasmania at the Walls of Jerusalem and a variety of different types of *Sphagnum* peatland at Pine Valley. These peatland communities are significant at a national scale as repositories of palaeoecological information and as indicators of global climate change (Whinam et al. 2003c).

Integrity

Bathurst Harbour/Port Davey and New River Lagoon provide superb examples of a dystrophic marine harbour and estuary. However, the fact that not all the adjoining coastal marine habitats are in the TWWHA reduces the integrity of the listing. Other estuaries of critical conservation importance in areas adjoining the TWWHA are the Wander Lagoon and South Port Lagoon (Edgar et al. 1999). Invasion of marine pests and weeds is a potential threat requiring monitoring and preventative actions.

While pollution has had minimal impacts on most of the TWWHA, the higher nitrates recorded in Macquarie Harbour probably reflect sediment discharge from townships such as Strahan and Queenstown. Heavy metal contamination from mine tailings has also affected the natural qualities of the sections of Macquarie Harbour that are within the TWWHA. Historical pollution from mining operations in Queenstown has been detected in lakes long distances away within the TWWHA (Cameron et al. 1993, Hodgson et al. 2000, Harle et al. 2002).

The lake systems of the TWWHA are generally pristine and of national significance, providing superlative examples of the various types. Despite integrity issues, the one remaining meromictic lake (Lake Fiddler) is still considered to be of World Heritage significance. Some high value lakes do nevertheless occur beyond the boundary of the TWWHA (e.g. Hibbs Lagoon and Lake Lea in the Vale of Belvoir).

The greatest impacts on the wetlands of the TWWHA have historically been in response to water regulation for power generation. The riparian vegetation of the Gordon River and the lakeshore around Lake St Clair have been permanently degraded. Even more serious is the loss of meromixis to all three of the meromictic lakes along the Gordon River due to changes to the summer flow patterns of the Gordon River. Meromixis has recently been reinstated by artificially increasing salinity levels within Lake Fidler (Gregory Vinall pers. comm.) thus restoring World Heritage value to one of these lakes.

[19] Only 17 ha of undifferentiated wetland vegetation has been mapped in the TWWHA since most wet herbfields and salt marshes in the TWWHA are smaller than can be mapped.

The need for artificial management to maintain meromixis means that the natural ongoing process has been lost. However by reinstating meromixis, this unusual habitat is able to continue to support the fascinating diversity of microbial organisms, which satisfies natural criterion (iv).

The condition of most *Sphagnum* peatlands in the TWWHA is generally good, although some have been affected by fire, but not to the same extent as outside the TWWHA (Whinam et al. 2001a). The most pristine examples of *Sphagnum* peatlands in Australia occur within the TWWHA. However, the best expression of rainforest *Sphagnum* communities occurs outside the TWWHA at Mother Cummings Peak (Whinam et al. 1989). An outstanding example of small-scale lake features within peatlands (string bogs) occurs at Newdegate Pass in Mt Field National Park outside the TWWHA (Kirkpatrick & Gibson 1984).

Riparian weeds such as blackberry are a threat to a few river systems in the TWWHA. Management is containing the extent of the threat to these disturbed sections of river such as the Collingwood and Andrew Rivers. Even in the areas where these weeds exist, native species are not being displaced to any great extent and the natural ecological processes remain undisturbed.

Figure 8.1: Wetlands and Coastal Vegetation map

9. Coastal ecosystems

The TWWHA coastline is a very high-energy one with a consequent diversity of landforms and associated plant communities and species. The coastal plant commuities of the TWWHA are largely free of exotic sand-binding plants. This enables natural dune formation and erosion to continue and supports natural diversity in the grassy dune vegetation. In sheltered embayments, natural geomorphic processes combined with grazing produce a globally unusual fen, known locally as marsupial lawns. These ecological processes meet natural criterion (ii). The diversity of geology, landform and vegetation, combines to produce a ruggedly beautiful wild coastline in which natural on-going processes continue undisturbed by human developments, fulfilling natural criterion (iii).

The coastal plant communities of the TWWHA contain a vegetation formation, marsupial lawn, which has no closely related analogue outside Tasmania. This vegetation is an important habitat for Tasmanian endemic and state listed rare plant species, thereby satisfying natural criterion (iv).

Background

The TWWHA coastline extends from Nye Bay in the west to Cockle Creek in the southeast and covers a total distance of about 630 km (Cullen 1998ab). It is a high-energy coastline, which lies in the path of the roaring forties with a vast fetch of ocean before the next landfall. The rainfall on the coast is less than the mountainous hinterland but is still very high (1246 mm average annual rainfall at Maatsuyker Island, Bureau of Meteorology). The coastal area can be divided into three main zones: offshore islands; the exposed coastline; and the sheltered estuaries (Harris et al. 1993). Coastal vegetation includes all formations with very close proximity to these coastal zones. It may extend into more distant areas if coastal processes such as salt winds or sand movement influence vegetation dynamics.

Justification

Comparative assessment within the biome

There are few undisturbed high-energy compartmentalised rocky and sandy coasts in the world's temperate zones that compare with those in Tasmania (Chapman 1977, Van der Maarel 1993ab, Sharples 2003). The most extensive elsewhere occur in southwest New Zealand and Patagonia.

These are considered significantly different types, being predominantly hard-rock and highly glaciated fjord-dominated coasts with on-going active glacial processes in hinterland areas (Sharples 2003). Much of the coastal ecosystems of southwest New Zealand WHA (*Te Wahipounamu*) have a dominant weed element in the vegetation.

Marram (*Ammophila arenaria*) and tree lupin (*Lupinus arboreus*) are most common but other species include elder (*Sambucus nigra)*, broom (*Cytisus scoparius*), gorse (*Ulex europaeus)* and blackberries (*Rubus fruticosus* aggr.). Native species include the endemic pingao (*Desmoschoenus spiralis*) and spinifex (*Spinifex sericeus*), while a number of low-growing native herbs are found in the deflation hollows and sand flats (Wardle 1991).

The coasts of South Africa and Namibia contain long coastal stretches where little compartmentalisation occurs (Sharples 2003, p.121), and there are numerous small towns and developments along the entire coast (Boucher & Le Roux 1993).

Comparison within the Australian Realm

The TWWHA coast forms part of the southeastern Australian coastal ecosystem, with which it has floristic similarities (Harris et al. 1993).

The variety of coastal landforms in a high-energy system and high rainfall environment (Baynes 1990) is reflected in the variety of plant associations and high species richness (Kirkpatrick 1993).

Native plant species are a key element in the natural dynamics of the coastal ecosystem.

The long, undisturbed coastline of the TWWHA is of outstanding universal geomorphic value (Sharples 2003). The lack of coastal development, combined with the absence of exotic weed species along most of the coastline, allows the natural geomorphic processes to continue on an on-going basis.

Unfortunately, exotic species are invading from the north and active eradication and control of these incursions is now an ongoing management practice.

The coastal landscape encompasses a superb variety of landforms from long white beaches, to rocky foreshores, towering sea cliffs and rugged rocky headlands carved from various rock types including dolerite, sandstone, ancient quartzite, granite and limestone. The beaches and headlands are exposed to the full ferocity of the roaring forties, while the more sheltered smaller bays and estuaries offer visitors the opportunity to enjoy the tinkling sound of the ocean waves surging over rocky cobbles. The view over the Southern Ocean is never monotonous, speckled as it is by the preserve of nearby islands, mysteriously tantalising to the shore-bound observer. The absence of human development and exotic species, together with the scenic quality and diversity of the region, makes this a coastline of outstanding universal aesthetic value.

The coastal environment in Tasmania contains a high proportion of the state's native plant species (about a third) while about 145 species (8% of the state's native flora) are largely confined to coastal areas. Within the TWWHA about 57 species (nine endemics) have most of their population within the coastal region but none are contained entirely within the TWWHA boundaries (Table 10.2 in section 10).

The vegetation on off shore islands and in coastal areas provides habitat for the conservation of threatened seabirds such as the Fairy Prion and Soft-Plumaged Petrel (Harris et al. 1993).

The plant diversity and endemism of the Tasmanian coastal flora, and that of the TWWHA, are insignificant in comparison with the Warren district of the southwest botanical province of Western Australia. The special combination of climate and soils of the entire southwest region has resulted in high endemism in the flora (Beard 1993). Seventy per cent (572 species) of the dry coastal flora are endemic to the southwest botanical province (Beard 1993). This region has the most significant temperate coastal flora in Australia in terms of its species richness and endemism.

The coastal habitats within the TWWHA offer specialised niches for some rare and restricted endemic plants, particularly short coastal herbfields, coastal cliffs, coastal beach sands, sea bird breeding colonies and coastal lagoons (DASETT 1989). The TWWHA has a distinctive Tasmanian element with 64 endemic plant species (Table 11.2), of which nine are restricted to coastal habitats and at least four taxa (*Ammobium calyceroides, Leptecophylla abietina*, *Persoonia muelleri* subsp. *densifolia* and *Westringia brevifolia* var. *raleighii*) have most of their population within the TWWHA.

There are no nationally listed threatened species in coastal habitats of the TWWHA but there are 16 species currently listed as rare and another one listed as vulnerable (*Veronica novae-hollandiae*) under the Tasmanian *Threatened Species Protection Act 1995* (Appendix 1). Of these, *Ranunculus acaulis* and *Westringia brevifolia* var. *raleighii* have strongholds within the TWWHA. *Crassula moschata*, an itinerant species more typical of subantarctic habitats, is occasionally found on the southern beaches of the TWWHA.

Coastal shrubberies and rocky foreshores

The southwest coast's cliff and closed coastal heath and scrub vegetation often occurs in a narrow fringe too small to map (Table 9.1, Figure 8.1). Only 1036 ha of this vegetation is mapped within the TWWHA. This vegetation is frequently dominated by endemic species such as *Leptecophylla abietina, Westringia brevifolia, Ozothamnus costatifructus, O. reticulatus,* and *Correa backhouseana* (Kirkpatrick & Harris 1999). The rare species *Lepidium flexicaule* occupies rock crevices in the littoral zone. The coastal heaths of Tasmania are largely a floristic and structural extension of the heaths of southeastern Australia (Kirkpatrick & Harris 1999). Only 8% of the 400 species recorded from Tasmanian heath are endemic and these are concentrated where precipitation is high and/or the substratum is dolerite. Species richness is usually between 20–40 per 100 m^2, but can reach 60 (Kirkpatrick & Harris 1999). The heathlands within the TWWHA are restricted to the narrow margin around exposed rocky coastline. Further inland, heathlands are replaced by buttongrass moorlands, which in the coastal region have a higher species richness than their inland counterparts (see section 7 'Buttongrass moorlands').

Wetlands and short coastal herbfield (Marsupial lawn)

Coastal estuaries, riparian margins and coastal lagoons are host to distinctive floras more diverse than their inland counterparts. Rare species (TSPA 1995) known from these wetland habitats within the TWWHA include *Lepilaena patentifolia* (New River Lagoon) and *Lachnagrostis robusta* (Bathurst Harbour/Port Davey). In the wet sands adjacent to creek outlets the herb *Crassula moschata* is an occasional resident.

The flora values of the nationally significant coastal lagoons are discussed in section 8, 'Wetland ecosystems'.

Another characteristic component of the wet coastal vegetation of southwest Tasmania is short coastal herbfield known as marsupial lawn. These communities are an unusual type of salt marsh which are closely grazed and lie just above the high water mark in sheltered bays and estuaries.

Succulents are absent and the major dominants are small mat forming sedges and forbs.

Leptinella longipes, Schoenus nitens, and *Plantago triantha* typically dominate this vegetation, which is a major habitat for the restricted endemics *Ranunculus acaulis* and *Ammobium calyceroides*. Other species associated with herbfields include more typically alpine species such as *Nertera depressa, Samolus repens* and *Selliera radicans*. Superlative examples of these communities are found within the TWWHA. No record was found in the scientific literature for such short wet herbfields occurring in coastal regions elsewhere in Australia or the world (Harris 1991, van der Maarel 1993ab). They have international significance because they are thought to have no analogue elsewhere and are the habitat of both rare and restricted endemic species.

Table 9.1: Extent of coastal vegetation types in Tasmania and the TWWHA[20]. (source TVMP 2005).

	TWWHA	Tasmania	% In TWWHA
seabird rookery complex	43	532	8%
coastal grass & herbfield	147	9604	2%
coastal heath & scrub	1036	70858	1%
littoral rainforest	1364	1488	92%

Dwarf littoral rainforest

Dwarf littoral rainforest is an unusual component of the coastal vegetation that is largely restricted to the TWWHA. It occurs on the west and southwest coasts in an area (1488 ha in total) that stretches from Macquarie Harbour to South Cape Bay (Table 9.1, Figure 8.1). It contains species considered typical of both rainforest and wet sclerophyll communities, but is encompassed within the rainforest definition (Jarman et al. 1991). Occasional trees of the uncommon endemic plant *Persoonia muelleri* subsp. *angustifolia* occur on the margin between beach and forest, as does the rare grass *Deyeuxia minor*.

These communities are also of considerable aesthetic value; mystical green rainforests border pristine white sands. There is nothing comparable to this coastal community in temperate Australia and it is therefore of national significance. Rainforest vegetation is common in temperate coastal areas of Chile and New Zealand, but the Tasmanian type is floristically and structurally distinct.

Offshore islands

Other superb natural phenomena of the TWWHA are the offshore islands. Most of these islands are very small with very little coastal vegetation (Brothers et al. 2001).

Although the species found on the islands reflect the species composition of the communities found on the nearby mainland (White 1980), some of the communities are distinct. The islands serve as important sea bird rookeries and have superlative examples of the distinctive rookery vegetation that is associated with the high nutrients and disturbance regimes (Brothers et al. 2001). The larger islands have vegetation that ranges from coastal heath and scrub to littoral rainforest, including one rookery vegetated with *Tasmannia lanceolata*-dominated dwarf forest. The rare species *Xerochrysum bicolor* and the grass *Poa poiformis* var. *ramifer* have been reported from Maatsuyker Island. The smaller islands are cloaked in the most beautifully verdant herbfields of succulents and fleshy rosette herbs. These cool temperate island floras are of national significance, with superb examples occurring within the TWWHA (Ile du Golfe, Maatsuyker Island and Flat Witch Island). The Island vegetation has yet to be mapped but about 43 ha of rookery vegetation is mapped on the southwest coast (Table 9.1, Figure 8.1).

Beach sand and dune vegetation

Austrofestuca littoralis is the dominant sand-binding species in the TWWHA. The mapped extent of these grasslands is only 147 ha but most are too small in extent to map (Table 9.1, Figure 8.1). Elsewhere on the southeastern Australian and Tasmanian coastline *A. littoralis* and other native species have been substantially replaced by *Ammophila arenaria* (Kirkpatrick 1993). On the west coast of the TWWHA, *A. littoralis* dunefields are being reduced through active beach erosion. At least two species listed as rare (TTSPA 1995) occupy the beach grasslands of the TWWHA: the grass *Lachnagrostis aequata*, and the herb *Ranunculus acaulis*. The natural dune formation and erosion processes, involving the presence native grassland vegetation, are of world heritage significance.

Integrity

The integrity of the coastal zone of the TWWHA is outstanding. There is over 630 km of undeveloped coastline with a wilderness hinterland, where the natural dynamic processes are virtually undisturbed. Introduced species are few and under management. The TWWHA coast is especially important in allowing on-going coastal vegetation dynamics in a pristine environment.

The TWWHA coastline comprises about 3% of the southeastern Australian coastline and contains all the elements except mangroves, which, while uncommon, do occur in areas of Victoria and

[20] Only 17 ha of undifferentiated wetland vegetation has been mapped in the TWWHA since most wet herbfields and salt marshes in the TWWHA are smaller than can be mapped (TVMP 2005).

South Australia. Cool temperate rookery herbfields and tussock grassland associated with offshore islands have some of their best examples in the TWWHA.

The uniquely Tasmanian formations of coastal marsupial lawns and dwarf littoral rainforests also have some of their best expressions in the TWWHA. These vegetation types are not restricted to the TWWHA, extending beyond its boundaries into the southwest conservation area to the west.

The TWWHA coastal vegetation is inhabited by some rare and endemic plant species and has relatively high plant diversity. Coastal heath and shrublands dominated by endemic species also extend beyond the TWWHA into the southwest conservation area.

Some areas of coastal vegetation are being lost through the natural processes of dune deflation and erosion. The underlying cause of the current erosion phase is not clear but is very recent, suggesting that global climate change may be a contributor.

The most serious threat to the beaches is from the invasion of coastal weeds. Although a few weeds are widespread such as *Cakile maritima* and *C. edentula*, which occur along all beaches, these do not appear to be competing with native species or altering the dynamics of sand accumulation. Weed invasion by sand-binding weeds is a very recent problem and is currently restricted to just a small number of locations. The risk of their spread is very high and on-going management is required to ensure that the natural values are preserved (Sharples 2003). Disturbance by walkers and the effects of illegal entry by off-road vehicles have localised impacts. The incursions from these threats are not sufficient to have resulted in significant loss at present.

10. A synthesis of plant endemism and diversity in the TWWHA

The TWWHA has a great variety of vegetation types leading to a rich and diverse flora for its size and latitude. The ecosystems of the TWWHA that contain internationally outstanding examples of biodiversity for their type include alpine, buttongrass moorland and wet sclerophyll forests.

Due to the remote nature of the TWWHA, limited human-induced threats are present. Listed species from this area are threatened due to their naturally small populations or restricted distribution. Seven vascular plant species and one liverwort occurring in the TWWHA are listed nationally on the *EPBC Act* 1999. Another 73 vascular species, three lichens and a moss from the TWWHA are listed as threatened under the *TSP Act* 1995. The presence of threatened species and a diverse flora rich in endemics and primitive species has enabled the TWWHA to be listed under natural criterion (iv).

The TWWHA nomination document of 1989 identifies alpine, wetland communities and rainforest as the richest in rare and endemic plant taxa. The alpine flora continues to qualify for World Heritage status. Insufficient data are available to justify whether the diversity of wetland communities is sufficient to qualify for World Heritage listing. The Tasmanian cool temperate rainforest is no longer considered to qualify, as the Valdivian rainforests of Chile are now known to have richer biodiversity and higher levels of endemism. However the TWWHA rainforests are considered to be internationally significant as they represent the best examples of this type in Australia and support a primitive flora.

The 1989 nomination document identified the presence of radiation in various plant groups including *Acacia, Eucalyptus, Euphrasia, Gonocarpus, Persoonia, Plantago, Orites* and *Ranunculus* as a globally outstanding feature meeting natural criterion (ii). There are likely to be better examples of radiation elsewhere in the world and these are no longer considered to be globally outstanding examples.

Background

Australia exhibits a mega-diverse biota with high levels of continental endemism that are comparatively significant on a world scale (Williams et al. 2001). Approximately 80% of flowering plant species in Australia are thought to be endemic to the Australian plate (Davis et al. 1995). Within Australia, plant species endemism and plant diversity are not evenly distributed. A number of botanical hotspots for both endemism and diversity have been identified at a national level (Boden & Given 1995).

Tasmania has been identified as one of the 12 centres of plant species richness and endemism within Australia making it nationally significant for biodiversity conservation (Crisp et al. 2001). The 2003 vascular plant census records about 1701 indigenous species in 534 genera and 134 families, of which 403 are endemic species (Table 10.2).

The diversity of Tasmania's flora reflects the environmental heterogeneity of the region, while the high rates of endemism reflect Tasmania's geographical isolation and the presence of environments rare on the Australian mainland.

This section serves to summarise the general case for endemism and diversity fulfilling the World Heritage Area natural criterion (iv).

Justification

Vascular pant species diversity and conservation

An internationally outstanding example for temperate endemism and diversity within Australia is the southwest province of Western Australia, while the best global example is found in the Cape

Province of South Africa (Williams et al. 2001). In comparison to these regions the TWWHA does not provide a globally outstanding example of endemism and diversity at the regional level. It nevertheless represents a distinctive and nationally significant component of Australia's plant diversity. The TWWHA provides habitat for about 916 vascular plant species (54% of the Tasmanian vascular flora), including 255 (63%) of Tasmania's endemic species and it is a stronghold for many of these (see Appendices 2 & 3). At least 27 of these species have a geographic range of less than 100 km (Appendix 2). There are 82 threatened vascular taxa of which seven are listed nationally on the *EPBC Act 1999* and are Tasmanian endemics, four of which have all or most of their population within the TWWHA (Appendix 1).

Endemism and diversity vary greatly between ecosystems and regions of the TWWHA (Brown et al. 1983ab, Harris et al. 1995, Heywood & Davis 1995, see Figure 10.1). Two of Tasmania's centres of local endemism fall within the TWWHA (Kirkpatrick & Brown 1984b, Hill & Orchard 1999).

One of these centres is on the Central Plateau (Figure 10.2); the other includes the southern coastal plains, southern and southwestern mountains. Patterns in the concentration of plant endemism have been positively related to precipitation (Kirkpatrick & Brown 1984a), protection from fire and oligotrophic soils (Kirkpatrick & Brown 1984a). Hill and Orchard (1999) note that the levels of endemism and diversity may have been reduced as a result of the climatic and sea level fluctuations experienced during the Pleistocene.

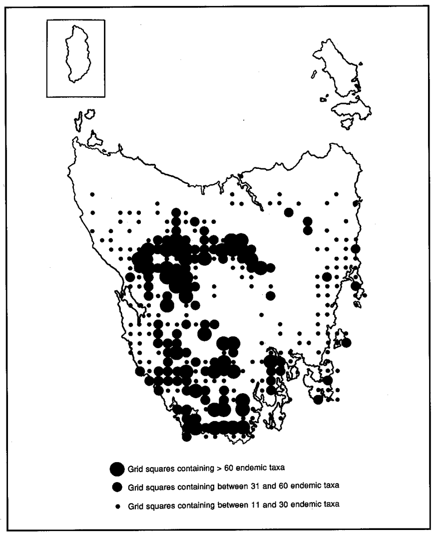

Figure 10.1: Map of Tasmania showing the distribution of endemic vascular plant taxa mapped on a 10 x 10 km grid square. Data from Brown et al. 1983, Menadue and Crowden (1985) and Coates (1991) (source Hill & Orchard 1999).

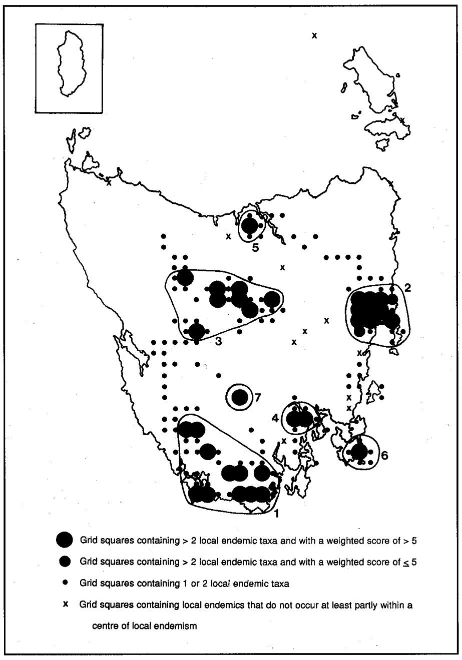

Figure 10.2: Map of Tasmania showing the distribution of locally restricted endemic plant taxa mapped on a 10 x 10 km grid square. Greater weight was given to non-hybridising taxa without morphologically similar Tasmanian relatives (source Kirkpatrick and Brown 1984b, Hill & Orchard 1999).

Non-Vascular pant species diversity and conservation

In terms of overall diversity, endemism and conservation of the non-vascular plant groups in the TWWHA, most is known about the lichens, bryophytes and marine macroalgae (Table 10.1). The freshwater algae have also had considerable research but a comprehensive list of species occurring in the TWWHA has not been compiled. The significance of these species has been discussed in section 8 'Wetland ecosystems' and will not be addressed again here.

Neither fungi nor terrestrial algae have been studied in sufficient detail in the TWWHA to be able to conclude anything about the significance of their diversity relative to other areas. The terrestrial algae are likely to comprise relatively few species relative to other taxonomic groups but may well include keystone species, particularly in the buttongrass moorlands where algae appear widespread and abundant on peat soils. Macrofungi are likely to be one of the most diverse groups within the TWWHA, possibly exceeding 1000 species (Dr Tom May pers. comm.). A study of macrofungi in the TWWHA in May 1989 by Simpson and Grgurinovic (undated) concluded that buttongrass moorlands appeared relatively depauperate in these species.

In contrast the fungi in the forests in the vicinity of the Lake St Clair area may well be amongst the highest diversity anywhere in Australia (Dr Tom May pers. comm. November 2004).

The results of these studies fit with the general observation that macrofungi have their greatest diversity in wet eucalypt forests and rainforests. No work has been undertaken on microfungi to allow observations about their diversity within the TWWHA to be made.

At least 277 described lichen species have been recorded within the TWWHA, which is 31% of lichens recorded in Tasmania (Table 10.1). A number of taxa present in the TWWHA have not been identified to species level and so the total number of species recorded in the TWWHA and Tasmania will almost certainly grow with further study (Brown et al. 1994). Most lichen species are widespread both within Tasmania and elsewhere. Only five percent of the lichens in the TWWHA are endemic to Tasmania, which is lower than the average for Tasmania overall (11%), and most other Australian regions (McCarty 2003). There are no Tasmanian lichens listed nationally as threatened. Of those listed on the *TSP Act 1995,* only three are known to occur in the TWWHA and each of these is listed as rare although their known extent is very small. One occurs in alpine regions (*Cetraria islandica* subsp. *antarctica*) while two species (*Parmeliopsis ambigua* and *P. hyperopta*) occur in montane pencil pine rainforests. None of these are endemic, although *P. hyperopta* does not occur on the Australian mainland.

Dalton et al. (1991) and Ratkowsky (1987) document a total flora of 361 mosses and 282 liverworts for Tasmania. Moscal and Kirkpatrick (1997) recognise a greater number of species (Table 10.1). Study is still required to determine the taxonomy of difficult taxa. Most of these species are widespread and about 59% of Tasmanian mosses and 79% of Tasmania liverworts occur within the TWWHA (Table 10.1). Endemism is low among bryophytes with only nine endemic moss species and 11 liverworts species recorded in the TWWHA (Table 10.1, Appendices 2 and 3). Only one moss and one liverwort of the TWWHA are listed as threatened (Appendix 1).

Only a small number of the Tasmanian marine macroalgae occur in the TWWHA. This is in part due to the small extent of marine areas within the reserve but also reflects the low richness in this region due to current patterns and cool sea temperatures. Only one endemic macroalgae is known from the TWWHA and none are listed as threatened (Table 10.1, Appendix 2).

Family and generic endemism and diversity

There are no endemic plant families in Tasmania. Of the 19 endemic vascular genera, 17 occur within the TWWHA (*Acion, Agastachys, Anodopetalum, Asterotrichion, Athrotaxis, Bellendena, Campynema, Cenarrhenes, Diselma, Isophysis, Microcachrys, Milligania, Odixia*, Planocarpa, Prionotes, Pterygopappus, Stonesiella*, Tetracarpaea, Winifredia* (*denotes genera not in TWWHA). Almost half of these genera are thought to be Gondwanan in origin. There is one endemic genus of moss, *Ambuchanania,* and one genus of lichen *Siphulella* that occur in the TWWHA (Kantvilas et al. 1992).

The Australian mainland has a generic endemism of 23%, a figure similar to that in New Zealand (McGlone et al. 2001). Tasmania has a low rate of generic endemism when compared with other regions of Australia and New Zealand. Consequently, the TWWHA has no significance at a national level with respect to generic endemism.

The greatest significance of the TWWHA for national conservation of plant families is the presence of high diversity of Epacridaceae with 61 species (two thirds of the Epacridaceae species in Tasmania) in the TWWHA. Of these 67% are endemic to Tasmania (Table 10.1).

The high degree of local endemism is suggestive of active evolutionary change and radiation. Within the TWWHA many superlative examples of the evolution of this plant group exist including the endemic *Richea pandanifolia*, the tallest heath species in the world and a common component of cool temperate rainforest, which closely resembles a grass tree. In contrast, *Dracophyllum minimum* has evolved into a cushion form with closely packed leaves at the tips of its branches, a form that is adapted to harsh and freezing winds of the Tasmanian alpine zone.

Epacridaceae include two endemic genera – *Planocarpa* and *Prionotes*. *Prionotes* is particularly noteworthy due to its taxonomic affinities with the family Ericaceae, having reticulated rather than parallel venation.

The other family of significance is Proteaceae. It has the greatest proportion of endemic species in the TWWHA (75%) but the diversity of this family is low compared to other regions (Table 10.1). It has three endemic genera and many primitive species represented in the TWWHA.

The three families with greatest diversity in the TWWHA (Asteraceae, Cyperaceae and Poaceae) are also diverse elsewhere and have cosmopolitan distributions so are not of national conservation significance (Table 10.1).

Conservation endemism and diversity at the ecosystem level

Endemic richness in Tasmania is correlated with those environments that are most different from those on mainland Australia (Kirkpatrick & Brown 1984a).

Examination of endemism at an ecosystem level reveals high richness in vascular plant endemism in alpine areas throughout Tasmania with the highest concentrations in western areas including the TWWHA (McGlone et al. 2001, Kirkpatrick 2002). Nearly two-thirds of the TWWHA endemic vascular species are found in alpine habitats.

The wet sclerophyll habitats which include rainforest species has just over one-third of the TWWHA endemic species while rainforest and buttongrass moorland vegetation each include about 25% of the TWWHA endemic flora (Appendices 2 and 3). At a local scale the proportion of endemics in the vegetation can be much higher than for the region. The alpine vegetation in western Tasmania can exceed 70% endemism on a single mountaintop. Montane and implicate rainforest communities are also often much richer in endemic vascular plant taxa at the local scale.

Alpine ecosystems

Tasmanian alpine ecosystems have high vascular plant richness and endemism at all scales of diversity. Within the TWWHA more than 400 vascular plant species have been recorded. Two thirds of these are endemic (Table 10.2). Species richness typically declines with increasing altitude, but in Tasmania it shows a contrary trend (Doran et al. 2003). Some researchers have suggested that this trend is a result of a depauperate lowland flora rather than a rich alpine flora. Buttongrass moorlands certainly have relatively low alpha and gamma diversity compared to heathland in Tasmania and the Australian mainland. Forests were reduced to relict patches during the glacial epochs that may have led to extinctions explaining the comparatively low species richness of Tasmanian wet forests (Ogden & Powell 1979, Kirkpatrick & Brown 1984b). High levels of alpine diversity could also have resulted from the more widespread distribution of alpine vegetation in the past (Figure 4.2). The expansion and retraction of species is linked to the glacial and interglacial periods of the Pleistocene (Kirkpatrick & Brown 1984b).

The alpine communities have the highest levels of vascular plant endemism in Tasmania at both generic and specific levels (Table 10.2). This is likely to have resulted from the rarity of this habitat on the mainland and Tasmania's geographic isolation. There is a marked pattern in the percentage of endemism from eastern to western mountains, with the percentage of endemism reaching 70% of species on some far southwest mountaintops (Kirkpatrick 1986a). Alpine habitats are also important for non-vascular plant groups particularly lichens, at least in long unburnt areas (Kantvilas and Jarman 1991, Brown et al. 1994). *Gyalideopsis graminicola* is an endemic lichen that occurs in montane grassland at the Walls of Jerusalem (Kantvilas & Vezda 1992).

Within the TWWHA it is alpine communities that harbour the greatest number of threatened species, with 38 listed as threatened (Appendix 1). Among these threatened species is the liverwort, *Pseudocephalozia paludicola,* which is listed on the *EPBC Act 1999* as vulnerable and is restricted to subalpine moorland and montane grassland of the Central highlands.

Buttongrass moorlands

The vascular flora has more than 200 species of which 66 are endemic most of which occur in the TWWHA (Table 10.2). In contrast the diversity and endemism of non-vascular species is low. A total of only 89 lichen species (excluding adventive taxa) are recorded from this habitat in Tasmania. Only two of these lichens are endemic (*Cladia moniliformis and Micarea isabellina*) and only these and four others are largely confined to buttongrass moorland (Kantvilas & Jarman 1988).

The diversity of bryophytes is even lower (Jarman et al. 1988a). The absence of a diverse non-vascular flora in this vegetation probably reflects the inability of these species to cope with frequent fire (Kantvilas & Jarman 1991).

Nine species are listed as threatened under the *TSP Act 1995*, of which only one, *Centrolepis pedderensis,* is listed nationally (Appendix 1). Among these rare species is the monotypic and endemic moss genus *Ambuchanania leucobryoides*, which is restricted to scalds in buttongrass moorlands of the TWWHA. All of the threatened species of buttongrass moorlands have all, or a substantial portion, of their populations within the TWWHA. At least three endemic vascular species remain undescribed from the alkaline pans of the TWWHA (Jarman et al. 1988a), one of which is listed as threatened (*Isoetes* sp. *nova* 'Maxwell River'). This habitat within moorlands has proved particularly rich in restricted endemic taxa.

Sclerophyll vegetation

The sclerophyll scrubs, woodlands and forests of the TWWHA include at least 92 endemic species and a total vascular flora diversity that closely rivals that of the alpine vegetation (Table 10.2). There is also a high non-vascular species richness in the sclerophyll forests of the TWWHA. In studies of an area adjacent to the TWWHA 134 species of lichen and 144 species of bryophyte have been recorded from undisturbed wet sclerophyll forest (Jarman & Kantvilas 2001ab, Kantvilas & Jarman 2004). A high altitude eucalypt forest site at the Pelion Plains within the TWWHA had 72 lichen species, 46 species of bryophytes, while supporting only 28 vascular plant species (Jarman & Kantvilas 1994). Threatened species found in sclerophyllous forests and woodlands include 19 vascular plants (Appendix 1) but only two *Lomatia tasmanica* and *Sagina diemensis* are confined the TWWHA. Neither of these two species is dependent on sclerophyll habitat but occurs within it only where it is associated with riparian rainforest or dolomite outcrops respectively.

Wetlands

A lack of surveys of the TWWHA wetlands makes formal assessment of its diversity and richness in endemism difficult. Riparian areas elsewhere are renowned for high levels of species richness, thought to be associated with the environmental heterogeneity of riverine situations (Askey-Doran 1993). Data for western Tasmania have shown that richness in riparian flora is relatively poor compared to other riparian vegetation, but that it is rich for subalpine and alpine riparian vegetation, especially on the Central Plateau (Daley 2003). About 58 (23%) endemic vascular plant species are known to occur in wetland vegetation of the TWWHA but a list of species for this habitat has yet to be compiled. At least 26 threatened vascular plant taxa are recorded from wetland situations in the TWWHA including riparian and aquatic habitats (Appendix 1).

Rainforests

The Tasmanian cool temperate rainforests are of national significance for their primitive vascular plant flora, high endemicity among woody plants and their high diversity of non-vascular species. Forty-one endemic vascular plant species occur within the rainforests of the TWWHA (Table 10.2).

Extant rainforest taxa are thought to have evolved *in situ* in response to the changing Tertiary climate and oligotrophic environments (Hill & Read 1987). This may have resulted in the higher levels of vascular plant endemism in implicate, thamnic and montane rainforests of the southwest than is found in rainforests elsewhere in Tasmania.

About 220 bryophytes (Jarman and Fuhrer 1995), 217 macrolichens and at least 200 crustose lichens have been found in Tasmanian rainforest and therefore substantially outnumber the vascular flora. Rainforest provides habitat for more than one third of all species of bryophyte and lichens in Tasmania (Kantvilas 1995, Kantvilas & Jarman 1999). At the local scale bryophyte and lichen diversity in rainforests is even more phenomenal. As many as 74 species of lichen and 40 species of bryophyte have been recorded from a single fallen tree of *Lagarostrobos franklinii* (Jarman & Kantvilas 1991). A rainforest site at Pelion Plains had a diversity of 83 lichens, 22 mosses and 52 liverworts, in an area that supported only 26 vascular plant species (Jarman and Kantvilas 1994). An intensive study of a rainforest by Kantvilas (1988a) at the Little Fisher River revealed the presence of more than 126 lichen species.

Despite the high diversity of non-vascular species in rainforest, endemism in these groups is low with less than 5% of bryophyte and lichen species being endemic to Tasmania. Whilst most non-vascular species are widespread, some specialisation does exist. For example two endemic lichen species *Roccellinastrum flavescens* and *R. lagarostrobi* are found only on the leaves of the conifers *Athrotaxis cupressoides* and *Lagarostrobos franklinii* respectively (Kantvilas 1990).

Integrity

The TWWHA contains two of Tasmania's seven centres of local endemism (the southern and southwestern mountains and coastal plains and the Central Plateau region (Hill and Orchard 1999). These centres do extend beyond the TWWHA boundaries. Omissions include Melaleuca, Southport Lagoon and Mt Field National Park.

The TWWHA includes superlative examples of restricted endemic plant species and contains entire populations of many restricted species including three nationally listed endangered species (*Lomatia tasmanica*, *Centrolepis pedderensis* and *Sagina diemenica*). There are a number of threatened, endemic and/or restricted species whose populations occur in areas adjoining the TWWHA. Some of these have been documented in previous sections.

Within Tasmania it is the alpine region that exhibits the greatest richness in endemism of all the ecosystems. About 83,130 ha (or 61%) of Tasmanian alpine vegetation is in the TWWHA, thereby meeting the condition of integrity. The rainforests and wet eucalypt forests harbour the greatest diversity of species, especially non-vascular plants. These forests are well represented, especially the more diverse and primitive montane rainforests. The major omission in the region is the lack of tall callidendrous rainforests, which may support lichen species not common in implicate and thamnic communities.

Table 10.1: Diversity and conservation status of plant taxa in Tasmania and the Tasmanian Wilderness World Heritage Area. Data for the 20 families with the highest species diversity. (Numbers in brackets refer to intraspecific taxa)

	Native Species[2]		**Endemic Species[2]**		**Rare Taxa[1]**		**Vulnerable Taxa[1]**		**Endangered Taxa[1] (extinct)**	
	Tas	**WHA**	**Tas**	**WHA**	**Tas**	**WHA**	**Tas**	**WHA**	**Tas**	**WHA**
Orchidaceae	196 (198)	51 (51)	62 (63)	10 (10)	16	2	3	0	47 (2)	0
Asteraceae	181 (209)	101 (108)	48 (59)	34 (40)	26	7	3	0	7 (4)	0 (0)
Poaceae	131 (152)	81 (86)	20 (24)	12 (15)	31	11	0	0	3 (1)	0
Cyperaceae	119 (124)	81 (82)	16 (17)	12 (13)	19	6	1	0	1	0
Epacridaceae	90 (101)	61 (67)	57 (62)	41 (46)	10	4	6	0	5	0
Fabaceae	56 (61)	17 (17)	3 (4)	0 (0)	7	1	9	1	3	0
Myrtaceae	52 (64)	33 (34)	24 (26)	16 (17)	7	1	0	0	2	0
Liliaceae	38 (49)	16 (16)	7 (8)	7 (8)	8	4	1	0	0	0
Apiaceae	38 (42)	24 (25)	6 (7)	6 (7)	1	0	2	0	0	0
Juncaceae	34 (36)	24 (24)	4 (5)	4 (5)	5	1	0	0	0	0
Proteaceae	29 (50)	20 (25)	17 (31)	15 (20)	7	4	3	0	1 (1)	1
Scrophulariaceae	27 (41)	16 (24)	8 (19)	3 (10)	8	3	3	1	6 (1)	0
Ranunculaceae	25 (25)	19 (19)	11 (11)	9 (9)	5	3	0	0	1 (1)	0
Rhamnaceae	23 (33)	4 (4)	8 (11)	2 (2)	7	0	4	0	3	0
Rutaceae	27 (39)	13 (15)	11 (15)	5 (6)	2	0	0	0	2	0
Brassicaceae	21 (21)	8 (8)	3 (3)	1 (1)	3	1	0	0	3 (1)	0
Mimosaceae	20 (27)	7 (9)	3 (4)	1 (2)	5	1	1	0	0	0
Haloragaceae	19 (22)	13 (13)	1 (1)	1 (1)	4	0	2	0	0 (1)	0
Rubiaceae	18 (25)	15 (15)	0 (1)	0 (0)	3	2	0	0	0 (1)	0
Thymelaeaceae	18 (24)	9 (10)	6 (6)	5 (5)	5	1	0	0	1	0
Mono-cotyledonae	598 (642)	297 (304)	127 (136)	61 (68)	93	27	7	0	52 (4)	1
Dicotyledonae	995 (1183)	540 (585)	263 (328)	182 (216)	164	46	50	1	44 (17)	3
Pteridophyta	100 (113)	73 (73)	7 (7)	6 (6)	10	3	6	0	2 (1)	0
Gymnospermae	10 (10)	8 (8)	7 (8)	7 (7)	0	0	2	1	0	0
Total Vascular[2]	1701 (1949)	917 (970)	403 (479)	255 (297)	267	76	65	2	98 (22)	4

	Native Species[2]		Endemic Species[2]		Rare Taxa[1]		Vulnerable Taxa[1]		Endangered Taxa[1] (extinct)	
	Tas	**WHA**	**Tas**	**WHA**	**Tas**	**WHA**	**Tas**	**WHA**	**Tas**	**WHA**
Mosses[3]	369 (383)	219 (225)	28 (31)	9 (10)	33 (34)	22 (23)	16 (17)	12	63 (18)	11 (2)
Liverworts[3]	321 (327)	254 (255)	14 (15)	11 (12)	47	32	11	11	38 (15)	14 (3)
Lichens[4]	881 (903)	277 (281)	91 (98)	15 (16)	12	3	4	0	7 (2) (1)	0
Marine Macro-Green Algae[5]	63 (67)	13	0	0	0	0	0	0	0	0
Marine Macro Brown Algae[5]	144	27	2	1	1	0	0	0	0	0
Marine Macro Red Algae[5]	421 (422)	50	12	0	0	0	0	0	0	0

1. Data listed here for vascular plants and lichens are derived from the Tasmanian *TSP Act 1995* schedules current in 2004. Data for Liverworts and Mosses are derived from the preliminary conservation assessment provided in Moscal et al. 1996, but species proposed by them as vulnerable, endangered and critically endangered are listed here as rare, vulnerable and endangered, respectively. (To date no liverworts have been listed on the threatened species schedule of the TSP Act 1995 and only one moss is listed as rare).
2. Data for the number of native taxa for all vascular plant groups have been derived from Buchanan 2003. The number of taxa recorded within the TWWHA has primarily been derived from Kirkpatrick et al. 1991b, the Tasmanian Herbarium database (as at 2001) and/ or Department of Primary Industries, Water and Environment GTSpot database (as at January 2002).
3. Data for the number of endemic and native species of Bryophytes within Tasmania and within the WHA have been derived from Moscal and Kirkpatrick (1997), while the number of threatened species of Bryophytes is sourced from Moscal et al. (1996).
4. Data for lichen numbers in Tasmania are derived from McCarthy (2003) and within the WHA from various sources including Peterson and Kantvilas (1986), Kantvilas (1988a), Kantvilas (1988b), Kantvilas and Vĕzda (1988), Vĕzda and Kantvilas (1988), Coppins and Kantvilas (1990), Kantvilas and James (1991), Kantvilas and Jarman (1991), Grgurinovic (1992), Kantvilas and Elix (1992), Kantvilas and Vĕzda (1992), Kantvilas et al. (1992), Grgurinovic (1994), Jarman and Kantvilas (1994), Kantvilas and Elix (1995) and Kantvilas et al. 2002.
5. Data for Tasmanian Algae have been derived from Sanderson and Balmer unpublished data (DPIWE files) and for species recorded from TWWHA marine environments: Barrett et al. 1998, Last and Edgar 1994, Edgar 1984ab.

Table 10.2: Diversity and endemism habitat within the TWWHA using data extracted from Jarman et al. (1984), Jarman et al. (1988), Kirkpatrick et al. (1988), Kirkpatrick and Harris (1995), Garrett (1996), Kirkpatrick (1997), Jones et al. (1999) and GTSpot (as at 2001). Table shows numbers of species occuring within various habitats within the TWWHA and Tasmania. The number of infraspecific taxa are listed in brackets.

	Alpine	**Rainforest**	**Wet Sclerophyll**	**Coast**	**Buttongrass moorland**	**Total TWWHA**	**Total Tas**
Number of species in each habitat that occur in the TWWHA (i)	402 (415)	152 (162)	385 (391)	293 (301)	195 (197)	916 (971)	
Number of species in each habitat for Tasmania (ii)	414 (434)	154 (164)	496 (502)	539 (555)	206 (209)		1701 (1949)
Number of endemics in each habitat that occur in the TWWHA (iii)	169 (194)	63 (70)	92 (99)	31 (33)	64 (68)	255 (297)	
Number of endemics in each habitat in Tasmania (iv)	173 (202)	63 (71)	103 (110)	66 (71)	66 (73)		403 (479)
% OF TOTAL NO OF ENDEMICS IN THE TWWHA = $^{(iii)}/_{255}$ x 100	66%	25%	36%	11%	25%	100	
Proportion of endemics per habitat in the TWWHA = $^{(iii)}/_{(i)}$ x 100	42%	41%	24%	12%	33%	28%	
Number of **genera** in each habitat in the **TWWHA**(v)	187	99	199	175	123	347	
Number of **genera** in each habitat in **Tasmania** (vi)	190	99	248	279	128		534
Number of **endemic genera** in each habitat in the TWWHA	10	10	10	1	6	17	19
Proportion of genera that are endemic in each habitat in the TWWHA	5%	10%	5%	0%	5%	5%	
Number of threatened taxa in each habitat within the TWWHA	37	7	12	17	5	81[21]	
Number of threatened taxa for each habitat listed on the EPBC Act 1999 in the TWWHA	4	1	1	0	1	7	

[21] Data for four threatened species (*Arthropodium strictum, Glycine latrobeana, Pultenaea prostrata* and *Brachscome sieberi* var. *gunnii*) were represented by singleton records in the TWWHA which were well outside their usual geographic and envionmental range and were excluded from the TWWHA list.

11. Bibliography

Column 1 indicates references that are cited in the text and lists the section numbers the citation appears in.

Column 2 indicates references that describe aspects of the TWWHA and lists the principle topic of relevance:

A	Alpine and subalpine treeless vegetation	K	Karst
B	Buttongrass moorlands	P	Palaeoecology & dendrochronology
C	Coastal communities	R	Rainforest
D	Disease or pests	S	Sclerophyllous forests, woodlands and scrub
F	Fire and succession	T	Taxonomy & Conservation
H	Human impact including trampling	W	Wetlands

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Appendix 1: Threatened species listed at the state or national level occurring within the TWWHA.

(1) Status of each taxa on the *Threatened Species Protection Act 1995* as at December 2004 (r=rare, v=vulnerable, e=endangered)

(2) Status of each taxa on the *Environmental Protection Act 1999* as at December 2004 (VU=vulnerable, EN=endangered, CR=Critically endangered)

(3) Distribution of each taxa (t=Tasmania is the only state in Australia the species occurs, EN=Tasmania endemic species, (en)=Tasmanian endemic intraspecific taxon).

(4) Proportion of the Tasmanian population contained within the TWWHA (H=more than 50%, M= 10-50% of populations, L=A minor proportion of the population).

(5) Habitat codes (A=alpine and subalpine treeless vegetation, B=Buttongrass moorland, C=coastal vegetation, K=karst areas, R=rainforest, S=sclerophyll scrub, forest and woodlands, W=wetlands including marine and riparian habitats.

1	2	3	4	Scientific name and authority	Family	Habitat (5)	Distribution notes for the TWWHA
				GYMNOSPERM			
v		EN	M	*Microstrobos niphophilus* J.Garden & L.A.S.Johnson	PODOCARPACEAE	A R	Sub-alpine coniferous heathland and montane rainforest in areas such as the Labyrinth, Pine Valley, Jubilee Range, Cheyne Range, Lake Ina and Lake Richmond.
				ANGIOSPERMS/DICOTYLEDONAE			
r		(en)	M	*Acacia mucronata* subsp. *dependens* (Hook.f.) Court	MIMOSACEAE	R S	Occasional in rainforest scrub and eucalypt forest and scrub the TWWHA.
r			L	*Asperula minima* Hook.f.	RUBIACEAE	S W	Eucalypt forest and creek banks in the Mersey and Meander Forest Reserves.
r			L	*Asperula subsimplex* Hook.f.	RUBIACEAE	W	Known from wet creek banks in the Lake St Clair area.
r			L	*Australina pusilla* subsp. *muelleri* (Wedd.) Friis & Wilmot-Dear	URTICACEAE	S	Eucalypt forest at Wayatinah and Quamby bluff.
r		EN	M	*Brachyscome aff. radicans* (A. Moscal HO121890)	ASTERACEAE	A W	Previously known as Brachyscome nivalis var. alpina. Grassy wet places and along stream banks on the Central Plateau.
r		t	L	*Brachyscome radicata* Hook.f.	ASTERACEAE	A	Montane grassland near Cradle Mountain.
r			L	*Centaurium spicatum* (L.) Fritsch ex Janch.	GENTIANACEAE	R S	Rainforest and eucalypt forest on Quamby Bluff and Western Tiers on the margins of the TWWHA.
r	VU	EN	L	*Colobanthus curtisiae* J.West	CARYOPHYLLACEAE	A	Grassland and grassy woodland vegetation near Lake Augusta and Split Rock on the Central Plateau.
r			H	*Colobanthus pulvinatus* F.Muell.	CARYOPHYLLACEAE	A	Fjaeldmarks on the Southern Ranges (Moonlight Ridge), the summit of Mt Ossa and Frenchman's Cap.
r			M	*Comesperma defoliatum* F.Muell.	POLYGALACEAE	B C	Rarely found species of buttongrass moorlands, alkaline pans and coastal dunes.
r		t	M	*Crassula moschata* Forst.f.	CRASSULACEAE	C	An itinerant species of the littoral zone on beaches along the southcoast.
r	EN	EN	L	*Epacris acuminata* Benth.	EPACRIDACEAE	S	Edges of the Central plateau in subalpine heathy woodland. This plant may be delisted soon.

1	2	3	4	Scientific name and authority	Family	Habitat (5)	Distribution notes for the TWWHA
r			M	*Epilobium willisii* Raven & Engelhorn	ONAGRACEAE	W	Wet montane herbfields around the Central Plateau.
r			M	*Eucalyptus radiata* subsp. *robertsonii* (Blakely) L.A.S.Johnson & Blaxell	MYRTACEAE	S	This species is restricted to the upper Fourth River catchment in the Lemonthyme and Mersey Forest reserve.
r			M	*Euchiton fordianus* (M.Gray) P.S.Short	ASTERACEAE	A	Grassy depressions in alpine heathland at Pine Lake on the Central Plateau.
r			H	*Euchiton poliochlorus* N.G. Walsh	ASTERACEAE	B	A buttongrass moorland site at Cradle Mountain.
r		(en)	M	*Euphrasia gibbsiae* subsp. *pulvinestris* W.R.Barker	SCROPHULARIACEAE	A K	Crevices in exposed faces of dolomite outcrops of the north-east ridge of Mt Anne.
r		EN	H	*Geum talbotianum* W.M.Curtis	ROSACEAE	A	Rocky dolerite scree at high altitudes in the southern mountains.
r			L	*Glossostigma elatinoides* (Benth.) Benth. ex Hook.f.	SCROPHULARIACEAE	W	Submerged in shallow water on the banks of streams and pools in the Cradle Mt- Lake St Clair National Park.
r			M	*Hovea montana* (Hook.f.) J.H.Ross	FABACEAE	A	Open heaths and montane shrubbery in the central part of the State including Lake Ada and Clarence Lagoon.
r		t	M	*Lepidium flexicaule* Kirk	BRASSICACEAE	C	Littoral habitats in skeletal soil within rock crevices of southwest coast.
e	CR	EN	H	*Lomatia tasmanica* W.M.Curtis	PROTEACEAE	R S W	Riparian habitat in mixed forest and rainforest Bathurst Harbour Range.
r		EN	H	*Monotoca submutica* var. *autumnalis* Jarman	EPACRIDACEAE	A	Alpine and subalpine heathland in the western and central mountains including Cradle Mountain- Lake St Clair National Park and Wild Rivers National Park areas.
r			M	*Muehlenbeckia axillaris* (Hook.f.) Endl.	POLYGONACEAE	A	Gravely, rocky places on the Central Plateau and Cradle Mountain - Lake St. Clair National Park.
r	VU	EN	H	*Oreoporanthera petalifera* Orch. & J.Davies	EUPHORBIACEAE	A K	Crevices on the exposed dolomite tower karst on the north-east ridge of Mount Anne.
r		EN	M	*Orites milliganii* Meisn.	PROTEACEAE	A R	Widespread in western and southwestern alpine, coniferous and deciduous heathland and montane rainforest.
r		EN	H	*Persoonia gunnii* var. *oblanceolata* Orch.	PROTEACEAE	R	Rainforest and rainforest scrub on the southern highlands including the Thumbs, Lake Judd and the Weld Valley.
r		EN	H	*Persoonia moscalii* Orch.	PROTEACEAE	A B	Largest population known from the top of Mount Counsel in alpine vegetation but also recorded from hills in buttongrass moorland.
r		EN	M	*Persoonia muelleri* subsp. *angustifolia* (Benth.) L.A.S.Johnson & P.H.Wilson	PROTEACEAE	R	Rainforest to dense scrub along the southern beaches and Port Davey as well as highland areas such as South Cape Range, Pyramid Mountain, Collingwood River, and Lake Vera.
r		EN	M	*Pimelea milliganii* Meisn.	THYMELAEACEAE	A	Alpine heaths on southwestern mountains.
r		EN	M	*Planocarpa nitida* (Jarman) Weiller	EPACRIDACEAE	A	Rocky situations in low open woodland and heath on the sand dunes of the eastern Central Plateau near Lake Augusta, Julian Lakes, Little Split Rock, Layatinna Hill and Wild Dog Plains.
r		EN	M	*Planocarpa sulcata* (Mihaich) Weiller	EPACRIDACEAE	A	Widespread in exposed alpine, coniferous and deciduous heath on shallow soils in the western mountains at altitudes above 950 m.
r			M	*Plantago glacialis* B.G.Briggs, Carolin & Pulley	PLANTAGINACEAE	A	Short alpine herbfields, associated with snow patches at Goulds Sugarloaf, Mt. Geryon and Mt Rufus.

1	2	3	4	Scientific name and authority	Family	Habitat (5)	Distribution notes for the TWWHA
r		t	M	*Ranunculus acaulis* Banks & Soland. ex DC.	RANUNCULACEAE	C	Found in seepage areas on the seaward sides of sand dunes on the south coast. It is no longer found on the original shore of Lake Pedder.
r		EN	M	*Ranunculus collicola* Menadue	RANUNCULACEAE	W	Wet sand and silt on the margins of lakes and lagoons in places prone to seasonal flooding on the Central Plateau.
r		EN	H	*Ranunculus jugosus* Menadue	RANUNCULACEAE	W	Short alpine herbfields associated with rivers and soaks in the Central Plateau region.
e			M	*Rhytidosporum inconspicuum* Cayzer et al.	PITTOSPORACEAE	A B S	Rocky slopes and in eucalypt scrub, buttongrass moorland, Poa tussock grassland and subalpine heath in the Cradle Mountain-Lake St Clair and Walls of Jerusalem National Park.
e	CR	EN	H	*Sagina diemensis* L.G.Adams	CARYOPHYLLACEAE	A K S	Dolomite cliffs and the rocky rims of a sinkhole near the dolomite/dolerite boundary on the northeast ridge of Mt Anne and also at the Weld River Arch on an exposed dolomite outcrop.
r			L	*Scleranthus brockiei* P.A.Williamson	CARYOPHYLLACEAE	A	Grassland and grassy woodland in subalpine to alpine areas at Mt Inglis
r			L	*Senecio velleioides* A.Cunn. ex DC.	ASTERACEAE	S	Occasional but widespread in moist places particularly after disturbance by fire has been found in forest and scrub vegetation.
r			L	*Stackhousia pulvinaris* F.Muell.	STACKHOUSIACEAE	A	Montane and sub-alpine grassy regions on the Central Plateau
r			L	*Stellaria multiflora* Hook.	CARYOPHYLLACEAE	A S	Rocky situations in the Central Plateau Conservation Area.
r			L	*Taraxacum aristum* Hagl. & Markl.	ASTERACEAE	A K	Found in a sinkhole and cliffs at Mt Gell.
v			L	*Veronica novae-hollandiae* Poiret	SCROPHULARIACEAE	C	Coastal short tussock grasslands at Macquarie Harbour/Gordon River and Recherche Bay.
r			L	*Veronica plebeia* R.Br.	SCROPHULARIACEAE	K	Has been found in the TWWHA on outcrops of limestone or dolomite at Tim Shea, Mt Ronald Cross and Mt Gell.
r			L	*Viola cunninghamii* Hook.f.	VIOLACEAE	W	Subalpine wetland areas possibly widespread in Central Highlands.
r		(en)	L	*Viola hederacea* subsp. *curtisiae* L.G.Adams	VIOLACEAE	A S W	Lake Ewart in wet subalpine situations and wet sclerophyll forest western tiers
r		EN	M	*Westringia angustifolia* R.Br.	LAMIACEAE	S W	Riparian scrub in central and southern Tasmania including Jubilee Range and Russell River.
r		EN	H	*Westringia brevifolia* var. *raleighii* (B.Boivin) W.M.Curtis	LAMIACEAE	C	Coastal heathland and forest along the south coast.
r			L	*Xerochrysum bicolor* (Lindley) R.J.Bayer	ASTERACEAE	C	Recorded from heaths on Maatsuyker Island.
				ANGIOSPERMS/ MONOCOTYLEDONAE			
r			M	*Agrostis australiensis* Mez	POACEAE	A S	Rare in moist, open areas such as rock crevices or on cliff faces within alpine areas and wet forests in the Central highlands.
r			M	*Agrostis propinqua* S.W.L.Jacobs	POACEAE	A W	Alpine fjaeldmark on Hartz Mountain, and from intermittent wetlands in the central highlands
r			L	*Australopyrum velutinum* (Nees) B.Simon	POACEAE	A	Grassland vegetation south of Lake Augusta in the Central Plateau Protected Area

1	2	3	4	Scientific name and authority	Family	Habitat (5)	Distribution notes for the TWWHA
r			M	*Baumea gunnii* (Hook.f.) S.T.Blake	CYPERACEAE	B S W	Wet moors, creeks and riverbanks near Lake St Clair and Adamsfield.
r			M	*Carex capillacea* Boott	CYPERACEAE	A W	Marshy habitat and short alpine herbfields including snow patches around the Central Highlands (600 -1400 m altitude).
r			H	*Carex cephalotes* F.Muell.	CYPERACEAE	A W	A snow patch on the lee side of Mount Eliza
r			H	*Carex hypandra* F.Muell. ex Benth.	CYPERACEAE	A W	Alpine fens on the central and western mountains
e	VU	EN	H	*Centrolepis pedderensis* W.M.Curtis	CENTROLEPIDACEAE	B W	Known only from one montane lakeshore but has also been collected from the Gordon River and an unknown alkaline pan.
r		t	H	*Deschampsia gracillima* Kirk	POACEAE	A	Fjaeldmarks on the Southern Ranges (Maxwell and Moonlight Ridges).
r			L	*Deyeuxia benthamiana* Vickery	POACEAE	S	Wet sclerophyll forest on the lower slopes of Moonlight ridge. Possibly also Ironstone mountain Central Plateau.
r			L	*Deyeuxia brachyathera* (Stapf) Vickery	POACEAE	S	Dry sclerophyll forest around Lake St. Clair, may also occur in grassy forest of the Central highlands.
r			L	*Deyeuxia densa* Benth.	POACEAE	C S	Lightly shaded heath, sedgeland and woodland at Lake St Clair and Port Davey.
r			L	*Deyeuxia minor* F.Muell. ex Benth.	POACEAE	C	Within the TWWHA this species has been found inhabiting the eucalypt forest margin at Whalers Cove, Port Davey.
r	VU	EN	M	*Hymenochilus pratensis* D. L. Jones	ORCHIDACEAE	A	Listed as Pterostylis pratensis. Montane and alpine grasslands around Lake Augusta and Lake Botsford in the Central Plateau Conservation Area
r			L	*Isolepis habra* (Edgar) Soják	CYPERACEAE	A	Wet montane and riparian habitats near Pelion Hut and Douglas Creek in the Cradle Mountain -Lake St. Clair National Park.
r			M	*Lachnagrostis aequata* (Nees) S.W.L.Jacobs	POACEAE	C	Beach sands on the southwest coastline.
r			L	*Lachnagrostis robusta* (Vickery) S.W.L.Jacobs	POACEAE	C W	Marshy, estuarine habitat at Port Davey.
r			M	*Lepilaena patentifolia* E.Robertson	ZANNICHELLIACEAE	C W	Coastal lagoons and estuaries at New Harbour lagoon.
r			H	*Luzula atrata* Edgar	JUNCACEAE	A W	Wet ground in alpine areas of the Central Highlands and southwest mountains.
r		EN	H	*Milligania johnstonii* F.Muell. ex Benth.	LILIACEAE	B	Alkaline pans and buttongrass moorlands of southwest Tasmania.
r		EN	H	*Milligania longifolia* Hook.f.	LILIACEAE	K R W	Riparian limestone cliffs in narrow ledges or crevices along the Franklin and Gordon Rivers and the Vale River.
r			L	*Poa poiformis* var. *ramifer* D.I.Morris	POACEAE	C	Coastal areas and offshore islands on sand dunes or rocky habitats.
r			H	*Prasophyllum tadgellianum* R.S.Rogers	ORCHIDACEAE	A	Subalpine grassland and grassy woodland in the Cradle Mountain area and near Bastion Bluff in the Great Western Tiers.
r			L	*Thismia rodwayi* F.Muell.	BURMANNIACEAE	S	Found in the Meander Forest Reserve in wet sclerophyll forests.
r			L	*Trithuria submersa* Hook.f.	HYDATELLACEAE	W	Marshy habitats on the Eldon Range and central highlands.
r		t	L	*Uncinia elegans* (Kük.) Hamlin	CYPERACEAE	W	Damp areas Cheyne Range and Central Highlands.
				PTERIDOPHYTES			
r		EN	L	*Isoetes humilior* F.Muell. ex A.Braun	ISOETACEAE	W	Submerged in slow-moving sections of running and still water around the Central Plateau at Lake St Clair and Clarence lagoons.

1	2	3	4	Scientific name and authority	Family	Habitat (5)	Distribution notes for the TWWHA
r		EN	H	*Isoetes sp. nova "Maxwell River"* (S.J.Jarman HO314082)	ISOETACEAE	B W	Creeks and pools associated with alkaline pans in southwest Tasmania.
r			L	*Pilularia novae-hollandiae* A.Braun	MARSILEACEAE	W	Mud or silt of shallow rivers and on the seasonally inundated creek margins in central highlands including Little Pine River, Nive River, and Lake St Clair.
				LICHENS			
r			H	*Parmeliopsis ambigua* (Wulf.) Nyl.	PARMELIACEAE	R	A single collection from under shrubs in open montane pencil pine forest, Walls of Jerusalem NP (Kantvilas et al. 2002)
r			H	*Parmeliopsis hyperopta* (Ach.) Arnold	PARMELIACEAE	R	Known only from bleached and dead wood in an open montane pencil pine forest, Walls of Jerusalem NP (Kantvilas et al. 2002)
r			M	*Cetraria islandica* subsp. *antarctica* Karnefelt	PARMELIACEAE	A	Growing over soil and cushion plants at Cradle Mt (Kantvilas et al. 2002)
				MOSS			
r		EN	H	*Ambuchanania leucobryoides* Yamaguchi et al.	SPHAGNACEAE	B	Scalds in buttongrass moorlands at Wallaby Bay (Port Davey) and the Jane River track.
				LIVERWORT			
	VU	EN	M	*Pseudocephalozia paludicola* Schust.	HEPATICAE	A	Subalpine sphagnum and moorland vegetation in the west and on the central highlands including Shadow Lake at Mt Rufus.

Appendix 2: List of Tasmanian endemic species that occur in the TWWHA.

(1) Status on the Tasmanian Threatened Species Protection Act 1995 (codes as for Appendix 1)
(2) Status on the *Environmental Protection and Biodiversity Act 1999* (codes as for Appendix 1)
(3) Locally restricted endemic species (R1 = plants largely confined to a range of less than 100 km).
(4) Habitats in which the species is known to occur (codes as for Appendix 1).

FAMILY	1	2	3	Scientific Name and authority	Habitat (4)
GYMNOSPERMAE					
CUPRESSACEAE				*Athrotaxis cupressoides* D.Don	A R S
CUPRESSACEAE				*Athrotaxis selaginoides* D.Don	A R S
CUPRESSACEAE				*Diselma archeri* Hook.f.	A R S
PODOCARPACEAE				*Lagarostrobos franklinii* (Hook.f.) Quinn	A R S
PODOCARPACEAE				*Microcachrys tetragona* (Hook.) Hook.f.	A R
PODOCARPACEAE	v			*Microstrobos niphophilus* J.Garden & L.Johnson	A R
PODOCARPACEAE				*Phyllocladus aspleniifolius* (Labill.) Rich. ex Hook.f.	R S
ANGIOSPERMS/ DICOTYLEDONAE					
APIACEAE				*Actinotus moorei* Rodway	A B
APIACEAE				*Anisotome procumbens* (F.Muell.) C.J.Webb	A
APIACEAE				*Diplaspis cordifolia* (Hook.) Hook.f.	A B
APIACEAE				*Oreomyrrhis gunnii* Mathias & Constance	K R
APIACEAE				*Oreomyrrhis sessiliflora* Hook.f.	A
APIACEAE				*Oschatzia saxifraga* (Hook.f.) Walp.	A B
ARALIACEAE				*Pseudopanax gunnii* (Hook.f.) K.Koch	R S
ASTERACEAE				*Abrotanella forsteroides* (Hook.f.) Benth.	A
ASTERACEAE				*Abrotanella scapigera* (F.Muell.) Benth.	A
ASTERACEAE				*Ammobium calyceroides* (Cass.) A.Anderb.	C
ASTERACEAE				*Bedfordia linearis* (Labill.) DC.	C S
ASTERACEAE				*Bedfordia salicina* (Labill.) DC.	C S
ASTERACEAE				*Celmisia asteliifolia* Hook.f.	A B
ASTERACEAE				*Celmisia saxifraga* (Benth.) W.M.Curtis	A
ASTERACEAE				*Craspedia glabrata* (Hook.f.) Rozefelds	A
ASTERACEAE				*Erigeron gunnii* (Hook.f.) F.Muell.	A
ASTERACEAE				*Erigeron pappocromus* Labill.	A B S
ASTERACEAE				*Erigeron stellatus* (Hook.f.) W.M.Curtis	A
ASTERACEAE				*Erigeron trigonus* S.J.Forbes & D.I.Morris	A
ASTERACEAE				*Ewartia catipes* (DC.) P.Beauv.	A
ASTERACEAE				*Ewartia meredithiae* (F.Muell.) P.Beauv.	A
ASTERACEAE				*Ewartia planchonii* (Hook.f.) P.Beauv.	A
ASTERACEAE				*Helichrysum milliganii* Hook.f.	A
ASTERACEAE				*Helichrysum pumilum* var. *pumilum* Hook.f.	A B
ASTERACEAE				*Helichrysum pumilum* var. *spathulatum* A.M.Buchanan	A
ASTERACEAE				*Olearia ledifolia* (DC.) Benth.	A S
ASTERACEAE				*Olearia obcordata* (Hook.f.) Benth.	A
ASTERACEAE				*Olearia persoonioides* (DC.) Benth.	C R S
ASTERACEAE				*Olearia pinifolia* (Hook.f.) Benth.	A R S
ASTERACEAE				*Olearia tasmanica* (Hook.f.) W.M.Curtis	A
ASTERACEAE				*Ozothamnus antennaria* (DC.) Hook.f.	S
ASTERACEAE				*Ozothamnus bracteolatus* Hook.f.	C
ASTERACEAE				*Ozothamnus costatifructus* (R.V.Smith) A.Anderb.	C
ASTERACEAE				*Ozothamnus ericifolius* Hook.f.	A
ASTERACEAE				*Ozothamnus expansifolius* (P.Morris & J.H.Willis) A.Anderb.	A
ASTERACEAE				*Ozothamnus ledifolius* (DC.) Hook.f.	A S
ASTERACEAE				*Ozothamnus purpurascens* DC.	S
ASTERACEAE				*Ozothamnus reticulatus* (Labill.) DC.	C
ASTERACEAE				*Ozothamnus rodwayi* var. *rodwayi* Orch.	A R
ASTERACEAE				*Ozothamnus rodwayi* var. *kingii* (W.M.Curtis) P.S.Short	A

FAMILY	1	2	3	Scientific Name and authority	Habitat (4)
ASTERACEAE				*Ozothamnus rodwayi* var. *oreophilus* (W.M.Curtis) P.S.Short	A
ASTERACEAE				*Pterygopappus lawrencei* Hook.f.	A
ASTERACEAE			R1	*Senecio papillosus* F.Muell.	A
ASTERACEAE			R1	*Senecio primulaefolius* F.Muell.	A
BRASSICACEAE				*Cheesemania radicata* (Hook.f.) O.E.Schulz	A
CAMPANULACEAE				*Wahlenbergia saxicola* A.DC.	A S
CARYOPHYLLACEAE	r	VU		*Colobanthus curtisiae* J.West	A
CARYOPHYLLACEAE	e	CR	R1	*Sagina diemensis* L.G.Adams	A
CASUARINACEAE				*Allocasuarina monilifera* (L.Johnson) L.Johnson	B C S
CASUARINACEAE				*Allocasuarina zephyrea* L.Johnson	B
CENTROLEPIDACEAE		VU		*Centrolepis monogyna* subsp. *paludicola* (W.M.Curtis) D.A.Cooke,	B
CUNONIACEAE				*Anodopetalum biglandulosum* A.Cunn. ex Hook.f.	R S
ELAEOCARPACEAE				*Aristotelia peduncularis* (Labill.) Hook.f.	R S
EPACRIDACEAE				*Archeria comberi* Melville	A
EPACRIDACEAE				*Archeria eriocarpa* Hook.f.	R S
EPACRIDACEAE				*Archeria hirtella* (Hook.f.) Hook.f.	R S
EPACRIDACEAE				*Archeria serpyllifolia* var. *serpyllifolia* Hook.f.	A R
EPACRIDACEAE				*Archeria serpyllifolia* var. *minor* Benth.	A R
EPACRIDACEAE				*Cyathodes dealbata* R.Br.	A R
EPACRIDACEAE				*Cyathodes glauca* Labill.	S
EPACRIDACEAE				*Cyathodes straminea* R.Br.	A R S
EPACRIDACEAE				*Dracophyllum milliganii* Hook.f.	A B R S
EPACRIDACEAE				*Dracophyllum minimum* F.Muell.	A
EPACRIDACEAE	r	EN		*Epacris acuminata* Benth.	S
EPACRIDACEAE				*Epacris corymbiflora* Hook.f.	B
EPACRIDACEAE				*Epacris heteronema* Labill.	B C
EPACRIDACEAE				*Epacris mucronulata* R.Br.	R S
EPACRIDACEAE				*Epacris myrtifolia* Labill.	C
EPACRIDACEAE				*Epacris navicularis* Jarman	A
EPACRIDACEAE				*Epacris serpyllifolia* R.Br.	A B C R S
EPACRIDACEAE				*Leptecophylla abietina* (Labill.) C.M.Weiller	C
EPACRIDACEAE				*Leptecophylla pogonocalyx* C.M.Weiller	A
EPACRIDACEAE				*Leucopogon milliganii* (F.Muell.) Rodway	A
EPACRIDACEAE				*Leucopogon oreophilus* Powell	A B
EPACRIDACEAE				*Monotoca empetrifolia* R.Br.	A S
EPACRIDACEAE				*Monotoca linifolia* subsp. *linifolia* (Rodway) W.M.Curtis	S
EPACRIDACEAE				*Monotoca linifolia* subsp. *algida* Jarman	A
EPACRIDACEAE				*Monotoca submutica* var. *submutica* (Benth.) Jarman	A B R S
EPACRIDACEAE	r			*Monotoca submutica* var. *autumnalis* Jarman	S
EPACRIDACEAE				*Pentachondra involucrata* R.Br.	C S
EPACRIDACEAE	r		R1	*Planocarpa nitida* (Jarman) Weiller	A
EPACRIDACEAE				*Planocarpa petiolaris* (DC.) Weiller	A
EPACRIDACEAE	r			*Planocarpa sulcata* (Mihaich) Weiller	A
EPACRIDACEAE				*Prionotes cerinthoides* (Labill.) R.Br.	A R S
EPACRIDACEAE				*Richea acerosa* (Lindley) F.Muell.	A S
EPACRIDACEAE				*Richea alpina* Y.Menadue	A
EPACRIDACEAE				*Richea gunnii* Hook.f.	A R
EPACRIDACEAE				*Richea milliganii* (Hook.f.) F.Muell.	A R
EPACRIDACEAE				*Richea pandanifolia* subsp. *pandanifolia* Hook.f.	A R S
EPACRIDACEAE				*Richea pandanifolia* subsp. *ramulosa* Y.Menadue	R
EPACRIDACEAE				*Richea procera* (F.Muell.) F.Muell.	A S
EPACRIDACEAE				*Richea scoparia* Hook.f.	A R S
EPACRIDACEAE				*Richea sprengelioides* (R.Br.) F.Muell.	A R S
EPACRIDACEAE			R1	*Sprengelia distichophylla* (Rodway) W.M.Curtis	A B
EPACRIDACEAE				*Trochocarpa cunninghamii* (DC.) W.M.Curtis	A R S
EPACRIDACEAE			R1	*Trochocarpa disticha* (R.Br.) Sprengel	R S
EPACRIDACEAE				*Trochocarpa gunnii* (Hook.f.) Benth.	R S
EPACRIDACEAE				*Trochocarpa thymifolia* (R.Br.) Sprengel	A S
ERICACEAE				*Gaultheria lanceolata* Hook.f.	A S

FAMILY	1	2	3	Scientific Name and authority	Habitat (4)
ERICACEAE				*Gaultheria tasmanica* (Hook.f.) Middleton	A S
ESCALLONIACEAE				*Anopterus glandulosus* Labill.	C R S
ESCALLONIACEAE				*Tetracarpaea tasmanica* Hook.f.	A R S
EUCRYPHIACEAE				*Eucryphia lucida* (Labill.) Baill.	R S
EUCRYPHIACEAE				*Eucryphia milliganii* subsp. *milliganii* Hook.f.	A R S
EUCRYPHIACEAE				*Eucryphia milliganii* subsp. *pubescens* R.W.Barnes, G.J.Jord., R.S.Hill & C.J.McCoull	A R
EUPHORBIACEAE	r	VU	R1	*Oreoporanthera petalifera* Orch. & J.Davies	A K
FAGACEAE				*Nothofagus gunnii* (Hook.f.) Oersted	A R
GENTIANACEAE				*Chionogentias brevisepala* L.G.Adams	A B
GENTIANACEAE				*Chionogentias demissa* L.G.Adams	A
GENTIANACEAE				*Chionogentias diemensis* subsp. *diemensis* (Griseb.) L.G.Adams	A
GENTIANACEAE				*Chionogentias eichleri* L.G.Adams	A
GENTIANACEAE			R1	*Chionogentias grandis* L.G.Adams	A
GENTIANACEAE				*Chionogentias pleurogynoides* subsp. *pleurogynoides* L.G.Adams	A
GUNNERACEAE				*Gunnera cordifolia* (Hook.f.) Hook.f.	A
HALORAGACEAE				*Myriophyllum austropygmaeum* Orch.	A
LAMIACEAE	r			*Westringia angustifolia* R.Br.	S
LAMIACEAE				*Westringia brevifolia* var. *brevifolia* Benth.	C
LAMIACEAE	r			*Westringia brevifolia* var. *raleighii* (B.Boivin) W.M.Curtis	C
LINACEAE				*Linum albidum* Ewart & Jean White	A
LOGANIACEAE				*Schizacme archeri* (Hook.f.) Dunlop	A
MALVACEAE				*Asterotrichion discolor* (Hook.) Melville	S
MENYANTHACEAE				*Nymphoides exigua* (F.Muell.) Kuntze	A B C
MIMOSACEAE				*Acacia riceana* Henslow	S
MYRTACEAE				*Baeckea leptocaulis* Hook.f.	B
MYRTACEAE				*Callistemon viridiflorus* (Sims) Sweet	B S
MYRTACEAE				*Eucalyptus amygdalina* Labill.	C S
MYRTACEAE				*Eucalyptus archeri* Maiden & Blakely	S
MYRTACEAE				*Eucalyptus coccifera* Hook.f.	A S
MYRTACEAE				*Eucalyptus gunnii* Hook.f.	B S
MYRTACEAE				*Eucalyptus johnstonii* Maiden	S
MYRTACEAE				*Eucalyptus nitida* Hook.f.	B C S
MYRTACEAE				*Eucalyptus rodwayi* R.Baker & H.G.Smith	B S
MYRTACEAE				*Eucalyptus subcrenulata* Maiden & Blakely	S
MYRTACEAE				*Eucalyptus tenuiramis* Miq.	C S
MYRTACEAE				*Eucalyptus vernicosa* Hook.f.	A B
MYRTACEAE				*Leptospermum glaucescens* S.Schauer	B C S
MYRTACEAE				*Leptospermum nitidum* Hook.f.	A B S
MYRTACEAE				*Leptospermum riparium* D.I.Morris	R S
MYRTACEAE				*Leptospermum rupestre* Hook.f.	A R S
ONAGRACEAE				*Epilobium fugitivum* Raven & Engelhorn	W
ONAGRACEAE				*Epilobium perpusillum* Hausskn.	R
PLANTAGINACEAE				*Plantago daltonii* Decne.	A
PLANTAGINACEAE				*Plantago glabrata* Hook.f., Hook.	A S
PLANTAGINACEAE				*Plantago gunnii* Hook.f., Hook.	A
PLANTAGINACEAE				*Plantago paradoxa* Hook.f.	A
PLANTAGINACEAE				*Plantago tasmanica* var. *tasmanica* Hook.f.	A
PLANTAGINACEAE				*Plantago tasmanica* var. *archeri* (Hook.f.) W.M.Curtis	A S
PROTEACEAE				*Agastachys odorata* R.Br.	B R S
PROTEACEAE				*Bellendena montana* R.Br.	A R S
PROTEACEAE				*Cenarrhenes nitida* Labill.	C R S
PROTEACEAE				*Hakea epiglottis* subsp. *epiglottis* Labill.	B
PROTEACEAE				*Lomatia polymorpha* R.Br.	A C S
PROTEACEAE	e	CR	R1	*Lomatia tasmanica* W.M.Curtis	R S
PROTEACEAE				*Lomatia tinctoria* (Labill.) R.Br.	S
PROTEACEAE				*Orites acicularis* (R.Br.) Roemer & Schultes	A R S
PROTEACEAE				*Orites diversifolia* R.Br.	A R S
PROTEACEAE	r			*Orites milliganii* Meisn.	A R

FAMILY	1	2	3	Scientific Name and authority	Habitat (4)
PROTEACEAE				*Orites revoluta* R.Br.	A R
PROTEACEAE				*Persoonia gunnii* var. *gunnii* Hook.f.	A B R S
PROTEACEAE	r		R1	*Persoonia gunnii* var. *oblanceolata* Orch.	R S
PROTEACEAE	r		R1	*Persoonia moscalii* Orch.	A B
PROTEACEAE	r			*Persoonia muelleri* subsp. *angustifolia* (Benth.) L.A.S.Johnson & P.H.Weston	C R
PROTEACEAE			R1	*Persoonia muelleri* subsp. *densifolia* (Orch.) L.A.S.Johnson & P.H.Weston	R
PROTEACEAE				*Persoonia muelleri* subsp. *muelleri* (P.Parm.) Orch	B R S
PROTEACEAE				*Telopea truncata* (Labill.) R.Br.	A R S
RANUNCULACEAE				*Anemone crassifolia* Hook.	A B
RANUNCULACEAE				*Caltha phylloptera* A.W.Hill	A
RANUNCULACEAE	r		R1	*Ranunculus collicola* Menadue	A W
RANUNCULACEAE				*Ranunculus decurvus* (Hook.f.) Melville	A W S
RANUNCULACEAE	r		R1	*Ranunculus jugosus* Menadue	A W
RANUNCULACEAE				*Ranunculus nanus* Hook.	A W
RANUNCULACEAE				*Ranunculus pascuinus* (Hook.f.) Melville	A W
RANUNCULACEAE				*Ranunculus setaceus* Rodway	A W
RANUNCULACEAE				*Ranunculus triplodontus* Melville	A B W
RHAMNACEAE				*Cryptandra alpina* Hook.f.	A
RHAMNACEAE				*Spyridium gunnii* (Hook.f.) Benth.	W
ROSACEAE				*Acaena montana* Hook.f.	A S
ROSACEAE	r		R1	*Geum talbotianum* W.M.Curtis	A
ROSACEAE				*Rubus gunnianus* Hook.	A B R
RUTACEAE				*Acradenia frankliniae* Milligan ex Kippist	R S
RUTACEAE				*Boronia citriodora* subsp. *paulwilsonii* Duretto	A B S
RUTACEAE				*Boronia citriodora* subsp. *citriodora* Gunn ex Hook.f.	A
RUTACEAE				*Boronia elisabethiae* Duretto	B
RUTACEAE				*Leionema montanum* (Hook.) Paul G.Wilson	A
RUTACEAE				*Leionema oldfieldii* (F.Muell.) Paul G.Wilson	A
SANTALACEAE				*Exocarpos humifusus* R.Br.	A B R
SANTALACEAE				*Leptomeria glomerata* F.Muell. ex Hook.f.	B
SCROPHULARIACEAE				*Euphrasia hookeri* Wettst.	A
SCROPHULARIACEAE				*Euphrasia striata* R.Br.	A B
SCROPHULARIACEAE				*Ourisia integrifolia* R.Br.	A
STYLIDIACEAE				*Forstera bellidifolia* Hook.f.	A B
THYMELAEACEAE				*Pimelea cinerea* R.Br.	R S
THYMELAEACEAE	r			*Pimelea milliganii* Meisn.	A
THYMELAEACEAE				*Pimelea nivea* Labill.	C S
THYMELAEACEAE			R1	*Pimelea pygmaea* F.Muell. & C.Stuart ex Meisn.	A
THYMELAEACEAE				*Pimelea sericea* R.Br.	A S
ANGIOSPERMS/ MONOCOTYLEDONAE					
CENTROLEPIDACEAE				*Centrolepis monogyna* subsp. *monogyna* (Hook.f.) Benth.	A B
CENTROLEPIDACEAE				*Centrolepis muscoides* (Hook.f.) Hieron.	A
CENTROLEPIDACEAE	e	VU	R1	*Centrolepis pedderensis* W.M.Curtis	B W
CENTROLEPIDACEAE			R1	*Gaimardia amblyphylla* W.M.Curtis	B
CENTROLEPIDACEAE				*Gaimardia fitzgeraldii* F.Muell. & Rodway	A
CYPERACEAE				*Carex cataractae* R.Br.	W
CYPERACEAE				*Carpha curvata* W.M.Curtis	A B
CYPERACEAE				*Carpha rodwayi* W.M.Curtis	A
CYPERACEAE				*Isolepis limbata* W.M.Curtis	W
CYPERACEAE				*Isolepis tasmanica* (S.T.Blake) K.L.Wilson	W
CYPERACEAE				*Lepidosperma inops* F.Muell. ex Rodway	A C
CYPERACEAE				*Lepidosperma oldfieldii* Hook.f.	S
CYPERACEAE				*Oreobolus acutifolius* S.T.Blake	A R
CYPERACEAE				*Oreobolus oligocephalus* W.M.Curtis	A B
CYPERACEAE				*Oreobolus tholicarpus* D.I.Morris	B K
CYPERACEAE				*Schoenus biglumis* Kük.	B W
CYPERACEAE			R1	*Schoenus pygmaeus* S.T.Blake	A W
HAEMODORACEAE			R1	*Haemodorum distichophyllum* Hook.	A B

FAMILY	1	2	3	Scientific Name and authority	Habitat (4)
Hydatellaceae				*Hydatella filamentosa* (Rodway) W.M.Curtis	A B W
Iridaceae				*Diplarrena latifolia* Benth.	A B S
Iridaceae				*Isophysis tasmanica* (Hook.) T.Moore	A B
Juncaceae				*Juncus astreptus* L.Johnson	W
Juncaceae				*Juncus curtisiae* L.Johnson	A C
Juncaceae				*Juncus ratkowskyanus* L.Johnson	A
Juncaceae				*Luzula poimena* W.M.Curtis	A
Liliaceae				*Blandfordia punicea* (Labill.) Sweet	A B C R
Liliaceae				*Campynema lineare* Labill.	A B S
Liliaceae				*Milligania densiflora* Hook.f.	A
Liliaceae	r		R1	*Milligania johnstonii* F.Muell. ex Benth.	B K
Liliaceae				*Milligania lindoniana* Rodway ex W.M.Curtis	A K
Liliaceae	r		R1	*Milligania longifolia* Hook.f.	R
Liliaceae				*Milligania stylosa* (F.Muell. ex Hook.f.) F.Muell. ex Benth.	A
Orchidaceae				*Chiloglottis gunnii* Lindley	C R S
Orchidaceae			R1	*Hymenochilus pratensis* (D.L.Jones) D.L.Jones & M.A.Clem.	A
Orchidaceae				*Prasophyllum alpinum* R.Br.	A
Orchidaceae				*Prasophyllum concinnum* Nicholls	C
Orchidaceae				*Prasophyllum rostratum* Lindley	C
Orchidaceae				*Pterostylis dubia* R.Br.	A
Orchidaceae				*Pterostylis furcata* Lindley	R S
Orchidaceae				*Pterostylis scabrida* Lindley	R S
Orchidaceae				*Simpliglottis grammata* (G.W.Carr) Jeanes	R S
Orchidaceae				*Speculantha aphylla* (Lindl.) D.L.Jones & M.A.Clem.	C
Poaceae				*Australopyrum pectinatum* (Labill.) A.Löve	A S
Poaceae				*Austrodanthonia diemenica* (D.I.Morris) H.P.Linder	A
Poaceae				*Ehrharta oreophila* var. *oreophila* (D.I.Morris) Willemse	A B
Poaceae				*Ehrharta oreophila* var. *minor* (D.I.Morris) Willemse	A
Poaceae				*Ehrharta tasmanica* var. *tasmanica* (Hook.f.) Willemse	B S
Poaceae				*Ehrharta tasmanica* var. *subalpina* (F.Muell. ex Benth.) Willemse	A
Poaceae				*Festuca plebeia* R.Br.	S
Poaceae				*Hierochloe fraseri* Hook.f.	A S
Poaceae				*Lachnagrostis collicola* (D.I.Morris) S.W.L.Jacobs	A
Poaceae				*Lachnagrostis lacunarum* (D.I.Morris) S.W.L.Jacobs	A
Poaceae				*Poa gunnii* Vick.	A B S
Poaceae				*Rytidosperma fortunae-hibernae* (Renvoize) Connor & Edgar	A
Poaceae				*Rytidosperma nitens* (D.I.Morris) H.P.Linder	A
Poaceae				*Rytidosperma pauciflorum* (R.Br.) Connor & Edgar	A
Restionaceae				*Acion hookeri* (D.I.Morris) B.Briggs & L.Johnson	B
Restionaceae				*Acion monocephalum* (R.Br.) B.Briggs & L.Johnson	B
Restionaceae				*Calorophus erostris* (C.B.Clarke) L.Johnson & B.Briggs	A B
Restionaceae			R1	*Winifredia sola* L.Johnson & B.Briggs	B
Xyridaceae				*Xyris marginata* Rendle	A B W
Xyridaceae				*Xyris muelleri* Malme	B W
Xyridaceae				*Xyris tasmanica* (D.I.Morris) A.N.Doust & B.J.Conn	B W
Pteridophyta					
Gleicheniaceae				*Gleichenia abscida* Rodway	A
Grammitidaceae			R1	*Grammitis garrettii* Parris	A

FAMILY	1	2	3	Scientific Name and authority	Habitat (4)
HYMENOPHYLLACEAE				*Sphaerocionium applanatum* (A.M.Gray & R.G.Williams) K.Iwats.	R S
ISOETACEAE				*Isoetes gunnii* A.Braun	A W
ISOETACEAE	r		R1	*Isoetes humilior* F.Muell. ex A.Braun	A W
ISOETACEAE	r		R1	*Isoetes sp.nova MaxwellRiver* (S.J.Jarman HO314082)	B K
LICHENS					
ARTHONIACEAE				*Arthonia sagenidii* Vezda & Kantvilas	R
ARTHONIACEAE				*Arthonia tasmanica* Kantvilas & Vezda	R
ARTHONIACEAE				*Arthothelium subspectabile* Vezda & Kantvilas	R
CLADONIACEAE				*Cladia moniliformis* Kantvilas & Elix	A B
GOMPHILLACEAE				*Gyalideopsis graminicola* Vezda & Kantvilas	A
ICHMADOPILACEAE				***Siphulella coralloidea*** Kantvilas, Elix & P.James	B
MEGALOSPORACEAE				*Megalospora lopadioides* Sipman	A R S
MICAREACEAE				*Micarea isabellina* Coppins & Kantvilas	B R
MICAREACEAE				*Micarea mutabilis* Coppins & Kantvilas	R
PANNARIACEAE				*Siphulastrum granulatum* P.M.Jørg. & D.J.Galloway	S
PARMELIACEAE				*Hypogymnia tasmanica* Elix	R S
PARMELIACEAE				*Menegazzia corrugata* P.James	R S
PARMELIACEAE				*Menegazzia elongata* P.James	S
PARMELIACEAE				*Menegazzia subbullata* P.James & Kantvilas	B R S
SIPHULACEAE				*Siphula jamesii* Kantvilas	A B
LIVERWORTS					
BALANTIOPSIDACEAE				*Isotachis nigella* Herz.	
BREVIANTHACEAE				*Brevianthus flavus* (Grolle) Engel & Schust.	
CEPHALOZIELLACEAE				*Calypogeia tasmanica* Rodw.	
GEOCALYCACEAE				*Clasmatocolea vermicularis* (Lehm.) Grolle	
GYMNOMITRIACEAE				*Herzogobryum teres* (Carringt. & Pears.) Grolle	
HERBERTACEAE				*Herbertus oldfieldianus* (Steph.) Rodw.	
LEJEUNACEAE				*Lejeunea norrisii* Grolle	
LEPIDOLAENACEAE				*Lepidolaena brachyclada* (Tayl. ex Lehm.) Trev.	
PLAGIOCHILACEAE				*Plagiochila ratkowskiana* H.Inoue	
SCHISTOCHILACEAE				*Schistochila tasmanica* Steph.	
TREUBIACEAE				*Treubia tasmanica* Schust. & Scott	
MOSSES					
ANDREAEACEAE				*Andreaea eximia* C.Muell.	
DICRANACEAE				Dicranoloma burchardtii (Par.) Par.	
DICRANACEAE				Dicranoloma eucamptodontoides (Broth. & Geh.) Par.	
DICRANACEAE				*Dicranoloma perichaetiale* Sainsb.	
HYPNACEAE				*Isopterygium acuminatum* Boswell	
PTEROBRYACEAE				*Rhabdodontium buftonii* (Broth. & Geh.) Broth.	
SPHAGNACEAE				*Ambuchanania leucobryoides* Yamaguchi et al.	
SPLACHNACEAE				*Tayloria gunnii* (Wils.) Willis	
SPLACHNACEAE				*Tayloria tasmanica* (Hampe) Broth.	
MARINE ALGAE RHODOPHYTA					
GIGARTINACEAE				*Gigartina recurva* Edyvane & Womersley	M

Appendix 3: List of Tasmanian endemic intra-specific taxa that occur in the TWWHA.

(1) Status of taxon on the Tasmanian Threatened Species Protection Act 1995 (codes as for Appendix 1)
(2) Status of taxon on the *Environmental Protection and Biodiversity Act 1999* (codes as for Appendix 1)
(3) Locally restricted endemic subspecies (R1 = taxa largely confined to a range of less than 100 km).
(4) Habitats in which the intra-specific taxon is known to occur (codes as for Appendix 1).

FAMILY	1	2	3	Scientific name and authority	Habitat (4)
ANGIOSPERMS/ DICOTYLEDONAE					
APIACEAE				*Dichosciadium ranunculaceum* var. *tasmanicum* (Hook.f.) Domin	A
ASTERACEAE				*Olearia phlogopappa* var. *angustifolia* (Hutch.) W.M.Curtis	S
ASTERACEAE				*Senecio pectinatus* var. *pectinatus* DC.	A
ASTERACEAE				*Senecio pectinatus* var. *ochroleucus* F.Muell.	A
EPACRIDACEAE				*Leptecophylla juniperina* subsp. *parvifolia* (R.Br.) C.M.Weiller,	A R S
MIMOSACEAE	r			*Acacia mucronata* subsp. *dependens* (A.Cunn. ex Benth.) Hook.f.	S
MYRTACEAE				*Eucalyptus delegatensis* subsp. *tasmaniensis* Boland	S
PITTOSPORACEAE				*Billardiera longiflora* var. *ovalis* (Lindley) E.Bennett	C
PITTOSPORACEAE				*Billardiera longiflora* var. *alpina* Rodway	A
PROTEACEAE				*Grevillea australis* var. *erecta* Hook.f.	S
PROTEACEAE				*Grevillea australis* var. *montana* Hook.f.	A
RUTACEAE				*Nematolepis squamea* subsp. *retusa* (Hook.) Paul G.Wilson	S
SCROPHULARIACEAE				*Euphrasia collina* subsp. *diemenica* (Sprengel) W.R.Barker	A
SCROPHULARIACEAE				*Euphrasia gibbsiae* subsp. *gibbsiae* Du Rietz	A
SCROPHULARIACEAE				*Euphrasia gibbsiae* subsp. *comberi* (Du Rietz) W.R.Barker	A
SCROPHULARIACEAE				*Euphrasia gibbsiae* subsp. *kingii* (W.M.Curtis) W.R.Barker	B
SCROPHULARIACEAE				*Euphrasia gibbsiae* subsp. *discolor* W.R.Barker	A
SCROPHULARIACEAE			R1	*Euphrasia gibbsiae* subsp. *microdonta* W.R.Barker	B
SCROPHULARIACEAE	r		R1	*Euphrasia gibbsiae* subsp. *pulvinestris* W.R.Barker	A
VIOLACEAE	r		R1	*Viola hederacea* subsp. *curtisiae* L.G.Adams	S
ANGIOSPERMS/ MONOCOTYLEDONAE					
CYPERACEAE				*Oreobolus oxycarpus* subsp. *brownii* Seberg	A
IRIDACEAE				*Libertia pulchella* var. *pygmaea* D.I.Morris	A
JUNCACEAE				*Luzula australasica* subsp. *australasica* Steudel	A
LILIACEAE				*Astelia alpina* var. *alpina* R.Br.	A B R S
POACEAE				*Pentapogon quadrifidus* var. *parviflorus* (Benth.) D.I.Morris	A
THELOTREMATACEAE				*Chroodiscus macrocarpus* subsp. *tasmanicus* (Kantvilas & Vezda) D.J.Galloway	R
LIVERWORT					
CEPHALOZIELLACEAE				*Cephaloziella pulcherrima* subsp. *sphagnicola* Schust.	
MOSS					
DICRANACEAE				*Dicranoloma billardierei* var. *angustinerve* (Rodw.) Sainsb.	

Appendix 4: Vegetation Tenure Areas (source: TVMP 2005)

		Area of each mapping class/group in:								
Mapping Classes[22]	**TASVEG version 1.0 map class codes**	**Tasmania**		**Secure conservation reserves outside the TWWHA**[23]	**Conservation reserves that allow mining**[24]	**Forest Reserves outside the TWWHA**	**TWWHA**		**Proportion of reserved area in the TWWHA**	**Proportion of mapping class in the TWWHA**
		ha	**%**	**ha**	**ha**	**ha**	**ha**	**%**	**%**	**%**
		a		**b**	**c**	**d**	**e**		**e/(b+c+d+e)**	**e /a**
Coniferous heath	HCH	6210	0%	466	9	0	5735	0%	92%	92%
Bolster heath	HCM	3083	0%	130	42	0	2909	0%	94%	94%
Alpine vegetation (eastern undifferentiated)	HUE	12,842	0%	9282	1718	725	0	0%	0%	0%
Alpine heath (eastern)	HHE	48,833	1%	876	3383	107	35,588	3%	89%	73%
Alpine heath (western)	HHW	3596	0%	4	1412	18	2104	0%	59%	59%
Alpine sedgeland/herbfield (eastern)	HSE	30,080	0%	778	3665	18	15,470	1%	78%	51%
Alpine sedgeland/herbfield (western)	HSW	7005	0%	0	2216	0	4473	0%	67%	64%
Deciduous heath	RFS	2117	0%	30	97	0	1953	0%	94%	92%
Highland grassland (*Poa*)	GPH	22,839	0%	123	503	26	14,900	1%	96%	65%
Total	**Alpine & treeless subalpine**	**136,606**	**2%**	**11,690**	**13,045**	**893**	**83,131**	**6%**	**76%**	**61%**
Athrotaxis cupressoides open woodland	RPW	16,276	0%	188	8	0	16,079	1%	99%	99%
Athrotaxis cupressoides rainforest	RPP	3577	0%	44	94	0	3426	0%	96%	96%

[22] Some mapping class names have been altered from names used in TASVEG version 1.0. (TVMP 2005).
[23] National Parks, State Reserves, Nature Reserves, Historic Sites, Games Reserves
[24] Regional Reserves, Conservation Areas.

		Area of each mapping class/group in:								
Mapping Classes[22]	**TASVEG version 1.0 map class codes**	**Tasmania**		**Secure conservation reserves outside the TWWHA**[23]	**Conservation reserves that allow mining**[24]	**Forest Reserves outside the TWWHA**	**TWWHA**		**Proportion of reserved area in the TWWHA**	**Proportion of mapping class in the TWWHA**
		ha	**%**	**ha**	**ha**	**ha**	**ha**	**%**	**%**	**%**
		a		**b**	**c**	**d**	**e**		**e/(b+c+d+e)**	**e /a**
Athrotaxis cupressoides/Nothofagus gunnii short rainforest	RPF	4426	0%	16	248	0	4162	0%	94%	94%
Subtotal	**Pencil pine forest & woodlands**	**24,279**	**0%**	**248**	**350**	**0**	**23,667**	**2%**	**98%**	**97%**
Athrotaxis selaginoides - Nothofagus gunnii short rainforest	RKF	3236	0%	84	2035	0	846	0%	29%	26%
Athrotaxis selaginoides rainforest	RKP	19,436	0%	117	5668	64	10,371	1%	64%	53%
Athrotaxis selaginoides subalpine scrub	RKS	6260	0%	19	384	12	5722	0%	93%	91%
Subtotal	**King Billy forest & woodlands**	**28,932**	**0%**	**220**	**8086**	**75**	**16,939**	**1%**	**67%**	**59%**
Highland low rainforest and scrub	RSH	18,978	0%	172	1438	54	16,120	1%	91%	85%
Highland rainforest scrub with dead *Athrotaxis selaginoides*	RKX	8587	0%	4	672	0	6959	1%	91%	81%
Subtotal	**Montane rainforest**	**27,565**	**0%**	**177**	**2110**	**54**	**23,079**	**2%**	**91%**	**84%**
Lagarostrobos franklinii rainforest an scrub (has not been consistently mapped)	RHP	2027	0%	117	417	7	138	0%	20%	7%
Leptospermum with rainforest scrub	RLS	22,790	0%	1125	3239	376	16,375	1%	78%	72%
Nothofagus - Atherosperma rainforest	RMT	440,766	6%	15,796	77,471	26902	204,809	15%	63%	46%
Nothofagus - Leptospermum short rainforest	RML	27,583	0%	564	6069	17	19,391	1%	74%	70%

		Area of each mapping class/group in:								
Mapping Classes[22]	**TASVEG version 1.0 map class codes**	**Tasmania**		**Secure conservation reserves outside the TWWHA[23]**	**Conservation reserves that allow mining[24]**	**Forest Reserves outside the TWWHA**	**TWWHA**		**Proportion of reserved area in the TWWHA**	**Proportion of mapping class in the TWWHA**
		ha	**%**	**ha**	**ha**	**ha**	**ha**	**%**	**%**	**%**
		a		**b**	**c**	**d**	**e**		**e/(b+c+d+e)**	**e /a**
Nothofagus / *Phyllocladus* short rainforest	RMS	171,259	2%	8312	52,824	10894	1673	0%	2%	1%
Rainforest fernland	RFE	493	0%	22	74	11	268	0%	71%	54%
Subtotal	**Other rainforest types**	**664,919**	**10%**	**25,937**	**140,094**	**38,207**	**242,654**	**18%**	**54%**	**36%**
Total	**Rainforest**	**745,694**	**11%**	**26,581**	**150,641**	**38,337**	**306,340**	**22%**	**59%**	**41%**
Eucalyptus coccifera forest and woodland	DCO	116,955	2%	5523	15,826	230	76,333	6%	78%	65%
Eucalyptus gunnii woodland	DGW	2177	0%	18	420	0	1428	0%	76%	66%
Eucalyptus pauciflora forest and woodland on dolerite	DPD	36,128	1%	724	679	306	5531	0%	76%	15%
Subtotal	**Dry eucalypt forest & subalpine woodland in the TWWHA**	**155,260**	**2%**	**6265**	**16,925**	**536**	**83,292**	**6%**	**78%**	**54%**
Wet forest types not in the TWWHA	**WGK, WVI**	**7814**	**0%**	**121**	**362**	**389**	**0**	**0%**	**0%**	**0%**
Eucalyptus delegatensis forest over *Leptospermum*	WDL	17,006	0%	858	102	173	12,292	1%	92%	72%
Eucalyptus delegatensis forest with broadleaf shrubs	WDB	7575	0%	620	139	401	2166	0%	65%	29%
Eucalyptus delegatensis over rainfores	WDR	58,873	1%	3630	1089	222	47,864	3%	91%	81%

		Area of each mapping class/group in:								
Mapping Classes[22]	**TASVEG version 1.0 map class codes**	**Tasmania**		**Secure conservation reserves outside the TWWHA**[23]	**Conservation reserves that allow mining**[24]	**Forest Reserves outside the TWWHA**	**TWWHA**		**Proportion of reserved area in the TWWHA**	**Proportion of mapping class in the TWWHA**
		ha	**%**	**ha**	**ha**	**ha**	**ha**	**%**	**%**	**%**
		a		**b**	**c**	**d**	**e**		**e/(b+c+d+e)**	**e /a**
Eucalyptus delegatensis wet forest (undifferentiated)	WDU	187,602	3%	6408	12,519	6606	887	0%	3%	0%
Eucalyptus obliqua forest over *Leptospermum*	WOL	4934	0%	429	59	7	3306	0%	87%	67%
Eucalyptus obliqua forest over rainforest	WOR	26,645	0%	1708	265	68	19,821	1%	91%	74%
Eucalyptus obliqua forest with broadleaf shrubs	WOB	5076	0%	1104	394	19	1724	0%	53%	34%
Eucalyptus obliqua wet forest (undifferentiated)	WOU	390,903	6%	12,878	27,064	20,622	1	0%	0%	0%
Eucalyptus regnans forest	WRE	68,784	1%	1479	915	5195	2243	0%	23%	3%
Subtotal	**Ash dominated wet forest types in the TWWHA**	**767,397**	**11%**	**29,116**	**42,544**	**33,314**	**90,304**	**7%**	**46%**	**12%**
Eucalyptus nitida dry forest and woodland	DNI	52,839	1%	3552	13,492	674	12,665	1%	42%	24%
Eucalyptus nitida forest over Leptospermum	WNL	110,243	2%	360	13,313	16	92,886	7%	87%	84%
Eucalyptus nitida over rainforest	WNR	82,222	1%	172	12,015	6	69,292	5%	85%	84%
Eucalyptus nitida wet forest (undifferentiated)	WNU	50,070	1%	742	23,404	1293	4	0%	0%	0%
Subtotal	**E. nitida forest types in the TWWHA**	**295,373**	**4%**	**4825**	**62,225**	**1989**	**174,848**	**13%**	**72%**	**59%**
Acacia dealbata forest	NAD	53,541	1%	613	2041	3957	874	0%	12%	2%

		Area of each mapping class/group in:								
Mapping Classes[22]	**TASVEG version 1.0 map class codes**	**Tasmania**		**Secure conservation reserves outside the TWWHA[23]**	**Conservation reserves that allow mining[24]**	**Forest Reserves outside the TWWHA**	**TWWHA**		**Proportion of reserved area in the TWWHA**	**Proportion of mapping class in the TWWHA**
		ha	**%**	**ha**	**ha**	**ha**	**ha**	**%**	**%**	**%**
		a		**b**	**c**	**d**	**e**		**e/(b+c+d+e)**	**e /a**
Acacia melanoxylon on rises	NAR	18,955	0%	93	4235	683	235	0%	4%	1%
Leptospermum forest	NLE	63,212	1%	350	10,392	2189	48,183	3%	79%	76%
Eucalyptus brookeriana wet forest	WBR	6597	0%	91	108	857	425	0%	29%	6%
Eucalyptus dalrympleana forest	WDA	13,455	0%	19	80	742	1214	0%	59%	9%
Eucalyptus subcrenulata forest and woodland	WSU	27,980	0%	1772	549	140	21,875	2%	90%	78%
Subtotal	**Other wet forest types in the TWWHA**	**183,740**	**3%**	**2938**	**17,405**	**8568**	**72,805**	**5%**	**72%**	**40%**
Eucalyptus amygdalina forest and woodland on dolerite	DAD	174,039	10%	6550	3452	13,420	1157	1%	5%	1%
Eucalyptus dalrympleana - Eucalyptus pauciflora forest and woodland	DDP	4548	0%	117	4	81	252	0%	56%	6%
Eucalyptus delegatensis dry forest and woodland	DDE	284,332	4%	8733	18,519	7614	13,914	1%	29%	5%
Eucalyptus obliqua dry forest and woodland	DOB	178,985	3%	11,100	14,872	8469	2255	0%	6%	1%
Eucalyptus ovata forest and woodland	DOV	12,396	0%	201	561	319	357	0%	25%	3%
Eucalyptus rodwayi forest and woodland	DRO	11,836	0%	41	400	104	138	0%	20%	1%
Eucalyptus tenuiramis forest and woodland on sediments	DTO	47,942	1%	2120	4014	602	265	0%	4%	1%
Subtotal	**Dry eucalypt forest & woodland types in the TWWHA**	**714,076**	**10%**	**28,862**	**41,822**	**30,607**	**18,337**	**1%**	**15%**	**3%**

		Area of each mapping class/group in:								
Mapping Classes[22]	**TASVEG version 1.0 map class codes**	**Tasmania**		**Secure conservation reserves outside the TWWHA**[23]	**Conservation reserves that allow mining**[24]	**Forest Reserves outside the TWWHA**	**TWWHA**		**Proportion of reserved area in the TWWHA**	**Proportion of mapping class in the TWWHA**
		ha	%	ha	ha	ha	ha	%	%	%
		a		b	c	d	e		e/(b+c+d+e)	e /a
Dry eucalypt forest & woodland types not in the TWWHA	**DBA, DSC, DAC, DAS, DAI, DAZ, DCR, DGL, DMO, DNF, DOW, DPO, DPE, DPU, DRI, DSO, DSG, DTD, DTG, DVC, DVF, DVG, DVS, DKW, DMW**	**707,989**	**10%**	**54,358**	**46,629**	**41,091**	**0**	**0%**	**0%**	**0%**
Non-eucalypt dry forest & woodland not occurring in the TWWHA	**NAL, NAV, NBA, NBS, NCR, NLA, NNP**	**50,528**	**1%**	**2477**	**9246**	**254**	**0**	**0%**	**0%**	**0%**
TOTAL	**Sclerophyll forests & woodlands**	**288,2178**	**42%**	**128,963**	**237,159**	**116,748**	**439,586**	**32%**	**48%**	**15%**
Alkaline pans	**MAP**	**616**	**0%**	**0**	**39**	**0**	**577**	**0%**	**94%**	**94%**
Buttongrass moorland (undifferentiated)	MBU	123,079	2%	2070	68,736	2509	8	0%	0%	0%

		Area of each mapping class/group in:								
Mapping Classes[22]	**TASVEG version 1.0 map class codes**	**Tasmania**		**Secure conservation reserves outside the TWWHA[23]**	**Conservation reserves that allow mining[24]**	**Forest Reserves outside the TWWHA**	**TWWHA**		**Proportion of reserved area in the TWWHA**	**Proportion of mapping class in the TWWHA**
		ha	**%**	**ha**	**ha**	**ha**	**ha**	**%**	**%**	**%**
		a		**b**	**c**	**d**	**e**		**e/(b+c+d+e)**	**e /a**
Buttongrass moorland with emergent shrubs	MBS	85,900	1%	73	10,644	81	72,725	5%	87%	85%
Eastern buttongrass moorland	MBE	20,134	0%	538	1804	0	15,624	1%	87%	78%
Pure buttongrass moorland	MBP	4184	0%	227	206	0	3612	0%	89%	86%
Restionaceae rushland	MRR	10,049	0%	279	1008	53	1902	0%	59%	19%
Sparse buttongrass moorland on slopes	MBR	142,347	2%	0	28,305	0	113,884	8%	80%	80%
Western buttongrass moorland	MBW	111,697	2%	21	14,445	0	94051	7%	87%	84%
Western lowland sedgeland	MSW	53,790	1%	11	10,937	0	42,819	3%	80%	80%
Subtotal	**Buttongrass moorland types**	**551,181**	**8%**	**3219**	**13,084**	**2643**	**344,626**	**25%**	**71%**	**63%**
Banksia marginata wet scrub	SBM	3282	0%	10	558	0	2578	0%	82%	79%
Broadleaf scrub	SBR	11,361	0%	1742	2060	1215	426	0%	8%	4%
Dry scrub	SDU	48,326	1%	14735	14,962	134	195	0%	1%	0%
Inland Heathland (undifferentiatec	SHU	5192	0%	328	80	86	364	0%	42%	7%
Leptospermum scrub	SLW	76,356	1%	2070	16,260	2034	23,698	2%	54%	31%
Lowland sedgy heathland	SHL	64,786	1%	4317	23,517	337	0	0%	0%	0%
Melaleuca squamea heathland	SMM	20,730	0%	359	4709	32	14,085	1%	73%	68%
Melaleuca squarrosa scrub	SMR	16,699	0%	1235	2192	152	7661	1%	68%	46%
Western wet scrub	SWW	138,615	2%	715	55,553	1485	61,212	4%	51%	44%
Subtotal	**Heath & scrub types in the TWWHA**	**385,347**	**6%**	**25,512**	**119,891**	**5475**	**110,219**	**8%**	**42%**	**29%**

		Area of each mapping class/group in:								
Mapping Classes[22]	**TASVEG version 1.0 map class codes**	**Tasmania**		**Secure conservation reserves outside the TWWHA[23]**	**Conservation reserves that allow mining[24]**	**Forest Reserves outside the TWWHA**	**TWWHA**		**Proportion of reserved area in the TWWHA**	**Proportion of mapping class in the TWWHA**
		ha	**%**	**ha**	**ha**	**ha**	**ha**	**%**	**%**	**%**
		a		**b**	**c**	**d**	**e**		**e/(b+c+d+e)**	**e /a**
Subalpine *Leptospermum nitidum* woodland	NLN	3850	0%	8	120	0	3684	0%	97%	96%
Subalpine heathland	SHS	6853	0%	304	1054	626	424	0%	18%	6%
Western subalpine scrub	SSW	6057	0%	0	1069	0	4570	0%	81%	75%
Subtotal	**Subalpine heath & scrub in the TWWHA**	**16,759**	**0%**	**312**	**2243**	**626**	**8679**	**1%**	**73%**	**52%**
Highland grassy sedgeland	**MGH**	**20,076**	**0%**	**209**	**1175**	**316**	**6942**	**1%**	**80%**	**35%**
Rushland largely absent from the TWWHA	**MDS**	**976**	**0%**	**7**	**375**	**0**	**9**	**0%**	**2%**	**1%**
Total	**Buttongrass moorland & scrub types in the TWWHA**	**973,980**	**14%**	**29,252**	**259,433**	**9060**	**471,043**	**34%**	**61%**	**48%**
Heathlands, Scrub & Coastal types not in the TWWHA	**SCA, SCH, SCK, SCW, SHC, SHF, SHG, SHW, SMP, SQR, SRI, SSK**	**102,955**	**2%**	**21,430**	**17,500**	**1686**	**72**	**0%**	**0%**	**0%**
Lowland Native Grassland Types not occuring in the TWWHA	GCL, GPL, GSL, GTL	119,936	2%	297	470	68	0	0%	0%	0%

		Area of each mapping class/group in:								
Mapping Classes[22]	**TASVEG version 1.0 map class codes**	**Tasmania**		**Secure conservation reserves outside the TWWHA[23]**	**Conservation reserves that allow mining[24]**	**Forest Reserves outside the TWWHA**	**TWWHA**		**Proportion of reserved area in the TWWHA**	**Proportion of mapping class in the TWWHA**
		ha	**%**	**ha**	**ha**	**ha**	**ha**	**%**	**%**	**%**
		a		**b**	**c**	**d**	**e**		**e/(b+c+d+e)**	**e /a**
Sphagnum peatland	MSP	3114	0%	51	49	9	2488	0%	96%	80%
Leptospermum lanigerum - Melaleuca squarrosa swamp forest	NLM	14,031	0%	132	2533	551	3393	0%	51%	24%
Total	**Wetland and swamp forests occurring in the TWWHA**	**17,145**	**0%**	**183**	**2582**	**559**	**5881**	**0%**	**64%**	**34%**
Saltmarsh, wetlands & swamp forest types largely not in the TWWHA	**AHF, AHL, AHS, ARS, ASF, ASS, AUS, AWU, NAF, NME**	**37131**	**1%**	**6139**	**4901**	**1609**	**18**	**0%**	**0%**	**0%**
Coastal grass and herbfield	GHC	9604	0%	1222	2092	0	147	0%	4%	2%
Coastal rainforest	RCO	1489	0%	49	76	0	1364	0%	92%	92%
Acacia longifolia coastal scrub	SAC	12,442	0%	1441	3586	0	37	0%	1%	0%
Coastal Scrub	SSC	25,986	0%	6259	7383	84	981	0%	7%	4%
Seabird rookery complex	SRC	532	0%	335	86	0	43	0%	9%	8%
Total	**Coastal vegetation types occurrin in the TWWHA**	**50,053**	**1%**	**9306**	**13,223**	**84**	**2572**	**0%**	**10%**	**5%**

		Area of each mapping class/group in:								
Mapping Classes[22]	**TASVEG version 1.0 map class codes**	**Tasmania**		**Secure conservation reserves outside the TWWHA[23]**	**Conservation reserves that allow mining[24]**	**Forest Reserves outside the TWWHA**	**TWWHA**		**Proportion of reserved area in the TWWHA**	**Proportion of mapping class in the TWWHA**
		ha	**%**	**ha**	**ha**	**ha**	**ha**	**%**	**%**	**%**
		a		**b**	**c**	**d**	**e**		**e/(b+c+d+e)**	**e /a**
Non-native vegetation and urban areas	FAG, FPE, FPF, FUM, FPL, FRG, FSM, FUR, FWU	1543370	23%	3918	11686	981	614	0%	4%	0%
Sand, mud	OSM	12506	0%	1286	6384	16	90	0%	1%	1%
Rock (cryptogamic lithosere)	ORO	18415	0%	5111	4696	108	5184	0%	34%	28%
Water, sea	OAQ	217899	3%	11298	58641	264	71399	5%	50%	33%
Untagged or unmaped areas	ZZZ	512		23	53	0	382			
TOTAL AREAS		**6859314**	**100%**	**255448**	**780789**	**170398**	**1386321**	**100%**	**53%**	**20%**

Appendix 5: Summary of the National, International and World Heritage Flora Values of the Tasmanian Wilderness World Heritage Area.

Natural criterion (i) be outstanding examples representing major stages of the Earth's history, including the record of life, significant ongoing geological processes in the development of landforms, or significant geomorphic or physiographic features.

WHA Values recognised in 1989 TWWHA nomination	Amended, additional and expanded values identified as at 2004	2004 assessment of Significance
Relict biota which show links to ancient Gondwanan flora including: Endemic conifers (including the King Billy pine *Athrotaxis selaginoides*, the Huon pine *Lagarostrobos franklinii* and the genera *Diselma, Microcachrys, Microstrobos*); Plant species in the families CUNONIACEAE, ESCALLONIACEAE and WINTERACEAE; The plant genera *Bellendena, Agastachys* and *Cenarrhenes* in the PROTEACEAE; Other plant genera with Gondwanan links (e.g. *Eucryphia, Orites, Lomatia* and *Nothofagus*).	Due to changes in the wording of the World Heritage Criteria since 1989, the TWWHA values relating to relict biota are now considered to meet natural criterion (iv). The **relict biota** currently considered to have national and international value are redescribed under natural criterion (iv) below. **Fossils** form part of the range of geomorphic and palaeobotanical features that provide evidence of the earths evolutionary history. The TWWHA contains fossil sites of national and international significance.	See natural criterion (iv)
The Permian-Triassic (Parmeener Supergroup) **fossiliferous sedimentary rocks** exposed in parts of the TWWHA, provide an accessible record of fossil Gondwanan flora.	Mostly of questionable significance within TWWHA; better exposure known outside the TWWHA. Requires further review. See Sharples (2004) for more detail.	
Not in the 1989 nomination.	**Significant macrofossil sites** Coal Head fossil forest site at Macquarie Harbour is dated 88 ka. It is one of only two sites in the Southern Hemisphere providing an example of pre glacial Pleistocene forest. Mersey-Cathedral is a late-Middle Pleistocene fossil site with well preserved conifer macrofossils.	National
Not in the 1989 nomination.	**Significant micro fossil site:** The Darwin Crater micro-fossil site is the longest unbroken sedimentary record for the Quaternary period in Australia. The crater was formed 700 ka and so provides a significant continuous record of the vegetation and climate of the late Cainozoic Ice Ages.	International
Not in the 1989 nomination.	**Other palynological resources** within the TWWHA include *Sphagnum* peatlands, buttongrass moorland bogs and numerous lakes. Sediments dating back earlier than the last glacial are rare. The undisturbed lake sediments of Lake Fiddler, a meromictic levee lake of the Lower Gordon River has previously been attributed great significance for anthropological research, however the longevity of the pollen profile is shorter than anticipated dating back only a few thousand years.	National

Natural criterion (ii) be outstanding examples representing significant on-going ecological and biological processes in the evolution and development of terrestrial, fresh-water, coastal and marine ecosystems and communities of plants and animals.

WHA Values recognised in 1989 TWWHA nomination	Amended, additional and expanded values identified as at 2004	2004 Assessment of significance
Ecosystems which are relatively free of introduced plant and animal species.	Naturalness is not a World Heritage value in its own right.	
Coastal plant communities free of exotic sand binding grasses and which show natural processes of dune formation and erosion.	Naturalness is not a World Heritage value in its own right and does not meet natural criterion (ii).	
	"The TWWHA **coastline** has outstanding universal value in its own right as the longest undisturbed stretch of high energy embayed temperate rocky and sandy coastline globally … ." See Sharples 2004.	WHA
	Native coastal grassland vegetation is a key element in the natural ongoing coastal dune formation and erosion processes on the temperate Tasmanian south coast.	International
	Marsupial lawns are a uniquely Tasmanian coastal fen, occupying sheltered habitats on sheltered banks of estuaries and bays. They are comprised of short herbfield vegetation unusual by the codominance of forbs and sedges and the dependence on grazing by native marsupials. This vegetation type represents the interaction of a range of factors and processes. It provides an internationally significant coastal community type, the best and most extensive examples of which are located within the TWWHA.	International
Undisturbed catchments, lakes and streams.	Naturalness is not a World Heritage value in its own right and does not meet natural criterion (ii).	
	The dark colloid-rich, highly acid, **dystrophic waters** in rivers and streams flowing out of the peatlands and collecting in the lakes, lagoons, estuaries and harbours in the TWWHA are unusual in a global context and provide habitat for an internationally distinct micro and macro algal flora.	National
	The **Bathurst Harbour-Port Davey Rio** provides another outstanding example of dystrophic waters with a superb array of deepwater marine communities in shallow situations.	WHA
	The meromictic levee lakes of the Gordon River provide an outstanding example of the inter-relationship between the microbial communities and their zonation and movement along a vertical chemo-cline. The natural processes that resulted in the permanent or semi-permanent stratification of the waters in three levee lakes on the Gordon River prior to the interference of natural water flows by the Gordon Power Station were considered to be of WHA significance.	International
	The TWWHA provides the best array of **green-window glacial lakes** to be found in Australia.	National
Alpine ecosystems with high levels of endemism.	High levels of endemism do not demonstrate in themselves a universally outstanding example of ongoing evolutionary and biological processes. The importance of Tasmanian alpine endemism is now addressed under criterion (iv).	

WHA Values recognised in 1989 TWWHA nomination	Amended, additional and expanded values identified as at 2004	2004 Assessment of significance
	The Tasmanian **alpine vegetation** has developed within a maritime climate and is globally unique because it is dominated by sclerophyllous heath vegetation. The rich diversity of sclerophyllous species in this region has evolved in isolation under the stress of nutrient deficiency and a variable climate including exposure to extreme winds. Sclerophyllous life forms such as the bolster heaths are a significant example of this flora.	International
The unusual 'cushion plants' (**bolster heaths**) of the alpine ecosystems.	The TWWHA has the greatest diversity of hard **bolster heath** plants in the world, providing a superb illustration of convergent evolution. They occur in a variety of habitats including staircase ponds and fjaeldmark.	WHA
Ecological transitions from moorland to rainforest.	The spatial mosaic and **transitions between moorland and rainforest** provide a globally outstanding illustration of the dynamic interaction between vegetation-type, environment and fire frequency. The vegetation types involved in the fire-dependent succession are buttongrass moorland, scrub, wet eucalypt forest and rainforest. Fertility has a strong influence on the tolerance of each vegetation type to fire frequency and there is a very strong feedback between vegetation type and the probability of burning.	WHA
Pristine **tall eucalypt forests.**	Naturalness is not a World Heritage value in its own right and does not meet natural criterion (ii).	
	Mixed forests are a later transitional stage of Wet sclerophyll forests that form part of the ecological transition between moorland and rainforest (see above). The tallest eucalypt forests occupy the most fertile of sites, where the probability of the vegetation reaching climax rainforest is greater. The tall wet eucalypt species are dependent on fire for regeneration, as they are unable to regenerate beneath the closed canopy of the understorey. Although many eucalypts are adapted to fire and may survive fire events, the tallest flowering tree species in the world, *Eucalyptus regnans* is usually killed by fire. These forests demonstrate the 'hot fire paradox' and are of World Heritage significance, as they illustrate the ecological dependence of fire sere communities on stochastic disturbance in the landscape. *Eucalyptus regnans* is able to regenerate from seed provided a seed crop is present on the tree, which means if a fire event takes place before the trees are sexually mature or in a poor seed year they may be lost from the site.	WHA
	Cool temperate rainforests represent the climax vegetation for the lowland regions of the TWWHA. The fuel levels are very low and beneath the shade of the closed canopy, the forests remain relatively cool and moist in all but the most extreme conditions. Angiosperms or conifers may dominate rainforests. Conifers represent the climax in the succession and are very fire sensitive. A single fire will remove *Athrotaxis* species from the site. These communities are of international significance in demonstrating regeneration patterns and processes within climax vegetation.	International

WHA Values recognised in 1989 TWWHA nomination	Amended, additional and expanded values identified as at 2004	2004 Assessment of significance
	Buttongrass moorlands are transitional between freshwater and terrestrial systems and are the only major vegetation type in the temperate world comprising extensively of hummock sedge. This vegetation dominates extensive blanket bogs that form the largest temperate peatland system in the southern hemisphere. This is a globally unique and significant scleromorphic ecosystem that has evolved under high stress conditions in adaptation to a highly variable climate, extreme nutrient deficiency and frequent fire. Buttongrass moorland is one of the most pyrogenic vegetation types in the world, burning at higher moisture contents than any other known plant community. This flammability is a keystone element in the significant successional vegetation dynamics of south-west Tasmania. Buttongrass moorlands are geomorphically and floristically distinct from peatlands in the northern hemisphere. The process of peat formation involves interaction between climate, vegetation, fire and hydrology in a complex geomorphic process of global significance (see Sharples 2004). Geology, fire and fluvial processes occasionally combine to produce waterlogged and apparently barren '**alkaline pans'** or acidic scalds with distinctive endemic floristic elements including endemic genera *Winifredia* and *Ambuchanania*. The symbiotic relationship present between buttongrass moorland vegetation and the burrowing freshwater crayfish is a globally unique example of bioturbation in a peatland system.	WHA
Examples of **active speciation** in the genus *Eucalyptus*, including sites of: hybridisation and introgression; clinal variation (e.g. *E. subcrenulata*); habitat selection (e.g. *E. gunnii*); and transition zones which include genetic exchanges between *Eucalyptus* species; plant groups in which speciation is active (e.g. *Gonocarpus, Ranunculus* and *Plantago*).	Speciation through isolation (allopatric speciation) evident within the TWWHA are no longer considered internationally significant examples of this process. Speciation within clinally varying populations (parapatric) speciation was first demonstrated in Tasmanian eucalypts. This example is unlikely to be the best example of its kind in a global context although is still considered of national significance in relation to adaptation to extreme cold.	National
Conifers of extreme longevity (including Huon pine, Pencil pine and King Billy pine).	Tree life spans of greater than 1000 years are globally unusual. The TWWHA has populations of tree species with extreme longevity including *Athrotaxis cupressoides, A. selaginoides* and *Lagarostrobos franklinii.* These species exhibit evolutionary stasis. Huon pine and members of the endemic Tasmanian genus *Athrotaxis* are of increasing international importance for dendrochronological research into global climate change.	National
Endemic members of large Australian plant families (e.g. heaths such as *Richea pandanifolia, Richea scoparia, Dracophyllum minimum* and *Prionotes cerinthoides*).	The presence of endemic members of Epacridaceae is not considered to be a value meeting natural criterion (ii) but contributes to the world heritage significance of the TWWHA under the natural criterion (iv).	
The diversity of plant and animal species.	Diversity is not considered to be a value meeting natural criterion (ii) and is instead discussed under criterion (iv).	

Natural criterion (iii) contain superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance.

WHA Values recognised in 1989 TWWHA nomination	Amended, additional and expanded values identified as at 2004	2004 assessment of Significance
Flowering heaths of the coastline.	In themselves the coastal heaths are no longer considered to meet natural criterion (iii).	
The south and south-west coasts comprising steep headlands interspersed with sweeping beaches, rocky coves and secluded inlets.	The high-energy coastal ecosystem of the TWWHA, when viewed as an integrated landscape, is globally exceptional in the aesthetics of the wide variety of the landforms, fierceness of the roaring forties, the absence of human development and other exotic influences.	WHA
Rainforests framing undisturbed rivers.	The dark coloured dystrophic waters flowing through rivers valleys, gorges and flats, when shrouded by the dense canopy of cool temperate rainforest are internationally distinct from other close analogues and are of outstanding aesthetic quality.	WHA
Buttongrass, heath and moorland extending over vast plains.	The buttongrass moorland ecosystem is a superlative aesthetic when considered as a whole landscape incorporating the changing ambient light, geology, topography, the appearance, scents and sounds and texture of the vegetation and fauna.	WHA
Eucalypt tall open forests including *Eucalyptus regnans*, the tallest flowering plant species in the world.	The internationally superlative element of the wet forests of the TWWHA is the tall mixed forest particularly forest dominated by *Eucalyptus regnans* greater than 60 m in height and more than 10 m in circumference. This fire sensitive and fire-dependent species has the potential to reach 100 m in height making it the tallest flowering species in the world.	WHA
Wind-pruned alpine vegetation. Deep, glacial lakes, tarns, cirques and pools throughout the ranges.	The individual elements of the alpine landscape such as the alpine vegetation or the glacial features and lakes are no longer considered to meet natural criterion (iii) in their own right. However the alpine landscapes of the TWWHA viewed holistically as a tremendously varied ecosystem with its richly varying mosaic of distinctively contrasting colours, textures, smells and sounds superimposed on dramatic extremes in weather has a universally outstanding natural aesthetic value.	WHA
The relatively undisturbed nature of the property. The scale of the undisturbed landscapes.	In itself naturalness is no longer a value meeting natural criterion (iii), however, it contributes to the integrity of the other identified values.	

Natural criterion (iv) contain the most important and significant natural habitats for in-situ conservation of biological diversity, including those containing threatened species of outstanding universal value from the point of view of science or conservation.

WHA Values recognised in 1989 TWWHA nomination	Amended, additional and expanded values identified as at 2004	2004 assessment of Significance
Rainforest communities.	Australian cool temperate rainforest has its greatest extent and diversity in the TWWHA. These forests are floristically rich in non-vascular species, which out-number the vascular taxa at around 6:1.	International
Rainforest communities cont'd.	The cool temperate rainforests provide habitat for a number of threatened flora and fauna species and exhibit relatively high levels of endemism amongst seed plants, particularly dicotyledon and gymnosperm species. There are currently10 threatened flora species represented in rainforest habitats of the TWWHA (Appendix 1). They include at least 51 species of endemic vascular plants and have a rich diversity of cryptogamic species. Rainforests, especially montane rainforests, are a habitat rich in relict Gondwanan and other primitive flora which are discussed below. Montane rainforests have their greatest extent in the TWWHA.	
Not in 1989 nomination.	The **Coastal ecosystem and off shore Islands** includes vegetation formations not found elsewhere in Australia such as the temperate dwarf littoral rainforest in Australia is largely restricted to and best expressed within the TWWHA. It includes threatened species such as *Persoonia muelleri* subsp. *densifolia.*	National
	Short herbfields or coastal fen known as **marsupial lawns** appear to be globally unique and include a diversity of endemic species.	International
	Significant sea bird rookeries occur within the TWWHA, especially on offshore islands.	National
Not in 1989 nomination.	**Sclerophyll forests and woodlands** The tall mixed eucalypt forests have their best and most diverse expression within the TWWHA. They are rich in endemic and relict biota.	International
Alpine communities.	There are unusually high levels of species richness and endemism within the vascular flora of Tasmania alpine ecosystems. More than 60% of the vascular species in western alpine areas are Tasmanian endemics. The sclerophyllous component of the alpine flora, especially bolster plants are globally unusual. There are currently 38 threatened flora species represented in alpine habitats of the TWWHA (see Appendix 1). Of particular national importance is the presence of alpine karst floras and montane and alpine grasslands.	WHA

WHA Values recognised in 1989 TWWHA nomination	Amended, additional and expanded values identified as at 2004	2004 assessment of Significance
Moorlands (e.g. in the far south-west).	About 33% of the vascular flora of buttongrass moorlands within the TWWHA are endemic to Tasmania. A new monospecific genus of moss *Ambuchanania leucobryoides* is restricted to moorlands of the TWWHA. Endemism within bryophytes is unusual and highlights the importance of this habitat at a national and international level. There are currently 9 threatened flora species represented in buttongrass moorland and alkaline pan habitats of the TWWHA (see Appendix 1).	WHA
Riparian and lacustrine communities (including meromictic lakes).	**Wetland habitats:** Many of the wetland habitats within the TWWHA are of national significance due to their diversity or rare biota. The Bathurst Harbour- Port Davey Rio and the meromictic lakes are the only wetlands of internationally significant because of the diversity and unusual nature of their microbial community. Dystrophic Rivers and Lakes known to have national significance for their biota include Lake Surprise and Sanctury Lake on the Frankland Ra, the Old River, South-East Cape Coastal Lagoons and New River Lagoon. A number of riparian communities are dominated by endemic species or contain a rich diversity of endemics including *Lagarostrobos franklinii* rainforest and *Leptospermum riparium* scrub. Green Window lakes known to be of particular significance for their microbial or flora composition include Clarence Lagoon, Golden Cloud Swamp and Lake Kay. Sphagnum peatlands at Mt Rufus and Shadow Lake are listed on the National estate for their floristic diversity and composition. There are currently 26 threatened flora species represented in riparian and lacustrine habitats of the TWWHA (see Appendix 1).	National & International
Not in 1989 nomination.	**Swamp forests** dominated by the endemic tree *Acradenia frankliniae* have their best examples within the TWWHA.	National
Habitats which are relatively undisturbed and of sufficient size to enable survival of taxa of conservation significance including endemic taxa.	This is not a value in itself meeting natural criterion (iv).	
Plant species of conservation significance.	At least 85 **threatened plant taxa** have been recorded within the TWWHA (Appendix 1). ***Lomatia tasmanica*** is the longest living plant clone recorded in the world and has is restricted to the TWWHA. Tasmanian **endemic plant genera** that occur within the TWWHA are *Agastachys, Ambuchanania*, Anodopetalum, Asterotrichion, Athrotaxis, Bellendena, Campynema, Cenarrhenes, Diselma, Isophysis, Microcachrys, Milligania, Planocarpa, Prionotes, Pterygopappus, Siphulella*, Tetracarpaea, Winifredia* (denotes non-vascular species). There is a flora of **endemic species** (255 species) reflecting the distinctive environment and long isolation of the region (endemic taxa are listed in Appendix 2 & 3).	National & International

WHA Values recognised in 1989 TWWHA nomination	Amended, additional and expanded values identified as at 2004	2004 assessment of Significance
In 1989 **relict biota** were listed under natural criterion (i).	The vegetation of the TWWHA and in particular cool temperate rainforests, especially montane communities, provide secure habitat for nationally significant examples of relict biota with ancestral origins in the ancient flora of the southern super continent, Gondwana. The following Tasmanian genera (all with substantial populations within the TWWHA) are identified as having ancient ancestral origins: For the list of relict biota of significance refer to Table 3.2.	International & National (see Table 3.2)
Not in 1989 nomination.	Nationally significant examples of **glacial refugia** areas critical for rainforest have been identified by Kirkpatrick & Fowler (1998) occurring within the TWWHA: • Lower Gordon River (TWWHA) • Lower New River (TWWHA) • Inland valleys below 200-300m in the western interior (TWWHA) • Regions to the North and south of Macquarie Harbour	National

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