Nature Conservation Review Victoria 2001

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Preface

For nearly 50 years the Victorian National Parks Association has been at the forefront of advocacy for the establishment and effective management of Victoria's conservation reserve system. A key role of the VNPA over the years has involved setting the community and political agenda for nature conservation in Victoria. To do this, one of the most important tools the association has employed has been the commissioning of Nature Conservation Reviews. These reviews have periodically assessed the adequacy and representativeness of the Victorian conservation reserve system, and made recommendations and set priorities for additions to the system.

Nature Conservation Review Victoria, 2001 is the third such review produced for the VNPA over the last 30 years. The first review, prepared by Judith Frankenberg and edited by Professor John Turner, was published in 1971. A second Nature Conservation Review, prepared by Doug Frood and Dr Malcolm Calder, was published in two volumes in 1987.

This third Nature Conservation Review has been prepared by Dr Barry Traill and Dr Christine Porter, and examines the state of nature conservation in Victoria in the year 2001. Over the decades, many areas and ecosystems have been reserved, to be protected forever. The development of this internationally significant reserve system is an achievement that both major political parties can take pride in. Many of our parks and natural areas draw visitors from all over the world.

Yet there are significant gaps in our conservation reserve system that must be rectified if we want to comprehensively protect biodiversity in this state. The ancient River Red Gums of the Barmah region are still being logged. Central Victoria's unique dry box–ironbark forests, although reduced to only 15% of their original extent, are still being mined and cut for firewood. And if we have a system of marine parks it is a system in name only, so tiny and fragmented are the areas we have, to date, deemed worthy of protection.

The *Nature Conservation Review Victoria, 2001* proposes recommendations that set us on the path to conserving our natural systems, both in and out of reserves. These recommendations must be pursued seriously if we are to halt the current decline in Victoria's biodiversity and maintain the natural systems on which our agriculture and other industries depend.

James Ensor
President, Victorian National Parks Association
February 2001

Section 1: Introduction

Extinctions are often perceived as a single event: the last Dodo or Passenger Pigeon dies and extinction has occurred. Extinction, however, is almost always an extended process; a process with many events that may occur over decades or centuries, or longer. As habitat changes, a species that was once common and abundant may begin to decline, local and regional extinctions occur and the total population slowly reduces in number and range to scattered and isolated populations. Because extinctions may occur slowly over many years, declines are often not readily perceived and acted upon until a species is close to the end point of complete global extinction. By then it has usually been lost from the great majority of its former range.

In Victoria, many gains in nature conservation have been made. However, often overlooked is that local and regional extinctions are continuing.

The *Nature Conservation Review Victoria, 2001* examines the current state of nature conservation in Victoria. The aim is to identify major gaps in conservation work and in the conservation reserve system. The Review then proposes recommendations that will help to slow and reverse our continuing losses of biodiversity, and stop these extinction processes continuing in Victoria.

Since 1987, there have been considerable developments in the mapping of terrestrial ecosystems, improvements in knowledge of the requirements of freshwater ecosystems and a long overdue focus on the need to preserve marine ecosystems, not examined in previous reviews. A further review is timely: to re-examine the state of nature conservation in Victoria in the light of the new knowledge; and to set a positive agenda for nature conservation into the future.

The previous reviews have been comprehensive analyses of the knowledge and references of their times. In this review, Section 2 details the key data sources for marine ecosystems. However, this is not attempted in Section 3. In 1987, the number of information sources and references made the task difficult; in 2000, the sheer mass of information on terrestrial and freshwater ecosystems makes this task prohibitive.

The review, then, in the terrestrial, and to some extent in the marine, is selective. The aim is to identify the further work required to maintain species, natural communities and ecosystems into the future. Inevitably such a review must exclude some specific areas or interest. Some readers may be concerned that coverage of some topics is too sparse, but it is emphasised that the review particularly aims to identify gaps requiring future attention, rather than to provide a compendium of references and complete coverage of all conservation issues.

Not examined in detail in the Review are the current set of Acts and policies that affect conservation. The Review does not attempt to detail the many mechanisms governing nature conservation. However, three very important new policy settings have arisen since the last review in 1987. These require a brief introduction.

In 1988, the Cain Government introduced the *Flora and Fauna Guarantee Act*. This sets out a detailed process for identifying threatened species, communities and threatening processes. As well, this innovative legislation was intended to set out processes by which threatened communities and species would be protected. Regrettably, though, when conservation of threatened species has come into direct conflict with commercial interests, the potentially strong powers of the *Flora and Fauna Guarantee Act* have often been stymied by other considerations. However, the *Flora and Fauna Guarantee* has helped greatly in setting directions for the identification and protection of threatened species. A continuing problem with its full implementation remains lack of adequate funds to carry out the works required to improve the status of threatened species and communities listed under the Act.

During the 1990s, considerable work was done by a range of government bureaucracies and non-government organisations in developing better structures for protecting native vegetation on private land. In Victoria, this work at least partly arose from pressures from some landholders in some regions to weaken the 1991 amendment to the *State Planning Act* which placed controls on the clearing of native vegetation on private land. Nature conservation on private land also gained impetus from the developing need for better catchment management mechanisms to confront the increasing scale and complexity of problems such as salinity. Catchment Management Authorities (CMAs) were set up to help administer policy and management of catchments. In parallel with the development of the CMAs, a State Vegetation Framework and Regional Vegetation Plans are being developed to provide policies for managing native vegetation. These plans have the potential to greatly improve management of native vegetation through devolving decisions to landowners and regional groups. However, there remains the possibility that in some regions some landowners will continue to pressure to increase clearing and that regional plans may be used to facilitate this. The Regional Vegetation Planning process and its successful, or unsuccessful, implementation will be a key factor in determining whether biodiversity is protected in many agricultural landscapes.

In 1997, the Kennett Government launched the Victorian Biodiversity Strategy. A detailed document, it sets out the key threats to biodiversity, the current state of biodiversity in different regions and broad mechanisms by which better conservation can be achieved. Although it could be criticised for its lack of policy specifics, it nonetheless sets out a clear vision of what is sought for nature conservation. Whether the Victorian Biodiversity Strategy stands or falls depends on the preparedness of government to enact the vision set out in the strategy and to provide the necessary political will and funding.

Government, business and the general public need to accept and implement a 'triple bottom line' approach to running Victoria, with environmental issues being considered equally along with social and economic decisions. Failure to achieve this will have a very measurable consequence.

Native plants and animals will continue to decline and disappear from our landscape.

Section 2: The Seas

The Conservation Status of Victoria's Marine Environment

2.1 Introduction

Victoria's coastline is about 2000 km long and is made up of a series of rocky promontories or headlands joined by long sandy bays (O'Hara 2000). A diverse array of habitats and features is evident: cliffed coastlines, exposed rock platforms, underwater reefs, muddy and sandy sea floors, sheltered shores, embayments, estuaries and offshore islands. Rivers are generally small and open into small inlets. Consequently, freshwater inputs to the ocean are low. A general description of physical, biological, cultural and landscape characteristics of Victoria's marine environment can be found *Marine and Coastal Investigation Descriptive Report* from the Land Conservation Council (LCC 1993). Environmental inventory research undertaken since 1993 has considerably advanced this understanding of Victoria's marine systems (e.g. Ferns 1999; Ferns & Hough 2000).

This report is about nature conservation, defined here as conservation of biodiversity. The aim is to make recommendations concerning development of a protected area system for Victoria as an essential, but not the only, tool for conserving biodiversity. This section first reviews the current status of Victoria's marine systems and describes the major threats to marine biodiversity. This is followed by a review of the literature on selection and design criteria for Marine Protected Areas (MPAs), including national and state initiatives towards a 'comprehensive, adequate and representative' (CAR) system of MPAs. Victoria's existing system of MPAs is then assessed and recommendations are made for the establishment of a system of MPAs that is better placed to achieve conservation of biodiversity.

The area covered by this study is from mean high-tide level to 5.5 km offshore, that is, the offshore limit of Victoria's territorial waters. Activities in the narrow coastal fringe and in catchments affect the quality of coastal waters. However, these ecosystems are considered terrestrial and are covered in the following section. Tasmania has jurisdiction over the waters of central Bass Strait, while Commonwealth waters extend over the continental shelf and continental slopes to the west and east of Bass Strait. A national representative system of MPAs would not be complete without examples selected from within these areas. An ecosystem-based approach may require the establishment of MPAs that cross these jurisdictional boundaries.

Terminology

'Marine Protected Area' is the general term that has been adopted to encompass all forms for reserves, parks and sanctuaries created in marine waters. The International Union for the Conservation of Nature (IUCN, now known as the World Conservation Union) definition for a MPA is:

'… any area of intertidal or subtidal terrain, together with its overlying water and associated flora and fauna, historical and cultural features, which has been reserved by law or other effective means to protect part or all of the enclosed environment.' (ACIUCN 1994)

This definition allows for a range of MPAs, from areas where all exploitative and habitat-degrading activities are excluded to those which are managed for many uses (‘multiple use’). Australia has at least 50 types of MPAs, of which 17 are marine extensions of terrestrial parks (McNeill 1991; Cresswell & Thomas 1997). The terminology that has evolved for labeling MPAs has become unnecessarily complex. The IUCN developed a classification scheme for terrestrial and marine protected areas that comprises six management categories, in recognition of the need for more uniformity in protected areas terminology and objectives (IUCN 1994).

This Review discusses high protection MPAs, equivalent to IUCN categories I and II (i.e. Nature Reserves, Wilderness Areas and National Parks – all ‘no-take’ areas: see Table 2.1). Two terms for MPA are recommended here for use in Victoria: ‘Marine National Park’ and ‘Marine Sanctuary’. These terms are more clearly associated with high-protection ‘no-take’ regulations than are other terms for MPAs that are in common usage. For example, the term ‘Marine Park’ is generally associated with multiple-use management areas such as the Great Barrier Reef Marine Park, while the existing ‘Marine Reserves’ in Victoria allow for a range of uses, including exploitative uses. The term Marine National Park is applied to areas larger than 2000 ha that are established for the conservation of nature. They are ideally places of minimal direct influence from human activities that can also serve as scientific reference, or benchmark, areas. Non-exploitative (passive) recreation is generally encouraged, but carefully monitored and regulated. Marine Sanctuary is recommended for MPAs for which the principal conservation objective is to protect a particular feature of significance, such as habitat for specific marine species or communities. These may be smaller than Marine National Parks. The terminology suggested here is consistent with the most recent terminology adopted by the Environment Conservation Council (ECC) for MPAs (ECC 1999). The main focus of Section 2 of the Review is the establishment of a system of Marine National Parks.

Table 2.1: Definitions for IUCN protected area categories

CAT	General objectives	Selection	Example types
Ia	Preserve species, habitats and ecosystems for scientific purposes	Relatively free of direct human influence and capable of remaining so	Nature Reserve
Ib	Preserve natural attributes for future generations	High natural quality, significant features and opportunity for solitude	Wilderness Area
II	Protect natural/scenic areas of national significance for research, education and recreation	Representative example large enough to contain entire relatively unmodified ecosystem(s)	National Park
III	Preserve specific outstanding natural features	Contains feature(s) of outstanding significance; Large enough to protect integrity of feature	Natural Monument
IV	Conserve habitat of significant species (e.g. rare) through active management	Habitat important to the species survival (e.g. breeding areas)	Wildlife Sanctuary
V	Maintain harmonious interaction of nature and culture; Provide for recreation/tourism	High scenic quality and diversity, unique or traditional land use patterns	Protected Landscape/Seascape
VI	Sustainable use of natural resources through sound management, while maintaining biodiversity	Two-thirds of area must be in natural condition; Large enough to absorb sustainable use	e.g. GBRMP

Objectives of Marine National Parks and Sanctuaries

Selection of sites to include in a system of Marine Protected Areas requires that the goals for this system are clearly identified from the outset. The principal objective of a system of Marine National Parks and Marine Sanctuaries is to facilitate nature conservation. This goal encompasses preservation of the diversity of marine life and maintenance of ecosystem processes. The long-term viability of Victoria's marine environment will be enhanced significantly by achieving both these aims. Preservation of biodiversity will be achieved by maximising the number of species and community types included in the system of protected areas, and then protecting the enclosed habitats from degradation and the species from harvesting. It should be noted that this is not the same as preservation of areas with the highest number of species: an estuary could never compete with a coral reef for inclusion within protected areas if this were the case. Conservation of ecological processes is more difficult to define: ecosystems are dynamic, and species assemblages often change with time in natural systems. This issue also has management implications. Distinguishing between change that would have occurred without human interference from change caused by human activities is not always possible. Thus, decisions may need to be made about whether or not to intervene to conserve an existing state (Caughley & Gunn 1996).

Other objectives for MPAs include providing areas managed for rehabilitation of environments, replenishment of fish stocks, sustainable use of resources, recreational enjoyment, education, scientific research and protection of cultural values. A Marine National Park established for nature conservation does not have to achieve any of these other goals, but available evidence suggests that such outcomes are likely (Porter 1999; see Appendix 2.1).

Marine National Parks and conservation of marine environments

Establishment of highly protected areas is an important, even essential, component of strategies to achieve conservation of marine environments (GBRMPA, the World Bank and the World Conservation Union 1995). A number of ecological and other benefits of 'no-take' MPAs have been demonstrated (see Appendix 2.1). However, establishment of a system of Marine National Parks is unlikely to be sufficient, by itself, to ensure marine conservation. The main concern of Marine National Park management is to control activities and events such as poaching and recreational use inside designated boundaries. Many marine areas, however, face problems from the downstream effects of coastal land use, pollution, exotic species introductions, depletion of resources and destruction of habitat (Kelleher & Kenchington 1991). The effectiveness of Marine National Parks in achieving nature conservation will thus depend not only on management within the boundaries, but how well they are integrated into a framework for coastal zone management.

2.2 Review of knowledge about Victoria's marine environment

This section of the Review covers biogeographical classification of Victoria's marine environment, important physical features of this environment, description of habitat types present, current knowledge on distribution of habitats, flora and fauna, and what is known about the conservation status of Victoria's marine flora and fauna. Significant sources of material for the Review have been reports that have resulted from the Environmental Inventory of Victoria's Marine Ecosystems (Ferns 1999, 2000; Ferns & Hough 1999, 2000; Hamilton 1994; VIMS et al. 1994) and the Marine, Coastal and Estuarine Investigation (ECC 1998, 1999). The Inventory is a multi-stage program to classify Victoria's marine ecosystems at various hierarchical scales, which has been conducted by the Department of Natural Resources and Environment (DNRE) since 1992 (see Appendix 2.2). The Investigation has been conducted since 1991 by the Environment Conservation Council (ECC) (formerly the Land Conservation Council) and has been undertaken primarily to recommend the progressive establishment of a representative system of MPAs and areas suitable for marine aquaculture (see Appendix 2.2).

Biogeographical and biophysical classifications

Victoria's marine environment is part of the temperate Flindersian Province encompassing much of southern Australia. The cold temperate element, which includes Victorian waters, is recognised by some biogeographers as the Maugean Subprovince (Edyvane 1998). However, analysis of the distribution of macroalgal assemblages does not support this distinction (Sanderson 1997). Marine species occurring in Victoria may be:

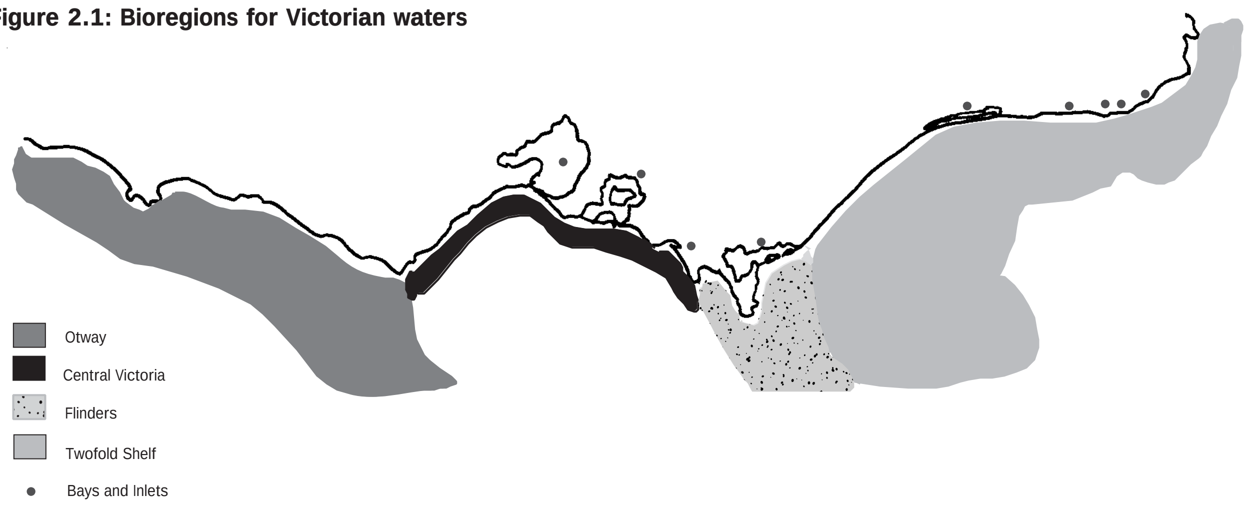
- species found throughout southern Australia;
- species with a western limit to distribution in Victoria;
- species with an eastern limit to distribution in Victoria;
- species endemic to Victoria and Tasmania (O'Hara 2000).

Exposure of Bass Strait during periods of glaciation, of which there have been 60 cycles over the past three million years, has provided a barrier to species dispersal. However, any differences in species composition that occur between the west and east of the state are more likely due to differences in physical features, such as temperature, than to these relatively brief periods of separation (T. O'Hara pers. comm.).

To assist with the identification of candidate MPAs a biophysical classification for Victorian waters and Bass Strait was undertaken (LCC 1995). Stage 1 of the Environmental Inventory Program involved analysis of physical and biological datasets to identify bioregions that are clearly different from each other (VIMS et al. 1994). Information on coastal geomorphology and orientation, oceanographic data (depth, tides, wave energy, sea surface temperature) and the distribution of intertidal invertebrates was used. Stage 2 of the Environmental Inventory Program extended the biophysical classification to waters throughout the Bass Strait (Hamilton 1994).

This biophysical classification formed the basis of Victoria's contribution to the development of the Interim Marine and Coastal Regionalisation for Australia (IMCRA Technical Group 1998). Four bioregions along the open coast have been identified, while all bays and inlets have been grouped together as one bioregion (Figure 2.1).

Figure 2.1: Bioregions for Victorian waters



Description of the physical environment

Physical factors influence species composition and species diversity of biological communities. Such factors include substrate type and structure, wave energy, depth, sediment movement, water temperature, salinity, water clarity, currents and up welling. Recent studies in Victorian waters have demonstrated some correlation between physical environmental factors and the assemblages of plants and animals present (Edmunds et al. 1999; O'Hara in prep.). An aspect of the physical environment relevant to selection of Marine National Parks is how physical features differ from place to place, particularly from west to east of the state. Knowledge about these factors for Victorian waters is summarised in the Land Conservation Council's Descriptive Report (1993). This section describes the influence of key physical features and how they vary across the state.

Currents and tides

Currents provide pathways for larval dispersal and nutrient transfer. They influence sorting of sea floor sediments, temperature and salinity. Currents along high-energy coastlines often contain a high sediment load. This has an abrasive effect, restricting the types of plants and animals that can live in such areas. Western Bass Strait coasts are influenced by the cold nutrient-rich Circumpolar Current, while coasts to the east are influenced by the warmer low-nutrient East Australian Current (both of which are oceanic currents). The currents of Bass Strait are tidal in origin. Upwelling currents, which bring nutrient-rich waters to the surface, occur infrequently on the eastern and western margins of Bass Strait.

As well as resulting in currents, tides influence the distribution patterns of intertidal animals and plants. Two tidal cycles a day are generally experienced along the Victorian coastline. Tides are mixed to the west and east of the state (only one obvious high and low per day) and semi-diurnal in the Central Victoria Bioregion (two obvious highs and lows per day). Tidal ranges are small, varying between 0.9–2.7 m. The small range means that the intertidal zone is generally fairly narrow and the different tidal patterns mean that the intertidal zone is exposed more frequently in the Central Victoria Bioregion but with shorter periods of emersion than in the other regions.

Depth contours

Depth contours have been digitally captured at 1:250,000 for Victoria's open coast and Bass Strait (Mahon 1997) and 1:25,000 for Victoria's bays and major inlets (Catlin and Ferns 2000a). The sea floor within Victoria's coastal zone is mostly less than 100 m below sea surface, with almost 80% of it less than 40 m (LCC 1993). Depth typically increases gradually with distance offshore. Exceptions include around Cape Bridgewater, Cape Otway, Wilsons Promontory (70 m depth within 500 m of shore) and Port Phillip Heads (depths up to 100 m). The continental slope begins at water depths of approximately 200 m and these occur between 30–60 km offshore. Water depths within Bass Strait reach a maximum of 85 m, with the shallowness of Bass Strait having a major effect on tides, waves and currents for the Victorian coast.

Substrate type

Substrate provides the habitat for animals and plants that live in the intertidal zone and on the sea floor. The structure of hard substrates (texture, slope, crevices etc.) will determine the variety of habitats available for marine organisms.

Intertidal

Victoria's coastline, including the open coast, bays and inlets comprises 26% rocky shore, 64% sandy shore, 7% muddy shore/sediments and 9% mangroves and mud (Fairweather & Quinn 1995). Detailed mapping of Victoria's open coastline has been undertaken at 1:25,000 (Roob et al. 1997). The resulting proportions, based on length of coast, are 35.2% rocky shore, 55% sand, 7.2% mixed sand/rock and 0% mud. The remaining length mainly comprises openings to rivers and estuaries. The main rock types on the open coast are sedimentary rock, granite, basalt, calcarenite and limestone.

Contour and rock type contribute to habitat diversity and, hence, species diversity for intertidal rocky shores (Handreck & O'Hara 1994). Intertidal granite and limestone have been found to support fewer species than do basalt, calcarenite and sandstone, for example. However, substrate structure, depth and wave energy appear to be more important than rock type in determining community structure on subtidal reefs (Edmunds et al. 1999).

Subtidal

Victoria's nearshore subtidal substrates have been mapped and classified for Stages 3 and 4 of the Environmental Inventory Program. Underwater substrates comprise about 65% sandy sediment and 35% rocky substrate (Roob 1999). Underwater rocky reefs occur either as extensions of intertidal rocky reefs or as isolated offshore reefs (LCC 1993). They have been classified as continuous or patchy, and either heavy, low profile, boulder, cobble or rubble for mapping of habitat types (Roob 1999).

All rock types are represented in the rocky shores of the Otway and Central Victoria Bioregions, while the Flinders and Twofold Shelf Bioregions do not have intertidal limestone or basalt reefs (LCC 1995). Basalt and calcarenite account for 64% of the underwater rocky substrate. The remainder is composed of granite, limestone, sandstone and mudstone (Roob 1999). Reef forms include low to high relief reefs, bommies, gutters, stepped reef, reef flats, boulders, boulder walls and cobbles. Rock types within each bioregion have been summarised in Table 2.2. The geographic distribution of rock types and reef forms is provided in a series of 42 colour maps produced as part of an inventory of marine ecosystems for Victoria (Roob 1999).

Sediment type has a strong influence on the composition of animal assemblages living in and on the sediments. The soft sediments of western Victoria are mainly calcareous sands derived from animals with shells (e.g. bryozoans and molluscs). The Twofold Shelf Bioregion has the highest proportion of sandy shore of all the bioregions. The Central Victoria Bioregion sediments are mainly derived from terrestrial sources, while those of the east coast are mainly sands with a high silicon content (LCC 1993). Five major classes of soft sediment were delineated as a result: fine, medium and course sand, muddy sand and mud/silt (Ferns 1999). Fine sand accounted for 72% of all sea floor sediments, medium sand for 20% and coarse sand the remaining 8%. The sediments of bays and estuaries, on the other hand, tend to comprise mainly fine clay and silt.

Table 2.2: Rock type and structure of subtidal reefs within each bioregion (Roob 1999)

Bioregion	Rock type	Examples of localities with each rock type
Otway	limestone	Cape Nelson, Port Campbell, Cape Otway
	sandstone	Port Campbell, Cape Otway
	calcarenite	Discovery Bay, Warrnambool (east of)
	basalt	Cape Bridgewater, Lady Julia Percy Island, Port Fairy, Moonlight Head, Cape Otway
	mudstone	Cape Otway
Central Victoria	limestone	Little Henty Reef
	sandstone	Kennett River, Point Addis, Point Nepean to Cape Schanck, Cape Patterson, Cape Liptrap
	calcarenite	Point Lonsdale, Point Nepean, Cape Schanck
	basalt	Cape Schanck to Flinders, Phillip Island
	mudstone	Morengo
	granite	Phillip Island (Pyramid Rock)
	ironstone	Flinders
Flinders	calcarenite	Waratah Bay, North of Tongue Point
	granite	Most of Wilsons Promontory
Twofold Shelf	calcarenite	Seaspray, Delray
	granite	Point Hicks, Rame Head, Cape Howe
	slate	Little Rame Head, Mallacoota
Bays and Inlets	unknown	

Surface temperature

Average 'sea surface temperatures' (SST) range from 12°C in August–September to 20°C in February–March (CSIRO Oceanography database). SST varies by 2–3°C from west to east of Victoria, the colder waters being in the west. Temperatures in bays and inlets are more extreme because of the shallow nature of the water masses involved. Most marine organisms have fairly narrow temperature tolerances, so differences in types of animals and plants present between the west and east of Victoria would be expected.

Waves and storm activity

Wave effects shape coastlines and result in sediment transport in and offshore and parallel to shore. Coastlines have been broadly classified into high, moderate and low wave energy; each energy type having characteristic species assemblages (Shepherd & Thomas 1982; Womersley 1984a).

The Otway Bioregion is characterised by high wave energy (up to 46 kw/m), as a result of incoming swell waves generated in the southern ocean. Wave energy is much lower in the central zone between Cape Otway and Wilsons Promontory, as wave fetch is broken by Tasmania and waters are relatively shallow. The section of coast between Cape Otway and Point Lonsdale has lower wave energy (9 kw/m) than the section from Point Nepean eastward (18 kw/m) as the former lies perpendicular to the predominant south westerly wave swell. The eastern zone from Wilsons Promontory receives considerable protection from Tasmania, Wilsons Promontory and the Bass Strait islands. The region is further subdivided into a more sheltered region from Wilsons Promontory to Lakes Entrance (4 kw/h), and the easternmost part of the state which is influenced more by south-westerly swells and by easterly swells generated in the Tasman Sea (13 kw/h) (energy values taken from VIMS et al. 1994)). Wave energy decreases with increasing depth from the sea surface, so that even along high energy coastlines, depths greater than 25 m would normally experience relatively low wave energy (Shepherd & Thomas 1982).

Inputs

Freshwater and sediment inputs from rivers and estuaries can have a localised effect on the species composition of nearshore communities. Deposit-feeding animals would be favoured over filter feeders where the sediment load is high, for example. The depth to which light will penetrate is influenced by run-off from abutting coastal areas and outlets of rivers and streams, and by re-suspension of sediments during period of high wave energy. This, in turn, has a major effect on the depth distribution of animals and plants (Womersley 1984a). River mouths are relatively small in Victoria. Thus the extent of any effect is likely to be limited to tens of kilometres from the input location. Significant areas of freshwater input occur at Warrnambool, Barwon Heads, Gippsland Lakes, Marlo and Mallacoota.

The biological environment

Open coast subtidal habitats and communities

Pelagic

The pelagic environment is the water that makes up the oceans. It is three-dimensional and supports plankton and fish communities, large mammals and seabirds. Organisms of the pelagic environment also contribute significantly to sea floor communities via detrital food webs. Maintenance of water quality in this habitat is essential to maintenance of healthy marine ecosystems. Pelagic communities of Victoria are low in biomass and diversity when compared with those of other regions: a reflection of the nutrient-poor waters of this region (O'Hara 2000). Zooplankton is dominated by a few abundant species of copepods. Large invertebrate plankton includes jellyfish, salps, comb-jellies and squid. Examples of pelagic fish species are pilchards, anchovies, Silver Trevally, barracouta and Jack Mackerel. Large marine mammals found in Victorian waters include Common and Bottle-nosed Dolphins, Australian Fur Seals and Southern Right Whales.

Little research effort has apparently been devoted to oceanographic studies of Victoria's open coast pelagic zone (although some fisheries-related research has been conducted by CSIRO [Commonwealth Scientific and Industrial Research Organisation] for which reports are in progress). Stock assessment of fish species of commercial importance is ongoing. These include compilation of annual catch and effort statistics. A fisheries habitat assessment for the opening coast has recently been initiated by the Department of Natural Resources and Environment (DNRE) (R. Bathgate pers. comm.). Factors influencing survival of Little Penguins have been investigated (Dann et al. 1996).

Soft sediments

Soft sediment habitats of the sea floor appear very uniform, although some surface structure is formed by ripple marks, burrows and faecal mounds (Nybakken 1997). The most apparent difference from place to place is the substrate grain size and composition (carbonate vs silicate). Soft sediments are home to an array of organisms that live in and on the substrate surface. Sediment grain size and water movement are the main factors influencing the composition of animal assemblages present. The dominant animals are marine worms, crustaceans, echinoderms (such as sea urchins and sand dollars) and shellfish. A variety of fish species occur on the sediment surface. Most open coast sediments lack vegetation, although isolated pockets of seagrass occur in more sheltered areas.

Species diversity in the sediments of Victoria's open coast are the highest reported in the scientific literature (Coleman et al. 1997). A study of open coast sediments within the Twofold Shelf Bioregion by Coleman et al. (1997) revealed an extremely species-rich fauna, with 104 samples (total area 10.4 m^2) yielding 60,258 individuals from 803 species. About half of the species collected were taxonomically undescribed.

A statewide assessment of fauna species diversity within the sediments of Victoria's open coast was recently completed by Coleman et al. (2000). The survey was undertaken to assist with the identification of candidate soft benthic MPAs (Ferns 1999, 2000). Species richness and diversity along Victoria's open coast are influenced principally by depth and then by sediment grain size (i.e. fine, medium and coarse grain sands). Species diversity is significantly higher in sediments at 40 m compared with 10 m, and more species are usually found in medium and coarse sand than in fine sand. The consistency in high species richness reinforced the findings by Coleman et al. (1997) that Victoria exhibits very high species diversity within its nearshore coastal waters.

No information is publicly available on the fish fauna of open coast soft sediment habitats for Victoria, despite the predominance of this habitat type. Many fish species associated with this habitat would be harvested in trawl fisheries, particularly in deeper offshore waters. Victoria has 71 licence holders for the inshore trawl fishery; a multi-species fishery for which the status (in terms of sustainability) is unclear (Bathgate 1999). The main damaging effects of bottom trawling are mobilisation of sediments which can result in smothering of sea floor organisms, destruction of long-lived sea floor communities (such as sponge gardens), physical alteration of habitat and by-catch of non-target species.

Rocky reefs

The surface of shallow water rocky reef tends to be covered in brown algae or kelps (e.g. *Phyllospora*, *Durvillaea*, *Ecklonia* and *Macrocystis*). Red algae are generally more abundant where light is reduced (e.g. as understorey plants and at greater depths). Assemblages of sedentary invertebrates, such as sponges, sea fans and lace corals, dominate rock surfaces below the zone of light penetration, in caves on vertical rock faces and under overhangs. The seagrass *Amphibolis antarctica* occurs around more sheltered underwater reefs on open coasts west of Wilsons Promontory. The stems support diverse epiphytic assemblages of plants and animals. Barrens created or maintained by sea urchin grazing are typical of the New South Wales coast and occur to at least Cape Conran (T. O'Hara pers. comm.). They are rare further west along the Victorian coast; the difference possibly due to a difference in urchin species present (Keough & Butler 1995).

Deposit feeders, such as brittle stars and small crustacea, are the dominant feeding group occurring on reefs, both in terms of species richness and abundance (O'Hara 1999a), highlighting the importance of the detrital food chain in marine benthic environments. The most obvious herbivores are the gastropod molluscs, sea urchins, amphipods and fish (such as wrasse). Scavengers include starfish, Southern Rock Lobsters, crabs and numerous fish species. Octopus and fish are the most visibly obvious predators.

Systematic and quantitative ecological surveys of rocky reefs across the entire Victorian coast have only recently been undertaken. Broad-scale mapping of shallow rocky reefs to characterise the dominant animals and plants has been completed (Ferns & Hough 1999). Taxonomic surveys of the very small animals associated with rocky reef vegetation have been conducted for representative reefs along the coast (O'Hara 2000a, 2000b). Assemblages of these animals appear to be influenced mainly by dominant vegetation species (*Amphibolis*, *Ecklonia*/*Phyllospora*, *Cystophora*/*Sargassum*) followed by geographic locality (O'Hara 2000a). O'Hara (1999b) has also examined the biogeographic distribution of rocky reef echinoderm and decapod crustacean assemblages across Victoria and southern Australia. He observed a 50% turnover in species occurrences across the State; in other words approximately 50% of species in Victoria have some biogeographic limit to their distribution here. Shifts in species composition also occur at a fairly local level (within tens of kilometres), possibly due to the limited distributional range of a number of invertebrate species (T. O'Hara pers. comm.).

Detailed classification of assemblages of large algae (macroalgae), macroinvertebrates and fish groups have been undertaken across the Central Victoria and Flinders Bioregions (Port Phillip Heads to Wilsons Promontory) (Edmunds et al. 2000). A number of distinct community types have been identified. Both regional (hundreds of kilometres) and local (tens of kilometres) scale trends are apparent for all groups, and overall there are obvious biogeographic patterns between Port Phillip Heads and Wilsons Promontory. That is, the combination of community types found changes with longitude. The sites chosen for the study by Edmunds et al. (2000) will serve as long-term monitoring sites (Ferns in prep.). Long-term monitoring will provide assessment on how these communities change through time.

Other research projects concerning flora and fauna on rocky reefs have been conducted for specific areas (Table 2.3) and specific management purposes (e.g. abalone reef habitats by McShane 1988; McShane et al. 1986 and site nominations for National Estate listing by Porter 1997).

Table 2.3: Research on open coast rocky reef biota

Location	Author and date	Description
Ingolby Reef, Anglesea	Beanland 1985	Composition of benthic algal communities
Point Impossible and Flinders	Porter 1997	Identification of areas to include on the Register of the National Estate
Point Impossible to Barwon Heads	Ashton 1994, 1995	Monitoring of sewage outfall effects
Cape Schanck Phillip Island and Wilsons Prom.	Edmunds et al. 1999	Effects of rock type on community structure
Bunurong	Keough & King 1991	Identification and monitoring of Marine Protected Areas
Bunurong and Wilsons Prom.	Wilson et al. 1990	Surveys of biota present at a number of sites to identify marine protected area locations
East Gippsland	Parry et al. 1990	Inventory
Port Campbell to Cape Conron	O'Hara in prep. O'Hara 1999	Species level data; analysis of surrogates for biodiversity

Open coast intertidal habitats and communities

Sandy shores

About two-thirds of Victoria's coastline comprises sandy shores, yet little research has been conducted into the physical and biological characteristics of this major habitat type (Fairweather & Quinn 1995). Study findings for sandy shores of the Ninety Mile Beach and in Port Phillip Bay are presented in the Land Conservation Council's Descriptive Report (LCC 1993). Ashton (1994) investigated the effects of the Black Rock sewage outfall on shores between Breamlea and Barwon Heads. Species composition, abundance, zonation patterns and temporal changes in these variables were studied for one sheltered sandy shore at Cape Patterson (Haynes & Quinn 1995). Similar studies have recently been undertaken for shores in south-western Victoria (Henry & Fairweather in press). Sediment particle size and water movement are the most important factors determining community composition of sandy shores. The most abundant animal groups are the crustacea, shellfish and marine worms. Species richness tends to be low when compared with other environments, because few species are adapted to the constant substrate movement typical of this habitat. The number of species tends to increase with increased beach energy and along a gradient from high to low water level.

Rocky shores

A range of habitats is available for colonisation by marine plants and animals on rocky shores. These include reef flats, rock pools, crevices, vertical faces, undercuts and boulders. The distribution of biota of rocky shores is strongly influenced by the rise and fall of the tides and by wave action. The first has resulted in a recognisable zonation pattern from high to low on the shore that is fairly similar from shore to shore. Wave action modifies this zonation pattern and species composition. In high wave energy areas the equivalent zones are higher up the shore than in low wave energy areas, for example. Waves are also a form of disturbance capable of dislodging organisms, clearing space for colonisation and hence causing local patchiness in distribution. Species composition of assemblages on shores that experience high wave energy thus tends to be different from that of sheltered coastlines.

The rocky shores of Victoria's open coast support a diverse assemblage of animals and plants which varies slightly according to the complexity/structure of rock, the exposure to waves and the water temperature (O'Hara 2000). The dominant habitat-forming animals and plants are fleshy algae (mixed greens and browns), Bull Kelp (*Durvillaea potatorum*), Neptunes Necklace (*Hormosira banksii*), turf-forming algae, coralline algae and Cunjevoi (*Pyura stolonifera*) (Ferns & Hough 1999). Lists of intertidal and shallow subtidal invertebrates accumulated by the Marine Research Group comprise the only data that covers the entire length of the coast (Handreck & O'Hara 1994). Most species had fairly widespread distributions, but distinct animal assemblages are recognisable for western Victoria, east of Cape Conran and bays and inlets. King (1972) surveyed a number of intertidal and shallow subtidal sites along the coast and around islands in Bass Strait, providing extensive species lists for both plants and animals and some semi-quantitative data. He found a pattern of high species turnover between west and east of the State for both algae and invertebrates. Other datasets are available for specific areas (Table 2.4).

Table 2.4: Recent research on intertidal rocky reefs of the open coast

Location	Author	Description
Boags Rocks	Brown et al. 1990	Sewage effects
Sorrento, Barwon Heads	Werner 1992	Identification of edible seaweeds
Point Nepean	Povey & Keough 1991	Effects of foot traffic on plants and animals
Phillip Island	Beovich & Quinn 1992	Effects of grazing gastropods
Bunurong Marine Park	King 1992	Effects of foot traffic and collecting
Black Rock, Barwon Heads	Ashton 1994, 1995	Sewage effects
Point Lonsdale, Point Nepean	Porter 1999	Effects of foot traffic and collecting; Biological diversity
Mornington Peninsula	Keough & Quinn 1998	Effects of foot traffic and collecting

Bays, inlets and estuaries

Victoria has three major embayments, one large estuarine lagoon system and a number of small inlets. The embayments are Port Phillip Bay, Western Port, Corner Inlet, Nooramunga and the lagoon system Gippsland Lakes. Minor inlets and estuaries include the Hopkins River estuary, the Barwon River estuary, Andersons Inlet, Shallow Inlet, Marlo Inlet, Tamboon Inlet, Wingam Inlet and Mallacoota Inlet. Appendix 2.3 provides specific information on each of the bays and inlets. The main habitats present are pelagic, unvegetated soft sediment, seagrass meadows, mangroves and sheltered rocky reefs (both intertidal and subtidal).

A diverse array of animals lives within unvegetated soft sediments. These animals provide food for large populations of migratory wading birds. Tidal currents cut channels into the soft sediment to support a fauna similar to that found on the continental shelf (O'Hara 2000).

Seagrass meadows occur primarily in the sheltered environments of estuaries and inlets. Seagrass is an ecologically significant habitat, providing food, shelter, a nursery area, and substrate for small animals and algae. The plants increase habitat complexity and stabilise sediments. Large amounts of seagrass enter the detrital food chain. The biomass, abundance and species richness of fish are higher in seagrass habitats than in adjacent unvegetated areas (Jenkins et al. 1993; Edgar and Shaw 1995a; Edgar and Shaw 1995b). The latter study of 14 localities across southern Australia showed that the majority of small fish fed on crustacea; this crustacean production correlated with seagrass biomass. Seagrasses also support more than twice the production of small fish than do the unvegetated habitats (Edgar & Shaw 1995a). Thus, loss of seagrass habitat is associated with reduced fish production.

Mangrove habitat is rare in Victoria: it covers a mere 41 km^2 (Bucher & Saenger 1989; Harty 1997). It is found in the Barwon Heads estuary, on Mud Islands, on western and northern shores of Port Phillip Bay, and in Western Port, Anderson Inlet, Corner Inlet and Nooramunga. The only species occurring here is the White Mangrove (*Avicennia marina*). Mangroves stabilise muddy sediments and prevent erosion. The trunks, aerial roots and underground roots add structural diversity to muddy shores, creating a diversity of microhabitats for marine organisms. The branches serve as roosting areas for wading birds. Mangrove wetlands are the breeding, nursery and feeding grounds for many marine animals, including several fish species important to the recreational and commercial fisheries (mullet, bream, Luderick and flounder). The mangrove food web is detritus-based and highly productive. Mangrove habitat is easily destroyed through reclamation, trampling and changes to freshwater flows (Harty 1997).

Intertidal and subtidal reefs occur in Port Phillip Bay, Western Port and Corner Inlet, but very little has been published about them. Watson (1977) described the underwater ecology at Port Phillip Heads, while Porter (1997) conducted semi-quantitative surveys of four reefs in this area. A number of student projects have been conducted on shallow reefs in Port Phillip Bay (see Porter 1997).

Mapping of the geographic distribution of habitat and community types

Mapping of intertidal and shallow subtidal habitats across the entire state has been underway since 1992 as part of the Environmental Inventory of Victoria's Marine Ecosystems program (see Section 2.2). A marine and coastal 'geographic information system' (GIS) for Victoria was developed concurrently. Development of the GIS has been completed in three stages (see Appendix 2.2) and covers the entire open coast. Data available from mapping is indicated in Table 2.5. Data is incrementally updated as it becomes available from field programs in progress (L. Ferns pers. comm.). Two immediate applications are identification of representative areas to aid selection of MPAs and development of the Victorian Oil Spill Response Atlas (OSRA). The latter is a project to support oil spill response decisions by the Victorian Marine Pollution Committee and Australian Maritime Safety Authority (D. Ball pers. comm.). The OSRA project has also consolidated and mapped shoreline categories, intertidal habitats, seal colonies and bird colonies across the state at a scale of 1:25,000. Map information products have been produced for the coast between Cape Otway and Cape Liptrap, as well as for Corner Inlet, Nooramunga, Western Port and the Gippsland Lakes.

Table 2.5: Example of GIS datasets/layers available for mapping
Coastal habitats and substrate types
Commercial ports
Coastal land management areas
Sites of zoological significance, particularly bird habitats
Terrestrial botanical sites of significance
Sites of geological and geomorphological significance
Marinas, moorings and boat ramps
Foreshore access points
Sites of cultural and historical significance
Commercial and recreational fisheries, including aquaculture zones
Commercial, industrial and domestic discharge outlets

Distribution patterns of the major taxonomic groups

Marine flora

Mangroves

The only species of mangrove occurring in Victoria is the White Mangrove, *Avicennia marina*. The range of this species here is from Barwon Heads estuary to Nooramunga, in the intertidal zone of sheltered muddy shores (see 'Bays, inlets and estuaries' above). The southernmost mangroves in the world occur at Millers Landing in Corner Inlet.

Seagrasses

At least eight species of seagrass occur in Victorian marine waters. Most of them occur in bay, inlet and estuarine environments with the eelgrasses *Heterozostera tasmanica* and *Zostera muelleri* dominant. *Amphibolis antarctica* is found around sheltered subtidal reefs on the open coast from the west to as far east as Wilsons Promontory (O'Hara 2000). Table 2.6 provides the approximate distribution for each species.

Table 2.6: Distribution of seagrass species in Victoria

Sources: Womersley 1984; Department of Conservation and Environment 1991a;
Roob & Ball 1997; Roob et al. 1998

Species	Distribution
Lepilaena marina	Swan Bay
Halophila australis	Swan Bay to Corner Inlet
Halopila decipiens	Swan Bay, Mallacoota Inlet
Amphibolis antarctica	Open coast from western Victoria to Wilsons Promontory, Western Port
Zostera muelleri	Barwon Heads estuary, Swan Bay, Port Phillip Bay, Western Port, Shallow Inlet, Corner Inlet, Nooramunga, Mallacoota Inlet
Zostera capricorni	Mallacoota Inlet
Heterozostera tasmanica	Swan Bay, Port Phillip Bay, Western Port, Shallow Inlet, Corner Inlet, Nooramunga, Wilsons Promontory Marine Park
Posidonia australis	Corner Inlet, Great Glennie Island (Wilsons Promontory)

Macroalgae

These marine plants are generally limited to hard substrates, including the surfaces of other marine organisms. The three major divisions are the Chlorophyta (green algae), Phaeophyta (brown algae) and Rhodophyta (red algae). Distribution patterns for all of the algae collected from southern Australia are documented in several volumes produced by Womersley (1984a, 1984b, 1994). Datasets derived from individual studies at specific sites are also available (Ashton 1994, 1995; Beanland 1985; King 1972; King et al. 1971; Porter 1997; Wilson et al. 1990). A biogeographic analysis of macroalgal assemblages in temperate Australia, based on existing datasets, was conducted as part of the State of the Environment reporting process (Sanderson 1997).

Distribution patterns documented in Womersley (1984b) were used by Bolton (1996) to determine the diversity and endemism of Victoria's brown algae. In a study of 100 km sections of coast in Victoria (Australia), California, Chile and South Africa, he found that western Victoria has the highest species richness (140 species per 100 km section of coast). A major drop to around 70 species was recorded east of Wilsons Promontory (cf. 60–80 species for California and 20–40 species for the other coastlines). Endemism was found to be high for the brown algae of Victoria (about 45% of species). Species turnover (change in species composition) was low except where the major drop in diversity from east to west occurred (a 200 km section of coast from about Shallow Inlet to west of Wilsons Promontory). The results are supported by

King (1972), who also found a major floristic discontinuity for intertidal and shallow subtidal algae between waters west and east of Wilsons Promontory, with *Caulerpa* and *Cystophora* species being less abundant or absent to the east. Bolton attributed the high diversity in southern Australia to the long coastline with a long period (geologically) of stability in water temperature and small difference between winter and summer temperatures, allowing for survival of wider range of species. The drop in diversity between west and east was attributed to a combination of the reduced amount of rock substrate and a less well-known seaweed flora (i.e. the apparent decrease may be an artifact). Also, it should be kept in mind that survey effort has not been evenly spread across the entire state, with some locations (e.g. Port Phillip Heads) being more favoured study sites.

A finer scale analysis of macroalgal communities, using new data collected from 58 sites between Point Lonsdale and Wilsons Promontory, has recently been completed (Edmunds et al. 2000). To date, eight distinct algal communities have been identified, with some biogeographic trends in distribution of these communities apparent. The findings will assist in our understanding of 'representative' areas within in Victorias marine environment (L. Ferns pers. comm.).

Marine fauna

Mammals

Marine mammals of Victoria include Australian Fur Seals, Common and Bottle-nosed Dolphins, and Southern Right Whales (calving area at Logans Beach, Warrnambool, from July to October). The location of Australian Fur Seal colonies is given in Table 2.7. Six other seal species have been recorded, and 19 species of whale have been found beached on Victorian shores (LCC 1993). Data on marine mammal distributions is stored on the Department of Natural Resources and Environment Wildlife Atlas (DNRE 2000); the basis of the distributions described in Menkhorst (1995).

Table 2.7: Geographic location of Australian Fur Seal colonies in Victoria (from the Victorian Oil Coastal Resources Atlas, MAFRI 1999)

Key: * = Colony size not given, but 338 pups in January 1999 and may include up to 35 New Zealand Fur Seals; ? = Unconfirmed report

Location	Mating and pupping	Colony size
Cape Bridgewater	?	2–650
Lawrence Rocks		30
Lady Julia Percy Island	√	4000–5200
Seal Rocks, Phillip Island	√	16,500
Black Rock, Phillip Island	√	16,500
Kanowna Island	√	5500
White Rock		2–300
Skerries	√	*
Caisson (Chinamans Hat)		30
Hayley Point		10
Notch Island		30
Rag Island		6–700

Sea birds, shore birds and waders

Data on distribution patterns of ocean and shorebirds is stored in the DNRE Wildlife Atlas. The other major source of data is Birds Australia (previously RAOU). Thirteen species breed on islands and beaches of the Victorian coast (LCC 1993). Significant ocean and shore bird sites have been mapped on the oil spill response team's Coastal Resource Atlas (D. Ball pers. comm.). Twenty-nine Little Penguin colonies are dotted along the coastline, with the main colony on

Phillip Island. The endangered Hooded Plover breeds and feeds on sandy ocean beaches, with colonies now restricted to beaches that receive little disturbance from the activities of people and their pets (e.g. Discovery Bay, Point Nepean, the sand spit separating the ocean from Corner Inlet and Nooramunga). The Little Tern and Fairy Tern are listed as endangered and vulnerable, respectively (LCC 1993). Significant wader bird habitats have been listed as Ramsar wetlands (Swan Bay, Western Port, Corner Inlet and Nooramunga).

Fish

Maps and descriptions of species distribution patterns are not readily available. Catch and effort data identify the main commercial species landed at the various ports across the state. This involves at least 43 species. However, catch and effort statistics have not been all that useful for identifying distribution patterns of fish species, as most commercial species occur commonly along the entire coast (Roob et al. 1995). Data on distribution patterns and species richness of reef fish for the Central Victoria Bioregion, based mainly on recreational diver records, is provided in Porter (1997). No particular pattern in species composition that would assist Marine National Park selection was detected, and there is insufficient information to determine which species are rare or endangered. Recent visual census surveys of 58 sites between Point Lonsdale and Wilsons Promontory distinguished two distinct clusters of fish species: Wilsons Promontory sites being different from all other sites (Edmunds et al. 2000).

Invertebrates

Handreck and O'Hara (1994) found three distinct assemblages of intertidal invertebrate fauna related to location on the coast of Victoria. One was characteristic of bays and inlets, while the coastlines east and west of Cape Conran each had distinct animal assemblages.

Until recently, little research effort has been devoted to the subtidal marine invertebrate fauna of Victoria and distribution patterns of species have not been documented in a systematic way. Some areas (e.g. Port Phillip Bay) have received intensive survey effort, while no information is available for others. Broad-scale distribution patterns for a number of southern Australian marine invertebrates are documented in a series of volumes produced by Shepherd and associates (Shepherd & Thomas 1982, 1989; Shepherd & Davies 1997).

New research conducted as part of Victoria's Marine Inventory has included surveys of invertebrate fauna. O'Hara (in prep.) has compared local and regional patterns of diversity and similarity of small animals associated with plant assemblages for a number of rocky reefs across the State. He also used available records to compare species richness and composition of echinoderms and crustaceans along sections of the southern Australian coastline (O'Hara 1999b). He found a 50% turnover in species composition between west and east of Victoria: that is, half the species have a distribution limit at some point within Victoria. For most species the distribution limit occurred somewhere between Port Phillip Bay and Wilsons Promontory. Only a very small proportion of the species (around 1–4%) were endemic to Victoria. Edmunds et al. (2000) have identified three distinct clusters of invertebate communities between Point Lonsdale and Wilsons Promontory, as a result of visual census surveys at 58 sites.

Invertebrates that are harvested commercially include abalone, rock lobster, squid, cuttlefish, octopus, mussels, periwinkles, scallops, sea urchins, crabs and prawns. Abalone landings are highest at Flinders/San Remo (248 tonnes per year) and Tamboon/Eden (298 tonnes). Under 100 tonnes per year are landed at all other ports. Rock lobster landings are highest to the west of Apollo Bay (Catch and effort statistics for 1998–99). Intertidal invertebrates, such as shellfish, sand worms, snapping shrimps and Cunjevoi, are also collected for bait, aquariums and human consumption. Overexploitation of intertidal invertebrates has occurred on shores close to large population centres (Keough et al. 1993).

Zooplankton

Plankton has been little studied in Victorian waters, with the exception of recent studies in Port Phillip Bay (CSIRO). Crustaceans dominate the zooplankton, while the microplankton (protozoa and bacteria) are an important component of the pelagic food chain (Holloway & Jenkins 1993). Port Phillip Bay and Western Port have distinct resident plankton faunas that differ from the fauna of Bass Strait (Kimmerer & McKinnon 1985). Fancett (1986) has described the jellyfish of Port Phillip Bay.

Meiofauna

Meiofauna is the collective name for organisms that live between the grains of sediments and are between 0.5–0.062 mm in size. They are an important, but often overlooked, component of marine food webs. Meiofauna are extremely sensitive to human-induced environmental change and are likely to be useful bioindicators for pollution (Nybakken 1997). Very little work has been conducted on Victoria's marine meiofauna. Research into the meiofauna of mangroves in the Barwon River estuary is in progress (J. Gwyther pers. comm.).

Conservation status of Victoria's marine biota

Identification of threatened, endangered and rare species, endemic species, and areas of high species richness is an important component of conservation planning. Some generalisations about conservation status have been made for marine environments of temperate Australia. They are described as 'biologically significant … due to some of the highest levels of marine biodiversity and endemism in Australia and in the world' and as 'extremely threatened' (Edyvane 1998). Southern Australia has an exceptionally high number of species of marine plants, bryozoa (lace corals), ascidians (sea squirts), nudibranchs (sea slugs), molluscs and echinoderms (Edyvane 1996; Poore 1995). These authors report high endemism in Australian temperate waters for fish (85% of species), molluscs (95%), echinoderms (90%) and red algae (75%). However, O'Hara (1999b) found that only 37% of echinoderm and decapod crustacean species are strictly endemic to southern Australia (below 30°S).

Knowledge about the conservation status of Victoria's marine plants and animals is limited (Winstanley 1996). This area of natural resource management is now receiving increased attention. In 1999, DNRE initiated a project to identify marine invertebrate species needing conservation management (O'Hara & Barmby 2000). The project concluded that the only taxonomic groups that could be confidently considered, based on available data, were molluscs, echinoderms and decapod crustaceans. Very few species of the animal groups examined appear to be endemic to Victoria (echinoderms 1%, decapod crustaceans 3%, mollucs 4%). The report recommended 12 species for listing under the *Flora and Fauna Guarantee Act 1988*. Presently only seven marine species (species of whale, sea slug and fish) and one marine community (at San Remo) are listed as threatened under this Act.

A range of assessment criteria are used to consider the conservation significance of marine species. The criteria usually involve aspects of population size, habitat availability, threatening processes and relative vulnerability. (Note: A national report on the conservation status of marine invertebrates is being drafted by the Australian Museum, but was not available in time for this report).

Some marine species have been suggested as rare or significant in the past because they occur at such low abundances they are not often found in surveys, even though they are widely distributed. For example, a number of molluscan and echinoderm species occur at low abundances but have been found at locations spread across southern Australia (O'Hara 1999b). Similarly, a popular dive location in southern Port Phillip Bay is of scientific interest because of the presence in the shallow coastal zone of primitive Aplacophoran molluscs rarely found alive and normally collected from much greater depths in Bass Strait (Porter 1997). Other species are considered significant because they have been found at only one location in the State. Examples are a primitive and rare brachiopod (*Magellania fluvescens*) and an undescribed seapen, both reported for the North Arm of Western Port (LCC 1993). However, the current status of the former is uncertain as the report is based on old data and this area has since undergone considerable habitat modification.

Species found in threatened habitats, and nowhere else, are of high conservation significance. Threatened habitats and the associated threatening processes (in brackets) identified by O'Hara and Barmby (2000) are:

- the intertidal and shallow subtidal zone (coastal development, pollution, overexploitation);
- embayments (poor water quality, introduced species, aquaculture, dredging);
- seagrass beds (dieback because of poor water quality etc.);
- the east Victorian shelf (bottom trawling).

The authors have identified a number of species found only in these habitats. For example, the seagrass, *Posidonia*, is almost entirely restricted to Corner Inlet within Victoria. A number of animal species associated with this seagrass have been found only in Corner Inlet. A second example illustrates the importance of habitat protection in preserving biodiversity. Around one-third of Victoria's crab species are restricted to intertidal habitat, thus protection of intertidal habitat is critical for preservation of crab species diversity.

Invertebrate species richness has proved high in areas where surveys have been undertaken (Coleman et al. 1997; Coleman et al. 2000; Norman & Sant 1995). Furthermore, species composition changes from west to east of the state. Thus, it is important to know the species composition of areas in order to protect the highest overall diversity of animals and plants within a system of Marine National Parks.

Marine sites that meet the relevant criteria for significance have been listed on the register of the National Estate (Appendix 2.4). These sites may also be suitable for consideration as Marine National Parks, because they have been identified using criteria based on conservation objectives.

A number of locations (see Appendix 2.5) with important biological and ecological values were identified by the Land Conservation Council (1994) using the criteria of:

- contribution to essential ecological processes;
- contains high diversity of habitats;
- contains high diversity of species;
- contains habitats of rare, endangered, uncommon, depleted species;
- contains rare or unique habitats.

These areas are also candidates for consideration as Marine National Parks.

2.3 Human use and major threats

Use of the marine environment by Aboriginal people

Sea levels were much lower than at present for most of the 40,000 years that Aborigines have occupied Australia. Large areas of present-day sea floor were available for hunting and habitation, including much of Port Phillip Bay, Western Port and Bass Strait. Numerous archeological sites of potential cultural significance to Aboriginal people no doubt exist on the present day sea floor. Sea levels rose about 6000 years ago, restricting the dryland territory available. Archeological records reflect intensive use of coastal resources by nine Aboriginal tribes since this time (LCC 1993). Clans often lived inland during winter and along the coast during summer, where intertidal shellfish, estuarine fish, muttonbird, seals and seaweeds were included in the diet (Louis Lane, unpublished notes).

Aborigines were rapidly excluded from access to coastal resources following European occupation and subsequent coastal development. However, a number of places continue to have strong cultural and spiritual significance for present-day Aboriginal communities. Currently, there are three native title claims before the National Native Title Tribunal that include coastal and marine areas of Victoria. These are the Gunnai/Kurnai claim over parts of Gippsland, the Gunnai/Kurnai and Boonerwrung joint claim over Wilsons Promontory and parts of East Gippsland, and the Gournditch Mara claim over parts of far south-western Victoria (Krishnapillai & Bathgate 1999).

General patterns of human use

Close to 96% of the Victorian coastline is public land, by virtue of the establishment of a permanent reserve along most of the coastline in 1879. Around 50% is managed under the *National Parks Act 1975* (Victorian Coastal Council 1997). This foresight has prevented the continuous coastal strip development so evident in New South Wales and Queensland, and has helped buffer the marine environment against impacts from land use and coastal development (Winstanley 1996). Even so, 84% of Victorians live in the coastal zone (Wescott 1992). This is partly due to the location of Victoria's largest cities on the shores of Port Phillip Bay (Melbourne with c. 3,321,700 people and Geelong with c. 153,000 people). The largest settlements on the open coast are Warrnambool (c. 28,000 people) and Portland (c. 19,000 people). Many of the remaining settlements that dot the open coast have relatively small populations that survive on coastal- or marine-related activities including tourism, fishing and the offshore oil and gas industry (O'Hara 2000). The main issues facing the marine environment as a consequence of urban development are pollution (stormwater and sewage) and habitat alteration.

Other forms of coastal developments are associated with ports and harbours, industry, agriculture, forestry, mariculture, tourism and recreation. The four main ports in Victoria are located at Melbourne, Geelong, Hastings (Western Port) and Portland. Many of the state's major industrial centres are located on the shores of Port Phillip Bay (Winstanley 1996). Oil and gas fields are a major offshore industry that has involved sinking of wells, laying of submarine pipes and onshore storage facilities. Major oil fields occur off the Ninety Mile Beach in East Gippsland, while exploratory drilling for oil and gas has taken place in the Otway basin. To date the operation of offshore rigs has been apparently without major incident (O'Hara 2000). Widespread clearing of native vegetation to establish farms and for forestry has taken place since Victoria was first settled. This land clearance combined with the widespread use of nutrients and chemicals has implications for water quality in nearshore waters. Both sea-based and land-based mariculture operations have been established. Sea-based mariculture of Blue Mussel occurs in Port Phillip Bay and at the western entrance of Western Port, while land-based ventures cultivate mainly flounder, abalone and Pacific Oyster. Tourism and recreational developments include location of buildings, such as resorts, restaurants and lifesaving club facilities, near or on the foreshore and the construction of marinas. Environmental issues associated with these coastal developments include clearing of coastal habitat, habitat alteration, impacts of dredging operations on benthic communities, degraded water quality from oil spills, ship-based pollution and industrial outfalls, the introduction of exotic species, and alienation of public land (O'Hara 2000; Winstanley 1996).

A major use of coastal and marine waters not encompassed by the general category of coastal development is fishing (commercial and recreational). Fisheries exist in almost all Victorian marine and estuarine waters. Bay and inlet fisheries are based on fin fish such as snapper, King George Whiting, bream, flathead and pilchards. Fishing gear includes beach seines, gill nets and long lines (O'Hara 2000). The main open coast fisheries are based on invertebrate groups: the abalone, rock lobster and squid fisheries. King Crab and live wrasse (a fin fish) fisheries have become established within the past 20 years. Recreational fishing is a popular pastime for many Victorians. The recreational catch has been estimated to be greater than the commercial catch for species such as snapper and Black Bream in bays and inlets (Coutin et al. 1995; Bathgate 1999). The major issues for and impacts of fishing are overexploitation, by-catch, plastics waste and habitat degradation from fishing gear.

Major threats and impacts from human use

The extent of impacts on marine communities and ecosystems is largely unknown, prompting emphasis on the need to proceed with caution (Precautionary Principle) when assessing appropriate types and levels of uses (ACIUCN 1994). Careful planning is required to reduce the risk of habitat degradation and land-based impacts on the marine environment (Victorian Coastal Council 1997). Threats and impacts need to be considered in the context of locating Marine National Parks for nature conservation. Logically, such Marine National Parks should be situated as far as possible from major sites of habitat degradation and sources of pollution. Both the risk and extent of degrading impacts also have implications for design and management of these reserves.

The main threats and impacts resulting from our use of Victoria's marine environment are covered well in previous publications of the Victorian National Parks Association (O'Hara 1996; Bathgate 1999). These can be categorised as habitat loss and alteration, decline in water quality, overexploitation of resources, introduced species and pathogens and global warming.

Habitat loss and alteration

Marine habitat loss and alteration has occurred as the result of a variety of human activities. These include coastal development, clearing of vegetation for agriculture and forestry, construction of permanent openings to estuaries, reduction in river flow, port maintenance (dredging), installation of structures that change long-shore sand movement, destructive fishing methods, aquaculture and recreational pursuits. Resulting physical effects include coastal erosion, increased sedimentation and turbidity, and increased salinity in estuaries (Winstanley 1996; O'Hara 2000). Turbidity reduces light available for photosynthesis, while sedimentation results in smothering of bottom-dwelling organisms, such as seagrass and filter-feeding invertebrates. In Western Port, accelerated sedimentation due to catchment erosion and channeling of stream is believed to have been a major factor contributing to the loss of about 70% of the seagrass beds during the 1980s (O'Hara 2000). Populations of species which can utilise the sediments as a food source are enhanced, resulting in changes to species composition of communities. Interruption of sand movement patterns leads to erosion of beaches (e.g. near Portland) and smothering of organisms on low-profile rocky reefs.

Oil-drilling operations raise concerns about the impacts of physical disturbance, drilling muds, blowouts and spills on marine communities (Winstanley 1996). Most oil and gas extraction currently occurs in the Twofold Shelf Bioregion outside the limit of Victorian waters. Some exploration and gas field development is currently taking place in the Otway Basin. Construction of pipelines to land is a significant threat to benthic habitats and their associated biological communities.

Trawling and dredging cause damage to the habitats, especially sponge beds and seagrass meadows, upon which a number of fish species depend (Andrew & Pepperell 1992; Guillen et al. 1994; Jones 1992). The effects can be likened to the clearfelling of native forests: the complex living structure of the sea floor habitat is destroyed, reducing biodiversity in the process (Watling and Norse 1998). Marine organisms of deeper waters that can live up to 500 years cannot survive continuous trawling pressure. Studies to assess the impact of dredging have been disadvantaged by the lack of nearby undredged sites for comparison. For example, a study to investigate the effects of scallop-dredging on benthic animal assemblages in Port Phillip Bay found biological impacts on most species were neither large nor long-lasting (Victorian Fisheries Research Institute 1996). However, given that only the small, short-lived, sediment-dwelling species were sampled, this conclusion is probably flawed. The likely explanation is that the animals living in scallop grounds had long ago shifted from long-lived species to short-lived opportunistic species adapted to the level of disturbance associated with regular dredging. Some bottom-trawling in nearshore waters takes place in the Twofold Shelf Bioregion, while more intensive bottom trawling occurs further offshore over much of the continental shelf and slope. Assessment of the impacts of this trawling has not been undertaken.

Even non-exploitative recreational activities are not exempt when it comes to effects on the environment, and the intensity of recreational use needs to be carefully monitored. For example, the density of algae on rocky shores is reduced by high levels of foot traffic (Povey & Keough 1991; Porter 1999), and significant reduction in the density of bryozoan species has been recorded soon after a closed areas were opened to scuba diving (Garrabou et al. 1998). A number of slow-growing sedentary marine invertebrates are not adapted to the continuous disturbance posed by high levels of diving activity and are very slow to recover: a possible argument for some 'no-go' scientific reference areas in the marine environment, in addition to 'no-take' areas.

Declining water quality

Pollution results in elevated nutrient levels, toxicants and solid rubbish. It arises from point-source discharges of sewage, stormwater drains and industrial waste, and from sources that are more diffuse in nature (such as run-off from agricultural land).

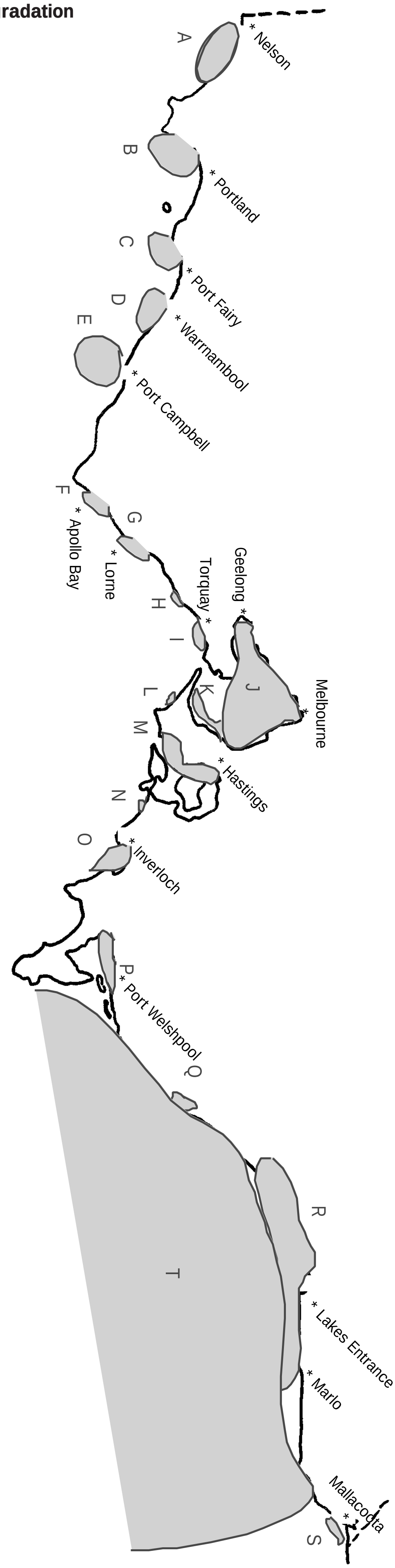
Twenty-one licensed outfalls discharge into Victorian waters. These are situated at Portland, Port Fairy, Warrnambool, Apollo Bay, Lorne, Anglesea, Black Rock (Breamlea), Port Phillip Bay (3), Boags Rocks, Western Port (3), Wonthaggi, Venus Bay, Foster, Toora, Port Welshpool and the Ninety Mile Beach (2) (from Map 4 of LCC 1993; also see Figure 2.2). Only half involve secondary treatment of waste, and none employ tertiary treatment, which removes nutrients and toxicants (O'Hara 2000). Dramatic changes in assemblages of seaweeds have been documented in the vicinity of ocean sewage outfalls (Brown et al. 1990; Ashton 1995). A reduction

Figure 2.2: Areas of Victoria's coast at risk of habitat degradation from threatening processes

(map not to scale)

THREAT	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
Pollution		■	■	■	■	■	■		■	■		■	■	■	■	■	■	■	?	
Sedimentation	■		■	■	■		■		■	■			■		■	■		■	?	
Dredging		■	■	■		■				■	■		■			■		■		
Fishing centre	■	■	■	■	■	■	■	■	■	■	■		■		■	■		■	■	
Port		■	■	■		■				■			■			■		■		
Introduced pests		■								■			■		■	■		■		
Oil/gas fields					■															■
Trawling	■																			■
Major population centre		■		■			■ *	■		■	■ *		■					■ *		

* Holiday season



in biomass of habitat-forming kelps has been the most noticeable effect. Loss of these species is likely to affect all other species that depend on them for shelter, substrate and food. Thermal outfalls may have a similar effect (Keough & Butler 1995). Numerous stormwater drains are associated with coastal settlements (over 300 in Port Phillip Bay alone). They carry litter, dog faeces, silt and residues from car emissions into marine waters, although their impact is considered to be localised (O'Hara 2000).

Industrial wastes (including heavy metals and organic toxicants) were originally discharged directly into the marine environment, predominantly into Port Phillip Bay and Western Port, resulting in accumulation of toxicants in sea floor sediments (Winstanley 1996). These toxicants persist within the sediments (LCC 1993). Most industrial waste is now discharged via treatment plants. However, this has not necessarily solved the problem, as the waste still contains a number of toxic chemicals. These chemicals are either still discharged into the sea or end up accumulating at treatment plants (Environment Victoria 1994). The former creates the potential for bioaccumulation of toxic substances, while the latter limits the potential for the resulting contaminated sludge and effluent to be re-used as fertiliser on land. In addition, toxicants reach the marine environment from diffuse sources, such as run-off from agricultural land. These include PCBs (polychlorinated biphenyls) and chlorinated pesticides such as dieldrin; persistent compounds that show high degrees of bioaccumulation in marine food chains (Winstanley 1996). The overall effects on populations, particularly of species at higher levels in the food chain, and on marine communities, is not clear.

Nutrient levels in the rivers and bays have become a problem with the increased use of chemical fertilisers in agriculture and aquaculture (and from additional sewage from growing populations). While algal blooms are a natural event that tend to happen most during spring in temperate waters, high nutrient levels accelerate and intensify these blooms. Blooms of toxic algae are associated with occurrence of particular combinations of nutrients, temperature and salinity and are generally restricted to bays and inlets in Victoria. The toxins accumulate in shellfish and pose a significant public health hazard. High nutrient levels also encourage the growth of epiphytic and filamentous algae, a potential cause of the reduction of seagrass by smothering in some bays (e.g. Swan Bay).

Plastics litter reaches the marine environment via stormwater, shipping, fishing vessels and beachgoers. Discarded plastics are reaching the shorelines of quite remote places, such as Macquarie Island. They have the potential to injure and kill marine life through ingestion and strangling.

Overexploitation of resources: fishing

Whales and seals were exploited to commercial extinction early in the European history of Victoria (O'Hara 1996). Other fisheries (e.g. shark) have been threatened with this in more recent times. Humans tend to fish down the food chain, first depleting one valuable species (often a predator) and then moving on to the next species down the food chain. Both the biodiversity and resilience of an ecosystem decline as the predators disappear, reducing the ecosystem's ability to recover (Wilder et al. 1999). There has been a steady to rapid decline in most Victorian fisheries and this reflects the situation elsewhere on the globe (Bathgate 1999). The long-term decline of snapper stocks in Port Phillip Bay has been linked to overharvesting. The Southern Rock Lobster is also currently overexploited. Pilchard, squid, king crab and live wrasse fisheries have developed over the past 20 years, targeting species that used to be considered by-catch or trash species. The latter two fisheries are already fully exploited, requiring management action (O'Hara 2000). Intensive fishing for pilchards in Port Phillip Bay has been blamed for poor breeding success and high mortality among the Little Penguin population of Phillip Island (Winstanley 1996). The Black-lip Abalone fishery is one of the few worldwide that has been effectively managed to prevent stock collapse, but faces a major problem from poaching (Norman & Sant 1995). The other issue of concern is the destructive effect of some types of fishing gear on marine habitats.

The decline in abundance of a number of species, as measured by 'catch per unit effort' (CPUE), has been linked to an increase in recreational fishing. Several fish species declined significantly in catches between 1972 and 1991. The likely cause of decline for Toothy Flathead (99.9% decline), Sand Flathead (47.2%), Yank Flathead (33.6%) and Common Gurnard Perch (80.7%) in Port Phillip Bay is increased fishing pressure (Harris et al. 1996 as cited in O'Hara 2000). The impact of recreational fishing over a broad range of species is arguably of more relevance when considering the ecology of rocky reefs. The territorial nature of reef fish tends to make them particularly susceptible to overfishing through both spearfishing (Bell 1983) and line fishing (Bennett & Attwood 1993).

Introduced organisms

A number of organisms have been introduced into Australia's marine environment in ballast water and on the hulls of ships. More than 175 introduced species have now been recorded from Port Phillip Bay, with several becoming sufficiently abundant to be considered pests (Hewitt et al. 1999). A marine fan worm (*Sabella spallanzanii*) has formed a carpet over large areas of Port Phillip Bay, smothering underlying sedentary organisms, competing for space and food with native species and reducing diversity. Larvae are dispersed by currents, giving considerable scope for invasion into new areas. A northern hemisphere starfish (*Asterias amurensis*), is also taking hold, as are the two shellfish species *Corbula gibba* and *Theora fragilis* and a species of brown algae from Japanese waters (*Undaria pinnatifida*) that was first discovered here in 1996 (Campbell 1998). The combined effect of these introductions will alter the structure of benthic communities, and may change the ability of these communities to recycle excess nutrients from sewage outfalls (O'Hara 2000). Diseases have also inadvertently been introduced. The spread of a virus introduced in frozen pilchards imported from overseas to feed farmed tuna has been implicated in the mass mortality of the pilchard, *Sardinops sagax*, along the Australian coast in 1995 (Griffin et al. 1997). In a situation analogous to the Cane Toad catastrophe, some species, such as Marram Grass and Rice Weed, have been purposely introduced only to subsequently become pests. Rice Weed (*Spartina anglica*) was introduced to stabilise river banks, but is now regarded as a major weed, clogging estuarine systems in Western Port, Andersons Inlet, and Corner Inlet and Nooramunga (O'Hara 2000).

Global warming

Cycles of global warming and cooling have been a natural feature of the Earth's climate for millions of years. However, the increased emission of so-called 'greenhouse gases' (e.g. carbon dioxide and methane) into the atmosphere through human activity over the previous century appears to have accelerated the rate of global warming. This is known as 'the greenhouse effect'). Global warming has a number of consequences for marine environments, the most important of which are increases in sea level, sea surface temperature and storms. Sea levels will rise and storms will affect intertidal and coastal habitats through inundation and erosion. A number of intertidal rock platforms may become shallow subtidal reefs, for example. Based on fossil evidence from previous glacial/interglacial cycles, an increase in sea surface temperature of 1–2°C is likely to result in a shift in range of a number of marine species (O'Hara in prep.). Warm temperate species from NSW are likely to penetrate into Victorian waters, while the cool temperate species with a range in temperature tolerance are likely to shift further south into the waters of Tasmania. A rise in temperature of more than this could lead to global extinction of southern cool temperate (Maugean) species (O'Hara, in prep.).

Implication of uses and threats on selection of Marine National Parks

If we define 'natural' in terms of extent of human influence on habitat and biota, then we can identify natural areas that are potential sites for Marine National Parks. The process would involve eliminating unsuitable sites based on what is known about uses and threats. Human activities on land impact in various ways on the marine environment. Thus, coastal land use, vegetation type and cover, location of river openings and outfalls, and human population density are all important variables to consider when determining the location of Marine National Parks. Coastal vegetation is a key variable influencing the quality of terrestrial run-off into marine systems, for example (Roob et al. 1995).

In general, the greatest effects of human activities have occurred within bays and estuaries, where population density is highest. Seagrass loss in Western Port was extensive between 1975 and 1984. The ecology of the Gippsland Lakes has been changed by construction of a permanent opening to the sea, reduced freshwater input, increased levels of nutrients and introduced species (e.g. European Carp). Some fisheries are considered to be overexploited in Port Phillip Bay.

For the open coast, the greatest effects of human use occur around population centres, ports, waste outfalls and boat-launching facilities. The geographic location of all of these are documented in the Land Conservation Council's Descriptive Report (LCC 1993) and the Victorian Coastal Council's coastal strategy (VCC 1997). The main issues and threats appear to be recreational overuse of some intertidal areas, overharvesting of some species by commercial and recreational fisheries, damage to sea floor habitats from trawling, dredging and exploration for oil and gas, and the potential for oil spills (O'Hara 2000). Available evidence suggests that Victoria's open coast marine waters are otherwise relatively healthy (e.g. O'Hara 1999a and Edmunds et al. 1999).

2.4 Selection and design of Marine National Parks

Establishment of Marine Protected Areas (MPAs) for strict nature conservation purposes requires preservation of representative ecosystems, representative habitats, and habitats critical to ecosystem processes, as well as protection of rare and endangered species (Edyvane 1998). The aim of this section is to identify criteria to use in the selection of Marine National Parks that have nature conservation as their principal objective. What is meant by nature conservation in this Review was discussed in Section 2.1. Design of both the reserve system and the individual reserves is then considered, as this issue cannot be separated from the process of selection.

Selection criteria

Historically, MPAs worldwide have not been selected according to a structured process. Instead, selection processes have largely reflected contemporary cultural, economic and political values. A number of criteria have been recommended for use in selection of MPAs since 1974 (Salm & Price 1995; Porter 1999). These are summarised in Table 2.8. 'Comprehensiveness', 'adequacy' and 'representativeness' have been favoured as key criteria for the proposed national system of MPAs and by the Environment Conservation Council (ECC) for MPAs in Victoria (ANZECC 1999; ECC 1998; see Appendix 2.6). Application of these criteria should provide a system of MPAs that includes all ecosystem and habitat types and that is large enough to conserve biodiversity and ecosystem processes.

Biological diversity is receiving increasing emphasis as a criterion for selection of protected areas (Norse 1993). This criterion needs to be used with care, however, as areas with higher biological diversity are not necessarily more worthy of protection than areas with lower diversity (Spellerberg 1991; Suchanek 1994). A danger in favouring areas with a high diversity (e.g. coral reefs) is that areas which are naturally less diverse (e.g. mudflats) may go unnoticed and unprotected. Protection of diversity must be placed in the context of habitat or ecosystem type: protection of species diversity will be maximised by protecting examples of the full variety of ecosystem or habitat types present. Protection of representative areas as a strategy for protecting biodiversity has been embraced at both federal and state levels in Australia (ANZECC 1999; ECC 1998). Best available oceanographic and ecological information has been used to define bioregions that are distinct from each other: the planning units for a representative system of MPAs (IMCRA Technical Group 1998).

Table 2.8: Summary of criteria recommended for selection of MPAs

Priority indicates the relative importance given to each criterion in this report for identification of potential locations for Marine Reserves

Adapted from Table 2.3, Porter (1999)

Criteria	Priority	Explanation
Ecological criteria		
Representative	1	Representative at the levels of biogeographic region, bioregion, ecosystem, habitat and community types
Comprehensiveness	1	The full range of biophysical diversity (habitat types) is included in a system of Marine Reserves
Naturalness	1	Degree of protection from human disturbance (favours remote locations and those adjacent to terrestrial parks)
Criticalness	1	Degree to which life stages of valued species (e.g. rare, endangered, commercial) and important ecosystem processes are dependent on the habitat or area
Irreplaceability	1	The degree to which a particular habitat is replaceable if lost to development or degradation
Ecological integrity, Adequacy	2	Ability to maintain conservation objectives of individual Marine Reserve (e.g. each unit large enough) and of reserve system (e.g. units close enough together)
Important species	2	Includes key species for maintenance of ecosystem processes (e.g. seagrass)
Rarity, Uniqueness	2	Contains rare, unique or unusual biogeographic qualities, habitats, geological or biological features
Vulnerability	2	Fragile areas receive higher ranking in selection process
Diversity	2	Variety of habitats or communities; Species richness, species diversity (within habitats)
Redundancy	2	Degree of replication built into the system
Productivity	3	Higher priority given to the more productive areas in the selection process
Scientific, cultural, pragmatic and economic criteria		
Benchmark areas	1	Value to monitoring of ecological effects of protection
International value	2	Areas covered by international conventions
Research	2	Scientific value for research
Diversity	2	People are more impressed by areas with high species diversity, and hence see more value in protecting them
'Special' species or features	2	'Feel-good' value of protecting unique, unusual, rare, endangered species (e.g. endangered mammals)
Feasibility	2	Take into account ability to manage, enforce and monitor (favours areas adjacent to existing coastal protected areas) Also, the level of conflict generated towards proposal
Educational value	2	
Restorability	2	Potential for restoration to natural state
Cultural value	3	
Recreational value	3	
Accessibility	3	For public education and involvement
Scenic beauty	3	

Selection of a reserve system to protect ecosystem processes will prove more difficult to put into practice. The necessary requirements will be to identify the essential processes driving ecosystem function, then to locate ecosystem components critical to these processes. Examples of processes are nutrient cycling, energy transfer through food webs, ecological succession of community types in time, and life history patterns of marine organisms. The assumption is usually made that ecosystem processes and long-term ecosystem viability will be protected in a representative system designed to preserve biodiversity.

The design of Marine National Parks

The number, size, shape and proximity of MPAs are likely to influence how effective they are in achieving specific and general conservation objectives. The design of MPAs is complicated by the greater degree of connectedness between places in the sea than on land, by virture of currents, waves and tides. The potential for larval dispersal makes it difficult to define biologically meaningful boundaries (McNeill 1994). For terrestrial protected areas, much of the theory has been derived from a combination of island biogeography (with its emphasis on size) and population dynamics (with emphasis on connections, dispersal and habitat quality) (Caughley & Gunn 1996). The dominant theme in recent MPA literature has been the need to develop networks of MPAs, which together can be inclusive of all of the features of a region (Ray and McCormick-Ray 1994).

Optimum size depends to a certain extent on what is to be preserved. Marine National Parks may need to cover areas large enough to maintain ecosystem function, to protect life-cycle stages of key species and to achieve adequate buffering or dilution of impacts from human activities (DEST 1996). The size of MPAs designed to protect particular species will depend on a number of population parameters such population size, number of populations, year to year fluctuations and recolonisation potential (Caughley & Gunn 1996). The appropriate size is likely to be different for each marine species investigated. Rowley (1992) suggests that the appropriate size is that which protects species of interest with the largest range. Some pelagic species have ranges in the hundreds of kilometres, meaning that large expanses of oceans would need to be protected. Alternatively, a network of smaller protected areas designed to protect breeding and feeding habitats critical to the survival of far-ranging species may be sufficient.

A large number of marine organisms have dispersive larvae, so knowledge of dispersal patterns, life span within the water column, sources and sinks of larvae and water movement patterns is important in defining areas (Fairweather & McNeill 1993; McNeill 1994; Roberts 1995). However, source areas can change in time and different species will have different sources and sinks. Easily identifiable sources are spawning aggregations and nursery areas. According to Roberts (1998) 'the surest way to achieve fishery and conservation objectives will be to establish dense networks of reserves that incorporate a wide variety of habitats and locations.' He argues that, because of overfishing, no-take MPAs will become sources, even if they were not previously. Each MPA in such a network must be capable of replenishing the nearest reserve (Rowley 1994).

Number, size and proximity are interrelated features. There has been some debate about whether a few large Marine Protected Areas or network of many small MPAs is the best design strategy. Larger protected areas with adequate buffering may be needed to mitigate outside influences such as pollution. On the other hand, in the case of seagrass beds, several small areas contained more biological diversity than one large area (McNeill & Fairweather 1993). Managed buffers is one way to increase protection of the core area without increasing the size of the reserve.

Another important aspect of design is shape (Rowley 1994). Circular reserves maximise within-reserve distance while minimising the ratio of circumference to area (hence impacts from outside). Conversely, fishery reserves designed to enhance productivity may be better designed to increase this ratio to encourage export of new recruits. Long and narrow reserves along gradients to encompass a range of habitats should be discouraged as the the population sizes in each habitat are likely to be too small to be self-sustaining (Caughley & Gunn 1996).

A range of different sized MPAs have achieved conservation objectives. MPAs that are quite small have achieved increased biomass, migration of juveniles and adults into adjacent areas, and increased species richness and/or diversity (Porter 1999). However, there is some evidence that MPAs can be too small (Rowley 1992; Shepherd 1990; Edgar & Barrett 1999). The latter authors found that a Marine National Park that extended along a 7 km length of coast (1500 ha) achieved increases in population abundances, mean size of species and species richness, while reserves less than 2 km in length (less than 100 ha) did not. Others have argued that MPAs should be large enough to provide for a 500 m wide buffer zone along each boundary (e.g. Kingsford 1998) to reduce the effects of activities outside the boundaries on core areas and allow for compliance and enforcement difficulties around the edges. Taking these points into consideration, each boundary would thus have to be greater than 2 km in length for the core area to be large enough to achieve effective protection. Conversely, MPAs may be too large to be managed effectively (Jennings et al. 1996). In this example, two MPAs of c. 10,000 ha proved too large to be policed against continued poaching, while an MPA of 1200 ha received high protection (i.e. enforcement effort). It also proved more effective ecologically, in that the highest biomass and species richness of reef fish occurred there. Thus, what is ecologically desirable needs to be balanced with practicality in terms of resources available for management.

The analysis so far has shown that there is no clear consensus about the best size for individual MPAs. A conservative recommendation is that the minimum area for Marine National Parks designed to achieve nature conservation should be 2000 ha. Marine Sanctuaries designed to protect particular habitats or species of significance could arguably be smaller than this, but a minimum area of 500 ha is suggested.

The distance needed between these units to maximise protection of biodiversity is open to debate. It depends on such factors as the scale of latitudinal variation in biological assemblages and habitat types, the nature of current patterns, the value of areas as sources and sinks for continued recruitment of species populations, and the desirable level of replication as an insurance against catastrophic events. A system of MPAs with individual units spaced about 50–100 km apart is suggested here as insurance for the future, but this design is open to review as new information becomes available.

Minimum proportion of habitats to include within a Marine National Park system

There is no consensus about the desirable minimum percentage of marine habitats that should be included within high protection MPAs. The current global goal of the International Union for the Conservation of Nature (IUCN) is 15% representation of all major marine ecosystems and habitat types in IUCN protected area categories I & II (Edyvane 1998). This is the value adopted by the Phillipines in its Fisheries Code 1998 for establishment of fish sanctuaries (Crawford 2000). Ward et al. (1998) demonstrated that at least 40% of each habitat type present in an embayment (Jervis Bay) would need to be included within Marine National Parks to ensure adequate preservation of the biodiversity present. Modelling estimates for fisheries range from 10–20% (Watson et al. in press) to as high as 50% of available habitat for fish species to be protected in MPAs to see fisheries harvest benefits (Polacheck 1990; Clarke 1996). It should be noted that Victoria's marine environment is all under public ownership and that 40% of Victoria's terrestrial public land, or 17% of the total area of the state, is currently included in reserves (G. Wescott pers. comm.). A conservative estimate of 20% of each major marine habitat by area to be included within IUCN categories I & II marine protected areas is recommended here as the goal to aim for in Victoria.

Criteria for assessing conservation effectiveness of Marine National Parks

Any system of MPAs needs to be reviewed at regular intervals to determine whether it is achieving the stated objectives for this system. One basis for review should the nationally recognised criteria of comprehensiveness, adequacy and representativeness (ANZECC 1999). Guidelines for how each of the criteria should be applied and assessed are provided in TFMPA (1999) (see also Appendix 2.6). The proportion of major habitats included in the system can be assessed against the desired goal (20%). Assessment against criteria such as inclusion of critical habitats, rare and endangered species require that sufficient available information. Apart from a few high-profile groups, such as marine mammals and wading birds, this is currently not the case in Victoria.

Assessment of an existing Marine National Park system requires not only analysis of whether all of the habitats and species groupings are sufficiently represented but also that each of the Marine National Parks is effectively achieving nature conservation goals. The general conservation objectives need to be described in terms of measurable parameters for assessment of the conservation effectiveness of individual reserves. A number of potential parameters are presented in Table 2.9.

Table: 2.9: Criteria for assessment of whether individual reserves are achieving marine conservation

Key: * = Values for each of these that reflect a return of conditions that would be expected with minimal human impact (not necessarily an increase for the first three)

*Genetic diversity
*Species diversity
*Species richness
*Species composition
Existence of viable populations of endemic species
Existence of viable populations of rare or endangered species
Diversity of habitats protected within Marine Protected Area
Protection of habitats critical to important species or communities
Protection/maintenance of habitat structure
Recovery of previously degraded habitats/ecosystems
Increases in abundance or biomass of previously exploited species
Increases in mean size and size range of previously exploited species
Increased recruitment to areas outside the Marine National Park
Reduced impacts from uses
Maintenance of water quality

2.5 Data requirements

Assessment of data requirements and availability

Selection of Marine National Parks ideally requires knowledge about the range, number and environmental health of habitats and ecosystems present, as well as the spatial patterns, diversity and abundance of species associated with them (Fairweather & McNeill 1993; Edyvane 1996). Specific information requirements are essentially determined by the selection criteria to be used. Potential criteria were identified in the previous section, with highest priority given to the criteria of representativeness, comprehensiveness, naturalness, criticalness and irreplaceability. The data required to apply these criteria is summarised in Table 2.10, along with an assessment of the availability of relevant data. The criteria that can be best addressed with the scientific information currently available are representativeness, comprehensiveness and naturalness.

The present knowledge base and the value of surrogate measures

The delineation of bioregions for Victoria was based primarily on physical data, for which reasonable datasets exist for the entire state (IMCRA Technical Group 1998). An assumption was made that this physical data is sufficient to explain distribution patterns of marine plants and animals. The available biological data provides some support for this assumption. Longitudinal patterns in physical characteristics correlate well with major shifts in species compositions for brown algae, echinoderms, crustaceans, and intertidal invertebrates (Handreck & O'Hara 1994; Bolton 1996; O'Hara 1999b). These results support conclusions that western and eastern Victoria are separate bioregions and that the Central Victoria Bioregion contains zones of rapid change in species compositions (transition zones).

Since then, considerably more biological data has been generated and this data provides Victoria with a basis for developing a 'comprehensive' MPA network, based on setting aside areas containing all major marine habitats. Within Victoria's nearshore waters the following generalised conclusions can be made, as a result of data collated for the Environmental Inventory Program (Ferns & Hough 1999):

- Depth is a major determinant of community structure: communities in water less than 2.5 m, 2.5–20 m depth and greater than 20 m depth are generally all different from each other.
- Geographically localised conditions of habitat structure (e.g. complex vs. simple reef forms) and wave exposure have the strongest influence on the composition of animals and plant assemblages present from place to place within each depth range.
- Some biogeographic patterns in animal and plant distribution from west to east of the state exist after the influence of depth and localised conditions have been removed.

Table 2.10: Assessment of information requirements and availability for application of selection criteria

Key: Yes = adequate information; Partial = some useful information; Limited = some data available, but not enough to be useful; No = no information

Ecological criteria	Information needs	Available?
Representative	Description and location of bioregions	Yes
	Spatial information on all:	
	ecosystems	Yes
	habitats	Yes
	communities or assemblages	Partial
Comprehensiveness	As above	
Naturalness	Location of human activity nodes	Yes
	Effects of impacts (physical and ecological) from human activities	Partial
	Area/distance over which effect detectable	Limited
	Physical structure and processes expected without human influence	Limited
	Community structure and dynamics expected without human influence	No
Criticalness	Habitat requirements of species at different stages of life-cycles:	
	marine mammals	Yes
	marine birds	Yes
	fish	Partial
	invertebrates	Limited
	plants	Limited
	habitats critical to ecosystem processes	Limited
Irreplaceability	Data on recovery of degraded habitats	No
Ecological integrity;	Effects of reserve size on ecological effectiveness	Partial
Adequacy	Effects of reserve distance apart on effectiveness	No
Important species	Knowledge about key species in ecosystem processes	Limited
Rarity,	Identification of rare/endangered species and communities	Partial
Uniqueness	Distribution of rare/endangered species and communities	Limited
	Identification of unique or unusual features	Partial
Vulnerability	Evidence about stability of habitats in response to disturbance	No
Diversity	Variety of habitats present in each bioregion	Partial
	Variety of species assemblages present in each bioregion	Limited
	Species richness or species diversity data comparisons within habitat types	Limited
Redundancy	Information on how much replication is needed in reserve system as insurance against catastrophic events	No
Productivity	Information on rates of production or yield at each level of food chain	Limited

Ferns and Hough (1999) conclude that the physical factors of depth, wave exposure, sea floor structure (such as reef vs. sediment, reef form, sediment characteristics) and longitude are useful surrogates for selecting areas to maximise the diversity of animals and plants included in a 'comprehensive' system of MPAs. Correlations have been found between physical parameters such as wave exposure, depth and substrate relief (but not rock type) and assemblages of the larger algae and invertebrates for rocky reefs within a 100 km segment of coast (Edmunds et al. 1999). More detailed examination of small animals associated with the dominant space covering plants,at least, suggests that the animal assemblages present are not so well predicted by physical variables, but bear closer relationship to the type of macroalgae present (O'Hara 2000a).

The main assumption with the 'comprehensive' approach to developing an MPA network is that each habitat type will contain distinctive assemblages of plants and animals, thus protection of representative examples of each habitat will protect biodiversity. The dominant habitat-forming plant or animal groupings (e.g seagrasses, kelp, sessile invertebrates) are incorporated into such categorisations. Ward et al. (1998) demonstrated that mapping of major habitat types is sufficient to make small-scale decisions about MPA placement (within an embayment), provided that 40% of each habitat type present is included within Marine National Parks.

Other studies suggest the need for detailed habitat and community assessments, including identification of plants and animals down to species level, before areas to be protected can be distinguished (Edgar et al. 1997; O'Hara 2000b). The problem with the use of habitat types on a broader geographic scale is that species and communities vary between different locations. Although bioregions attempt to account for spatial variations in species compositions within given habitat types and physical variables, it is unlikely that 100% of all species will be represented within a 'comprehensive' MPA system that uses these surrogates as a basis for representation. For example, Ward et al. (1999) calculate that major habitat types could account for approximately 93% of all known taxa surveyed for Jervis Bay, NSW. Their conclusion was that mapping and characterising major habitat types provided a highly cost-effective method for the planning and management of marine biodiversity. The nature of finer scale (within bioregion) variation in habitats and communities is currently being investigated. Quantitative sampling across major habitat categories has been initiated for subtidal rocky reefs of the Central Victoria and Flinders Bioregions (Edmunds et al. 2000).

Can we identify potential Marine National Parks with the data available?

The excuse of insufficient information should not be used to postpone development of a system of Marine National Parks for Victoria and, in fact, this excuse is no longer justifiable. Identification of potential areas to include in a 'comprehensive' Marine National Park system is possible with the data available. The investigations of the Environment Conservation Council (ECC) have involved an extensive review of Victoria's marine environment and have resulted in description of features and conservation status of a number of potential MPA locations. Bioregions have been delineated and the major habitat types present have been identified. Sufficient information is available to conclude that biological community structure within several different habitat types changes along a gradient from east to west of the state. The distribution patterns of some important marine groups are known (e.g. mammals and sea birds) and human use patterns have been mapped. The ECC has used this information in preparation of its recently released recommendations for a system of Marine National Parks and Sanctuaries (ECC 1999).

Despite the recent gains in knowledge indicated so far, significant gaps exist in the biological and ecological information available on Victoria's marine environment. Our understanding of the species composition and ecology of unvegetated soft-sediment shores is limited (Fairweather & Quinn 1995). Qualitative descriptions of assemblage types on rocky shores are available (e.g. Bennett & Pope 1953; Handreck & O'Hara 1994), but studies that quantify species and assemblage distribution patterns across the coastline are still required. Ecological studies of subtidal assemblages of marine animals and plants are at an early stage and worth progressing.

Ongoing research needs for establishment and implementation of MPAs

An extensive research and performance assessment program will be required to develop a system of Marine National Parks that is fully representative, and ensure that it is adequate in meeting biodiversity conservation objectives for Victoria. High priority research and management needs are:

- Extend the subtidal rocky reef work outlined by Edmunds et al. (2000) to the remaining bioregions to provide estimations of biodiversity 'representativeness' within habitat types and between sites across the entire coastline.
- Develop and implement classification and monitoring protocols for intertidal and soft sediment habitat types throughout Victoria.
- Identify uncommon, rare and endangered species, map the distribution of these species and identify habitat requirements at all stages of their life-cycles.
- Map breeding aggregations and nursery areas for a wide range of species.

Other desirable research will only become possible once sufficient Marine National Parks have been established, and will guide establishment of further reserves to provide a comprehensive and adequate network. Such research includes:

- assessment of ecological effects of human activities on the different habitat types and associated assemblages;
- effects of Marine National Park size and proximity on ecological effectiveness.

2.6 Description and assessment of Victoria's current system of MPAs

Victoria's existing system of Marine Protected Areas (MPAs) has developed over the past 20 years in a more or less ad hoc fashion. It comprises eleven MPAs that cover a total area of 53,501 ha, or about 4.5% of the marine environment under state jurisdiction. The major habitat types included are intertidal and inshore subtidal calcarenite and mudstone reefs, inshore granite boulder reefs, sandy beaches, and shallow embayments with associated seagrass meadows and mangroves. Most of these MPAs allow for many uses, with only c.600 ha (0.05% of the marine environment) effectively assigned high protection status (IUCN category I and II). The 'no-take' areas are Popes Eye Fisheries Reserve, part of the Point Cook Fisheries Reserve, the intertidal zones of Point Lonsdale and Point Nepean Fisheries Reserves, and the 'sanctuary zone' of the Bunurong Marine Park. The 'marine reserve' zone of the Wilsons Promontory Marine Park has not been included here, because of failure to prevent commercial fishing in this area.

Information on management of each of the MPAs is summarised in Table 2.11. Porter (1999) performed an assessment of effectiveness of individual MPAs in terms of the stated conservation objectives for the MPAs. Indirect scientific evidence and questionnaire responses were used to assess conservation effectiveness, as no direct tests of reservation effects have been published. On the whole, the scientific evidence covered few of the communities or populations present in the MPAs and was inconclusive. The analysis used indicated that the high protection MPAs have the greatest probability of achieving conservation objectives.

Existing Marine Protected Areas

The Harold Holt Fisheries Reserves (HHFRs)

The HHFRs, in the southern end of Port Phillip Bay, were declared as Marine Reserves in 1979 under Section 79A of the *Fisheries Act 1968* for the purposes of conservation and recreation. They became Fisheries Reserves upon introduction of a new Fisheries Act in 1995. The conservation objectives are to protect representative habitats and to protect and enhance flora and fauna. The only activities excluded from all reserves are shell collecting, amateur netting and amateur harvesting of rock lobster and abalone. The HHFRs are not representative of the surrounding marine habitats, as habitats in waters deeper than 10 m (most of southern Port Phillip Bay) are not included. The MPAs are small, most are not buffered from outside impacts and regulations are not sufficiently restrictive.

Table 2.11: Summary of management for Victoria's Marine Protected Areas, based on data for 1997

Key: MR = Marine Reserve; PL = Point Lonsdale; PN = Point Nepean; S&En = Surveillance and enforcement; Educ. = education and information;

T = proportion of management effort devoted to the terrestrial component; Med. = medium

* For management effort, percentages reflect proportion of total work effort devoted to the particular task e.g. Daily ≈ 10% means 10% of daily work load. Adapted from Porter 1999.

MPA	Size (ha)	Zones	Level of protection		Management plan	Funding per year	Staff	* Management effort				Infringements detected
			On paper	Actual				S&En	Educ.	Monitoring	Other	
Mud Is. FR	68	No	Low	Low	No	$15,000	0	0	0	0	T = 100%	
PLFR	110	No	Med	Med	No	0	0	?	?	?	?	About 12/yr
PNFR	300	No	Med	Med	No	0	0	20 days/yr	?	?	?	
Popes Eye FR	3	No	High	High	No	0	0	20 days/yr	?	0	?	
Swan Bay FR	2300	No	Med	Med	Draft	?	0	?	?	?	T = 100%	
Point Cook FR	120	Yes	Med-High	?	No	?	0	0	?	?	?	?
Shallow Inlet	2300	No	Low	Low	Draft						T = 65%	0
Corner Inlet	15000	No	Low	Low	Draft	$250,000	4	1–2 patrols	≈3%	≈5%	+*Spartina* control	0
Nooramunga	22000	No	Low	Low	Draft			per month			+ Admin	0
Wilsons Prom.	9700	Yes	High	Med	Draft	?	?		?	?	?	0
Bunurong	1600	Yes	Med-High	Low-High	Draft	$72,000	≈1.5	Daily≈10%	5–15%	0–5%	T=65–85%	25-30/yr

The reserve complex comprises the following individual reserves:

- Point Lonsdale Fisheries Reserve (110 ha) comprises exposed and sheltered intertidal and shallow subtidal calcarenite reefs. It is situated close to the coastal towns of Point Lonsdale and Queenscliff and public access has never been restricted. The majority of the reserve area comprises two large intertidal, wave-cut platforms of Pleistocene calcarenite (Lighthouse and Glaneuse Reefs) and sandy ocean beaches. A very small area of shallow underwater reef is included. The area is well known for its diversity of marine algae, of which there are some species not known from other areas.
- Point Nepean Fisheries Reserve (300 ha) contains both open ocean and sheltered bay rock platforms and near shore submerged reef. Hazardous sea conditions and restrictions on public access for more than 100 years have limited resource use of the open ocean component. It is a valuable scientific reference area as a result (Department of Conservation Forests and Lands 1989; Malcolm 1993). Several species of mollusc are larger in mean and maximum size at Point Nepean than at Point Lonsdale (Porter 1999). This result is possibly a reflection of the difference in use levels of the two shores. The abutting land is a National Park.
- Popes Eye Fisheries Reserve (3 ha) is an artificial blue stone annulus which rises 2.5 m above and descends 12 m below the water surface. It is the only HHFR from which all exploitative activities have been excluded. A huge variety of reef fish are found in this small reserve, which has become an extremely popular destination for scuba diving and snorkeling. The species richness of reef fish appears to be higher than at other locations in southern Port Phillip Bay (Porter 1997).
- Swan Bay Fisheries Reserve (2300 ha) is a shallow tidal marine area partially enclosed by spits and barrier islands and fringed by saltmarsh (DCE 1991a). Extensive seagrass beds, comprising five species of seagrass, support a high diversity of fish and wader bird species. They provide an important nursery area for several commercially fished species (Jenkins et al. 1993). Swan Bay is included on the Ramsar list of Wetlands of International Significance and is recognised as an area of high conservation value at the national and state levels.
- Mud Islands Fisheries Reserve (68 ha) comprises shallow seagrass beds, mangroves and mudflats that are important feeding and breeding areas for fish and birds. The area is listed on the Register of the National Estate and under the Ramsar Convention on Wetlands of International Significance.

Point Cook Fisheries Reserve

The Point Cook Marine Reserve (120 ha) was declared in 1982 to protect the intertidal shores from over exploitation. It is now a Fisheries Reserve managed under the *Fisheries Act 1995*. The reserve is zoned, with the inner zone a 'no-take' area and an outer zone that allows for regulated fishing. Insufficient information is available to assess the effectiveness of this reserve.

South Gippsland Marine and Coastal Parks

The South Gippsland Marine and Coastal Parks were established in 1986 under Schedule 4 of the *National Parks Act 1975* and the *Crown Land (Reserves) Act 1978*. They comprise a system of three large shallow embayments (inlets) and a 300 m wide fringe around the Wilsons Promontory National Park. The stated conservation objectives are to ensure long-term viability of marine and coastal ecosytems, maintain genetic diversity, allow natural processes to continue and to protect depleted, endangered and rare species and their habitats (DCE 1991b; DCFL 1990).

The ‘inlets’ are essentially multiple-use management areas, with few activities prohibited. Shallow Inlet contains seagrass, mudflat and saltmarsh communities. It is sheltered by a coastal dune system and sand spit – a significant geomorphological feature. This inlet is recognised as having high value as a wildlife habitat, especially for wading and shore birds (DCFL 1990). It is a popular location for camping, water skiing, windsurfing and fishing. Corner Inlet and Noorumunga Marine and Coastal Parks are situated between Wilsons Promontory and Ninety Mile Beach. Corner Inlet supports Victoria's largest *Posidonia australis* beds and the most southerly mangroves in the world. Nooramunga includes a number of barrier islands of national conservation significance for rare and endangered animals. Both inlets are Ramsar listed Wetlands with International Status as nature conservation areas (DNRE 1996).

The principal conservation objectives for the inlets are maintenance of migratory bird habitat, maintenance of the critical habitat for fisheries and achievement of sustainable exploitation. Catch and effort statistics suggest that the regulations for these parks have not been sufficient to ensure sustainable fisheries. However, the farming of Pacific Oyster has been prevented in adjacent channels as a result of the reservation and considerable effort had been put into combating invasion of *Spartina* – the major environmental problem for the inlets. Thus, declaration of the South Gippsland Marine and Coastal Parks has improved the chances of ecological sustainability of the ‘inlets’. The main threats to continued sustainability are overfishing and sedimentation from poor catchment management.

Wilsons Promontory Marine Park was established in recognition of the significance of the marine ecosystems of the area (DCE 1991b). Steeply sloping granite outcrops drop to 50 m below the sea surface, creating a habitat that is unique for Victoria (DCE 1991b). The adjacent land has been a National Park since 1905, affording a considerable degree of protection from land-based impacts. A large ‘no-take’ zone was declared around the southern end of the National Park (3000 ha). This proved unenforceable, after a successful legal challenge by the fishing industry, as the *National Parks Act 1975* does not have the ability to impose regulations on fisheries. Insufficient information is available to assess the effectiveness of this marine park.

Bunurong Marine Park

The Bunurong Marine Park, in South Gippsland, extends along 17 km of coastline and 1 km out to sea from the high-tide mark (DCE 1992). It contains the largest ‘no-take’ zone (about 300 ha) supported by legislation of any of the existing MPAs in Victoria. The general objective for the adjacent ‘conservation zones’ is protection of all non-fished biota while allowing for ‘sustainable’ fishing. The abutting coastal strip is a Coastal Park that is managed in conjunction with the Marine Park.

The coastline comprises sandstone and mudstone cliffs up to 40 m high, with extensive rock platforms which extend underwater for many kilometres offshore. They support a high diversity of marine life (153 algal species and 87 fish species) and biota representative of this habitat type (DCE 1992). Important archeological sites, bearing Cretaceous fossils and remains of Aboriginal occupation, occur along this coastline.

An important recent development has been a program by the Department of Natural Resources and Environment (NRE) to determine if protection measures are having an effect on biodiversity or sustainability of resources in the Bunurong Marine Park (L. Ferns pers. comm.). This study focused on five components of the Bunurong reef ecosystem: habitat structure; plant assemblages; invertebrate assemblages; fish assemblages; and fished populations. Several findings support continuation of the MPA as a Marine National Park (as proposed by the ECC 1999). These include that:

- Algal communities within the sanctuary are unique, and only represented at one location in the adjoining Conservation Zones.
- Although the Sanctuary Zone was not declared to manage or enhance fishery species, it appears to be acting as a reserve for male Blue-throated Wrasse, which are targeted for the live-fish market.

Table 2.12: Representation of major habitat types in high protection marine reserves

Key: (a) = artificial structure; MR = marine reserve

	Otway		Central		Flinders		Twofold		Bays	
Habitat types	**present**	**in MR**	**present**	**in MR**	**present**	**in MR**	**present**	**in MR**	**present**	**in MR**
Sandy shore	√		√	√	√		√		√	
Rocky shore – exposed	√		√	√	√		√			
Rocky shore – sheltered					√				√	√
Mangroves									√	
Muddy shore									√	
Seagrass meadows					√				√	
Soft substrate < 20 m	√		√	√	√		√		√	
Soft substrate 20–40 m	√		√		√		√		√	
Underwater reef < 20 m	√		√	√	√		√		√	√(a)
Underwater reef 20–40 m	√		√		√		√		√	
Deep water habitats > 40 m	√		√		√		√		√	
Pelagic habitats	√		√	√	√		√		√	

Assessment of the existing MPA system and analysis of gaps

An analysis of the adequacy and conservation effectiveness of the existing system against assessment criteria (see Section 2.3) is not necessary, as only c. 600 ha (about 0.05%) of Victoria's marine environment is included in high protection 'no-take' areas. These 'no-take' areas all occur within two bioregions (Central Victoria and Bays and Inlets). The existing system of MPAs is clearly not representative of all habitats present in each bioregion or comprehensiveness.

The representativeness of habitats currently included in Marine National Parks is poor (Table 2.12). Two of the five bioregions identified for Victoria have no MPAs at all (Otway and Twofold Shelf). All the major habitat types in each bioregion need to be included in any system developed. Furthermore, habitat types vary from place to place within bioregions, in terms of physical structure, communities or assemblages they support, species present etc. Inclusion of one example of a major habitat type in each bioregion will not be sufficient. As an example, the Bays and Inlet Bioregion groups all bays and inlets together, yet each is essentially different in terms of depth, seagrass species, presence of mangroves and other vegetation types, tidal regimes and, no doubt, fauna.

Brief assessment of Victoria's performance: the draft recommendations of the ECC

Victoria has undertaken extensive ecosystem and habitat mapping programs, and is making progress towards identification of a comprehensive system of MPAs. Efforts over the past ten years to develop a system of MPAs for nature conservation have culminated in draft final recommendations by the ECC (ECC 1999). The system of MPAs proposed is a good approximation of the basic system of MPAs required, and should be supported in principle. However, the ECC's proposal is limited by the requirement to take the economic considerations of their proposal into account. Also, the recommendations do not sufficiently address variation within bioregions. Suitable areas are likely to have been omitted from consideration as a result. Additions to the systems will be required. It is essential that the process of data collection continue to identify necessary additions and modifications to the total system, and to provide a basis for performance assessment. Frequent review will be required as this new information comes to hand to identify gaps and take steps to fill them.

Victoria will not be making true progress towards advancing nature conservation, however, until the proposed recommendations of the ECC are implemented.

2.7 Recommendations

The process used for selecting recommended Marine National Parks

Available information indicates that each bioregion is physically and biologically distinct. Furthermore, species composition of animal and plant communities varies longitudinally within each bioregion. A logical progression from the reasoning presented in the previous section is subdivision of the Interim Marine and Coastal Regionalisation for Australia bioregions, with the intention of recommending at least one location within each segment to cover at least 20% of each habitat type present in each of these segments. To arrive at the areas recommended here, each of the bioregions was divided into approximately 50 km lengths of coast and each bay and inlet was considered separately. The distance chosen is to a certain extent arbitrary – small enough to take into account small-scale changes in plant and animal communities, but large enough to enable Marine National Parks greater than 2000 ha.

Identification of precise locations will require sophisticated mapping and overlays using geographic information systems – a task beyond the scope of this project. The process used here to identify candidate areas for marine protection was as follows:

- Base map of main habitat types provided by the Department of Natural Resources and Environment/Marine and Freshwater Resources Institute were used.
- Locations of Little Penguin and Australian Fur Seal colonies, areas listed on the register of the national estate and coastal parks and reserves were marked on these maps.
- Major coastal uses and activity nodes that impact on marine systems were superimposed. These included ports, urban centres, outfalls, major industrial centres and concentrations of infrastructure for fishing (see Figure 2.2 in Section 2.3).
- The criteria of representativeness and naturalness were then applied to identify potential and priority locations.

The areas identified represent large regions within which eventual Marine National Parks could be located (see Table 2.13; Figure 2.3). Once these regions have been decided, available ecological information on them needs to be assessed to refine the area for selection.

The following recommendations for Marine National Parks should be implemented in conjunction with establishment of 'no-take' Marine Sanctuaries with objectives to protect particular natural features of significance, such as habitat of specific animals and plants (see Table 2.14).

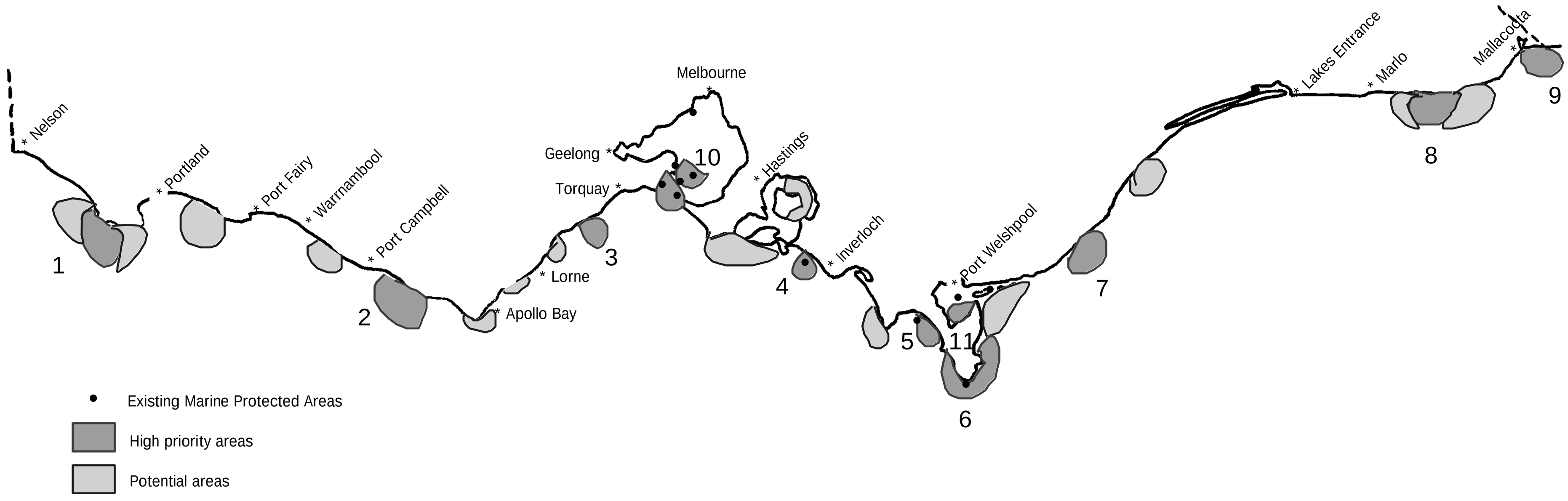


Figure 2.3: Potential marine and coastal areas for inclusion within a system of Marine National Parks for Victorian waters

'Priority areas' make up the initial system. 'Potential areas' are areas within which Marine National Parks should be established to ensure a representative, comprehensive and adequate system of protected areas for Victoria. Additional smaller areas may be considered for inclusion within Marine Sanctuaries to protect particular features or to rehabilitate degraded areas.

(map not to scale)

Table 2.13: Sections of coast to consider for location of Marine National Parks

Key: * = Long stretches of isolated sandy ocean beaches uncommon in the Central Victoria Bioregion;
** = Intensive trawling in the Twofold Shelf Bioregion –- some trawl-free zones needed

Bioregion	Section of coast
Otway	Descartes Bay/Cape Bridgewater Shaw River to west of Port Fairy Bay of Islands Twelve Apostles to Moonlight Head Point Franklin to Shelley Beach (Otway National Park)
Central Victoria	Kennett River to Point Sturt Boggaly Creek to Cumberland River Reedy Creek to Cinema Point Point Addis to Bells Beach West of Point Lonsdale to East of Point Nepean Cape Schanck to Flinders or Phillip Island open coast Bunurong Marine Park A segment of coast between Venus Bay and Cape Liptrap*
Flinders	Shallow Inlet to Shellback Island Southern Wilsons Promontory, including the offshore islands
Twofold Shelf	Vicinity of Delray Beach** Segment between Delray and Loch Sport** Segment between Lake Tyers and Marlo** Segment(s) between Sydenham Inlet and Winghan Inlet ** Cape Howe
Bays and Inlets	Port Phillip Bay – southern end plus Swan Bay Corner Inlet/Nooramunga – southern Corner Inlet

Table 2.14: Locations to include within Marine Sanctuaries

Note: All mangrove habitat needs to be included within protected areas, as so little of this habitat type is found in Victoria.

Location	Significance
Lady Julia Percy Island	Seal colony, cultural value
Port Fairy – Griffiths Island and west of	Sea bird colonies
Logans Beach	Southern Right Whale breeding and nursery
Port Campbell – I km offshore	Spectacular underwater limestone formations and diverse marine life
Little Henty Reef – Morengo	Variety of habitats in very small area
Eagles Nest Reef – Aireys Inlet	Sandstone and basalt reef provide for a variety of habitats
Point Danger	High species richness for sea slugs
Port Phillip Bay	
Point Cook	Representative of marine habitat of north western Port Phillip
Jawbone Flora and Fauna Reserve	Long history of protection, mangroves
Mud Islands	Seagrass, mangroves, sea and wader bird habitat
The Nobbies/Seal Rocks, Phillip Island	Seal, kelp gull and little penguin breeding habitat
Cape Woolami, Phillip Island	Variety of marine habitats, deepwater close to shore
Western Port Bay	
Warneet/Quail Island area	Mangrove habitat
North of French Island	Seagrass, mangroves, remnant invertebrate species, Crawfish Rock
Rhyll Inlet and Observation Point	Mangroves, mudflats, basalt reef, seagrass, wader bird habitat
Corinella to San Remo	Intertidal cobble/shingle shores, fish nursery, wader bird habitat, marine community listed under the *Flora and Fauna Guarantee Act 1988*
Beware Reef, Cape Conran	Offshore granite reef, diversity of marine life
Sydenham and Tamboon Inlets	Fairly unmodified estuaries surrounded by National Park
Mallacoota Inlet – part of	Fairly unmodified inlet surrounded by National Park

Recommendations

R2.1 That a comprehensive system of Marine National Parks with the principal objective of nature conservation be established in Victorian waters.

R2.1a A system of Marine National Parks representative of the full diversity of marine life present in Victoria's marine environment is required.

R2.1b Marine National Parks should be assigned high protection 'no-take' status (equivalent to the International Union for the Conservation of Nature categories I and II).

R2.1c The system of Marine National Parks should include at least 20% by area of each major habitat type occurring in each bioregion.

R2.1d Marine National Parks should be situated along the coastline to account for west to east gradients in composition of plant and animal communities.

R2.1e Marine National Parks need to encompass the full range of depths present in each of Victoria's bioregions to be representative of all community types present.

R2.1f The minimum size for Marine National Parks should be 20 km^2 (2000 ha) to reduce impacts from outside the boundaries on core areas and to increase viability of populations within the boundaries.

R2.1g Marine National Parks need to be established in adjacent Commonwealth and Tasmanian waters to better represent the diversity of marine life in cool temperate waters of Australia.

R2.2 That a number of smaller 'no-take' Marine Sanctuaries with specific species, community or habitat protection objectives be established to complement the system of Marine National Parks.

R2.2a Marine Sanctuaries may be smaller than Marine National Parks, depending on objectives. However, a minimum size of 500 ha is recommended to protect the identified values in a core area.

R2.2b The system of Marine National Parks and Marine Sanctuaries should be designed to maximise connectivity between them, with a minimum distance apart of 50–100 km.

R2.2c Marine National Parks and Marine Sanctuaries would ideally be located as far as possible from human activity nodes (and associated impacts), particularly from ports, industry, ocean outfalls and urban centres. However, less than pristine areas may need to be included to ensure a fully representative system (e.g. in bays, inlets and estuaries). The feasibility of rehabilitation should be considered when selecting such areas.

R2.2d The Bays and Inlets Bioregion contains bays and inlets that are ecologically different from each other, thus Marine National Parks or Marine Sanctuaries within each will be required.

Recommendations on priority areas to nominate for Marine National Park status

R2.3 That, initially, a minimum of two Marine National Parks in each bioregion be established as a matter of urgency.

Several areas proposed in Table 2.13 stand out as candidates for these initial Marine National Parks. The areas are listed according to bioregion below, along with a brief description. (Information is derived from the database compiled for preparation of Roob 1999; ECC 1999; Handreck & O'Hara 1994; LCC 1995, 1996; Porter 1997). The number following the area corresponds to locations as represented in Figure 2.3. Most are included, in part, in the recently released Environment Conservation Council Draft Recommendations (ECC 1999).

Otway Bioregion

R2.3a Descartes Bay/Cape Bridgewater (1)

Description: The diversity of habitat types present include sandy beaches, soft sediments (mainly fine sand with a high carbonate content), intertidal rocky reef (basalt), and subtidal rocky reef (calcarenite and basalt). The subtidal reefs display a variety of forms: platforms, gutters, walls, bommies (patches of rock emerging from the sea floor), boulders and rubble. Five species of large kelps occur here. Many rock surfaces in shallow water are covered in coralline algae and mussels. Abundant abalone are present near shore. The dominant fish is wrasse.

Significant features: Cape Bridgewater is the largest coastal basalt formation for the Otway Bioregion. The area is representative of the highest wave energy coastline for the state. Deep water sedentary invertebrate assemblages occur here (e.g. sponges and fan corals). The species richness of animals in the intertidal and shallow subtidal areas is high. According to the Land Conservation Council (1996), the only mainland breeding colony of Australian Fur Seals in Australia is found at Cape Bridgewater. The adjacent coastline is on the register of the National Estate and contains areas of biological significance.

R2.3b Twelve Apostles to Moonlight Head (2)

Description: The diversity of habitat types present includes sandy beaches, soft sediments (mainly fine sand), cliffs, intertidal sandstone platforms, extensive subtidal rocky reefs (limestone, sandstone and basalt). Subtidal reefs display a variety of forms: low profile platforms, gutters, cobbles, rubble, high relief basalt reef, ledges and overhangs; some are in deep water (55 m). Reefs are covered in kelps, coralline algae, small red and brown algae, sea tulips, sea stars and lace corals. Sponges, lace corals, sea whips and sea squirts are found on the deeper reefs.

Significant features: The abovewater and underwater scenery is spectacular (arches, canyons, bright coloured animals) and extends for several kilometres offshore. The diversity of intertidal and shallow subtidal animals is high (the highest diversity on limestone and sandstone in Victoria). A number of sea bird breeding colonies occur along this section of coast (e.g. Black-faced Cormorant). The adjacent coastline is a National/Coastal Park that contains numerous sites of geomorphological and biological significance.

Central Victoria Bioregion

R2.3c Point Addis (3)

Description: The habitat features a mixture of low- and high-profile limestone/sandstone reef among sandy sediment, with some expanses of cobblestones. Clumps of sedentary invertebrates arise from course sand in deeper water (49 m). These contain sponges, hydroids, sea squirts and lace corals, providing habitat for fish and mobile invertebrates. Kelp covers the low-profile reef in shallow water. Large expanses of sandy beach and subtidal soft sediment, with some solid patches of nearshore reef, occur to the east (includes Bells Beach). The soft sediment is a mixture of fine, medium and coarse sand grains with very high carbonate content. Species lists of algae on Ingoldsby reef are available (Beanland 1985).

Significant features: The clumps of invertebrates are an unusual feature. The proposed park includes Ingoldsby Reef at which Leafy Sea-dragons (significant species) have been found. Point Addis limestone is of State Geological Significance. Bells Beach recently achieved National Heritage listing.

R2.3d Cape Paterson to Inverloch (4)

Description: Intertidal rock platforms and sandy beaches extend along this coastline. The underwater environment is a mix of high- and low-profile solid and patchy reef, with some cobbled reef and rock rubble. The reef becomes more patchy, with a higher proportion of sand further offshore (3–5 km). Rock type is a mixture of sandstone, calcarenite and basalt. Dominant cover is made up of kelps, with some foliose red algae and an understorey of coralline algae. Red algae are more abundant at increased depths offshore, along with some sponges and stalked ascidians (sea tulips). Sea whips, stalked ascidians and sponges apparently growing out of sand have been observed at 50 m depth and greater (about 5 km offshore). Little Penguins, seals, dolphins and Southern Right Whales have been recorded in the area. A total of 153 species of algae and 87 fish species were recorded in Museum of Victoria surveys in the 1980s (DCE 1992).

Significant features: Such extensive areas of intertidal and underwater reef are uncommon in Victoria. The area is species rich for intertidal chitons, subtidal algae and fish. Eagles Nest is a fossil dinosaur locality. Peregrine Falcon and Hooded Plover habitat.

Flinders Bioregion

R2.3e Shallow Inlet to Shellback Island (5)

Description: High- and low-relief calcarenite reef, with a high density of caves and crevices, is surrounded by sandy substrate. Some granite boulder reef occurs around Shellback Island. The calcarenite reefs are covered in kelps, foliose red and erect green algae, with pits and ledges covered in sponge and ascidian communities. The granite boulders are covered in a rich variety of invertebrates. Dense seagrass (*Amphibolis*) beds grow on sandy substrate east of Shellback Island and a species of sea pen is found on the sandflats near the calcarenite reefs.

Significant features: This locality represents the only occurrence of calcarenite reef within this bioregion. The area has high natural values, as it is adjacent to a fairly inaccessible area of the Wilsons Promontory National Park. The dense seagrass beds and diversity of sedentary animal life are also significant features.

R2.3f Wilsons Promontory (6)

Description: The underwater terrain is characterised by steep granite boulder drop-offs from the intertidal to a sandy sea floor. Caves, vertical walls and tunnels characterise the reef habitat. Kelps are the dominant cover from the sea surface to about 30 m depth, while the cover of sponges, ascidians, sea whips and sea tulips is very high at greater depths (40 m). Aggregations of sponges and ascidians (sea squirts) have been observed on sandy sea floor at depths greater than 60 m. Some aggregations are extensive enough to be referred to as sponge gardens, with many different species present. Seal and penguin colonies occur on some of islands. Seagrasses grow in the shallows of sheltered bays (*Amphibolis, Heterozostera, Halophila* and *Posidonia*).

Significant features: The area has high natural values, as much of the proposed area abutts National Park with little access from the immediate coastline. Granite boulder habitat, combined with deep waters, is uncommon in Victoria. This feature provides for spectacular underwater scenery. The *Posidonia*, present at Great Glennie Island, is uncommon in Victoria (the most extensive beds being in Corner Inlet). Extensive sponge gardens are also uncommon in Victoria. Wilsons Promontory forms a transition zone between west and east, with the western and eastern distributional limits of some species occurring here. This results in distinctive assemblages of animals and plants. The presence of seal and penguin breeding colonies adds to the significance of this area.

Twofold Shelf Bioregion

R2.3g Delray Beach area (7)

Description: The main habitat groupings present are sandy beaches, underwater reef and soft sediment. Patchy, low-profile calcarenite reefs extend from about 1–4 km from shore at depths of about 10–18 m. A diversity of invertebrates are found here, especially large sponges, ascidians, bryozoans and hydroids. The soft sediments are a mixture of fine to medium sand, with some silt and course sand in patches. The species richness of sediment fauna is notably high compared to shallow water soft sediment habitats elsewhere in the world (L. Ferns pers. comm.). Waters off the coast in this bioregion appear to be relatively unpolluted (Haynes et al. 1995).

Significance: This represents the only occurrence of calcarenite reef to the east of Wilsons Promontory. It is the only known locality for one crab species (*Halicarcinus* sp.) and an unusual species of soft coral. Bottom-trawling occurs along most of the coastline in this bioregion, so protection of this area would provide a small trawl-free zone for recovery of benthic communities.

R2.3h Sydenham Inlet to Point Hicks (east of) (8)

Description: Habitats include intertidal and underwater sand and reef. The intertidal habitat at Point Hicks has the highest species richness recorded on granite in Victoria. The underwater reef comprises granite bommies covered in kelp and sedentary animals.

Significance: Natural values are high, as the area is next to a National Park. This locality is representative of the Twofold Shelf Bioregion. The species richness is high, particularly for soft sediment and intertidal invertebrates. The area would provide a valuable scientific reference area.

R2.3i Cape Howe (9)

Description: Habitats include intertidal and underwater sand and a mixture of granite reef and sandstone reefs reef, with a variety of reef forms. These provide habitat for a high diversity of marine animals.

Significance: The southern distributional limit of many species occurs here. Sandstone reef occurs at only this location in this bioregion. Natural values are very high, as the area abutts the Cape Howe Wilderness area.

Bays and Inlets Bioregion

R2.3j Southern Port Phillip Bay, including Swan Bay and Port Phillip Heads (10)

Description: Habitats include sandy and rocky shores, shallow to deep water, underwater reef, soft sediment and seagrass. Strong currents, a range of wave energies and depth range from 0–100 m provide for a high diversity of animal and plant life. The reefs are composed of calcarenite and display a variety of forms, such as reef flats, bommies and stepped reef, escarpments, deep cut ledges and drop offs. These contribute to a high diversity of subtidal habitats in a relatively small area. Biodiversity and species composition of the area is considered rich and unique for Australian waters. Point Lonsdale intertidal platforms have been found to have the highest invertebrate species richness of any calcarenite reef in Victoria. A high number of algal species and a number of distinct algal communities occur here, also. The Point Nepean intertidal platforms are similar, but have been largely protected from impacts from human disturbance. Also see Appendix 2.3.

Significance: This is a unique environment in Victoria, with a diverse and abundant marine life. The area is noted for spectacular underwater scenery.

R2.3k Southern Corner Inlet (11)

Description: See Appendix 2.3. Habitats include intertidal sandy beaches, mudflats, seagrass meadows and mangroves.

Significance: Southern Corner Inlet has high natural values, as it abutts an area of National Park for which access is restricted to walkers and small boat traffic. It contains part of the only large area of *Posidonia* (broad-leafed seagrass) found in the state. The area is significant wader bird and waterfowl habitat and contains soft sediment channels; a habitat that has not been included in any other Marine Protected Area.

Recommendations to ensure effective management of the reserve system

Adequate funding priorities and staffing levels emerged as the most common theme to ensure effectiveness of Marine Protected Areas in Victoria (Porter 1999). Lack of expertise about the marine environment of regional management staff has compounded the problem of low staffing levels. The ability of managing authorities to carry out regular surveillance and enforcement operations, provide public education programs and materials, and provide signage and boundary markers has been limited. The coordinated monitoring and performance assessment of Victoria's Marine Protected Areas, which was initiated in late 1997, is a major achievement but requires ongoing funding and commitment across Victoria's marine management authorities.

The following recommendations are therefore made:

R2.4 That the level of funding for Marine Protected Areas be increased so that effective management is possible.

R2.5 That the day-to-day management of Marine Protected Areas be improved. Measures to achieve this include:

R2.5a Development of a management plan for each Marine National Park and Marine Sanctuary.

R2.5b Development of strategies for maintaining permitted uses within sustainable limits.

R2.5c Monitoring of use levels and patterns.

R2.5d Development of volunteer programs.

R2.5e Encouragement of community involvement.

R2.5f Long-term commitment to monitoring of performance. Ongoing monitoring is required to i) assess the ability of Marine National Parks and Marine Sanctuaries to preserve biodiversity and enhance sustainability of resources; ii) to continually refine management needs through adaptive management; and iii) to help convince public and stakeholders of the value of Marine Protected Areas.

R2.6 That public and stakeholder understanding and support for Marine Protected Areas be promoted. Measures to achieve this include:

R2.6a Programs to educate the general public, stakeholders, the media and decision-makers about the vulnerability of marine environments and the value of Marine Protected Areas.

R2.6b Widespread promotion of procedures for public participation in all stages of the process of establishment and management of Marine Protected Areas.

R2.6c Implementation of measures to reduce financial impact on any affected stakeholders.

Water quality and introduced species are just two problems that will not be solved by establishing Marine Protected Areas.

The following recommendation is therefore made:

R2.7 Marine National Parks need to be integrated in a framework of coastal zone management to achieve ecological sustainability of Victoria's marine environment.

Guidelines are provided in *Victoria's Coastal Strategy* (1997) and the *Interim Report of the Environment Conservation Council* (1998). These need to be implemented through cooperation and coordination of management authorities and sectoral interests.

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Section 3: The Land, Rivers and Wetlands

The Conservation Status of Victoria's Terrestrial Environment

3.1 Introduction

This chapter reviews the conservation status of the terrestrial and freshwater ecosystems of Victoria. A complete review of current knowledge as completed by Frankenberg (1971) and Frood and Calder (1987) is not attempted here. The increase in knowledge since those reports has been great and any encyclopaedic attempt to list and summarise all current information is beyond the resources of this project. Only the points that are considered key to the future of nature conservation in Victoria are discussed in detail. A particular focus is given to identifying gaps in the current conservation reserve system.

The Review defines 'nature conservation' as the conservation of biodiversity: natural ecosystems, species and genetic diversity. Other important environmental issues, such as salinity, sustainable agriculture, loss of aesthetic values, wilderness values, pollution and many others are only covered in relation to their impacts on biodiversity. The Review provides recommendations for major nature conservation issues that are judged to be not adequately addressed by conservation organisations in Victoria.

Section 3.2 reviews the current state of Victorian terrestrial and freshwater biodiversity. Section 3.3 analyses the current major threats to this biodiversity. Sections 3.4 and 3.5 examine the status of freshwater ecosystems and conservation on private land respectively. The current gaps in Victoria's reserve system are analysed in Section 3.6. The literature on criteria for creating a 'comprehensive, adequate and representative' reserve system is briefly reviewed and best-practice criteria identified. Gaps in the current conservation reserve system are identified. Finally, Section 3.7 makes specific recommendations for additions to the current reserve system, control of environmental weeds and feral animals, strategies to combat the likely effects of the greenhouse effect and improvements to the conservation of freshwater ecosystems.

3.2 Current knowledge of terrestrial and freshwater biodiversity

Background

Victoria is the smallest state in the far south-east of the Australian continent. Its area of 22 million hectares (220,000 square kilometres) is just under 3% of the total area of mainland Australia and Tasmania combined. Most of the state has a relatively high annual rainfall of above 500 mm, with some drier areas in the north-west. Most of the state is flat to undulating. Nowhere is the northern border more than 380 kilometres from the sea (Taylor 1947; Bureau of Meteorology 1989). In 1998 the population was 4.66 million with approximately three-quarters of these people living in Greater Melbourne (Australian Bureau of Statistics 2000).

These statistics indicate that relative to other mainland states, Victoria is small, well-watered, has a high proportion of arable land and supports a high human population density. As well, all of the state is relatively close to the sea. These factors have greatly affected how the state has been settled and developed by Europeans and have important consequences for nature conservation in Victoria.

Geographically the state is aligned east to west, and is split along most of this axis by the Great Dividing Range. The Great Dividing Range (the 'Divide) forms high ranges in the east, but diminishes in Central Victoria to lower hills and plains with only the Grampians forming higher mountains in the west. North of the Divide, the rivers flow through alluvial plains to the Murray River on the northern border. South, they flow directly to Bass Strait through the Gippsland coastal plains and the volcanic and limestone plains of the south-west. Rainfall is generally highest south of the Divide and in the higher ranges, with rainfall declining steadily northwards to the semi-arid lands of the Mallee in north-western Victoria. Some smaller dry rainshadow areas occur south of the Divide.

Geologically the state is highly diverse, with consequent variations at both the regional and local scale in soils (Cochrane et al. 1991). This complexity of geology, climate and topography has produced striking diversity in the natural environment, both within and between different regions. A wide spectrum of vegetation types includes warm and cool temperate rainforests, wet and dry eucalypt forests, heathlands, heathy woodlands, grassy woodlands, native grasslands, mallee, saltmarsh, mangroves and saltbush shrublands (Foreman & Walsh 1993).

Ecological history of Victoria

Prior to European invasion in the 1840s, Aboriginal management of land had been in place for at least 40,000 years (Mulvaney & Kamminga 1999). Current knowledge of historic Aboriginal land management practices in Victoria remains poor. However, some ecosystems are likely to have been at least partly maintained by regular and deliberate burning practices (for example, the native grasslands of the western volcanic plains, dominated by Kangaroo Grass, *Themeda triandra*). Dry forests and woodlands may also have been maintained in specific states by particular burning patterns (Stuwe & Parsons 1977; Yates & Hobbs 1997). Wetter sclerophyll forests and rainforests are unlikely to have been affected by regular burning. In addition, Aboriginal hunting may have controlled numbers of some species such as kangaroos and Koala (R. Martin pers. comm.). (In many cases detailed knowledge of Aboriginal management of different vegetation types has been lost.)

In other areas some clans have retained knowledge through oral history or practices can be reconstructed to some extent from historical accounts by early European observers.

The arrival of Europeans produced rapid changes in ecosystems throughout Victoria. These changes can be categorised as occurring in three phases: initial settlement, agricultural and industrial expansion, and intensification of land use.

Early European settlement

In the first phase changes inevitably followed the arrival of stock, the grazing of native vegetation, the decimation of the Aboriginal people and the consequent removal of indigenous land practices, the clearing of small areas with soils favoured for agriculture, and the hunting or removal of native plants and animals of especially high values. Areas preferred for early European settlement were those close to safe sea ports and those having native vegetation or wildlife that could be immediately exploited for markets.

In Victoria, this phase of change led to the almost complete removal of fur seal colonies and Southern Right Whales from along the Victorian coast (Menkhorst 1995). Shortly after came the great wave of pastoral expansion into the native grasslands and grassy woodlands of western Victoria; then northern Victoria, the alpine herbfields, and the central Gippsland Plain. Riparian vegetated river flats close to settlements were largely cleared for cropping. Depending on the date of settlement in different regions this phase occurred in different districts up into the end of the nineteenth century.

At this time virtually all small- to medium-sized ground mammals, such as bettongs, bandicoots and native rodents, disappeared from lowland Victorian grassy ecosystems (Menkhorst 1995). Large birds and other animals favoured for food, such as Magpie Geese and Bustards, became very rare or regionally extinct in settled districts (Emison et al. 1987). Plant species in native grasslands and grassy woodlands that were particularly susceptible to grazing by European stock declined rapidly in number.

Agricultural and industrial expansion

The second phase was one of agricultural and industrial expansion. The discovery of gold massively increased Victoria's population in a single decade: from 97,000 in 1851 to 540,000 in 1861 (Clark 1963). This had immediate impacts on gold-bearing areas, most of which were in box–ironbark country in central Victoria. Woodlands and forests on mined areas were cleared for mining. Massive volumes of timber were removed from surrounding areas for mine props and to fuel the steam engines that powered the ore-processing machinery.

In parallel and following this influx of people there was a massive increase in agriculture in Victoria. The Land Acts of the 1860s opened up several million hectares for selectors. Cereal cropping rapidly expanded in central Victoria, parts of the northern plains, the Wimmera and the southern Mallee. By 1878, 40% of Victoria's area had been alienated, with all or most of the native vegetation removed. By the turn of the century most of the Strzelecki Ranges and much of the Otway Ranges were cleared for dairy farming, and virtually every river valley in Victoria was cleared for cropping or dairying (Woodgate & Black 1988).

Broad-scale clearing of vegetation continued up to the Second World War. In a few areas, such as parts of the eastern Strzelecki Ranges, agricultural settlement was abandoned as increasing mechanisation made some types of country uneconomic to farm. Following the war, extensive clearing of remnants continued in previously settled areas and two large schemes also led to the clearing of new areas. The Australian Mutual Provident Society (AMP) was given extensive leases in the 1950s to destroy mallee vegetation in the Little Desert for cropping. The Heytesbury Forest near Colac was destroyed for a soldier-settlement dairy-farming scheme which commenced in the 1950s. Such large-scale agricultural schemes ceased in the early 1970s following the public outcry over plans to remove a large area of mallee vegetation in the Little Desert (Woodgate & Black 1988). However, large-scale clearing for plantations continued until the 1980s. The then Forests Commission of Victoria and some private forestry companies removed large areas of native forest in Gippsland, north-eastern Victoria and south-western Victoria to establish pine and eucalypt plantations. The State Government finally banned this practice in 1984 (Department of Conservation, Forests and Lands 1986). Before clearing controls on private land were introduced in 1989, around 15,000 hectares were still cleared annually for agriculture and plantations (Woodgate & Black 1998).

In uncleared forest and woodlands areas logging and woodchipping operations had (and have) a major impact, changing the structure and, in some areas, the floristics of the vegetation (e.g. Ough & Ross 1992; Gibbons & Lindenmayer 1995). Prior to the 1940s operations were largely selective and concentrated in accessible areas. Post-war forestry rapidly expanded into previously unlogged areas of the Alps and East Gippsland. Clearfelling was introduced when mechanisation made this the most economic silvicultural technique in most forest types. This led to a rapid reduction in the area of mature forest and woodlands in most regions from the 1960s to the present time (e.g. Woodgate et al. 1994; Traill 1996).

Most major Victorian wetlands and rivers were altered to some degree during this expansion phase. More than 50% of freshwater marshes have been drained to increase agricultural lands (DNRE 1997). Major dams were constructed on most larger Victorian rivers and one or more weirs were built on many smaller streams and rivers. Major irrigation schemes commenced along the Murray River and some of its tributaries such as the Goulburn River. Increasing volumes of water were diverted for other agricultural, domestic and industrial uses. These changes altered the usual water cycles of streams (DNRE 1997).

Lastly, this phase of change saw the introduction and spread of a wide range of foreign plants and animals. This included well-known problem species such as rabbits and foxes, and the relatively lesser known problem of environmental weeds, including deliberate introductions such as blackberry and accidental introductions and escapes from pastures and gardens (Carr 1993; Low 1999).

The cumulative result of these impacts was a very rapid reduction in the extent of vegetation communities that occurred on soils favoured for agriculture. All ecosystems restricted to lowlands on arable soils in Victoria are now reduced to small fragments (DNRE 1997). Temperate woodlands had occupied 32% of Victoria prior to European settlement. By 1987, 92% had been cleared (Lunt & Bennett 2000). In the most extreme case, the grasslands of the Victorian Volcanic Plains Bioregion covered approximately one million ha. Less than 0.5% of these grasslands now remain (McDougall and Kirkpatrick 1993; DNRE 1997). In remaining vegetated areas the effects varied greatly. Ecosystems with no economic timber and/or on poor soils, such as mallee areas on deep sands, had relatively little disturbance. Accessible areas of forest and woodland with commercial volumes of timber have largely been converted into regrowth forest (e.g. Woodgate et al. 1994). The changes have been deleterious to most native species but have produced habitats which, in some areas, have favoured a few native species, such as Eastern Grey Kangaroos, Corellas, Noisy Miners and others (Blakers et al. 1984; Menkhorst 1995).

As would be expected in this phase the greatest losses have been in habitats on those soils most preferred for agriculture (DNRE 1997). Habitats in uncleared areas have been affected to varying degrees by forestry activities and continuing overgrazing, the effects of environmental weeds, feral animals and changed fire regimes. In many areas the impacts of this phase are only now being felt. Woodland birds, for example, are now undergoing a major wave of regional and statewide extinctions in south-eastern Australia (Robinson & Traill 1996). This is a response to past clearing exacerbated by continuous poor management practices. Populations in remaining fragments may hold on for some years or even decades but in many cases the populations are too small to survive in the long term and eventually die out when a drought or other 'bad' year occurs (Traill & Duncan 2000). Similarly, the impacts of salinity caused by past clearing of native perennial trees, shrubs and grasses is only recently becoming apparent in some regions. In some cases, the few native species that have increased have created problems for other native species. Noisy Miners, for example, aggressively exclude other native birds from small remnants of woodland and forest (Grey et al. 1998).

Intensification of land use

The third phase is the current and continuing phase of intensification of agriculture, forestry and other human activities. While generally more subtle and incremental in impact than the wholesale changes of the previous phases, current land use practices are also causing continuing losses in biodiversity.

The major force of change in many regions is the continuing intensification of agricultural practices. Changes in the demand for different products and the exposure in recent decades to world commodity prices has led to changes in the products being grown in different regions. In some areas this has added pressures to remove and degrade remnants of native vegetation and wetlands.

A major recent example is the rapid conversion of large areas of former sheep grazing land on the northern and western plains to carry grain crops (S. Mudford pers. comm.). Previous land management had maintained areas of native grasslands and grassy woodlands which were used for low-intensity sheep grazing. The consistent sheep grazing had removed some grazing sensitive indigenous plant species since European settlement, but a number of native plants and animals were able to survive low grazing regimes. Conversion to cropping drastically reduces this diversity and leaves only a few very hardy native species to survive. Similar changes have occurred in recent times, with the extension of Blue Gum eucalypt plantations in western Victoria, the expansion of vineyards and the government planting of the pasture grass and environmental weed Phalaris on native pastures in hill country (R. Waterman pers. comm.; Waterman 1999).

In addition, increasing urbanisation with increasing population has led to the direct destruction and degradation of habitat by housing, infrastructure construction, industry development and the subdivision of farms and bushland into rural residential blocks.

In tandem with these direct effects, degradation and fragmentation of habitat increases the probability of, and rate of, weed invasion into remnant areas of native vegetation. In some cases it also increases populations of feral animals such as rabbits and foxes.

Steadily rising human demand for fresh water continues to incrementally degrade rivers, streams and wetlands.

On public land managed for wood production, there is a trend towards more intensive forestry operations, with mechanical thinning of trees, and, in some areas, reduced logging rotation times (e.g. Commonwealth 1996b). In some forest types the regeneration techniques favour regeneration of some tree species over others (Woodgate et al. 1994).

The combined consequence of these processes is an incremental reduction in the diversity of native species through the settled areas of Victoria. Once common species become rarer; rare species become threatened. Local and regional extinctions occur. The exceptions are the 'increasers', native species favoured by the changes in land use noted above. In some cases these species become either environmental problems themselves or economic pests.

This continual incremental loss is difficult to slow. Each change may have only a small environmental effect. While Victoria has unprecedented economic strength to deal with environmental problems, many of the problems such as weed control and increasing salinity are extremely expensive to combat. An expanding human population also creates direct and difficult conflicts between conservation values and human demands, particularly for land use in and around urban centres and in some agricultural areas.

Current status of biodiversity in Victoria

Biodiversity is usefully defined as 'The variety of all life forms – the different plants, animals and microorganisms, the genes they contain, and the ecosystems of which they form a part' (Commonwealth 1996a). The status of biodiversity can therefore be analysed at three different levels: genetic diversity, species diversity and ecosystems. Each of these is discussed further below.

Genetic diversity

Genetic diversity is the diversity in the genes of living organisms. This may vary greatly within a species or even with a single population of a species. For example within a population of River Red Gums there may be considerable variation in the degree to which individual trees survive in very dry or very wet conditions, variation in tolerance of salinity, variation in susceptibility to insect pests, variation in form, ultimate size and growth rates and other factors. This variation often enables the species as a whole to survive in a range of sites and conditions.

Nothing is known of the genetic diversity of all but a handful of Victorian species. With the exception of these few species (e.g. Koala, Helmeted Honeyeater) the lack of knowledge prevents any specific conservation measures to conserve genetic diversity. At this time the only mechanism to attempt to broadly preserve genetic diversity is to protect populations throughout the geographic range of a species and make the assumption that this will preserve the full range of genetic diversity.

Species diversity

Diversity of species generally refers to the number of species and their densities that occur within an area. Estimates of the number of native terrestrial species found in Victoria are given in Table 3.1. The figures indicate the relatively detailed knowledge of which vertebrates (mammals, birds, reptiles, frogs and fish) and vascular plants (trees, shrubs, herbs and grasses) are present in Victoria.

Invertebrates and non-vascular plants (mosses, lichen, algae, fungi) remain very poorly known. Many species are still undescribed and for most species there is no information on their distribution or habitat requirements beyond those sites where specimens have been collected. For only a very few species in particular groups (e.g. butterflies) sufficient information is generally available to make judgements on their status.

Table 3.2 shows the number of native species and sub-species currently listed as threatened in Victoria. The strong bias towards vertebrates and vascular plants is likely to be due to lack of knowledge, rather than lack of threatened invertebrates or non-vascular plants.

In addition to the lists derived administratively, 282 taxa (species, sub-species and populations) are listed under the state *Flora and Fauna Guarantee 1998*. This bestows specific legal protection as discussed briefly in the introduction.

Table 3.1: Number of native terrestrial species in Victoria

Key: # = Invertebrates and non-vascular plants underrepresented due to lack of knowledge

Taxonomic group	Number of species	Source
Mammals	91	Menkhorst 1995
Birds (excluding sea birds & vagrants)	approx. 330	Emison et al. 1987
Reptiles	149	DNRE 2000
Frogs	55	DNRE 2000
Fish (freshwater)	50	DNRE 2000
Invertebrates# (insects, spiders, worms, snails etc.)	no estimate for Victoria probably in high tens of thousands	
Vascular plants	4336	DNRE 2000
Lichens#	approx. 900	G. Scott pers. comm.
Mosses & liverworts#	approx. 1500	G. Scott pers. comm.
Algae#	?1000	T. Entwhistle pers. comm.
Fungi#	?35,000	T. May pers. comm.

Table 3.2: Number of threatened terrestrial taxa in Victoria

Key: * = 'Threatened', includes 'Critically Endangered', 'Endangered' and 'Vulnerable' categories
** = 'Near Threatened/Data Deficient', includes 'Lower Risk – Near Threatened', 'Rare' 'Insufficiently Known' and 'Data Deficient' categories
# = Invertebrates underrepresented due to lack of knowledge

Sources: DNRE 1999a (vertebrates); DCNR 1995b (invertebrates); DNRE 2000

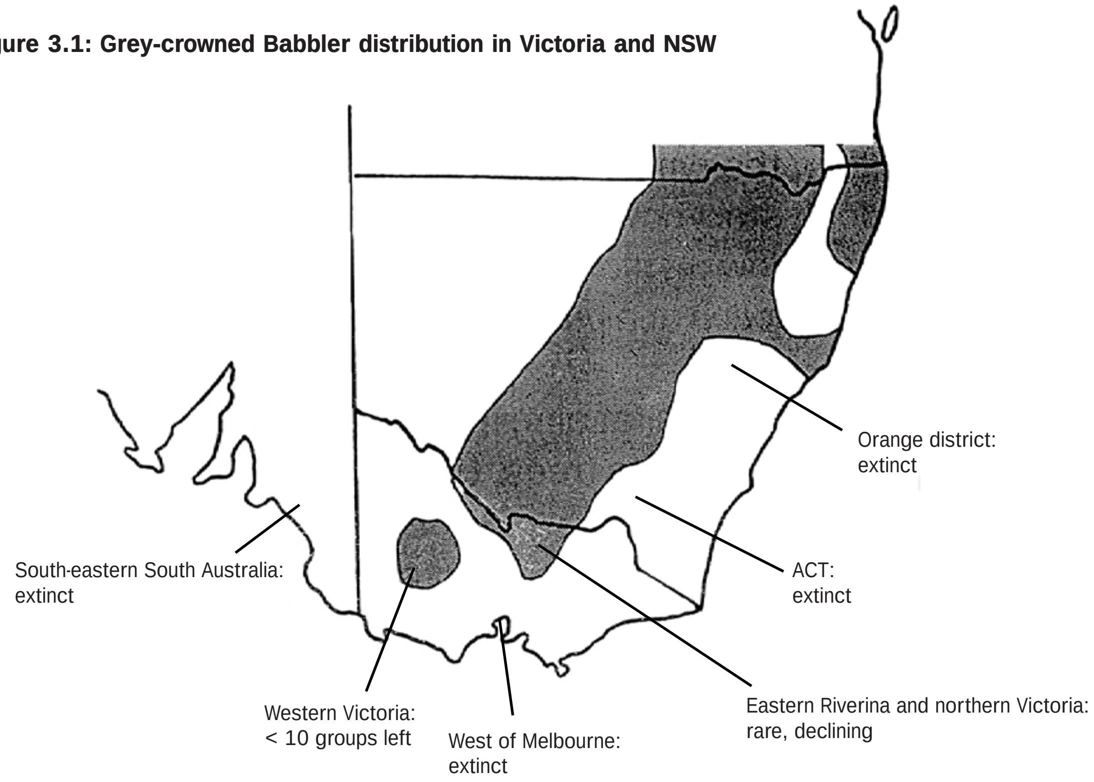
Taxonomic group	Extinct	Threatened*	Near Threatened/ Data Deficient**
Mammals	20	23	16
Birds	1	74	19
Reptiles	1	27	4
Frogs	0	10	0
Fish (freshwater)	1	18	9
Invertebrates#	1	25	41
Vascular plants	33	613	857

As well as the existing threatened species, many others are continuing to decline in all or parts of their range. At current rates of loss these will become officially listed as 'Threatened'. A well-documented example is the continuing decline in range and abundance of many woodland birds. A number of formerly widespread species such as Speckled Warblers, Hooded Robins and Diamond Firetails are now declining throughout their range nationally, and in Victoria (Robinson & Traill 1996; Reid 1999; Traill & Duncan 2000). Some species, such as Grey-crowned Babblers (Figure 3.1), are now highly threatened in the state. Others, such as Hooded Robins, remain widespread but are declining and are likely to continue to do so at current rates of loss.

These declines are occurring as small populations progressively die out in remnant woodlands left after clearing for agriculture (Reid 1999). Degradation of habitat by factors such as weed invasion, firewood collection, logging and overgrazing exacerbate this problem (Yates & Hobbs 1997).

Similar patterns of decline are known to be occurring or are likely to be occurring in other groups of species, particularly those found in landscapes that have been highly altered by clearing for agriculture.

Figure 3.1: Grey-crowned Babbler distribution in Victoria and NSW



Source: NSW Birds Atlassers Inc. and D. Robinson pers. comm.

Ecosystems

Ecosystems are the third level of biodiversity. Ecosystems are the plants and animals of an area together with the non-living environment, such as soils, in which they interact. In recent years conservation efforts have been increasingly focused at this level, rather than at preserving single species (e.g. Noss 1996; DNRE 1997). Preservation of whole ecosystems is more likely to produce long-term gains than protection of only the species for which information is available. In practice, a subset of ecosystems – *ecological communities* – are usually identified in Australia as the biodiversity unit for which adequate conservation is sought. Ecological communities are simply distinct groups of plants and animals which co-occur. As of November 2000, 23 threatened communities are listed under the *Flora and Fauna Guarantee Act* (M. O'Brien pers. comm.). Worrying enough as this is, it represents only a small proportion of the threatened ecological communities in Victoria. The conservation of ecological communities in Victoria is dealt with at length in Section 3.6. That section discusses the conservation status of different ecological communities, the current reservation levels of different communities and makes recommendations on future requirements for reservation.

3.3 Human land use and major threats to biodiversity

Of the 22,787,000 ha in Victoria, 15,242,000 ha is now privately owned freehold land. This constitutes 66% of Victoria's area (Woodgate & Black 1988). More than 90% of public land remains with some form of native vegetation or wetland. Only 6% of private land retains native vegetation or wetlands (approximately 935,000 ha) (Woodgate and Black 1988; DNRE 1997). Previous patterns of human land use mean that the remaining natural habitat occurs disproportionately across the state.

As discussed in Section 3.2, incremental changes to the environment continue. The major current threats are listed and discussed briefly here. They are not given in any priority order.

Habitat destruction

'Clearing' of native vegetation and draining of wetlands for agriculture, urbanisation, mining, infrastructure (roads, pipelines etc.) and plantation development continues in Victoria. The Australian Bureau of Resource Sciences estimates that 2450 hectares were cleared each year in Victoria between 1990 and 1995 (Australian Bureau of Resource Sciences 1999). This is the latest available official figure. More recent information shows that clearing applications for 2183 hectares were referred to the Victorian Department of Natural Resources and Environment (DNRE) between 1 April 1997 and 30 March 1998. Of these, 1018 hectares (47%) were approved for clearing (120 out of 147 applications, an approval rating of 82%). This does not include applications for clearing less than 10 ha, which are handled by local government (no information available), illegal clearing or clearing for purposes exempt under the Act.

These figures indicate that the annual clearing rates for Victoria are over 2000 hectares. However, the small, incremental nature of much deliberate clearing means that clearing is not likely to be recorded in official applications. A more likely figure is around 3000 ha each year (R. Waterman pers. comm.). In addition to this active clearing there remains the ongoing losses through the degradation of vegetation by factors such as weed invasion, and the loss of remnant vegetation by salinity. A major incremental loss to be seen starkly in the coming decades is the lack of recruitment to replace ageing trees in agricultural land.

Balanced against these losses are revegetation works with indigenous plants and natural regeneration of previously cleared areas. To be successful as long-term revegetation, plantings need to become self-perpetuating: maturing and setting seed which successfully establishes itself. Unless this occurs plantings will eventually die and need to be replaced by further assisted plantings. Changes in soils and the presence of dense weed swards make such self-perpetuating revegetation unlikely in many areas where indigenous vegetation has been planted. The actual figure for plantings that will become self-replicating is likely to be in the low hundreds of hectares per year. On some areas of poor soils, and steep country such as ridges in box–ironbark country, East Gippsland and parts of the Strzelecki Ranges, natural regeneration of native vegetation is occurring slowly over significant areas of previously cleared farmland (pers. obs.; Woodgate & Black 1994). No accurate figures are available on how much land is naturally regenerating. For both plantings and natural regeneration the regrowth will not contain the full complement of native plants or animals found in mature uncleared vegetation in the short or medium term (100–200 years).

Environmental weeds

After direct destruction of habitat, environmental weeds are probably the single most important cause of habitat loss and degradation in Victoria at present. In the medium and long term they are likely to be the most important cause of degradation (Wilson 1996; Carr 1993; Low 1999). Severe weeds such as Blackberry, English Broom and Phalaris have the potential to completely alter ecosystems by replacing all or most existing native plants and preventing future regeneration. The effects cascade through to all native plants and animals in weed-invaded areas.

Currently, naturalised plants comprise approximately 30% of the total Victorian flora. Carr *et al*. (1992) listed 584 serious or potentially serious environmental weeds in Victoria, 129 of which were rated as very seriously invasive in indigenous vegetation. Naturalisations of new species are estimated to increase at around eight species per year (Carr 1993).

In addition to directly replacing native species, environmental weeds can impact on other ecosystem processes and functions. Displacement of deep-rooted perennial native species by annual or shallow-rooted weed species can alter hydrological patterns and changes in fuel loads and flammability can affect fire regimes. Stream flows and flooding characteristics can be altered (e.g. as a result of willows invading streams). Geomorphic processes such as erosion and dune formation may also change (Environment and Natural Resources Committee 1998).

Weeds are typically perceived by the general public as a generic category, but different species may be regarded as weeds in different situations, and may be perceived differently by different individuals and interest groups. Some weed species, such as Blackberry, St Johns Wort and Chilean Needle-grass, cause economic agricultural problems, an environmental problem for native vegetation and even a garden weed in some areas. Yet others, such as Bridal Creeper, English Broom, Tall Wheat Grass and Phalaris may be valued as garden or agricultural plants but be severe environmental weeds in some types of native vegetation. This can lead to direct conflict between agricultural and environmental interests. Sowing of Phalaris and Tall Wheat Grass is currently encouraged and subsidised by Agriculture Victoria, despite being identified as severe environmental weeds which directly affect some threatened plant species (Environment and Natural Resources Committee 1998).

Despite the severity of the problem, the effects of environmental weeds have been consistently underrated by governments, most non-government conservation groups and individual conservationists, and the general public. In part, this may be because of the relatively slow nature of change, in human terms, caused by weeds. Changes that take a year or more can give the illusion of little cumulative effect. As well, areas of woodland and forest are often perceived to be in a natural state when in fact all, or most, of the understorey vegetation may be introduced weeds with only the easily recognisable eucalypts and acacias indigenous.

More recently the profile of the problem has increased. The report into weeds by the Victorian Parliamentary Committee (Environment and Natural Resources Committee 1998) made a number of recommendations to improve weed control. The Department of Natural Resources and Environment has produced a *Victorian Weeds Strategy* (DNRE 1999b). The book *Feral Future* by Low (1999) examines the nationwide scale of weeds and feral animals.

The weed problem requires attention on two fronts. First, further invasions into the state must be prevented. Second, existing environmental weeds must be controlled, contained and, if possible, eradicated. Specific recommendations on weed control are discussed further in Section 3.7.

Feral animals

Feral animals are often targeted as being key causes of decline in biodiversity. Introduced herbivores such as rabbits, hares, feral goats, cattle, horses and pigs certainly can cause significant impacts on some vegetation types, as well as constitute an economic pest. Increasingly, it is recognised that high densities of certain native herbivores, such as Koalas and kangaroos, will also damage some native ecosystems.

However, for the impact of most or all introduced *non-herbivores* there is a lack of detailed evidence. Foxes and cats are frequently demonised for devastating native wildlife but there is little evidence that they are currently a significant problem for *populations* of more than a handful of existing native species in Victoria. Nationwide there is reasonably strong evidence that foxes, and sometimes cats, can reduce the populations of some small ground dwelling mammals. However, most of these species such as Rufous Bettongs and Tasmanian Pademelons are now extinct in Victoria. Well-organised fox control programs may assist in specific areas for protection of small existing populations such as the endangered Eastern Barred Bandicoot. However, it is not clear that the current broadscale fox control programs currently promoted by DNRE and commercial poison bait manufacturers have any beneficial effects in either consistently reducing fox populations or assisting existing populations of native birds and mammals. In fact, populations of one endangered native carnivore, the Tiger Quoll, are likely to have been reduced by these programs (Murray 1996; Belcher 2000).

Carp cause considerable changes in water quality through disturbing sediments and eating water plants. This may impact on other plant and animal species (Cadwallader & Backhouse 1983). Trout are a significant predator on some native fish, including the endangered Double-barred Galaxid. However, as predators they do not alter the habitat of the rivers they inhabit, as do carp. Their environmental effects are therefore less severe (Cadwallader & Backhouse 1983).

For most other introduced animals any known impacts are localised and specific, such as possible competition by Indian Mynas with native birds for nesting hollows in urban areas (Pell & Tidemann 1997). It is possible that impacts may occur that are difficult to quantify. Introduced slugs are known to cause heavy grazing pressure on some rare native herbs in native grasslands (e.g. the Sunshine Diuris, *Diuris fragrantissima* [DCNR 1993]). The introduced European Wasp has spread rapidly into some types of bushland. It may predate heavily on some species of native invertebrates (pers. obs.).

Ill-considered introductions continue to occur and to be proposed for Victoria despite Australia's long history of disastrous introductions. A deep-burrowing earthworm was introduced by farmers into the Western District of Victoria from Tasmania in 1998. This could potentially alter soil conditions and affect native plant and animal species in native grasslands (T. Barlow pers. comm.) European Bumblebees have been recently proposed for introduction to mainland Australia to assist in pollinating tomato crops. They could increase the spread of some environmental weeds by increasing their pollination rates (Hingston & McQuillan 1998).

As for weeds a key requirement is the prevention of further invasions into Victoria of new species which could become environmental problems. Second, adequate control, if possible, is required for particular existing problem species. Specific recommendations on feral animal control are discussed further in Section 3.7.

Logging and firewood removal

Logging of native forests and woodlands occurs over approximately 40,000 ha of Victoria annually. Of this approximately 14,000 ha of forest are clearfelled and approximately 16,000 are selectively logged or 'thinned' (DCNR 1995a). Logging occurs in all regions except the Mallee. Despite claims from industry, government departments and forestry schools to the contrary, there is clear evidence that current logging techniques and volumes have significant deleterious ecological impacts through altering the structure and floristics of forests and woodlands and increasing sedimentation in streams (Ough & Ross 1992; Ough & Murphy 1997; Mueck et al. 1996; Gibbons & Lindenmayer 1995; Davies & Nelson 1994; for a lay summary of papers see Traill 1995). Logging has caused local extinctions, including in areas that have only been intensively logged for 40 years (e.g. Traill 1991; McCarthy & Lindenmayer 1996). It is reasonable to predict regional extinctions will accelerate if planned intensification of logging practices continues.

In addition to logging for woodchips and sawn timber, commercial and private collection of firewood also has important conservation impacts. Around two million tonnes is taken annually in Victoria (Read Sturgess 1995) equivalent in scale to the amount of woodchips taken from wetter mountain and foothill forests. Most firewood collection occurs in the drier, slower-growing woodlands and forests north of the Divide. Sources include fallen and standing dead timber collected from both private and public land (Wall & Reid 1993). This timber is ecologically important as habitat for a range of species; nesting sites for the endangered Red-tailed Black Cockatoo, for instance. In addition to removal of dead timber, there is increasing removal of live trees for firewood, a practice that has probably accelerated the loss of larger trees in box–ironbark and other woodlands (pers. obs.).

Overgrazing

Grazing by stock remains a significant degrading factor in many areas of native vegetation on public and private land. It is also a significant degrading factor for many wetlands and rivers. Grazing typically leads to the loss of palatable shrubs and herbs favoured by the stock and the replacement of native perennial grasses with native and introduced annual species. This in turn may reduce the diversity of native invertebrates (Bromham et al. 1999) and vertebrates (Robinson & Traill 1996). Heavy grazing also prevents the regeneration of most eucalypt species. Along streams, unrestricted stock access causes erosion of streamside banks and reduces water quality (DNRE 1997).

The effects of grazing vary greatly with the type of vegetation, the stocking rate and the season of grazing. In some lowland grasslands, reduction of native grass biomass by Aboriginal burning and/or marsupial grazing probably helped maintained plant diversity by preventing native grasses from overgrowing and smothering other native plants.

Recent studies have demonstrated the importance for nature conservation of maintaining low levels of seasonal grazing by stock on some types of lowland grasslands which have a long history of previous stock grazing, such as the grasslands of the Terrick Terrick Park (Foreman 1996; Milne et al. 1999). However, this does not apply to other grassy ecosystems, including Riverine Red Gum Grassy Woodlands or Alpine Herbfields which have native plant diversity significantly reduced by current grazing practices on private and public land, including in reserves supposedly designated for conservation (Chesterfield 1986; Williams 1990; Muir 1991; Wahren et al. 1994, 1999).

As a generalisation, grazing of any native wooded vegetation is likely to reduce plant diversity, and only some native lowland grasslands, with a previous long history of stock grazing, may require light, non-continuous grazing to maintain diversity (Lunt 1991; Barlow 1998).

Salinity

Currently around 140,000 hectares of irrigated land and 120,000 of dryland are significantly affected by salinity in Victoria (DNRE 2000a). Salt loads in many rivers in northern and western Victoria have increased greatly since European settlement, affecting aquatic life and the quality of the water for human use. Groundwater levels are rising over large areas of dryland Victoria and by 2050 a ten-fold increase in the area affected by salt is projected. At high risk are most of northern and western Victoria, and parts of the lowlands in Gippsland (DNRE 2000a). This will reduce agricultural productivity on affected areas, affect the quality of downstream water for agriculture, domestic and industrial use and the environment. The recent audit of the Murray–Darling Basin indicated that 3 to 5 million hectares of land in the Basin will become salinised in the next 100 years to such an extent that agriculture, the environment and built infrastructure will all be substantially affected (Murray–Darling Basin Commission 1999).

Salinity from irrigation is caused by excess irrigation water entering the groundwater, raising the watertable and bringing the salt-laden water to the surface. It can be managed to some extent by improved irrigation systems such as drip irrigation techniques which apply the correct amount of water in a way which maximises water use by the crop and minimises 'leakage' to the groundwater.

Dryland salinity refers to areas where the watertable reaches the surface, bringing high salt loads from sub-soil salt deposits, killing salt-intolerant plants or slowing their growth. Watertables are rising to dangerous levels in many areas of Victoria because introduced annual grasses or crops have replaced deep-rooted, perennial, native vegetation which used more water. The resulting increased 'leakage' into the groundwater raises watertables. Recent groundwater and catchment modelling indicates that current 'best practice' cannot reduce the amount of water leaking into the groundwater system to anything even approaching the low leakage rates under native vegetation. Radically new cropping systems and use of deep-rooted perennial plants are needed to reduce leakage rates to acceptable levels (Walker et al. 1999).

A consequence of both forms of salinity is that more salt from the soil is mobilised and enters river systems through groundwater and surface flow.

In eastern Australia there has been relatively little focus on the effects of salinity on nature conservation. This contrasts with the south-west of Western Australia where the salinity effects have been more widespread to date and have directly affected many areas of remnant woodland in the Western Australian wheatbelt (George et al. 1995). Particularly susceptible are remnants in lower parts of the landscape where saline watertables surface. Up to 90% of private land remnants and 50% of public land remnants in such parts of the landscape are estimated to be at risk in south-western Western Australia. Vegetation types such as River Red Gum and Black Box woodlands, which occur on low-lying land, are likely to be especially at risk in the longer term.

Increased salinity levels have already affected streams and wetlands. The Loddon and Avoca Rivers already have salinity levels greater than 800 EC (electrical current in microsiemens per centimetre) above the World Health Organisation upper limit for drinking water and a level at which damage can occur to horticultural (Murray–Darling Basin Commission 1999). The Third Marsh at the terminus of the Avoca River is already severely affected by salt. In general, though, future salinity increases for Victorian rivers are predicted to be modest. An exception is the Avoca River, in which salt levels are predicted to rise to 2040 EC in the next century (Murray–Darling Basin Commission 1999).

The solutions required to tackle salinity are complex due to the need to effect catchment scale changes in land-use. Some current practices in tackling salinity are likely on balance to be deleterious to nature conservation. Phalaris and Tall Wheat Grass continue to be promoted for salinity control purposes, including in areas with native grassland understoreys. Both these species are severe environmental weeds. In addition, some engineering solutions damage native vegetation and wetlands, pushing drainage schemes through native vegetation and draining saltwater into wetlands.

Greenhouse effect

Major changes in climate are predicted to occur within the next few decades due to an increase in carbon dioxide, methane, nitrous oxides and other greenhouse gases. The consequent enhanced greenhouse effect has the potential to be the greatest threat to nature conservation in Victoria, and of course the rest of the Earth. Current predictions of the scale of climate change vary but there is a strong consensus by climatologists that temperature change in the order of 2–5°C are likely to occur by the middle of this century (Climate Impact Group 1992).

In Australia, the CSIRO (Commonwealth Scientific and Industrial Research Organisation) Climate Impact Group estimates warming of 0.5–2.5°C in inland areas and 0.5–2.0°C in southern coastal areas by 2030. By 2070, the CSIRO scenarios suggest warmings of 1–5°C in southern coastal and inland areas (Climate Impact Group 1992). These patterns will not necessarily be uniform. Recent CSIRO modelling indicates that the El Niño Southern Oscillation may occur more regularly, every three years, rather than the present-day average of every five years. This could lead to more drought and flooding events (CSIRO 1999). In Victoria, likely patterns of change in vegetation are that sub-alpine and alpine vegetation will reduce in area or disappear as temperatures warm. Wetter foothill forests will migrate to higher altitude areas. Drier vegetation types will move southwards.

The Commonwealth Government now has a major program working on reducing Australia's greenhouse gas emissions, although part of the Australian Government's international efforts continue to be to maintain a slower rate of reduction of greenhouse gases in Australia than in other industrialised nations.

After some work in the early 1990s (Bennett et al. 1991; VNPA 1991) remarkably little detailed attention in Victoria has been paid to the likely effects of the climate changes predicted, both on nature conservation, and on economic and social aspects such as agricultural changes and rises in sea levels. Climate change is generally perceived to be a distant problem for nature conservation, compared with more immediate changes arising from habitat loss and degradation (Hughes 1998). However, the impacts are likely to be *enormous* if the climate changes predicted above occur. For nature conservation, the impacts in Victoria would dwarf in scale the combined current effects of all other human induced disturbances and effects. Very simply, for many species their preferred climatic regimes may shift into other regions, with all or part of their current distribution becoming unsuitable because of temperature and/or rainfall changes. Extensive modelling of the climatic requirements of different species was completed by the then Department of Conservation and Environment in the early 1990s. Bennett et al. (1991) used simulation models of different future climates to model the effects of 1°, 2° and 3°C temperature rises on the bioclimates of 42 species of Victorian animals. The models indicated major shifts in the climatic regimes for most species. The results from the modelling study indicated that the effects of climatic warming on fauna will be quite severe. Of the 42 species, 24 (57%) will lose between 90% and 100% of their present bioclimatic range with a 3°C rise in temperature. In a study of likely effects on eucalypt distributions in Australia, Hughes et al. (1996) came to similar findings. They examined 819 species of eucalpyts and found that 53% of species have current ranges spanning areas with less than 3°C variation in annual mean temperature, 41% with a range of less than 2°C and 25% with less than 1°C variation. Twenty-three per cent of the eucalypts had ranges where mean annual rainfall varies less than 20%.

The tolerances to climate of some native plants and animals may be wider than the climatic zones they currently occupy. However, the available data indicates that many species will disappear from some regions as changes in temperature and rainfall make areas unsuitable for life or reproduction for sensitive species. In addition to direct responses to temperature and rainfall changes the reality of changed distributions on particular species will depend on habitat determinants such as microhabitat, soil type, slope, aspect and relationships with others species. For example, the Mountain Pygmy-Possum may be physiologically able to tolerate higher summer temperatures and milder winters. However, its preferred food plants may disappear from mountains with increases in temperature. And in a warmer climate competing species such as Bush Rats may become more abundant and out-compete the Mountain Pygmy Possum for food.

Climate change is not a new feature of the environment. Recent geological time has seen regular glacial and interglacial periods during profound shifts in climate. However, two factors mean that the effects of the projected current warming are likely to be more severe than previous climatic shifts in their effects on biodiversity.

The first problem is that species may not be able to 'migrate' quickly enough to new distributions with their preferred climatic regime. The speed of the climate change is likely to be much faster than previous warming or cooling episodes. Current human-enhanced production of greenhouse gases means that the temperature changes are likely to occur at a rate much faster than previous periods of climate change. Most animals are relatively mobile. However, plants may not be able to move from areas that have become unsuitable to areas that are newly suitable. For plants, such as eucalypts, without specialised wind-borne or animal-borne agents, seeds disperse a limited distance (e.g. < 50m), grow to seed-bearing age, then disperse again to expand the distribution. In previous climate change episodes, species had some centuries to respond, sufficient time for most species to migrate fast enough to move progressively across the landscape. However, the current scenarios for rapid climate change make it very likely that such migration may not be possible for some species.

Probably of greater importance for many species is that many landscapes are now highly fragmented. Even if species had sufficient time to migrate, they may be constrained from doing so in a fragmented landscape. For example, the species remaining in fragments of Wimmera woodland are likely to have their preferred climatic conditions shift southwards. However, such dispersal cannot occur across a landscape that is now more than 95% cropping land. A likely consequence is that the current native vegetation in highly fragmented areas may partly die out due to changed climate and that there will be no dispersal into those areas of native species from nearby areas and which may find the new climatic conditions favourable. The result is likely to be an accelerating drain of species from fragmented landscapes with a concurrent increase in resilient weed species.

The greenhouse effect presents an extraordinarily difficult problem at a statewide level. The effects are caused by global emissions into the atmosphere. Only worldwide changes in lowering greenhouse gas production will reduce it. Aside from reducing greenhouse gas production, the only comprehensive statewide response is to protect as much remnant vegetation as possible to maximise the chances of protecting species. Particularly valuable are ensuring connectivity between reserves, establishing conservation reserves with long latitudinal length (i.e. north–south) and reserves with broad altitudinal and topographical variation (Hughes 1998). This will assist in providing areas within which distribution shifts can alter for as many species as possible. Specific recommendations on work required on the greenhouse effects are discussed further in Section 3.7.

Changes to water flows

Changes to the quality and quantity of water flows to streams, wetlands and estuaries is a major threat to biodiversity. This is discussed in more detail in the next section on freshwater ecosystems.

3.4 Freshwater ecosystems

The term 'freshwater ecosystems' is used here to describe what might more accurately be called 'non-marine aquatic ecosystems' in Victoria. They include rivers and streams (henceforth referred to as 'streams'), wetlands (freshwater and saline standing bodies of water such as lakes and swamps), estuaries (the interface between freshwater streams and marine systems), and groundwater.

It is difficult to establish conservation reservation figures for stream environments because water usually flows in from a wide catchment, only parts of which may be reserved. The reservation of water itself is influenced by a range of factors such as upstream impoundments and water taken off for purposes such as irrigation, both of which can greatly influence the temperature and flow.

Wetlands and estuaries are also dynamic. There is some scope for establishing their reservation status based on protection of the physical habitat where they occur, but management of feeder streams and outlets as well as the water body itself must also be taken into account when assessing their health.

Groundwater is an important freshwater resource for a number of ecosystems. In Victoria it supplies water to many wetlands such as the Ramsar-listed wetlands in the basalt plains of the Western District and some riparian and terrestrial vegetation such as River Red Gum forest. It is therefore integrally tied to the status of each aquatic system described above. The condition of groundwater resources is partly reflected in the condition of the aquatic or terrestrial systems dependent on them.

Described below are details of the current status of these aquatic systems and potential threats. Specific recommendations for freshwater ecosystems are discussed in Section 3.7.

Streams

Streams traverse all but some Mallee areas of Victoria, with 42% of the total stream length in the state occurring in cleared areas (Mitchell 1990). For this reason their conservation must be considered in the context of both public and private land management. In order to document their status, it is necessary to look at reservation both of the physical habitat of streams and of water. Discussed here are key issues relevant to the long-term conservation of streams.

Heritage rivers and catchments

A type of reservation of streams and natural catchments occurs under the *Heritage River Act 1992* which sets out specific protective controls for listed heritage rivers and natural catchments.

Currently 18 heritage river areas and 26 natural catchments areas are protected under the Act. In addition, 15 'representative streams' were identified for additional protection following recommendations by the Land Conservation Council (LCC 1991). These representative rivers were established by order of Governor in Council, not through legislation.

Neither heritage rivers nor representative rivers form a distinct reserve system in a formal way, as they overlay existing land status (in many cases parks and state forests). However, designation of these rivers and catchments does, at least in theory, provide additional protection of the riverine systems and catchments – with heritage rivers receiving more secure protection than representative rivers (Nevill 2001). As required by the *Heritage Rivers Act*, management plans are being prepared for heritage river areas and natural catchment areas. Draft management plans for heritage rivers have been released but – after 8 years – are still to be finalised. Of the 15 representative rivers, four remain without the management prescriptions or guidelines which the original LCC recommendations foreshadowed (Nevill 2001).

Riparian vegetation

Indigenous vegetation plays a major role in maintaining the integrity of the stream. It protects the banks from erosion by binding the soil with root material. Sediment, animal faeces and chemicals from surrounding agricultural or urban landscapes, are filtered by vegetation and the soil that it stabilises so that they do not directly enter the stream. Shading is provided by overhanging vegetation, maintaining a stream temperature that is suitable for aquatic organisms and shelter for species that avoid sunlight. Submerged tree roots are often used by fish and other stream animals as habitat. Trees, wood debris, leaves and bark that fall in the stream complement this habitat; leaves in particular are the basis of the food chain in many streams (Koehn & O'Connor 1990). Because native aquatic fauna have adapted to the continous leaf fall of native plant species, the major autumn leaf fall of exotic species such as willows is detrimental to native fish (O'Connor 1996). Streamside vegetation also provides habitat for invertebrates, which in turn are eaten by fish (Koehn & O'Connor 1990).

Coarse woody debris found on floodplains is also of great importance ecologically. In flood times it provides habitat for fish, aquatic invertebrates and microorganisms and traps finer debris, nutrients and sediment which are valuable to both aquatic and terrestrial flora and fauna using the floodplain. It has been estimated that the existing levels of coarse woody debris on the lower Murray–Darling basin may be only 15% of pre-European-settlement levels (MacNally & Parkinson 1999).

Protection of indigenous riparian vegetation requires that it is inaccessible to livestock. This means that it must be fenced off and water pumped to a trough to water livestock if needed. This will not only protect the vegetation but also the streambanks from trampling and stop the introduction of faeces into the stream. A useful buffer of riparian vegetation should be *at least* 20 m on either side of the stream and would ideally be much broader (W. O'Connor pers.comm.). The larger the stream and the steeper the slopes on either side, the wider the buffer required to protect the stream (W. O'Connor pers.comm.). Wider zones of vegetation also ensure that there are more natural inputs of leaves and woody debris to maintain instream habitat and nutrient cycles.

The health and extent of riparian vegetation is the best way of describing the conservation status of streams. It may be considered that a stream would require 100% of its length to be well protected by riparian vegetation for it to be considered healthy as even relatively small breaks can provide major sources of sediment (T. Doeg pers. comm.).

Environmental flows

The term 'environmental flow' is used here to describe the flow regime of a stream that maintains all the natural physical, chemical and ecological processes of that stream. These processes include channel maintenance, maintenance of pH, sediment flushing, transport of nutrients and organic matter, reproduction of plants and animals and migration of fish (an event which is often related to breeding events). An environmental flow is not a set rate of flow all year round, it must take into account natural seasonal variation in a stream. For example, flooding events that rely on high stream flows may naturally occur at a certain time of year (usually winter and spring) and these floods play a critical role in the physical and ecological maintenance of the stream and surrounding wetlands. If flood level flows are released into a stream at an inappropriate time of year (which can happen below irrigation release dams), it may fail to stimulate breeding or other important events which are tied equally to other seasonal environmental cues such as stream temperature. If a flow is too low, oxygen levels in the stream decrease, temperatures rise and saline bottom layers form where the stream is reduced to pools (Koehn & O'Connor 1990). All these changes can be detrimental to stream organisms.

Much analysis and debate surrounds the question of how much water can be extracted from a stream before compromising its effective environmental flow (see Arthington et al. 1998a; Arthington et al. 1998b; Arthington 1998c; Arthington & Zalucki [eds] 1998). Full environmental flow assessments are usually recommended to determine this but such studies are costly and time-consuming. A quicker *interim* method has been devised by Doeg (unpublished) which may be particularly useful for regional stream managers who are dealing with small streams. This is called the 'cascading seasonal flow' (CSF) method. It is designed to identify which streams are most stressed by reduced flow and to determine how much water can be taken out of a relatively natural stream before damage is done to the health of the stream. Using this method it is possible to assess the environmentally sustainable yield for any given month or season.

Water impoundments

All dams and weirs cause environmental damage. Discharges from storages that are used for irrigation purposes generally reverse natural flows. This results in high flows during summer and low flows during winter and spring. Fish-breeding and other ecological processes are disturbed by this change to natural flows (see 'Environmental flows' above). The regulation of water also prevents natural fluctuations in water levels and flooding events which play both physical and ecological roles in maintaining the health of the stream. (Koehn & O'Connor 1990).

Another problem with impoundments that have large dam walls is the formation of colder bottom layers lacking in oxygen. Water released from these impoundments is generally taken from the lower levels of the dam; the stream thus receives very cold water which can also be deoxygenated. This is a particular problem with older dams. It has has an impact on fish habitat with the low temperatures limiting the growth rates of fish and possibly resulting in breeding failure in some species if the release is during their summer breeding season (Koehn & O'Connor 1990). Impoundments may also act as nutrient traps by allowing organic particles which normally flow down the stream to settle out. This means that the productivity of the stream below the impoundment is likely to be reduced (Koehn & O'Connor 1990). The problems associated with release of bottom layer water from existing impoundments can be minimised by the retrofitting and management of variable level offtakes on existing impoundments. The water released needs to be regulated so that its temperature mimics natural temperatures (Koehn & O'Connor 1990). Newer dams such as the Thomson Dam are already equipped with these mechanisms but older dams require attention (T. Doeg pers. comm.).

Impoundments with walls of less than 2 m in height are generally referred to as weirs (although it should be noted that large walled impoundments are variously called dams or weirs). The smaller weirs can have less environmental impact than those with larger walls because they spill water over the top of the wall when the weir fills, so both the temperature of water and the season of release are slightly closer to a natural regime than in a regulated impoundment. However, any diversion or pumping of water from above the weir for irrigation or other purposes affects environmental flows. Weirs also create cold bottom layers like other impoundments. Where weirs are no longer needed, they should be removed.

The problems associated with release of bottom layer water from impoundments could be minimised by the retrofitting and management of variable level offtakes on current impoundments. The water released would need to be regulated so that its temperature mimicked natural temperatures (Koehn & O'Connor 1990).

Impoundments present a major barrier to those fish species that need to move up and down streams to spawn, recolonise areas and select suitable habitat. Some 70% of native fish species that occur in the streams that drain to Victoria's coast need to migrate at some stage in their lifecycle, but about half of these streams have been obstructed by barriers. The installation of fish 'ladders' at smaller barriers (they work most effectively where impoundment walls are less than 2 m in height (W. O'Connor pers. comm.) and at other obstructions such as causeways and road crossings, would allow fish to move over, through or around the obstacle. Some research may be required to determine suitable designs (Koehn & O'Connor 1990)

Snags

Trees and logs in streams are generally referred to as snags or 'large woody debris' (LWD). They have been removed from many Victorian streams with the intention of aiding navigation and reducing flooding. Their widespread removal from Australian streams has led to alterations in stream channel morphology (Brooks 1999a) and has been detrimental to fish species such as the Murray Cod and Blackfish which use them for habitat and spawning sites (Koehn & O'Connor 1990). Invertebrates also use them for attachment sites (NRMS & DCNR 1995). In a study on the Cann River in East Gippsland, it was found that full desnagging of a previously undisturbed channel led to a ten-fold increase in the movement of materials on the streambed. Realigning the logs to 30° from the bank was equivalent to removing 50% of the LWD (Brooks 1999a). In addition, the Centre for Applied Hydrology at the University of Melbourne concluded that there was 'little evidence to support the contention that desnagging reduces flood frequency or significantly improves conveyance' (NRMS & DCNR 1995).

Although many streams have changed fundamentally since European settlement and cannot be restored to a pre-European condition (Brooks 1999b), there is scope for stabilisation of streams. The simplest actions are to halt all removal or realignment of snags and to protect or restore riparian vegetation so that there is a natural source of LWD for the stream in the future.

Channelisation of streams removes most instream habitat for fish. The high water velocities associated with uniform channels can also prevent the passage of fish (Koehn & O'Connor 1990). As such, channelisation should not be undertaken on streams.

Water quality

Pollution of streams and other water bodies with excessive loads of nutrients, salts and agricultural/industrial chemicals can have a serious impact on aquatic life. As indicated above, restoration and maintenance of riparian vegetation can play a critical role in filtering out many of these pollutants. However, additional measures are often required where the pollutant originates from sewage, saline groundwater which is disposed of in streams, salinisation of surrounding land through vegetation clearance, and direct discharge of chemical pollutants into streams. To this end, sewage treatment plants in some cases should be upgraded, policies should be developed to eliminate the impact of saline groundwater disposal in streams and wetlands, and pollution discharge licences should be tightly regulated and monitored.

Other issues

Exotic freshwater aquatic organisms have some negative impacts on natural ecosystems but these are minor relative to the habitat conservation issues described above. As such, the problems they cause should be addressed *after* the major issues have been effectively tackled.

Twelve species of introduced fish are found in Victorian waterways. The main impacts of these exotic species on native fish are predation and competition. Brown and Rainbow Trout and Redfin are widely distributed and are serious predators, with native fish possibly forming a large part of their diet. There has been a documented fragmentation of the distribution of Mountain and Climbing Galaxids as a result of trout predation, and trout and Redfin appear to be a threat to the Australian Grayling. Another introduced species, the Mosquitofish, is also a predator. Based on its behaviour in Africa and Asia, it is likely to eat fish eggs and young of native fish. The diets of trout and Redfin, and to a lesser extent Carp, overlap those of some native species so they provide direct competition (Koehn & O'Connor 1990). Carp may also impact on aquatic habitat by disturbing stream bottoms (W. O'Connor pers. comm.).

Summary of the condition of streams throughout the state

The least disturbed river basins are in the south-east of the state. They include the East Gippsland, Snowy, Tambo, Mitchell and Thomson basins. These streams have >80% of their length in excellent or good condition (Mitchell 1990). The condition of these catchments reflects both their remoteness and the mountainous nature of the basins. Clearing this landscape for agriculture has always been limited because of the difficulty of human access.

River basins that have 51–80% of stream length in excellent or good condition are the Upper Murray, Kiewa and Ovens (all in the north-east of the state), the Goulburn, Yarra, La Trobe and streams in the Otway Ranges. In the next category are basins with 31–50% of stream length in excellent or good condition (this includes the Barwon, Werribee, Bunyip and South Gippsland). The most disturbed basins, with <30% of stream length in excellent or good condition, are the Campaspe, Loddon, Avoca and Wimmera (Mitchell 1990). The gradations of disturbance clearly mirror the accessibility of these landscapes for agriculture and associated clearing of vegetation. In addition, where agriculture and urban areas can be readily established, water impoundments, weirs and modifications such as channelisation and snag removal are more likely to impact on streams.

Wetlands

Ecological Vegetation Class (EVC) mapping has been undertaken for Victoria's wetlands but is highly variable in its resolution across the state (D. Parkes pers. comm.). The EVC data that is available on extent and reservation of wetlands is listed in Section 3.6. Another classification system based largely on hydrology has been employed in the survey of Victoria's wetlands over many years. This is included here as it provides a useful statewide perspective on wetland protection. Categories are defined by salinity, period of inundation and the persistence of vegetation types (A. Corrick pers. comm.). It should be noted that another classification system is currently being investigated that reflects the invertebrate composition of wetlands (R. Butcher pers. comm.). However, the following categories are in common usage at the time of this report (DNRE 1997):

- Freshwater meadows
- Shallow freshwater marshes
- Deep freshwater marshes
- Permanent open freshwater wetlands
- Semi-permanent saline wetlands
- Permanent saline wetlands

Since European settlement there has been a dramatic reduction in wetland area. Major losses have been in:

- Freshwater meadow (43%)
- Shallow freshwater marsh (60%)
- Deep freshwater marsh (70%) (DNRE 1997).

More significant than this is the proportion of the original wetland type that has been modified by partial drainage or some other alteration to the water regime. The total areas lost or modified are:

- Freshwater meadow (65%)
- Shallow freshwater marsh (75%)
- Deep freshwater marsh (84%)
- Permanent open freshwater (60%)
- Semi-permanent saline (31%)
- Permanent saline (61%). (DNRE 2000b)

Some categories have 'recruited' modified wetland types, for example creation of farm dams has resulted in a net increase in the area of permanent open freshwater (DNRE 2000b). However these 'recruited' wetlands are generally of low ecological value as they have unnatural water regimes and lack the habitat diversity of natural wetlands (DNRE 1997).

As with streams, both the management of the catchment that feeds a wetland and the status of the land immediately surrounding a water body need to be taken into account in order to develop a picture of the conservation status of wetlands. The main factor that has led to loss or modification of wetlands is drainage, with most of the decline being on private land. The areas most affected are in south-western Victoria and the irrigation areas around Shepparton and Kerang. Other factors that have modified water regimes are lowered or raised watertables, construction of levee banks, the use of wetlands for water storage or waste water disposal associated with irrigation and drainage schemes, and urban development. Land clearing, overstocking and inappropriate use of fertilisers and irrigation waters have been the cause of rising watertables, sediment run-off, excess nutrient run-off and salinity. These impacts are detrimental to the ecology of wetlands (DNRE 1997). A number of government and community initiatives have been taken to protect and restore wetlands (see DNRE 1997).

Table 3.3 presents a statewide summary of the extent of each wetland category on private and public land (DNRE 2000b). Figures are not available for the reservation status of wetlands using the categories shown. Generally wetlands on public land will be better conserved than those on private land.

Restoration of wetlands may usefully restore part of Victoria's original wetland estate. Restoration of water flows can often be achieved through engineering works such as removing drainage channels. However, restoration of indigenous vegetation is not always straightforward in wetland sites. The invasion of weeds such as Phalaris may require that a livestock grazing regime is employed for at least part of the year initially, to suppress weed growth and allow full or partial recovery of indigenous grazing pastures for species such as swans and coots. Manipulation of hydrological regimes may be preferable as a technique for control of weed species (e.g. Spiny Rush). Fencing in close proximity to wetlands creates a hazard for young

Table 3.3: Statewide summary of wetland extent

Wetland category	Public wetlands (ha)	Private wetlands (ha)
Freshwater meadow	36,465	78,636
Shallow freshwater marsh	20,869	33,523
Deep freshwater marsh	34,164	19,617
Permanent open freshwater	173,689	16,520
Semi-permanent saline	49,510	18,366
Permanent saline	145,069	2938

birds learning to fly and for some larger birds such as swans, pelicans and brolgas (A. Corrick pers. comm.), so the placement and design of fencing to exclude livestock must be carefully considered.

Recreational duck shooting on wetlands affects both target and non-target bird species. Shooting seasons are regulated to fall between, and avoid, the moulting season earlier in the year and the breeding season which begins for some species soon after May (A. Corrick pers. comm.). It is essential that hunting seasons are not extended to avoid conflict with these events when birds are extremely vulnerable. Another related issue is the poisoning of waterbirds by ingested spent lead shot used by hunters (DNRE 1997). Lead shot is currently being phased out in favour of non-toxic shot.

Estuaries

Estuaries are the partially enclosed bodies of water at the mouths of rivers. Freshwater and saltwater mix in these areas and they are influenced by tides (Meagher 1991). They basically start where truly freshwater streams end, and finish where the marine system is dominant. As such they have a range of salinities. What may be perceived as the lower freshwater reaches of a stream will sometimes be freshwater with a saltwater wedge in the bottom layers even in flood (D. Tiller pers. comm.). Victoria has many small estuaries with ephemeral entrances and they are either river- or tide-dominated. Others are small wave-dominated lagoons (NLWRA 2000a).

Relatively little research has been undertaken on estuaries. The Freshwater Sciences Unit at the Victorian Environment Protection Agency (EPA) are involved with an ongoing study of 30 estuaries along the Victorian coast. By monitoring temporal differences in these estuaries it will be possible to determine appropriate management. This study has already found that the higher the human-generated impacts on an estuary, the greater the loss in its quality (D. Tiller pers. comm.).

The Victorian Environment Protection Agency is also involved in a national assessment of the health of estuaries through the National Land and Water Resources Audit (NLWRA in prep.). The factors identified by the audit as contributing to loss of health in an estuary are:

- the loss of natural vegetation cover in the catchment
- changes in the hydrology of the catchment e.g. presence of water impoundments
- land use disturbance in the catchment e.g. agricultural activities, urbanisation
- impediments to natural tidal flows such as causeways and bridges
- dredging, filling in and artificial training of estuaries e.g. construction of marinas, ports and canal estates
- disturbance to floodplain and estuarine ecology
- overexploitation of fish resources
- presence of aquaculture
- and presence of pests and weeds in the estuary
- weeds in the catchment (NLWRA in prep.; NLWRA 2000a; NLWRA 2000b).

Estuaries in western and central Victoria are modified to varying degrees by urbanisation and industrial, agricultural and forestry activities in the adjacent catchments. Some eastern Victoria estuaries are in near pristine condition and are largely protected within national parks, for example, Mallacoota (NLWRA 2000a).

The Museum of Victoria is currently characterising the physical features, fauna and mixing of water in a sample of estuaries along the Victorian and southern NSW coasts (J. Moverley pers. comm.). The study indicates that environmental conditions at a site will vary hourly according to the tides and seasonally with rainfall. Sometimes chaotic long-term changes occur associated with unusual rainfall patterns. As a result, unique communities of plants and animals occur in these highly variable environments (Museum of Victoria 2000).

The Museum study suggests that monitoring programs are important to ensure the maintenance of healthy estuaries. Such programs can look directly at the animal and plant communities, or the physical and chemical variables that influence them to ensure that these are within the range normally experienced by the natural community. Communities that are frequently used in monitoring programs are macrobenthos, plankton, fish, birds and single-celled diatom plants. Macrobenthos (the larger animals such as worms and shrimps that occur in or close to the sediment), may be the best community to monitor because they are relatively simple to sample, many of the benthic animals have limited mobility, short-term pollution events will be detectable in the benthos for some time and concentration of pollutants is likely to occur there. Benthic organisms show a response to pollutants before the animals in the water column (Museum of Victoria 2000).

Groundwater

Groundwater is the water found in the saturated zone below the watertable (NCCNSW 1999). An ecosystem that uses groundwater is described as a 'groundwater dependent ecosystem' (GDE). Hatton & Evans (1998) define four types.

These are:

- terrestrial vegetation dependent ecosystems (use groundwater via the root system)
- river baseflow dependent ecosystems (streams dependent on groundwater inputs)
- aquifer and cave ecosystems (where plants and animals live within aquifers or cave systems)
- and wetland ecosystems (watertable always or periodically at the surface from groundwater discharges).
  (NCCNSW 1999 for information in parentheses).

Management issues faced by GDEs involve both the quantity and quality of groundwater available. Pumping groundwater to the surface for domestic, agricultural and other purposes obviously depletes the supply for GDEs, potentially affecting many components of the ecosystem. Land practices such as vegetation clearance that lead to saline watertables will reduce the quality of water available to a GDE. Similarly, seepage of above-surface pollutants such as fertilisers or septic waste will contaminate groundwater. Little information is available on GDEs in Victoria and research is needed to identify ecosystems dependent on groundwater.

3.5 Private land conservation

In Victoria, private land comprises a large and significant area (approximately 800,000 ha of forest and woodland and approximately 135,000 ha of wetland [DNRE 1997]). More important than the gross area, though, is that many of the rarest and most threatened ecosystems and species are now largely or totally found on private land or small remnants of public land on roadsides, streamsides or cemeteries. These latter areas may be leased or managed by private individuals, local committees, or statutory authorities with little knowledge or expertise of management for conservation.

Current programs and trends

Australia generally has a poor record of conservation on private land. While world leaders in many ways in public land conservation, models and practice of private land conservation in Australia are behind that of many other first world countries, particularly some European countries and the United States. For example, in the United States the non-government Nature Conservancy has protected more than 12 million ha in the US and more than 61 million ha outside the US. It is one of the largest landholders in the world (Nature Conservancy 2001). After the US military, it is the second largest landholder in the country. There are also several hundred smaller state and regional land trusts which protect large areas. Victoria has been fortunate, though, in being a leader among Australian states in private land conservation with the innovative Land for Wildlife and Trust for Nature programs. Along with South Australia it also has the only native vegetation clearing controls that have been (mostly) enforced on the ground.

This clearing control legislation and the two programs currently underpin private land protection in Victoria and are discussed briefly here.

Vegetation clearing controls

In 1989 planning provisions were amended to regulate clearing of areas greater than 0.4 ha. Local councils are responsible for administration of the planning controls, with applications greater than 10 ha requiring referral to the Department of Natural Resources and Environment (DNRE) for advice. In practice, most councils rely on DNRE for advice on approvals. The advice of DNRE has varied with the officers involved and with the local and state politics of the day. In at least a few cases there has been direct Ministerial intervention to ensure that permits are granted (eg granting of permits in 1996 by the Kennett Government for extensive clearing for plantations by the paper company Amcor in the Strzelecki Ranges, overruling an Administrative Appeals Tribunal decision). However, the controls have generally been upheld. Prior to the introduction of the controls the average rate of clearing on private land in Victoria was at a high rate of 15,000 ha each year. It is now probably around 3000 ha a year

(R. Waterman pers. comm.). At the time of writing new regional native vegetation plans are being drafted and changes to planning provisions are being considered which may alter the way in which clearing controls are enforced (DNRE 2000c).

Trust for Nature

The Trust for Nature (Victoria) is an independent statutory body established in 1972. It operates under a voluntary board appointed by the Minister for Conservation and receives both public donations and government funding.

The Trust's charter is to promote nature conservation on private land. On the ground it focuses on achieving permanent protection of significant areas. This is done through land purchases and conservation covenants. Purchased land is bought on the open market. It is either retained and managed by the Trust, passed on to the government for inclusion in reserves, or re-sold with a protective covenant in place. The money from the latter process (the 'Revolving Fund') is then used to purchase further properties at risk.

Conservation covenants are management agreements between a landowner and Trust for Nature. While entered into voluntarily, once placed on the land title they are binding on the current and all future owners. The covenants work by prohibiting or controlling certain activities such as logging, grazing, clearing, subdivision and planting of environmental weeds. The covenants can also include proactive management clauses such as the use of certain grazing practices to maintain lowland grasslands. Each covenant is negotiated individually, although most provide for a residence and garden to be placed on the land. Staff from the Trust periodically visit covenanted properties to ensure that the covenant is being upheld. In cases of breaches of covenants the Trust has recourse through the civil courts for breach of contract.

In its early years the Trust had not attempted to focus on the most threatened habitats. This has altered since the early 1990s and the Trust now has proactive programs aiming to achieve protection on grasslands, grassy woodlands and other highly threatened habitats.

As of June 2000, the Trust had protected 23,579 ha of habitat. This includes 138 purchased or donated properties covering an area of 10,051 ha and 333 covenants covering an area of 13,528 ha (P. Foreman pers. comm.). This is not distributed equally around the state. A disproportionate number of covenants occurs on non-farming, rural residential blocks, which are patchily distributed in different regions (Fitzsimons 1999).

Land for Wildlife

Land for Wildlife is a voluntary, non-binding scheme which provides recognition of conservation work by owners, a network of other interested landowners and extension support and management advice. The scheme is run by DNRE. A team of regional staff assess Land for Wildlife properties and provide advice to landholders. In addition, an excellent regular newsletter provides high-quality information on managing land for conservation. As participation is voluntary, landowners can leave the scheme if they wish and Land for Wildlife status does not automatically switch to new owners. The scheme has the highest participation rate of any private land conservation scheme in Australia. As of July 2000 there were 5083 properties, totalling 518,465 ha, 137,772 ha of which are being managed as wildlife habitat (117,695 ha with existing habitat and 20,118 ha being restored) (F. Nicholls pers. comm.).

Other programs

There are now a range of other organisations and programs carrying out conservation work on private land. The Landcare movement has been instrumental in improving land management since its inception in Victoria in the 1980s. Currently there are 890 Victoria Landcare groups. A 1999 survey indicated that three million trees and shrubs were established by Landcare groups in 1998 and 4500 km of fencing was erected for Landcare (Curtis & Van Nouhuys 1999). Curtis and Van Nouhuys estimated that the 197 respondent groups had protected 806 ha of remnant vegetation and riparian strips. Groups also undertook significant amounts of erosion and salinity control work and control of feral animals and pest plants. While the majority of the work completed or encouraged by Landcare groups is of value directly or indirectly to nature conservation, some aspects can be deleterious, for example, sowing 'improved' pastures in areas of native grassland. Recent evidence indicates that Landcare groups are suffering from insufficient administrative and other support leading to burn-out of volunteers and reduced effectiveness of results (Curtis & Van Nouhuys 1999). This may affect the long-term sustainability of the movement.

Greening Australia (Victoria) is a non-government organisation which carries out a range of conservation works to achieve sustainable land and water management. This includes a range of extension, education and revegetation programs. The principal focus is on revegetation works but Greening Australia also does some work on fencing and protection of remnant vegetation (Greening Australia 1998).

Due to the close proximity of the successful Bookmark Biosphere Reserve in the South Australian Riverland, Biosphere Reserves are often discussed in the context of private land conservation in Victoria. The Biosphere Reserve concept arose from the United Nations 'UNESCO Man and the Biosphere' program in 1968. The concept was to designate significant terrestrial and coastal sites within which three related functions would occur: conservation; development that was culturally, socially and ecologically sustainable; and logistic support for research, monitoring, education and information exchange related to conservation and development (Bookmark Biosphere Trust 1997).

There are 12 designated Biosphere Reserves in Australia three of which are in Victoria: Croajingolong, Wilsons Promontory and Hattah–Kulkyne. While these Victorian Biosphere Reserves exist in theory, in practice their designation has had no discernible effect on management or protection of these areas. In the South Australian Riverland, adjacent to the north-west corner of Victoria, is the Bookmark Biosphere Reserve which has an active management program administered through the Bookmark Biosphere Trust. The 13 members of the Trust are appointed by the South Australian Environment Minister. Within the reserve are both public and private lands. The Biosphere Trust acts as a co-ordinating body for work and obtains both government and private funding to maintain administrative needs and complete on-ground works. Lands included in the reserve do not necessarily meet IUCN reserve standards.

Unless a similar approach is made in Victoria, having Biosphere reserves on paper will remain irrelevant to achieving any conservation outcomes.

Private conservation co-operatives protecting private land have also been active in some parts of Victoria. The co-operatives are set up under the *Victorian Co-operatives Act 1994*. The typical approach has been for a group of individuals to purchase a piece of land at risk and manage it passively for conservation. Members may have the camping rights on the land. New members pay a non-refundable fee to join the co-operative and may pay an occasional small levy fee. Often the protected status of the land is confirmed by placing a Trust for Nature conservation covenant on it. Four such conservation co-operatives are known from Victoria protecting several thousand hectares of land. If promoted they have the potential to increase rapidly as they offer an immediate positive result for conservation-minded people who cannot afford to buy their own land.

In addition to smaller private co-operatives there are now larger conservation organisations set up specifically to purchase and protect private land in other states. The two national organisations focused on this work are the Australian Bush Heritage Fund and Earth Sanctuaries Pty Ltd. The Australian Bush Heritage Fund currently has 11 properties nationally. It targets the purchase of highly threatened ecosystems. It has yet to purchase a Victorian property but is likely to do so in the near future as the Fund expands (D. Humann pers comm.). The Fund retains ownership of properties and manages them with the assistance of local committees.

Earth Sanctuaries operates as a publicly listed company. In its marketing it highlights its fencing programs to exclude feral animals and re-introduce previously extinct mammals into areas. Its best known site, Warrawong Sanctuary in the Adelaide Hills, is effectively a open plan zoo, developed on old farmland. The mammals in the reserve occur at high densities and are provided with food. Some of the species on display are not known to have occurred naturally in the district. While of use educationally and for captive breeding of mammals, it is not relevant to onground nature conservation of complete ecosystems. However, some of the sanctuaries established in more isolated areas in South Australia and at Scotia in New South Wales appear to be genuine conservation reserves where the aim is to preserve the natural habitat as well as introducing species extinct from the areas since European settlement (Earth Sanctuaries 1996, 1999). Earth Sanctuaries have recently purchased a property in the You Yang Ranges near Geelong. It is unclear at this stage what type of reserve will be developed on the land.

Trends in individual ownership

Lastly, and probably most importantly, there is now a significant and increasing number of landholders willing as individuals to manage land for conservation. At its most altruistic are landowners who purchase property specifically and solely to retain the conservation values. More commonly, owners seek a 'lifestyle' block on which to live or to visit as a 'weekender'. However, for many people part of the attraction is to own, protect and manage an area important for nature conservation. This trend towards lifestyle bush blocks has increased property values for areas with bushland around Melbourne and around large provincial towns. In some cases, properties may be purchased a considerable distance from the day-to day residence. This is part of a general trend in ownership of land away from smaller family farms to larger agribusiness and to lifestyle blocks supported by income earned off the land.

This trend is likely to have both positives and negatives for conservation. Lifestyle blocks may directly damage areas of native vegetation in some areas that were previously little disturbed, as occurs in many areas on the fringes of Melbourne (pers. obs.). In other areas, removal of grazing may greatly improve conservation management. Relatively wealthy agribusinesses have a greater potential than most family farms to put significant resources into onground conservation works. However, they also have greater access to capital to put in place large-scale developments which remove remaining native vegetation.

Many primary producers are improving the management of land for conservation. However, this is not a universal trend. Establishing a truly ecologically sustainable agricultural system for Australia is a distant goal. Many, or most, current practices continue to be unsustainable because of the changes they cause to hydrological cycles in highly saline soils (Murray–Darling Basin Commission 1999; Hatton & Nulsen in prep.).

Future work on private land conservation

The scale, diversity and effectiveness of current private land conservation programs is likely to continue to rapidly improve in the next 5–10 years. A number of factors have led to the rapid increase in the focus on private land in recent years.

Since the mid 1980s it has become increasingly obvious that some ecosystems such as grasslands were largely on private land, or public land managed by private landholders. New policy mechanisms were obviously required to help assist with conservation of such ecosystems. This knowledge fortuitously coincided with ideological changes at the state and federal level which emphasised a reduction in government control and a shift to private conservation work. In part it also reflected the slow maturation of programs initiated in the 1970s and early 1980s, such as the Trust for Nature covenant program and Land for Wildlife. The increase in focus nationally has led to the recent establishment of the Conservation on Private Land Network (CONPLAN). Land for Wildlife programs and covenanting programs are now spreading rapidly interstate. As new organisations develop nationally there will be an increasing momentum for further private land work. Current impediments are likely to be removed relatively rapidly. A recent example was the concerted lobbying at a federal level by CONPLAN to make land donations to charitable conservation organisations tax deductible (B. Whelan pers. comm.).

The increase in private land work is likely to be generally positive for nature conservation in Victoria. There are however, some caveats that need to emphasised. The ideology of privatising conservation has already been used to argue that the conservation reserve system on public land in Victoria is virtually complete and that future work needs to concentrate on private land conservation work (Stone 1998). This push is also manifested nationally and internationally in moves over the last decade to weaken the protection on public conservation reserves accorded a high level of protection from human interference. In extreme cases it is used to justify the privatisation of public land reserves and wildlife (e.g. Moran 1992). These attempts at shifting policy are analysed in detail in Figgis (1999).

At the opposite end of the political spectrum many conservationists argue that public reservation will ensure the best conservation outcome. This view criticises covenants and other mechanisms as being impermanent and less valuable than public ownership and reservation of lands with high conservation values. In Victoria this has led to some muted controversies where public land with bush has been sold with Trust for Nature covenants in place. The funds from the sale were used to purchase other land which had high conservation values. It has also arisen where covenants were used as part of the package of housing development and protection outcomes for the Anglesea heathlands in the 1990s (pers. obs.).

Arguments in both directions are likely to increase as conservation work on private land rapidly increases. Inevitably there will be both successes and failures as new techniques are developed and tested on the ground and as new organisations commence and old organisations struggle to expand rapidly.

Stripping competing ideologies aside, overseas experience from countries with generally similar cultures and land tenures (USA and UK) does indicate that using a multitude of methods will ensure the best long-term protection. Land tenures that are appropriate to protect Wilsons Promontory may not be appropriate when applied to an isolated 2 ha native grassland at risk of destruction by weed invasion, and vice versa. The most important factor for the conservation of Wilsons Promontory is likely to be control of human developments and adequate funding for management. The most important factor for the continued survival of the grassland may well be a positive attitude of neighbouring property owners, itself dependent on good relationships with the organisation managing the grassland.

Some useful generalisations are that large areas are best managed in the public estate by a bureaucracy such as Parks Victoria dedicated to that end. The only possible exception would be the purchase and management of large areas by sizeable, stable, and sophisticated conservation organisations such as Trust for Nature or the Australian Bush Heritage Fund. On the other hand, smaller and more fragmented areas are always difficult for large bureaucracies to manage. This was true for the Department of Natural Resources and Environment even before the massive staff cuts that occurred in the mid and late 1990s. Lunt and Morgan (1999a, 1999b) document the severe degradation of the rare grassland habitat at the Derrimut Grassland near Melbourne after the land was reserved and management was taken over by DNRE. Even stable, well-led and well-funded bureaucracies find it difficult to rapidly adjust management tactics and strategies to deal with the issues that arise on small blocks of land. No matter how good individual staff may be, the size of bureaucracies and consequent difficulty in making rapid decisions means that they are also generally poor at enlisting the support of local communities in conservation work. Small blocks of land may *in some cases* be better partly or wholly managed by non-government conservation organisations or conservation-minded local committees supported by appropriate funding and technical advice. This may be especially the case for habitats such as grasslands and grassy woodlands which usually require active management such as continued grazing and weed control.

One future model is the idea of 'Protected Area Networks' (Prober & Thiele 1993; Thiele & Prober unpub.) . A Protected Area Network is a single, multi-site reserve with individual sites protected through a range of different mechanisms, while retaining their existing tenure and management authorities or owners. The different sites are linked by an overarching management and policy structure provided by a centralised agency. The concept was developed to protect areas of highly fragmented habitat where remaining areas now occur in a mix of private and publicly owned tenures such as private farms, cemeteries, roadsides, stock routes, rail lines and crown land. The concept is being implemented in Victoria by Trust for Nature. The Trust has begun development of this system in rare Forest Red Gum woodlands on the Gippsland Plains around the Perry River. Four covenants have been signed, eight other covenants are being negotiated and five areas have been purchased by the Trust or donated to the Trust (Edwards 1999). Several other properties have had remnants fenced off and protected. However, an overarching management system that draws the areas together into a single 'reserve', as described by Prober and Theile has not yet been developed.

The successful expansion of private land conservation is likely to depend in part on the diversity of approaches and organisations that develop. Private land conservation depends on the passion of people to protect land they own or are otherwise attached to. Large bureaucracies can tend to work against local passions to protect land by introducing decision-making away from local areas. A significant constraint in the current environment is that the two major organisations involved, Land for Wildlife and Trust for Nature, are both centralised bureaucracies where major decisions are mostly made in Melbourne. This can work against strong involvement of local conservationists (pers. obs.). In the case of Land for Wildlife it is part of DNRE and subject to the vagaries of departmental budget decisions. Thanks to the skills of staff in both organisations problems created by centralised decision-making have been minimised to date. However, experience overseas of Land Trusts (the equivalent of Trust for Nature) in the United States indicates that a very powerful alternative model exists which gives regions and local districts the power to purchase land and to enter into covenants. Where decision-making (and fund-raising) can be put into the regions, locals working with professional staff have greater incentive to produce greater net results than that obtained by more centralised statewide operations run largely or solely by paid staff.

3.6 Gaps in Victoria's current conservation reserve system

Background

Establishment and management of highly protected conservation reservations is crucial for conservation and there is general community acceptance of the concept in Australia (Figgis 1999; VNPA 1997). Historically, National Parks and other reserves were initially concentrated in areas of recreational, scenic or particular scientific interest. Ecosystems that humans wished to exploit or that were perceived to be unattractive, such as native grasslands and box–ironbark woodlands, were not highly protected. The development of improved ecological knowledge and mapping of threatened species and natural communities indicated the need to preserve adequate areas of all types of ecosystem (Soule & Sanjayan 1998).

How much is enough?

Determination of reserve criteria has generally reflected what different societies have been willing to protect rather than any objective criteria for what is needed to adequately conserve biodiversity in the long term. As noted in the previous conservation review by Frood and Calder (1987), the consequence in Victoria is a reserve system disproportionately occurring in the land types which are not desired for human exploitative uses.

Many species have very localised distributions and there are many species for which we have little if any knowledge of their ecology and distribution. Therefore, only complete protection of *all* remaining native habitat *and* major restoration works can definitely ensure no further local, regional or statewide extinctions occur in Victoria. However, this is not at the current stage an outcome likely to be acceptable to society. Implicitly or explictly accepting this, criteria for assessing what reserve area is required usually aim to:

- maintain all *known* species throughout most or all of their current range;
- protect ecological processes both biotic and abiotic e.g. hydrological processes, nutrient flows into the soil, gene flows through landscapes, fire regimes.

This is the aim of the criteria set out in this study. Off-reserve conservation is crucial but in the current socio-political system there remains a consistent trend for the conservation of even highly threatened species to be compromised in areas where the tenure allows for 'multiple use' to occur (e.g. Figgis 1999; Kirkpatrick 1998). These political and economic pressures mean that an extensive conservation reserve system is required to ensure that the aims set out above are achieved. It is also assumed here that the quality of the management within conservation reserves will be funded and implemented to adequately conserve diversity (Westcott 1995).

The area required to achieve this will vary according to the ecological communities and the species. Hundreds of thousands of hectares may be required to protect large predators such as

Tiger Quolls and Powerful Owls, a few hectares may only be needed to protect some naturally restricted plants. Ideally reserves would be established on the basis of detailed knowledge of species' requirements. However, given our current knowledge this is not possible, with the exception of some vertebrates and vascular plants. Current practice is therefore to set criteria aiming to reserve target percentages of different ecological communities. By protecting ecological communities it is assumed that the entire spectrum of native plants and animals is partly or wholly protected, covering both well-known and poorly known species. Furthermore, the persistence of any groups of species requires the continued operation of natural processes. Protection of whole communities, which takes into consideration natural disturbances, succession, nutrient cycling, hydrology, species interactions and other processes, should sustain conditions necessary for persistence of most species (Noss 1996).

Early targets set in this way set fixed percentages to be achieved for all ecological communities or ecosystems (e.g. IUCN 1992). Recent, more sophisticated criteria, set variable targets, with the aim being to achieve higher targets for ecological communities that have been proportionally more cleared or face other threats.

There are two parts to establishing reservation targets in this way. The first step of the process is to rate the ecological communities into different levels of conservation status, in the same way that species are categorised as endangered, vulnerable or not under threat. The second step is to set appropriate conservation reservation targets for the communities at different levels of threat. These two different processes are described separately below.

Criteria for assessing the conservation status of ecological communities

While there have been internationally accepted criteria for assessing the conservation status of species (IUCN 1994), criteria for ecological communities have only recently been developed, with several new papers examining the topic.

In Australia, criteria have been developed by a number of Australian ecologists and bureaucrats as part of the Commonwealth Government's work to establish listings for threatened ecological communities under the *Environment Protection and Biodiversity Conservation Act 1999*. These criteria are now formalised for listing of threatened communities nationally (Environment Australia 2000). The criteria follow the pattern of IUCN criteria for species, with categories of 'Critically Endangered', 'Endangered' and 'Vulnerable'. The general cut-offs for each category are:

- Critically Endangered: < 5% of original (pre-European) extent of the community remaining;
- Endangered: < 10% remaining of original extent;
- Vulnerable: 10–30% remaining of original extent.

However, these targets are highly qualified depending on the original rarity of the community, the degree of modification of the remaining vegetation of a community, and the degree of current and future threat to a community. Similar criteria are suggested by English and Blyth (1999) and Benson (in prep.) with some variation in the details of the criteria and thresholds.

In his paper Benson (in prep.) suggests the addition of an important overlay which changes the thresholds for communities in fragmented landscapes. This is due to the higher level of threats, such as weed invasion and lack of gene flow, that occur in a fragmented landscape. An example using this approach would be for communities in fragmented landscapes with between 30% and 50% of the community remaining, to be downgraded from 'Depleted' to 'Vulnerable' status because of the higher level of threats in a fragmented habitat.

In Victoria, criteria have been developed by DNRE for use in a Biodiversity Reporting Framework and in Regional Native Vegetation Plans DNRE 2000c). These criteria set specific thresholds for 'Presumed Extinct', 'Endangered' (<10% remaining), 'Vulnerable' (10–30% remaining), 'Depleted' (30–50% remaining) and 'Least Concern' (greater than 50%). Specific additional criteria are applied for communities that are rare or have naturally restricted distributions. These criteria are developed for use within the context of bioregions according to the approach outlined in Victoria's Biodiversity Strategy (DNRE 1997). These bioregions divide Victoria into 22 regions on the basis of distinct environmental features such as climate and topography (Figure 3.2). At the time of writing, some refinements to these bioregions were being considered, particularly some additional regions along the Murray River system, as part of a national review.

The more detailed criteria of the *Environment Protection and Biodiversity Conservation Act* are probably most applicable for close analysis of a relatively limited number of ecological communities. However, some of the Environment Protection and Biodiversity Conservation Act criteria rely on qualitative assessments. This level of assessment is currently very difficult to do accurately and consistently for the entire spectrum of ecological communities in Victoria. In addition, the Commonwealth criteria only assess 'Endangered' and 'Vulnerable' status levels, not 'Depleted'.

A decision was therefore made to base the conservation status criteria of this study on those developed by DNRE for the Native Vegetation Management planning process (DNRE 2000c). These criteria generally follow the approach used by the *Environment Protection and Biodiversity Conservation Act* criteria but rely more on remaining extents to determine thresholds with consequently less provision for bias or mistakes when analysing a large number of ecological communities. The final criteria used in this study are given in Table 3.4. The only difference from the criteria used in the above process (DNRE 2000c) is that a separate 'Naturally Restricted' category is not used in this study as the reservation targets set are the same as for the 'Least Concern' category.

Figure 3.2: Victoria's terrestrial bioregions

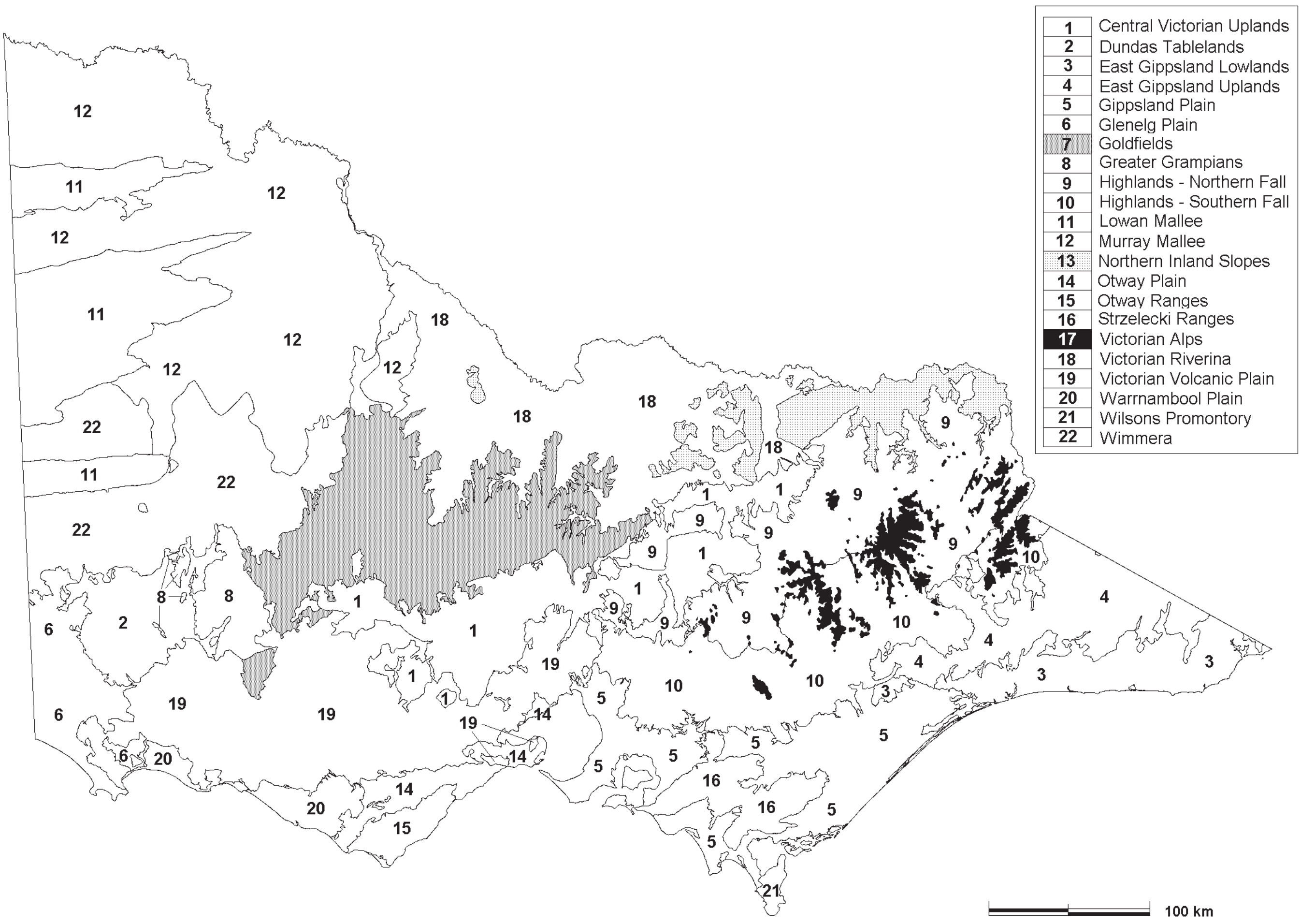


Table 3.4: Threat status and reservation criteria used in the study

Key: * Naturally restricted = pre-European extent in a Victorian bioregion less than 10,000 hectares

Conservation status	Conservation status criteria	Reservation criteria and target levels
Presumed Extinct Vegetation presumed extinct (very small areas may remain but are not mappable)	X Probably no longer present in the bioregion	Rehabilitation and revegetation is the only option and, where successful, consider reservation
Endangered Vegetation on the verge of extinction	E E1 Contracted to less than 10% of former range; or less than 10% pre-European extent remains; E2 Combination of depletion, degradation, current threats and rarity is comparable overall to E1: • 10 to 30% pre-European extent remains and severely degraded over a majority of this area; or • naturally restricted* EVC reduced to 30% or less of former range and moderately degraded over a majority of this area; or • rare EVC cleared and/or moderately degraded over a majority of former area.	90% of remaining extent reserved (100% preferred target)
Vulnerable Vegetation moving towards extinction if remedial action is not taken	V V1 10 to 30% pre-European extent remains; V2 Combination of depletion, degradation, current threats and rarity is comparable overall to V1: • greater than 30% and up to 50% pre-European extent remains and moderately degraded over a majority of this area; or • greater than 50% pre-European extent remains and severely degraded over a majority of this area; or • naturally restricted* EVC where greater than 30% pre-European extent remains and moderately degraded over a majority of this area; or • rare EVC cleared and/or moderately degraded over a minority of former area.	60% of remaining extent reserved 90% in fragmented bioregions
Depleted Vegetation is likely to become threatened if clearing continues or threatening processes continue at current levels	D D1 greater than 30% and up to 50% pre-European extent remains; D2 Combination of depletion, degradation and current threats is comparable overall to D1: greater than 50% pre-European extent remains and moderately degraded over a majority of this area;	60% of remaining extent reserved 90% in fragmented bioregions
Rare Vegetation that is inherently rare and naturally restricted in range	R R1 Total range in a bioregion generally <10,000 ha R2 Pre-European extent in bioregion <1000 ha R3 Patch size generally <100 ha	90% of remaining extent reserved (100% preferred target)
Least Concern Vegetation that is not rare or under specific threat	LC Greater than 50% extent remaining and subject to little or no degradation over a majority of this area.	30% of remaining extent in conservation reserves 50% in fragmented bioregions

Criteria for setting reservation targets for ecological communities

The International Union for the Conservation of Nature (IUCN) has set a global target for protection in conservation reserves of 10% of all ecosystems (IUCN 1992). This however, was a target set as a politically acceptable compromise (Soule & Sanjayan 1998). Studies indicate that widespread extinctions occur when habitat levels are reduced to 10% (Soule & Sanjayan 1998 and papers cited therein). This includes studies in southern Australian temperate woodlands that indicate that bird extinctions are occurring in landscapes where 20–30% of the landscape remains as some form of native vegetation (e.g. Robinson & Traill 1996; Traill et al. 1996; Reid 1999). Modelling of species–area relationships indicates that if only10% of the land remains protected in an ecosystem then approximately 50% of the species will ultimately become extinct (MacArthur & Wilson 1967; Soule & Sanjayan 1998).

Possibly because the questions are politically and socially difficult, surprisingly little published work attempts to answer the question of what reservation targets are needed. Soule and Sanjayan suggest a broad target of 50% of all ecosystems to be managed as 'wildlands' as necessary to prevent widespread extinctions. In the NSW Mallee, Freudenberger et al. (1997) suggests a target of at least 20% reservation, in a landscape where most native vegetation is retained in some form. The most detailed paper of use is probably that of Kirkpatrick and Brown (1991) who examined what degree of protection in a reserve system was required to adequately protect species and ecological communities in Tasmania, a state with similar European history and, excluding the semi-arid mallee, a somewhat similar range of vegetation types to that of Victoria. Kirkpatrick and Brown devised a '30/60/90' target: 90% reservation of the *current extent* of communities that are endangered or highly susceptible to threats due to their small remaining area or other factors; 60% reservation of communities that are vulnerable to extinction due to a large reduction since European settlement or are susceptible to a series of disturbances; and 30% reservation of the current extent for less threatened communities.

The initial criteria devised as part of the development of the National Forest Policy followed the general approach of Kirkpatrick and Brown in setting criteria for protection of forests nationally. The aim was to set out a 'CAR' (comprehensive, adequate and representative) reserve system (Table 3.5). As developed by the independent scientific panel, the original criteria set out to guarantee adequate protection for ecosystems facing different levels of threat. Of the areas remaining 'Vulnerable' and 'Endangered' ecosystems were to receive at least 60% and 90–100% protection respectively. A basic level of protection of 15% of the *pre-European* extent of all ecological communities was set out in the criteria. These details were later modified by the bureaucracies involved to form the final criteria agreed to by the federal and state governments (JANIS 1997). The modifications meant that set targets for reservation were avoided (Kirkpatrick 1998) with consequent weaknesses in the implementation of the criteria during the Regional Forest Agreement processes. A more detailed critique of the Victorian Regional Forest Agreement processes is given in Appendix 3.1 (see also Kirkpatrick 1998).

Table 3.5: National Forest Policy definitions of a CAR reserve system
Comprehensiveness: includes the full range of forest communities recognised by an agreed national scientific classification at appropriate hierarchical levels
Adequacy: the maintenance of ecological viability and integrity of populations, species and communities
Representativeness: those sample areas of the forest that are selected for inclusion in reserves should reasonably reflect the biotic diversity of the communities.

Because of their widespread use in the debate over forests, the JANIS criteria have often been used or discussed in relation to forest areas not covered by the Regional Forest Agreements and non-forest ecosystems (e.g. ECC 2000). Often overlooked is that the JANIS criteria were designed for use in forest ecosystems in which relatively little of the landscape had been completely cleared (J. Kirkpatrick pers. comm.). They were not designed for highly fragmented landscapes, such as most of central, western and northern Victoria and the Gippsland Plains where ecosystem processes are breaking down due to loss of connectivity between remnants, and other problems caused by having only smaller, more isolated fragments remaining.

Recently, criteria have been developed for Draft Regional Native Vegetation Plans by some of the Catchment Management Authorities (EGCMA 2000; WGCMA 2000). These set out criteria for vegetation protection in regions for both fragmented and unfragmented landscapes. The basis for the criteria are the JANIS forest criteria: the 15% of pre-European extent target is used for 'Depleted' (see previous section) and 'Least Concern' Ecological Vegetation Classes (EVCs). In the JANIS criteria, all *remaining* stands of 'Endangered' and 'Rare' Ecological Vegetation Classes require full protection and 'Vulnerable' has a target of 60% of remaining extent for reservation. However, in an important addition, the CMA criteria set higher protection levels for EVCs that occur in fragmented landscapes. The targets they set are for 90% of 'Vulnerable' vegetation be protected in fragmented landscapes (compared with 60% in unfragmented landscapes). A fragmented landscape is defined as Victorian bioregions where less than 35% of any native vegetation remains. A higher target of protection for the 'Depleted' and 'Least Concern' categories is also set for such fragmented landscapes.

This approach is sensible in the case of Victoria where 13 of the 22 bioregions have been highly fragmented by clearing. Fragmented landscapes require higher reservation targets due to their higher level of threats, such as weed invasion and isolation and extinction of small populations (e.g. Traill & Robinson 1996; Benson in prep.).

The reservation criteria used in this study follow those established for vegetation protection by some of the Catchment Management Authorities for native vegetation protection (EGCMA 2000; WGCMA 2000). The only significant alterations in this study are that the criteria provide higher targets for reservation in the 'Depleted' category and protection of 30% of the current extent of habitat for 'Least Concern' communities rather than 15% of pre-European extent. The 'Depleted' target has been increased as there is increasing evidence of declines and extinctions of some vertebrates in depleted ecological communities (e.g. Robinson & Traill 1996; Reid 1999; Traill & Duncan 2000. The reservation of 30% *of current extent* of an ecological community is judged to provide greater surety of protection for communities than the generally lower target of 15% of pre-1750 extent (Kirkpatrick & Brown 1991).

The reservation targets used in this study are given in Table 3.4 along with the conservation status categories and criteria.

Analysis of Victoria's terrestrial communities

To analyse the current gaps in Victoria's reserve system two separate analyses are completed.

Firstly, an analysis is made of the conservation status and reservation status of Broad Vegetation Types (BVTs) at a statewide level in Victoria. BVTs are a generalised theoretical view of vegetation classified and mapped by DNRE in the early 1990s to provide a rapid analysis of the current status of vegetation in Victoria. (See Appendix 3.2 for further details.) There are 28 BVTs mapped in Victoria. They are mapped using land systems (Rowan 1990) and consequently rely on non-biological data such as soil type, climate and altitude. Within each BVT there are generally a wide range of distinct vegetation types. The analysis of BVTs at a statewide level is necessarily coarse and is useful only to indicate the general current status and reservation patterns of different types of vegetation. The criteria set out in Table 3.4 are not applied to this dataset as the level of information is insufficient for the criteria to be applied to BVTs at a statewide level.

The second, and more rigorous, analysis uses the two sets of criteria developed in this study (Table 3.4). The criteria are used to analyse the current conservation status and reservation status of Victorian ecological communities at a regional level.

The data used in this more detailed analysis is primarily information on Ecological Vegetation Classes (EVCs) and Victorian bioregions provided by DNRE. EVCs are 'one or more floristic communities which exist under a common regime of ecological processes and which are linked to broad landscape features' (Woodgate et al. 1994; Muir et al. 1995). Each vegetation type is identified on the basis of its floristic composition (plant species present), vegetation structure (e.g. woodland, forest, grassland etc.), landform (gully, foothill, plain etc.) and environmental characteristics (soil type, climate etc.).

EVCs generally relate to features that people can identify on the ground, as distinct from more narrowly defined vegetation communities that rely solely on floristics for identification. Examples of EVCs are Shrubby Dry Forest, Rocky Outcrop Shrubland and Plains Grassy Woodland. A critique of the use of Ecological Vegetation Classes is given in Appendix 3.2. A list of the published references for EVC descriptions is also given in Appendix 3.2.

The pre-European distribution, current extent and area of reservation of EVCs has been mapped for most of Victoria. However, coverage is not complete. Of the 22 bioregions, none of the Lowan Mallee Bioregion and only 4% of the Murray Mallee have been mapped for both pre-European and complete current extent (note that current extent on public land has been mapped). Some other bioregions have had partial coverage: 41% of the Wimmera, 75% of the Gippsland Plains, 77% of the Riverina and 99% of the Goldfields Bioregions have been mapped.

Due to the low coverage (< 50%), the EVCs of the Murray Mallee and Wimmera were not analysed in this study. To determine the conservation status and reservation status of vegetation types in these bioregions the extent and reservation of BVTs was examined, and mapped within the Australia-wide Interim Biogeographic Regions of Australia (IBRA) developed by Thackway and Cresswell (1995). These IBRA regions cover much broader geographic areas than the Victorian bioregions and also cross state boundaries. To fill in the gaps in the coverage of EVCs, the BVTs of the Murray–Darling Depression IBRA region were analysed. This covers the northern half of the Wimmera and the entire Mallee region.

The EVC dataset includes a number of 'complexes' and 'mosaics'. The vegetation complexes are mixtures of two or more EVCs where separate EVCs are unable to be distinguished on the ground but which are known to exist separately elsewhere. The vegetation mosaics are areas in which two or more EVCs occur separately on the ground but intermingle too closely to be separated at the mapping scale used. Both complexes and mosaics are treated as separate entities in the analysis. However, their conservation status and reservation status is not assessed here as their inclusion potentially distorts the analysis. For example, a mosaic may be made up of two common and well-reserved EVCs. However, the area where the mosaic occurs may have been largely cleared and the mosaic, if assessed, would be listed as 'endangered'. Exclusion of complexes and mosaics leads to the exclusion from the analysis of large areas of country. In a broad analysis such as this though general trends will still be apparent.

Excluded from analysis are 'minor occurrences' of EVCs and BVTs. These may occur where a vegetation type found extensively in a particular bioregion extends just into an adjoining bioregion. These are occurrences of where the pre-European extent in a bioregion of the EVC or BVT was less than 1% of the statewide extent of that class or type *and* less than 1000 ha.

Datasets for bioregional analyses of Broad Vegetation Types and Ecological Vegetation Classes were provided by the Department of Natural Resources and Environment from mapping done by the Parks, Flora and Fauna Division of the Department. The data was the best available as of June 2000. Continuing refinement of mapping and datasets are likely to alter some of the figures in the future.

For the purposes of this study, what constitutes a 'conservation reserve' follows the protocols established for the Catchment Management Authority Regional Native Vegetation Plans. A list of the categories of reserves included as conservation reserves is listed in Appendices 3.3 and 3.4.

Broad Vegetation Types at a statewide level

There are 28 complexes mapped by DNRE (DNRE 1997). They are listed in Table 3.6 with figures on their pre-European area and current area in conservation reserves and private ownership. As discussed previously, these figures are useful as general indicators only of trends in Victoria. An arbitrary three-level scale was used to roughly rank the conservation status of the BVTs. Using this scale, seven of the BVTs have a poor conservation status at a statewide level (< 10% remains of the pre-1750 extent of the BVT), ten of the BVTs are moderately well conserved (11–50% remains) and eleven are well conserved (> 50%) remains. The BVTs that are poorly conserved are all restricted to relatively flat lowland areas and have relatively fertile soils (e.g. Grasslands, Herb-rich Woodland). BVTs that are moderately well conserved lie in lowland or hilly areas but have areas of infertile soils or have some steeper country which has partly protected them from a very high level of clearing for agriculture (e.g. Box–Ironbark Forest, Valley Grassy Forest). BVTs that are well conserved lie in areas with very infertile soils or mountainous country (e.g. Mallee Heath, Montane Moist Forest).

Regional status of Ecological Vegetation Classes and Broad Vegetation Types

After exclusion of minor occurrences and mosaics and complexes, 166 EVCs by 19 bioregions were analysed using the criteria. Not all EVCs are found in all bioregions so there were 632 combinations of EVCs by bioregions. In the BVT analyses for the Murray–Darling Depression there are 14 BVTs.

The full dataset for EVCs in the Victorian bioregions is given in Appendix 3.3. Appendix 3.4 provides an analysis of the BVTs in the Murray–Darling Depression. *It is strongly emphasised that there may be minor mapping errors due to the difficulties in accurately mapping and ground truthing vegetation at the scale at which this data has been collected by DNRE.* In addition, at the time of writing a complete typology of EVCs had not been finalised and there may be minor changes in the naming of some EVCs as typologies developed in different regions are merged more fully. It is therefore not the intention here to use this data for detailed planning of the work required at a local level. The data is used here to indicate major trends and gaps at a statewide level.

A summary of the EVC results is given in Table 3.7, and the Murray–Darling BVT data in Table 3.8. Of immediate notice is the very high proportion of EVCs and BVTs that are 'Endangered' or 'Vulnerable'. In Table 3.7 more than half of the EVCs are highly threatened, either 'Presumed Extinct', 'Endangered' or 'Vulnerable'. Another 6% are 'Depleted' and 15% are 'Rare'. Only 138 (22%) of the 632 EVCs in different bioregions are in the 'Least Concern' category. For the BVTs in the Mallee and northern Wimmera the results are similar (Table 3.8). Of the 14 BVTs in these the Murray–Darling Depression Bioregion 10 (72%) are 'Endangered' or 'Vulnerable', two are 'Depleted' and two are of 'Least Concern'.

Statewide the results for the reservation status indicate very poor achievement of target levels using the reserve criteria established for this study. Reservation is judged to be 'adequate' where the on-ground reservation of a particular EVC in a bioregion is equal to or greater than the reservation targets set out in Table 3.4. Of the 632 EVCs in Victorian bioregions, 117 (19%) are adequately reserved using these targets. Of the remainder, 482 or 478 (76%) are not adequately reserved, there is inadequate data to judge reservation status on four EVCs and 33 are 'Presumed Extinct' and therefore have no reservation targets. For the 14 BVTs in the Murray–Darling Bioregion, 12 are inadequately reserved.

Table 3.6: Extent of Broad Vegetation Types in Victoria

Conservation status: poor = poorly conserved (<11% remaining); moderate = moderately well conserved (11–50% remaining); good = relatively well conserved (>50% remaining)

Broad Vegetation Type	Conservation status	Pre-1750 area (ha)	Total extant area (ha)	Extant / pre-1750 (%)	Conservation reserves (ha)	% Reserved / extant area	Private / extant (ha)	% Private / extant
BOINKA-RAAK	Moderate	167443	39277	23	28923	74	1922	5
BOX IRONBARK FOREST	Moderate	975760	258640	27	26453	10	74197	29
COASTAL GRASSY WOODLAND	Moderate	173402	34590	20	15867	46	8808	25
COASTAL SCRUBS AND GRASSLANDS	Moderate	120817	25628	21	13852	54	5502	21
DRY FOOTHILL FOREST	Good	3449844	2311275	67	644145	28	303023	13
GRASSLAND	Poor	1882411	8277	0	2504	30	4938	60
HEATH	Moderate	118010	46163	39	15833	34	12279	27
HEATHY WOODLAND	Good	734895	390950	53	109089	28	119666	31
HERB-RICH WOODLAND	Poor	691205	67836	10	28219	42	32675	48
INLAND SLOPES WOODLAND	Moderate	336568	134863	40	71545	53	28857	21
LOWLAND FOREST	Moderate	1207455	512645	42	83520	16	79378	15
MALLEE	Moderate	2756937	1028288	37	809762	79	83567	8
MALLEE HEATH	Good	553745	502628	91	396637	79	22957	5
MALLEE WOODLAND	Moderate	224256	60780	27	45152	74	7965	13
MOIST FOOTHILL FOREST	Good	1841242	1380267	75	397159	29	124264	9
MONTANE DRY WOODLAND	Good	296664	287236	97	97102	34	6370	2
MONTANE GRASSY WOODLAND	Good	59362	38735	65	7341	19	8198	21
MONTANE MOIST FOREST	Good	157152	149703	95	47624	32	3424	2
PLAINS GRASSY WOODLAND	Poor	4140397	128344	3	13308	10	66365	52
RAINSHADOW WOODLAND	Good	76793	43401	57	29089	67	11713	27
RIPARIAN FOREST	Poor	166716	16842	10	3633	22	6634	39
RIVERINE GRASSY WOODLAND	Moderate	996996	201132	20	74261	37	38700	19
SEDGE-RICH WOODLAND	Poor	25726	2309	9	872	38	1293	56
SUB-ALPINE GRASSY WOODLAND	Good	28815	24004	83	18508	77	477	2
SUB-ALPINE WOODLAND	Good	177835	168216	95	110123	65	3738	2
SWAMP SCRUB	Poor	99618	2060	2	129	6	1307	63
VALLEY GRASSY FOREST	Moderate	264549	67664	26	10157	15	22718	34
WIMMERA MALLEE/WOODLAND	Poor	862449	2386	0	657	28	1634	68

Table 3.7: Summary of conservation status of EVC results

Conservation status	Number in bioregions	Percentage of total
Presumed Extinct	33	5%
Endangered	229	36%
Vulnerable	103	16%
Depleted	36	6%
Rare	93	15%
Least Concern	138	22%
Total	**632**	**100%**

Table 3.8: Summary of conservation status of BVT results for Murray–Darling Depression Bioregion

Conservation status	Number in the bioregion	Percentage of total
Presumed Extinct	0	0%
Endangered	5	36%
Vulnerable	5	36%
Rare	0	0%
Depleted	2	14%
Least Concern	2	14%
Total	**14**	**100%**

When analysed by bioregion some distinct trends emerge (Table 3.9). The unfragmented bioregions, as expected, have lower numbers of endangered EVCs or BVTs. Wilsons Promontory has had very little clearing and is entirely protected by the Wilsons Promontory National Park. It has no endangered, vulnerable or depleted EVCs. The Greater Grampians Bioregion is relatively well protected, as are the bioregions in the largely uncleared mountains and foothills in the eastern part of the Great Dividing Range and the Otway Ranges. All these regions have had relatively little clearing for agriculture.

A notable exception to the generality that forested and mountainous/hilly bioregions are better protected is the Strzelecki Ranges, with three of its 15 EVCs 'Presumed Extinct, eight 'Endangered' and two 'Vulnerable'. With the exception of the East Gippsland Lowlands, all the lowland bioregions are fragmented (< 35% of native vegetation of any type remaining in the bioregion) and have less than 16% of their EVCs or BVTs in the 'Least Concern' category.

This pattern is also reflected within other bioregions. EVCs and BVTs found on lowland districts on more fertile soils typically have 10% or less of their original extent remaining and are consequently highly endangered. Examples are Plains Grassland, various herb rich and grassy woodlands, Plains Grassy Woodlands, Swamp Scrub and various communities found in fertile river valleys. Heaths, Heathy Woodland and Mallee Heath found on sandy, infertile soils are proportionally much less cleared.

Reservation status follows similar patterns. The unfragmented bioregions, found in the mountain and foothill regions, have higher proportions of EVCs reserved within the reservation targets. With the exception of the Wilsons Promontory Bioregion (100% of which is reserved), Victorian Alps (76% of EVCs adequately reserved[1]) and the Greater Grampians Bioregion (60% of EVCs adequately reserved), the proportions are still disappointingly low, with around 20–30% of EVCs achieving the reservation targets in the East Gippsland Uplands and Lowlands, Highlands North Fall and South Fall and Otway Ranges. For the fragmented bioregions the proportions achieving reservation targets were extremely low. The Dundas Tablelands, Goldfields and the Otway Plain had no EVCs achieving the reservation targets. The Central Victorian Uplands, Northern Inland Slopes, Strzelecki Ranges, Victorian Riverina and Victorian Volcanic Plain had only one EVC achieving the reservation target. Generally, adequately reserved vegetation types tend to be those occurring on the more infertile soils of these bioregions. EVCs on fertile soils remain almost wholly inadequately reserved.

Not analysed here due to lack of EVC mapping is the Lowan Mallee Victorian Bioregion, part of the Murray–Darling Depression IBRA region. The Lowan Mallee Bioregion includes the infertile deep mallee sands of the Little Desert, and parts of the Big Desert and Sunset Country. Although detailed figures are not available, the available maps indicate that this bioregion has been relatively little cleared and is well reserved in the National Parks covering these three areas (DNRE 1997).

1 However, cattle grazing continues throughout extensive areas of the Alpine National Park. This makes 'adequate reservation' effective on paper but not in practice for some of the alpine ecological communities sensitive to grazing. It was beyond the resources of this study to make an assessment of the real reservation status of ecological communities affected by alpine grazing.

Table 3.9: Status of Ecological Vegetation Classes in different bioregions

Key: * = Fragmented bioregions (<35% of native vegetation of any type remaining in the bioregion)
X = Extinct, E = Endangered, V = Vulnerable, D = Depleted, R = Rare, LC = Least Concern

Victorian bioregions	Total extant/ pre-1750	X	E	V	D	R	LC	Total	Number of adequately reserved EVCs (%)
Central Victorian Uplands*	29%	1	28	6	2	1	7	45	1 (2%)
Dundas Tablelands*	11%	1	14	7	2	3	1	28	0 (0%)
East Gippsland Lowlands	85%	2	7	4	2	8	12	35	8 (23%)
East Gippsland Uplands	89%	0	3	3	5	8	17	36	8 (22%)
Gippsland Plain*	21%	7	15	14	1	7	6	50	4 (8%)
Glenelg Plain*	34%	1	22	9	5	7	3	47	6 (13%)
Goldfields*	14%	2	25	7	6	0	1	41	0 (0%)
Greater Grampians	75%	0	9	4	2	7	18	40	25 (62%)
Highlands North Fall	79%	1	9	4	2	8	14	38	9 (24%)
Highlands South Fall	86%	1	5	8	3	11	21	49	10 (20%)
Northern Inland Slopes*	24%	1	10	1	2	0	4	18	1 (6%)
Otway Plain*	30%	0	14	7	2	5	5	33	0 (6%)
Otway Ranges	81%	1	1	2	0	2	7	13	4 (31%)
Strzelecki Ranges*	19%	3	8	2	1	1	0	15	1 (7%)
Victorian Alps	98%	0	0	1	1	6	9	17	13 (76%)
Victoria Riverina*	5%	4	16	6	0	1	1	28	1 (4%)
Victorian Volcanic Plain*	5%	6	33	9	0	4	2	54	1 (2%)
Warrnambool*	12%	2	10	9	0	2	2	25	3 (12%)
Wilsons Promontory	100%	0	0	0	0	12	8	20	20 (100%)
Totals		**33**	**229**	**103**	**36**	**93**	**138**	**632**	**117**
Australian bioregions									
Murray–Darling Depression* (Mallee & northern Wimmera)	**28%**	**0**	**5**	**5**	**2**	**0**	**2**	**14**	**2 (14%)**

3.7 Recommendations

Major recommendations

As discussed in Section 3.1, it is not the intention in the Review to analyse in detail the gaps within local regions, but to identify major gaps requiring further attention. Given the past and continuing extinctions occurring in the fragmented bioregions, it is most urgent to work for the reservation of all or the great majority of the remaining areas in these regions. With extinctions already progressing, this presents an enormous challenge. Further extinctions are probably inevitable in the very highly cleared and fragmented bioregions such as the Victorian Volcanic Plain, the Dundas Tablelands, parts of the Mallee and Wimmera and most of the Victorian Riverina, where less than 5% of the native vegetation remains. Only major reconstruction of ecosystems, if possible, could ensure no further losses. Because of the highly fragmented nature of such areas one view suggests that scarce conservation resources may be wasted in trying to protect the small remnants in what are otherwise almost entirely agricultural landscapes. Such reasoning may appear to be economically tempting but ignores the reality that for agriculture to remain in many of these landscapes then major changes are required, such as massive tree-planting to stabilise hydrological systems for the control of salinity. Loss of the remnants in these landscapes will remove the potential genetic building blocks necessary for such landscape reconstruction.

For fragmented bioregions with some larger blocks of vegetation remaining, such as the Goldfields, Glenelg Plain and the Victorian Riverina, greatly increased reservation is required to halt degrading activities and minimise further biodiversity losses. These relatively large blocks of native vegetation could form reserves with viable populations of most species potentially able to survive major natural disturbances such as climate change. Of these areas, the highest priority lies in increasing protection for the drier woodland and forest areas as these have a higher proportion of species that are not protected in the better vegetated and relatively better reserved bioregions of the mountains and foothills. However, the wetter forests of the Strzelecki Ranges Bioregion stand out as a forested bioregion requiring special attention due to the high level of threatened Ecological Vegetation Classes (EVCs) and very poor reservation.

The specific major recommendations are therefore made:

R3.1 That all remnants in highly fragmented landscapes be protected

Ensure protection and effective conservation management of remnants in highly cleared and fragmented bioregions: agricultural parts of the Mallee; northern and southern parts of the Wimmera; the northern plains of the Victorian Riverina; the Dundas Tablelands; the Gippsland Plain; the Victorian Volcanic Plain; and the Warrnambool and Otway Plains away from the Otway Ranges foothills. This is particularly important for the conservation of native grasslands, grassy woodlands and wetland ecosystems. In part this will have to occur through rapidly increasing the protection of remnants on private land through covenants, revolving funds, direct purchases and other mechanisms. It will also require an increased focus by local and state governments on protection of native vegetation on public land. The first step in the process would be a review of the status and management of public land in agricultural areas where the native vegetation is highly fragmented: streamside reserves, roadsides, small bushland reserves and other areas.

R3.2 That a major new park system be established in south-western Victoria to conserve the diversity of the region

The woodlands, wetlands and forests of the far south-west form a unique system of vegetation communities with a number of threatened species. A new park system should include all major blocks of woodland in the Glenelg Plain and Dundas Tablelands Bioregions and parts of the Victorian Volcanic Plain Bioregion and the south-western parts of the Wimmera Bioregion.

R3.3 That a major new park system be established to conserve riverine forests and woodlands

The riverine forests and woodlands of the Murray, Goulburn and Ovens Rivers include the largest remaining River Red Gum forests in the world. A major new park system is needed to conserve these unique flood forests. The only current large reserve is Barmah State Park. However, this ‘park’ has continued logging and stock-grazing and does not fit International Union for the Conservation of Nature (IUCN) criteria as a conservation reserve (DNRE 1996b). These riverine woodlands and forests are largely in the Victorian Riverina Bioregion, but also occur in the Murray Mallee Bioregion further along the Murray River.

R3.4 That a major new park system be established to conserve the biodiversity of the Strzelecki Ranges

The Strzelecki Ranges Bioregion forms a distinct and isolated area of tall wet forests and associated foothill forests. Land clearing and intensive forestry has fragmented and degraded the forests of the ranges. A major park system in the Strzelecki Ranges is needed to ensure protection of the remaining biodiversity of the wet and damp eucalypt forests and cool temperate rainforests of the region. The special circumstances of land tenure in the Strzelecki Ranges are discussed briefly in Appendix 3.5.

R3.5 That a major new park system be established to conserve box–ironbark woodlands and forests

The box–ironbark woodlands and forests of central Victoria are important for the protection of a number of specialised woodland species, many of which are rapidly declining. Establishment of a major new park system is required to protect woodland ecosystems and woodland species in the Goldfields and Northern Inland Slopes Bioregions. At the time of writing, a government process is in train, with the Environment Conservation Council (ECC) to make recommendations on the tenure of public land in the region.

Other recommendations

If minor threats were to be included in the Review, hundreds of distinct threats to nature conservation in Victoria could be identified. However, in many cases the major threats such as logging, overgrazing and clearing of bushland are relatively well known and documented, with community groups and government departments working on the issues to a greater or lesser extent.

The intention here, therefore, is to highlight some major issues that are not receiving a sufficiently high level of attention but which pose current or future threats to biodiversity in Victoria. These issues require further attention from individual conservationists, conservation groups, and the relevant government departments if their deleterious effects are to be reduced or prevented.

Environmental weeds and feral animals

After direct destruction of habitat, existing environmental weeds and feral animals are probably the current most important cause of habitat loss and degradation in Victoria. In the long term they may become the most important cause. New introduced species, such as the proposed introduction of the European Bumblebee, also have the potential to have major adverse impacts on native species. Current work on weed control is inadequate both to control current weeds within the state and to prevent future weeds being introduced deliberately. Tighter controls need to be established for introductions of all new animal species, including invertebrates.

The following recommendations are therefore made:

R3.6 That quick-response weed and feral animal control teams be permanently established

Quick-response teams could destroy known and likely weeds and new animal introductions that become newly established in the state, or in regions within Victoria from which they were formerly absent. The teams would work full-time to identify and control recent incursions.

R3.7 That the sale of environmental weeds be banned

The sale of known and potential environmental weeds should be prohibited from nurseries and other outlets.

R3.8 That there be a legal onus on growers to control plantation and crop species from spreading

Some plants such as Radiata Pine are commonly and legally grown in plantations and crops but can invade native vegetation in some areas. There needs to be a legal onus on growers of such species to control any wildlings that develop on adjoining land.

R3.9 That promotion of severe environmental weeds as pasture species cease

There should be a cessation of promotion of known environmental weeds such as Phalaris and Tall Wheat Grass by Agriculture Victoria and other government instrumentalities.

R3.10 That quarantine controls be made tighter

Tighter quarantine restrictions are needed to control and reduce the flow of new plant and animal species into Australia.

Greenhouse effect

There is a high awareness among people working or interested in nature conservation that an enhanced greenhouse effect is likely to cause major environmental problems. However, climate change is generally perceived as a distant problem for conservation, or simply as an impossibly intractable one. However, there are possible strategies for improving conservation outcomes in a world with rapid climate warming. Two key steps are improving connectivity between reserves and identifying areas of remaining native vegetation that are likely to form refuges for ecological communities threatened by a warming climate. Part of this solution is discussed in the recommendations for increased reservation and protection of remaining ecological communities. In part, though, detailed modelling and research of a level beyond the scope of this report is required to identify key areas and required onground works.

The following recommendation is therefore made:

R3.11 That research be conducted on likely effects of climate change on species and ecological communities

The latest climate change predictions should be used to model likely shifts in the areas suitable for Victorian ecological communities and species. This can then be used to identify key refugia areas for communities and species susceptible to climatic changes. The modelling may also identify areas requiring increased connectivity of native vegetation to potentially allow shifts in distribution by communities and species.

Freshwater ecosystems

Until very recent years conservation of freshwater ecosystems had received far less attention than terrestrial systems. Before the campaign to restore a suitable environmental flow to the Snowy River, there had been no major public campaign to protect or restore the environmental flows of a river in Victoria. Nationally, there is increasing competition for water between different human users and between human use and the environment. This competition is likely to accelerate with continued population growth and increasing water demand for agriculture. It is crucial that sufficient water quality and quantity is provided to maintain environmental processes in streams, wetlands and estuaries.

The following recommendations are therefore made:

R3.12 That environmental flows be maintained or restored

Maintenance of adequate environmental flows is key to maintaining stream, wetland and estuarine health. In particular, streams must not be allowed to reach unnaturally low levels during dry periods. In determining environmental flows, both seasonality and annual volume of flow need to be considered.

R3.13 That indigenous riparian vegetation be retained or re-established on all streams

Indigenous vegetation plays a major role in maintaining the integrity of the stream and associated wetlands and estuaries. It should provide a buffer of at least 20 m on either side of a stream. A statewide policy is required to ensure that streams are fenced off, indigenous vegetation re-established where absent, and riparian vegetation protected along all streams.

R3.14 That further reservation of rivers be considered

Further analysis and review is required of what additional rivers and catchments require protection under the *Heritage Rivers Act 1992* to ensure adequate protection of riverine ecosystems. In addition, urgent work is needed to finalise management plans for heritage rivers areas, representative rivers and natural catchment areas.

R3.15 That no more water impoundments be established

Dams and weirs cause environmental damage. They fragment rivers, alter natural water flows, sediment levels and water temperatures.

R3.16 That existing impoundments be fitted with water offtakes that maintain ecologically appropriate stream temperatures

The ecology of a number of rivers is being affected by release of cold water from the lower water layers of large dams.

R3.17 That snag realignment, channelisation of streams and removal of snags cease

Snag removal, snag realignment and stream channelisation continues on some streams. A statewide policy is needed to prevent these activities.

R3.18 That groundwater-dependent ecosystems in Victoria be identified and appropriate management determined

There is increasing exploitation of groundwater resources for human use but there has been little or no attempt to identify ecosystems which may depend on groundwater resources. A study is needed to identify these ecosystems in Victoria and to develop appropriate policies to protect them.

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Section 4: Future Reviews

Future reviews

The Victorian National Parks Association (VNPA) has commissioned three Nature Conservation Reviews: in 1971, 1987 and this volume. These reports were all designed to review the contemporary situation for nature conservation in Victoria and to indicate gaps and work requiring attention. The gaps identified in this report are likely to take five to ten years, as a very minimum, to remedy. Due to past and continuing degradation of habitat the current high rate of local and regional extinctions in Victoria will continue. It is imperative that the VNPA and other non-government conservation organisations continue to drive a strong agenda to slow and eventually stop this rate of loss. It is therefore recommended that the VNPA examine the need for further work in 2005 or shortly thereafter. Further work may not need to be as formal or as detailed as this report. A large part of the *Nature Conservation Review Victoria, 2001* is the examination of gaps in the reserve system. Further refinement of the known gaps could be done more informally at any time in the future using new information as it becomes available. Due to the work of the Flora and Fauna Program of the Department of Natural Resources and Environment (DNRE), Victoria is fortunate in having relatively high-quality data on the type and extent of its ecological communities in Victoria. As the DNRE databases improve, further analyses could be rapidly done to identify remaining gaps in the reserve system. For marine ecosystems there is likely to be a continuing and relatively rapid increase in knowledge of the distribution and ecology of marine communities and species. As well, an increase in marine reserves is likely to occur in the short term.

For terrestrial ecosystems, it may be valuable simply to focus on short unpublished reviews examining best-practice for reserve criteria and applying these to the available databases held by the conservation department of the time or other authorities. For marine ecosystems, the detail required of the review will depend on the quality of the available databases. For both marine and terrestrial ecosystems, a review of some description is likely to be useful by 2005, five years from publication of this report.

Appendices

Appendix 2.1

Benefits of Marine Protected Areas

Conservation benefits

Scientific research supports the success of marine reserves in achieving conservation benefits (Porter 1999). This conclusion was based on a review of 74 papers, representing research conducted in 47 Marine Protected Areas (MPAs) from 18 countries. Far more research has been conducted for underwater habitats in tropical than in temperate marine reserves. Much of the early work addressed the effects of protection measures on populations of intertidal marine invertebrates subject to subsistence and recreational collecting (see Fairweather & McNeill 1993; Castilla 1999). Most of the remaining research has focused on the effects of removal of fishing pressure on abundance and size of fin fish species within MPA boundaries (see Dugan & Davis 1993). Only recently have questions relating to species diversity, community composition or habitat structure been addressed (Dufour et al. 1995; Francour 1994; Grigg 1994; McClanahan & Obura 1995; Edgar & Barrett 1999). Some of the recent scientific evidence for the effectiveness of marine reserves in temperate waters is summarised in the table below. Ecological effects detected include increased abundance and size of previously fished species, increased biodiversity and prevention of further habitat loss and degradation.

Selected papers on the effects of protective management in temperate waters

cpue=catch per unit effort

Source	Habitat	Organisms	Test	Main result
Tegner 1993	rock reef	abalone	transplant experiments	increased recruitment
Palsson & Pacunski 1995	rock reef	fish	compared 3 species on fished and unfished reefs	increased abundance and size
Dufour et al. 1995	rock reef	fish	compared before and after visual census	increased abundance and size
Harmelin et al. 1995	rock reef	reef fish assemblages	reserve vs non-reserve, repeat sampling of fixed transects	increased abundance, size and diversity
Francour 1994	rock reef and seagrass	fish	compared 3 levels of use (no, low, high)	increased abundance, size and diversity
Guillen et al. 1994	seagrass beds	seagrass	constructed artificial reef barriers to deter trawling	increased seagrass cover
Cole et al. 1990	rock reef subtidal	15 fish species rock lobster urchins	compared 5 protected with 3 similar fished sites	increased abundance and size for some species
Buxton & Smale 1989	rock reef	3 fish species	4 vs 1 fished sites	increased abundance and size
Bennett & Attwood 1991	rock reef subtidal	fish	catch rates before and after reservation	increased catch rates and size
Bennett and Attwood 1993	rock reef subtidal	fish	compared cpue data of reserve with fished areas	order of magnitude greater for unfished
Edgar & Barrett 1999	rock reef	reef fish invertebrates plants	before and after, inside and outside reserve comparisons	increased abundance, size and diversity; community structure changes

Socio-economic benefits

The economic benefits of establishing MPAs are likely, in many cases, to outweigh losses (Ballantine 1991; Dixon 1993). Maintenance of a large gene pool benefits future generations by allowing for the possibility of new discoveries (Tisdell & Broadus 1989). Examples here include the discovery of chemicals in marine algae for pharmaceutical use and sources of antiviral and antitumour medicines (Norse 1993). MPAs that protect breeding and nursery areas for commercial species are considered an essential aspect in fisheries management (Salm & Clark 1984) and are being increasingly viewed as insurance against management failure. Abundance, average size and total egg production may be increased in a protected area (Dugan & Davis 1993). Not only the species normally fished, but also by-catch species and those affected by habitat-altering fishing methods, are likely to flourish. In addition, MPAs allow for replenishment of stocks to adjacent waters via dispersal of larvae and adults (Bohnsack 1993).

Tourism is a major industry expected to benefit from establishment of MPAs. The economic value of tourism to the Great Barrier Reef Marine Park is far greater, at $1,159 million per year, than the returns from commercial fishing, for which the comparable figure is $256 million (Van Oosterzee 1995). Considerable profit to the local economy was achieved through creation of the Virgin Islands (Marine) National Park (Dixon & Sherman 1990, as cited in Gubbay 1995). In MPAs where tourism promotion is a real possibility, opportunities for employment in new industries are likely to more than offset any lost from other sectors. However, the issue is not simply one of jobs, but of who gets the jobs. Tourism and fishing require quite different skills and infrastructure. Job loss will remain a real social issue for local communities, unless incentives are provided for retraining and diversification.

Scientific research benefits

By allowing natural processes to continue, marine reserves can act as valuable places for ecological research. Areas of high protection have importance as scientific reference areas, particularly for monitoring of long-term changes (Agardy 1994; Ballantine 1991; Bohnsack 1993). Such work is necessary to distinguish which changes are natural and which are caused by human activities. They may be used as controlled environments for experiments conducted to assess the impacts of certain human uses (e.g. fishing). MPAs have potential value as relatively undisturbed environments for pure research. They also provide a mechanism for testing effectiveness of management measures and for establishing feedback between science and management (Ballantine 1991). Because of the requirement for relatively undisturbed environments, the setting aside of areas for the purposes of scientific research and monitoring is highly compatible with conservation objectives.

Recreational benefits

Protection of marine areas from exploitative uses has created a greater opportunity for recreational uses such as nature appreciation, scuba diving and snorkeling. Vicarious users gain enjoyment from reading about such areas and knowing they exist (Hundloe 1980). Recreational use may have the added benefit of increasing public support for MPAs in general. The value of MPAs to recreational enjoyment will be strongly linked to their economic value through increased tourism (ACIUCN 1992). Recreational objectives imply uses traditionally labeled as passive pursuits, such as sightseeing and photography. However, some MPAs may be established for use by recreational fishers, with all commercial fishing activity excluded. It is debatable whether these MPAs can achieve conservation objectives.

Educational benefits

MPAs provide places where people can observe and learn about marine life. The assumption is that people will learn from seeing the real thing more effectively than from theory (Ballantine

1991). Well-designed interpretation programs promote environmental awareness and encourage a conservation ethic towards the marine environment (Cheatley 1989) and 'serve as an anchor for fostering a sense of stewardship for ocean resources' (Agardy 1994). Educational objectives require provision of accessible areas, not necessarily pristine areas, which can be used for the education of students and the general community about the marine environment and the value of its conservation.

Cultural benefits

Protection of sites with significance to indigenous peoples is an important issue for maintenance and recognition of indigenous cultures, particularly in countries where native title is deemed to have been extinguished by colonisation. This may involve providing protected areas, or places within protected areas, where indigenous people can continue traditional practices and uses (Clark et al. 1989). Traditional use does not automatically equate with sustainable use (Andersson & Ngazi 1995). This is particularly the case where these uses have been modified by new technologies.

Aesthetic benefits

Aesthetic benefits refer to experiences such as inspiration, spiritual enrichment and enjoyment. All are enhanced in protected areas, because they are more natural places (Salm & Clark 1984). Scuba divers can truly appreciate the beauty of underwater seascapes first hand. Glass-bottom boats, underwater videos, marine aquaria, nature documentaries and omnitheatres are making the experience available to a far wider population.

Appendix 2.2

Data sources relevant to selection of a representative system of marine reserves

Environmental Inventory of Victoria's Marine Ecosystems

This is a multi-stage project to provide information on the diversity of marine ecosystems at various spatial scales (Ferns & Hough 1999). The results are intended to support decisions in several policy areas, including: 'identification, declaration and ongoing management of a comprehensive, adequate and representative system of marine protected areas (MPAs)' (Ferns & Hough 1999). The environmental inventory has been completed in stages:

Environmental Inventory – Stage 1 (1992, 1994)

Available datasets were compiled (Consulting Environmental Engineers 1992).
A biophysical regionalisation of Victoria's marine waters was derived from these datasets to act as the template for the IMCRA process (Victorian Institute of Marine Sciences et al. 1994).

Environmental Inventory – Stage 2 (1994)

The regionalisation was extended via a physico-chemical classification of marine waters of Bass Strait (Hamilton 1994).

Environmental Inventory – Stage 3 (1999, 2000)

The shallow (< 30 m depth) subtidal marine habitats along Victoria's open coastline have been categorised and mapped to produce 1:100,000 scale substrate maps of the entire Victorian coastline (42 colour A4-sized maps). The project used Landsat TM imagery, aeromagnetic and hydro-acoustic remote sensing techniques, supplemented in places with ground truthing observations from bounce dives, video deployment and collection of substrate samples (Roob 1999). The mapping work then progressed to employ side scan sonar for mapping the Bunurong Marine Park at 1:25,000 (Leach et al. 2000). The biological component of the Stage 3 study involved various studies on flora and fauna assemblages associated with rocky reefs (Edmunds et al. 1999; O'Hara 1999; Edmunds et al. 2000; O'Hara 2000a; O'Hara 2000b) towards understanding biodiversity representativeness of Victoria's marine ecosystems (Ferns & Hough 2000).

Environmental Inventory – Stage 4 (1999, 2000)

This study has classified soft sediment types, based on sampling of soft sediments at depths of 10, 20 and 40 m at approximately 20 km intervals (Ferns 1999), to refine the classification of Victoria's open coast soft benthic ecosystems. Analysis of associated biological samples for patterns in distribution of animals that live in sediment was undertaken to establish biogeographic patterns and major physical determinants of infauna species distributions (Coleman et al. 2000). Other work involved a review of soft sediment habitats of Victoria's bays and inlets (Catlin & Ferns 2000b).

Marine and coastal geographic information system (GIS)

A marine and coastal geographic information system (GIS) for Victoria is being progessively developed using data collected during the Environmental Inventory:

Development of a Marine and Coastal GIS for Victoria – Stage 1 (1995)

This study outlined the requirements for a marine and coastal GIS for Victoria, including identification of preliminary datasets (Roob et al. 1995).

Development of a Marine and Coastal GIS for Victoria – Stage 2 (1997)

Development of five information products, including the substrate mapping developed for Stage 3 of the Environmental Inventory program (Mahon 1997).

Development of a Marine and Coastal GIS for Victoria – Stage 3 (1999, 2000)

About 50 information products have been entered on to the Marine and Coastal CGDL, which will support a range of programs and information dissemination tools (Ferns & Catlin 1999; Catlin and Ferns 2000a).

Marine, Coastal and Estuarine Investigation

A Marine and Coastal Special Investigation was commenced by the Land Conservation Council (LCC) in 1991 with the main aim of selecting candidate sites for a representative system of MPAs. It has been continued, as a Marine, Coastal and Estuarine Investigation, by the Environment Conservation Council (ECC) since the demise of the Land Conservation Council in 1996. The Environmental Inventory has provided ecological data and information products to assist with these investigations (Ferns & Hough 1999). A number of reports have been produced by the LCC/ECC:

Descriptive Report (LCC 1993)

Compilation of physical, biological and human use information about Victoia's marine environment. A number of useful maps are included.

Proposed Recommendations (LCC 1995)

Proposed recommendations for management of human activities in marine and coastal environments and for location of a system of marine parks and reserves. Brief descriptions of the recommended areas are provided.

Draft Final Recommendations (LCC 1996)

Similar to above, but with modifications based on feedback from submissions. Has brief descriptions of the special features of a number of sites not included in the previous report.

Marine, Coastal and Estuarine Investigation Interim Report (ECC 1998)

Principles for the selection, design and management of Marine Protected Areas, plus a detailed proposal for a marine park at Port Phillip Heads.

Marine, Coastal and Estuarine Investigation Draft Final Report (ECC 1999)

Contains recommendations for a system of Marine National Parks for Victoria. Final Recommendations to the Minister for a Marine National Park at Port Phillip Heads will be released independently from this report. Submissions have been considered and final report was expected in August 2000.

Other sources used

Department of Natural Resources and Environment (DNRE, DCNR, DCE, DCFL) draft management plans

Draft management plans contain detailed information about biological, physical and cultural resources. They have been produced for Swan Bay, Bunurong Marine Park, Shallow Inlet, Corner Inlet and Nooramunga, and Wilsons Promontory.

Victorian Coastal Strategy (1997)

Contains maps of population/activity nodes, coastal public land and land use, priority areas for managing threats, strategic priorities for recreation and tourism facilities and boat access.

Victorian Oil Spill Response Atlas

Mapping of a number of coastal features (e.g. significant sites, habitat types) at 1:25,000 scale for the Surf Coast, Western Port and Corner Inlet and Nooramunga. Focuses primarily on habitats at risk from oil spill. Maps/atlas held at the Marine and Freshwater Resources Institute (contact David Ball).

Porter (1997)

Provides descriptions of a number of rocky reef sites in the central region.

Appendix 2.2: References that provide useful data in terms of selecting areas for protection in marine reserves (see table following page)

KEY

1 Land Conservation Council 1993
2 Environment Conservation Council 1998
3 Land Conservation Council 1996
4 Land Conservation Council and Department of Conservation and Natural Resources 1994
5 Victorian Coastal Council 1997
6 Ferns, L.W. (Ed.) 1999
7 Porter 1997
8 O'Hara in press; O'Hara 1999
9 Edmunds et al 1998
10 MAFRI 1999: Coastal Resources Atlas
11 Porter 1999
12 VIMS 1996: Western Port Coastal Resources Atlas
13 Coleman 1997
14 Jenkins 1998
15 Edgar 1995
16 Norman & Sant 1995
17 Roob et al. 1998
18 Roob et al. 1997
19 Gunthorpe et al. 1997: Gippsland Lakes
20 Bolton 1996
21 Coleman et al. 1999
22 Roob et al. 1995
23 O'Hara in prep
24 Handreck & O'Hara 1994
25 Coleman et al. 1997
26 Beanland 1985
27 Ashton 1994, 1995
28 Keough & King 1991
29 Wilson et al. 1990
30 Brown et al. 1990
31 Harty 1997
32 Department of Conservation and Environment 1991: Swan Bay
33 Department of Conservation and Environment 1992
34 Department of Conservation and Environment 1991: Wilsons Promontory
35 Department of Conservation, Forests and Lands 1990
36 Gunthorpe et al. 1997: Port Phillip Bay
37 CSIRO, Port Phillip Bay Environmental Study
38 Land Conservation Council 1994

U&T = uses and threats

References that provide useful data in terms of selecting areas for protection in marine reserves (refer to key previous page)

		Data available													
Bioregion	Segment of coast	Physical	Sand shore	Rocky shore	Mud shore	Mang-grove	Seagrass	Soft substrate	Subtidal reef	Deep water	Pelagic/ plankton	Animals Plants	General descript.	Signif. sites	U&T
OTWAY	SA–Portland	1,4,6,22		1,24			1	1,21	1			20,23	3,5	1,38	1,5
	• Port Fairy	1,4,6,22		24				21				1,20,23	3,5	1,38	1,5
	• Port Campbell	1,4,6,22		24				21	8			20,23,	3,5	1,38	1,5
	• Apollo Bay	1,4,6,22		24				21				20,23	3,5	1,38	1,5
CENTRAL	AB–Lorne	1,4,6,10		24				21	7			20,23	3,5	1,38	1,5
	• Point Lonsdale	1,6,10,22	27	11,24,27				21	1,7,26,27			20,23,	3,5	1,38	1,5
	• San Remo	1,6,12,22		11,24,30				21	7,8,9			1,20,23	3,5,12	1,12,38	12
	• Cape Liptrap	1,4,6,12, 22, 33	33	24,28,33				21	7,8,9,28, 29,33	34		20,23,33 34	3,5,12 33,34	1,12 33,34	1,5,12 33,34
FLINDERS	Cape Liptrap– Wilsons Prom.	1,4,6,22, 34	43	24,34				21	9,29,34			1,20,23	3,5	1,38	1,5
TWOFOLD SHELF	Ninety Mile Beach	1,4,6,22	1	24				1,21	1			20,23		1,38	1,5
	• Cape Conron	1,4,6,22		24				13,21,25	8			20,23	3,5	1,38	1,5
	• Point Hicks	1,4,6,22		24				21,				20,23	3,5	1,38	1,5
	• Cape Howe	1,4,6,22		24				21				20,23	3,5	1,38	1,5
BAYS AND INLETS	Otway Region Estuaries/Inlets	1,4,22		24									3,5	1	1,5
	Barwon Estuary	1,4,22		24			31						3,5	1,38	1,5
	Swan Bay	1,22,32		11,24			32	32				32	3,5,32	1,32	1,5,32
	Port Phillip Bay	1,4,2,22, 36,37	1,37	2,24,37	37		1,2,31,36 ,37	1,2,36,37	2,14,36 37	2	1,36,37	1,23,36 37	3,5,36 37	1,38	1,2,5 37
	Western Port	1,4,12,22		24		1,12	1,12,15 31	1,15				1,16,23	3,5,12, 19	1,12,38	1,5,12
	Andersons Inlet	1,4,22		24								1	3,5	1,38	1,5
	Shallow Inlet	1,4,22,35		24	35		35	35				1,35	3,5,35	1,35	1,5,35
	Corner Inlet/ Nooramunga	1,4,10,22		24		1,10	10,17, 31					1	3,5	1,38	1,5
	Gippsland Lakes	1,4,22		24			10,18					1	3,5	1	1,5
	Minor Twofold Estuaries/Inlets	1,4,22		24								1	3,5	1,38	1,5
	Mallacoota	1,4,22		24								1	3,5	1,38	1,5

Appendix 2.3

Bays, Inlets and Estuaries

Port Phillip Bay

Considerable research has been conducted within Port Phillip Bay. An extensive bibliography of previous work and a description of current work on each of the recognised habitats in Port Phillip Bay are contained in Appendix 1 of Gunthorpe et al. (1997). The following information is derived from this source, unless otherwise referenced.

Port Phillip Bay (including Swan Bay) is a marine embayment in central Victoria. It covers 1950 km^2 and is connected to the open sea via a narrow opening called 'the heads'. Average depth is about 12 m, but depths greater than 30 m are reached at the southern end. Sea surface temperatures range from 9˚C to 24˚C and salinity is the same as in the open sea. Bottom sediments range from sand around the edges and at the southern end to clay near the centre. Shallow subtidal reefs occur around the edges of Port Phillip Bay, with deeper reef at the entrance. Reefs of importance to the abalone industry occur mainly along the western side of the bay. The intertidal zone is limited by the narrow tidal range in Port Phillip Bay (0.8 m) and comprises sandy, muddy and rocky shores.

Port Phillip Bay sustains a diverse and productive (up to 2673 tonnes per annum) commercial fishery. In terms of quantity caught, the most important commercial species are pilchard, anchovy, King George Whiting, snapper and garfish, while the most important recreational species are snapper, flathead, garfish and whiting.

An extensive study to determine the status of the bay in terms of toxicants and nutrients was commenced in 1992, the results of which have recently been published (the CSIRO Environmental Study as referred to in Gunthorpe et al. 1997). This study indicated that Port Phillip Bay is a phytoplankton-driven ecosystem, thus nutrient status of the pelagic habitat is critical to the health of the entire ecosystem. Denitrification in the sediments, through the activities of infauna and bacteria, plays a critical role in maintenance of water quality. Bottom-dwelling communities appear to have changed during the past 20 years, primarily due to the rapid expansion of exotic species. There are 175 introduced species recorded for Port Phillip Bay, of which several have spread extensively to the point of being considered pests (O'Hara in press). Nevertheless, benthic surveys have listed 713 species: species richness is high when compared to embayments elsewhere (Coleman et al. 1997).

Habitat types recognised in Port Phillip Bay are pelagic, soft sediments, seagrass, estuarine, subtidal reef, shoreline and artificial. Seagrass habitat is most abundant in Swan Bay and around the Geelong Arm. A detailed description of the resources of Swan Bay is provided in the proposed management plan (DCE 1991a). The seagrass areas are important nursery and foraging habitats for a number of fish species. Species richness and population abundances are generally highest in seagrass and lowest in un-vegetated sand. Some species normally associated with seagrass also recruit into reef-algal habitat (Jenkins et al. 1998). The only limited estuarine habitat in Port Phillip Bay occurs at the mouths of rivers such as Yarra, Werribee and Little Rivers. Reefs at the southern end of Port Phillip Bay are recognised as being of high biological diversity. Reef habitats range from shallow flats dominated by algae (especially *Ecklonia*) to deep, highly dissected reefs dominated by sponge-bryozoa communities.

The main threats to habitat in Port Phillip Bay are excess nutrients, exotic species, toxicants, physical disturbances, sedimentation, overharvesting and climate change. The cycling of which is now well understood and the aim is to keep nutrient levels below that which causes eutrophication. Increased fishing pressure (trawling) and reduction in seagrass cover are the most likely explanation for declines in several important commercial and recreational species (Hobday et al. 1999).

Several areas within Port Phillip Bay were identified by the Land Conservation Council as potential locations for MPAs. These are Point Cook, Williamstown, Ricketts Point and Mount Martha (see LCC 1996 for descriptions).

Western Port

Western Port is a tidal embayment with two entrances. It contains two large islands and an extensive tidal channel system. It covers 680 km^2, with at least one-third of this area exposed at low tide. Tidal range is from 1.6–2.2 m, with net tidal movement in a clockwise direction around French Island (VIMS 1996). Approximately 108 km of the shoreline is fringed by mangroves, which are most dense in the northern reaches. Beaches of mixed cobble and shingle, an uncommon habitat in Victoria, are scattered along the eastern shorelines of the bay and French Island.

Western Port contains extensive intertidal mudflats and sandflats that support large populations of migratory waders and is a Ramsar-listed wetland. Seagrass meadows occur throughout, with the most abundant species being *Zostera muelleri* and *Heterozostera tasmanica*. Twice as many fish species are associated with seagrass habitat compared with the unvegetated habitat (Edgar et al. 1995). Benthic surveys have listed 572 species for Western Port – high when compared with embayments elsewhere (Coleman et al. 1997). An unusual and highly diverse assemblage of more than 600 larger invertebrate animals (including 130 species of sea slug, or one quarter of the known southern Australian sea slug fauna) occurs at San Remo (O'Hara 1995).

Extensive mapping of the coastal and marine resources of Western Port has been undertaken (VIMS 1996). New information, particularly seagrass mapping data, is currently being integrated into the Coastal Atlas Database to produce AO-sized maps that incorporate a number of biophysical resources and human uses (e.g. sites of biological and geomorphological significance, habitat types, boat ramp locations, wader bird roosts) (D. Ball pers. comm.).

Western Port has been extensively modified by human activities. Freshwater flow into the bay was once limited, so that the waters were clear and supported extensive seagrass beds (O'Hara in press). Freshwater now flows freely into the north-eastern section of the bay via several large drains, bringing with it nutrients and sediments from stream erosion, land clearing, agriculture and urban development. Constant dredging to maintain port facilities contributes to high turbidity. More than 70% of seagrass beds disappeared between 1974 and 1984, possibly as a result of high turbidity caused by large quantities of sediments generated during the building of roads and the Cardinia Dam. Smothering of seagrass by blooms of epiphytic algae in response to high nutrient levels was another likely factor. Some localised recovery has occurred.

A Marine National Park, including a small 'no-take' zone, was proposed for north-eastern Western Port by the Land Conservation Council (1996).

Corner Inlet and Nooramunga

Corner Inlet and Noorumunga are situated between Wilsons Promontory and the Ninety Mile Beach. They are currently multiple use Marine and Coastal Parks. Corner Inlet supports Victoria's largest *Posidonia australis* beds and the most southerly mangroves in the world. Nooramunga includes a number of barrier islands of national conservation significance for rare and endangered animals. Extensive intertidal mudflats and sandflats support large populations of migratory waders. Both are Ramsar-listed wetlands with International Status as nature conservation areas (DNRE 1996). At least 15 fish species are caught commercially, with King

George Whiting, Australian Salmon, garfish and Rock Flathead making up the bulk of the catch (Fisheries Victoria 1998). Many of these species depend on seagrass meadows for at least part of their life-cycle. Benthic communities show considerable variability throughout these inlets (Morgan 1983, as cited in DNRE 1996). *Posidonia* meadows were found to be the richest habitat for macrobenthos. Several infaunal echinoderm species apparently occur only in *Posidonia* beds (O'Hara unpublished data).

The extent of seagrass cover has been mapped recently (Roob et al. 1998). This mapping data has been incorporated into the most recent version of a Coastal Resources Atlas, along with information about significant sites, wading and sea bird habitats, other vegetation types and important human uses (Corner Inlet–Nooramunga Coastal Resource Atlas Maps 1–5, MAFRI). The seagrass species present are *Zostera muelleri, Heterozostera tasmanica, Posodonia australis* and *Halophila australis*, with the first two species the most abundant. They are found from 0–6 m depth, generally in areas outside of the channels. A considerable tidal flow keeps the seagrass generally clean of epiphytic algae. Analysis of historical photographs for a number of sites indicated that continual fluctuation in cover is the main pattern. Most sites have shown a recent increase in cover, with about 25% of the combined inlet area currently vegetated with seagrass. The area covered has been much higher in the past (as high as 44% coverage for Posidonia).

The main threats are overfishing and sedimentation. Seagrass is adversely affected by high sediment loads in the water column. This has occurred in Corner Inlet as a result of logging of plantations in the catchments. Pollution from excess nutrients is an issue, as treated water from Toora sewage works is discharged into a tidal creek on the northern shore of Corner Inlet (Dennis et al. 1993). Boat drag and propellor damage has occurred as a result of boating in the shallow waters where the seagrass grows.

Gippsland Lakes

Very little recent scientific information about the Gippsland Lakes is available, with much of the previous research being conducted in the late 1970s and early 1980s. According to O'Hara (in press), the Gippsland Lakes are still adjusting to the opening of the permanent entrance in 1889, which resulted in a shift in the aquatic system from freshwater to marine. Some monitoring of water quality (by the Environment Protection Authority) and Black Bream recruitment (by the Marine and Freshwater Resources Institute) is in progress. The following information about the lake system was obtained from two recent reports (Gunthorpe et al. 1997; Roob & Ball 1997). The first is an assessment of fisheries habitat and the second a report on mapping of seagrass cover.

The Gippsland Lakes form a group of interconnected estuarine waterways covering about 400 km^2, one of the largest inland waterways in Australia. They are fed by five major river systems (Latrobe, Avon, Mitchell, Nicholson and Tambo) with a catchment area of about 20,000 km^2. The maximum depth of 10 m is reached in Lake King. Before 1889, a natural dune barrier system, breached only at times of high rainfall, separated the lakes from the sea. A permanent entrance was created in 1989, allowing for permanent intrusion of seawater and lowering the level of the lakes. A saltwater wedge, the extent of which varies with seasons and rainfall, now flows into the lakes.

Six habitats important for fisheries were identified in the fisheries assessment report: pelagic, sediments, seagrass, snags/fringing vegetation/structures, other vegetation and wetlands (Gunthorpe et al. 1997). The species of seagrass occurring here are *Ruppia spiralis*, *Lepilaena cylindrocarpa*, *Zostera muelleri* and *Heterozostera tasmanica*. The lake system supports over a hundred fish species, of which 17 are targeted by commercial and recreational fishers. The annual commercial catch has ranged from 701 to 1180 tonnes over the past ten years; the second largest bay and inlet fishery in Victoria. The most abundant species in terms of catch are Black Bream, carp and Yellow-eyed Mullet, with the recreational catch of Black Bream equivalent to the commercial catch. Polychaete, molluscan and crustacean species are used for bait.

Threats that could lead to loss of habitat and deterioration in water quality include increased nutrients (resulting in algal blooms), low dissolved oxygen, high turbidity, European Carp and toxicants. Circumstantial evidence suggests that water quality has declined over the past decade, particularly the increased frequency of algal blooms, increased abundance of filamentous and epiphytic algae and low dissolved oxygen (resulting in fish kills). Epiphitic algae smother seagrass when at high densities.

The seagrass mapping project identified a pattern of continual fluctuation in cover over time. Peaks in cover occurred in the 1960s and when the recent survey was conducted (about 8.5% of the total lake system vegetated with seagrass). Substantial loss of seagrass occurred from the 1920s to the 1950s, matched by a corresponding decline in commercial catches. There was also a decline at most sites during the 1980s.

Shallow Inlet

Shallow Inlet is one of the South Gippsland Marine and Coastal Parks. The biological resources of this inlet are documented in the proposed management plan (DCFL 1990). Shallow Inlet contains seagrass, mudflat and saltmarsh communities. It is sheltered by a coastal dune system and sand spit – a significant geomorphological feature. This inlet is recognised as having high value as a wildlife habitat, especially for wading and shore birds. It is a popular location for camping, waterskiing, windsurfing and fishing. Five commercial fishermen hold licences that will lapse when the fishermen retire.

Mallacoota Inlet

Mallacoota Inlet is an estuarine lagoon resulting from a drowned river valley and has a relatively unmodified catchment (LCC 1996). The subtropical seagrasss *Zostera capricorni* is found here (Womersley 1984). There are at least 14 commercial fish species. Of these luderick constitutes 33% of the total catch (17 tonnes) (Fisheries Victoria 1998).

Other bays, inlets and estuaries

Otway region

The minor inlets in this region are Aire River, Curdies, Belfast Lough, Glenelg River and Lake Yambuk. All but Lake Yambuk (a shallow estuarine lagoon) receive some level of protection, as components of either coastal reserves or heritage rivers (see LCC 1996 for a description of the latter).

Central region

The Barwon River estuary and Andersons Inlet are the minor inlets and estuaries for this region. The Barwon River estuary receives waters from a catchment heavily modified through agriculture and urbanisation. However, it contains significant mangrove stands that require protection. Andersons Inlet is a barrier inlet with tidal mudflats that are important habitat for wader birds (LCC 1996).

Twofold Shelf region

A number of small, relatively unmodified inlets, estuaries and lagoons occur within the Croajingolong National Park (Eastby Creek, Red River, Benedore River, Wingham Inlet and Tamboon Inlet). These receive a high level of protection as a result, but are also candidates for marine nature conservation reserves (none is included in the state's existing nature conservation reserve system). Sydenham Inlet and Lake Tyers are the other minor embayments in this region. The coastline vegetation and catchment of the latter are largely intact (see LCC 1996 for description).

Appendix 2.4

Coastal and Estuarine National Estate Places (Natural) in Victoria (up to 1997)

National Estate Places which extend past low water mark

Swan Bay and Islands
French Island and Environs
Bunurong Cliffs Coastal and Marine Area
South Gippsland Marine and Coastal Parks (includes Wilsons Promontory Marine Park)

Marine areas nominated to the Register

Western Port (VNPA)
Phillip Island to Cape Patterson (Cam Williams)

Coastal sites which extend to high water mark or low water mark

Discovery Bay Coastal Park
Cape Bridgewater
Cape Sir William Grant
Cape Nelson Park
Portland to Cape Nelson Coastline
Lady Julia Percy Island State Faunal Reserve
Lawrence Rocks State Faunal Reserve
Port Campbell National Park
Otway National Park (low)
Angahook/Lorne (low)
Aireys Inlet (low)
Mud Islands State Faunal Reserve
South Channel Island (in process of updating)
Point Cook (in process of updating)
Point Wilson/Avalon coastal area
Point Nepean Area
Cape Schanck Coastal Park
Phillip Island southern coastline
Seal Rocks State Faunal Reserve
Cape Woolamai State Faunal Reserve
Jacks Beach and Sandstone Island
Wilsons Promontory National Park
Quail Island State Faunal Reserve
Jack Smith Lake State Game Reserve
Gippsland Lakes Coastal Park
Tamboon Inlet
Coronet Bay area
Croajingolong area
Wingan Inlet National Park
Mallacoota Inlet National Park

Appendix 2.5

Sites with important biological and ecological values identified by the LCC (1994)

Mallacoota Inlet

Bastion Point to Little Rame Head

Sandpatch Point to Point Hicks

Cape Conran to Lake Tyers

Ninety Mile Beach from Woodside Beach to Delray Beach

Corner Inlet and Nooramunga

Wilsons Promontory

Shallow Inlet

Cape Liptrap (south end of Morgan Beach) to North Walkerville

Andersons Inlet

Bunurong

Western Port area (Flinders to San Remo including Phillip Island)

Port Phillip Bay (Sponge Gardens, Lonsdale Wall, Heads area, Point Nepean, Point Lonsdale, Jawbone Flora and Fauna Reserve, Swan Bay)

Point Danger, Torquay

Point Grey, Lorne

Cape Otway Area (Point Flinders to Point Bunbury)

Bay of Islands to Gibsons Steps

Port Fairy

Port Fairy to Gauls Cave, including Logans Beach

Portland Bay

Blacknose Point to Cape Bridgewater

Discovery Bay

Sea bird colonies at Gabo Island, Tullaberga Island, Tamboon Inlet, Sydenham Inlet, Jack Smith Lake, Apollo Bay breakwater, Griffith Island (Port Fairy), Lady Julia Percy Island

Appendix 2.6

National approach and criteria for selection of a system of Marine Protected Areas

The Commonwealth has coordinated the Strategic Plan of Action for a National Representative System of Marine Protected Areas (NRSMPAs). This lists more than 30 key actions to be undertaken by the Commonwealth and state and territory governments for the progressive establishment of a national system. The key criteria employed to develop the NRSMPAs are 'comprehensiveness', 'representativeness' and 'adequacy' (CAR). Use of each of the CAR principles allows measurement and reporting on different aspects of biodiversity and is therefore essential to the NRSMPA.

The Strategic Plan describes the three principles as follows:

Comprehensiveness: The NRSMPA will include the full range of ecosystems recognised at an appropriate scale within and across each bioregion.

Adequacy: The NRSMPA will have the required level of reservation to ensure the ecological viability and integrity of populations, species and communities.

Representativeness: Those marine areas that are selected for inclusion in MPAs should reasonably reflect the biotic diversity of the marine ecosystems from which they derive.

(Source: ANZECC TFMPA 1999)

Application of the criteria

Comprehensiveness

Application of this criterion involves definition and mapping of the type, extent and location of marine ecosystems, habitats and communities at a suitable scale, then selection of an example of each ecosystem, habitat and community (i.e. a comprehensive set) to be included in the NRSMPA. Performance assessment at a state level involves identification of the proportion of known ecosystems protected by MPAs in each of the IMCRA regions.

Adequacy

This refers to the ability to maintain conservation objectives of individual MPAs and of the system of MPAs. Assessment methods for adequacy at the individual MPA level will depend on the MPA objectives. Assessment of adequacy to achieve marine conservation requires reporting on whether management arrangements are sufficient to ensure the long-term maintenance of biodiversity within a defined area. Thus, factors to consider include reserve shape and size, population dynamics, level of protection within the MPA and the management regimes in the surrounding area. Performance assessment will involve assessment of the quality and condition of species populations, biological assemblages (communities) and habitats over time.

Representativeness

MPAs should include examples that are typical of the known species, communities and habitats within an ecosystem. This requires identification of areas that are 'typical' of their surroundings at a chosen scale, in addition to those areas that are rare, vulnerable, endangered or distinct (e.g. spawning areas). This approach is aided by compilation of a knowledge base or database for the marine environment (e.g. geographical information systems). Performance assessment involves comparing known diversity (at species, community and habitat levels) with the diversity that is included within MPAs.

Appendix 3.1

Critique of the Regional Forest Agreement process in Victoria

Historically, the Regional Forest Agreement (RFA) process arose out of the lengthy and vitriolic debate on native forest conservation in southern and eastern Australia. As bluntly described in a paper by Kirkpatrick (1998) forests have been a source of entrenched conflict between conservation and what he terms 'growthist' values for several decades. This has put great political pressure on governments to find solutions to remove the conflict. A range of previous enquiries and studies had failed to quell arguments. Intense pressure by conservation groups in the early 1990s, and counter pressure by the native forest industry, led to the development of the Regional Forest Agreement (RFA) process. Politically it was intended to ensure resource security for forest industries and to put in place a reserve system satisfactory to conservation interests. The clear intent was to defuse the debate by convincing both sides that their interests had been reasonably met. As part of the process the Commonwealth would release export controls from regions where an agreed RFA had been completed.

RFAs have been completed in Victoria in East Gippsland, Central Gippsland, North-eastern Victoria, the Central Highlands, 'Western Victoria' (the Otway Ranges, the Wombat Forest and surrounds, and the woodlands and forests of the far south-west and other small forests mostly south of the Great Dividing Range). Interstate, RFAs have been completed in Tasmania, Western Australia and New South Wales. South-eastern Queensland is a notable exception in that it has developed a joint agreement between the industry and conservation groups on reservation targets and a staged phase-out to plantations from native forests.

Establishing a 'comprehensive, adequate and representative' reserve system for biological diversity was a central plank of the national forest policy (Commonwealth 1992: 1995) from which the RFA process evolved (Kirkpatrick 1998). As initially designed, the RFA process was intended to achieve this by using scientifically credible criteria. Kirkpatrick (1998) discusses how the draft criteria were formulated by a panel of independent scientists (Kirkpatrick was one of the scientists). These criteria set out requirements that 15% of the pre-European extent of each forested vegetation community should be in a reserve system. The criteria made further provision for larger proportional representation of rare and threatened communities. These criteria were predicated on the assumptions that the reservation targets would be met almost entirely within reserves with a high level of security (e.g. requiring parliamentary approval for revocation), rather than 'administrative' reserves readily altered by bureaucracies. Further, the criteria assumed that the non-reserved area of the native forest estate would be managed sympathetically for biological diversity.

The criteria finally agreed to by state government and the Commonwealth Government (JANIS 1997) had been altered by bureaucrats setting up the RFAs. Key additions and deletions were made to avoid the setting of any concrete conservation targets. The targets set in the criteria were altered to state that they could be varied for 'socio-economic' reasons. The words where 'practicable and possible' were added in a number of places.

In practice, on the ground, there were significant gains in the reservation added in most or all regions where an RFA was completed. However, the RFAs failed to deliver the promised 'comprehensive, adequate and representative' reserve system.

In addition to the weakened criteria' all five Victorian RFAs had three types of failings which contributed to the inability to deliver the promised comprehensive conservation reserve system.

Lack of protection in statutory reserves

The Victorian RFAs used newly devised administrative reserves in reaching the targets that were achieved. A high proportion of the land set aside as part of the RFA 'reserve system' was in 'Special Protection Zones' from which logging would be excluded. However, these zones do not fit any of the criteria of an IUCN protected area (DNRE 1996b).

The zones can be changed administratively. The RFA documents explicitly note that these reserves are flexible and can be shifted if the values for which they are set up can be reserved adequately elsewhere.They are not protected from mining or from other practices adverse to conservation, such as grazing. Many of the Special Protection Zones are small with irregular boundaries that may be difficult to identify on the ground. No evidence is provided that there will be management of these areas funded to deal with issues such as environmental weeds. They will not have management plans. Due to all these factors they cannot be regarded as a legitimate part of the conservation reserve estate.

Adequate protection of some rare and threatened species and communities

Protection of some rare and threatened species and communities was demonstrably inadequate in the Victorian RFAs. In a number of cases, the targets for protection of a known threatened community were not reached, even allowing for the counting of areas included in Special Protection Zones.

For a number of threatened species protection was minimalist. Barnett (1997) reviewed the protection afforded to a number of threatened species in the East Gippsland RFA. Barnett's report noted that the size of areas set aside for Powerful Owls and Tiger Quolls was lower than the targets set in the prescriptions. In addition, a number of sites known to contain the species were not protected due to the timber values, and replaced with sites in which the species were only predicted to occur.

Other unexplained anomalies were the protection of 800 ha at sites for Powerful Owls recorded in East Gippsland but only 500 ha for the same species in other RFA areas in Victoria. This is despite lower numbers of likely prey occurring in at least some of the western forests (Traill 1996). No justification was made for these discrepancies presumably because of constraints of timber volumes in the western areas.

Failure to ensure adequate off-reserve protection of forests

The Victorian RFA documents highlight the 'Ecologically Sustainable Forest Management' review which involved assessment of Victorian processes by an independent panel of foresters and ecologists. RFA documents imply that this review found that Victorian forest management practices are sustainable. The panel did give general approval of the written management procedures and codes of practice for Victorian forestry operations and made some relatively minor criticisms.

Unfortunately, as noted by the panel, the exercise did not involve any analysis of what actually happens on the ground. No attempt was made to invite comments in private from the DNRE staff actually on the ground, or take comments or submissions from stakeholder groups living and working in the forests.

A number of points indicate that current practices in timber production forest are not ecologically sustainable. There are persistent breaches of the Code of Forest Practice including recent logging of Powerful Owl habitat supposedly protected in a Special Protection Zone in the Wombat Forest near Daylesford (Redwood 2000). DNRE's own studies indicate that there are significant problems in regenerating eucalypts in some forest types after clearfelling (Wilson &

Fagg 1994). The RFAs state that rotation times are 80–120 years in wetter forest types. In practice, rotation times of 45 years are widespread. Recent research indicates that the retained 'habitat' trees have a very low survival rate (Gibbons 1999). In addition, there is an increasing push for intensification of forest practices in some Victorian forests. This involves practices such as thinning of regrowth and fertiliser application.

The combined effect of these changes on the ground is a likely general and consistent reduction in the conservation values sustained in timber production forests in Victoria. This is likely to accelerate as areas are repeatedly logged during future logging rotations.

It is noteworthy that these and similar criticisms have also been made in Western Australia and Tasmania by independent ecologists (Kirkpatrick 1998; Horwitz & Calver 1998).

Future controversy

In addition to these ecological problems, there remains the fundamental political problem which the RFA has failed to solve. The process has failed to deliver an adequate conservation reserve system which will satisfy conservation groups and defuse conflict over forest issues (Kirkpatrick 1998). This problem has been exacerbated by poor consultation processes with the general public and interest groups. A large bureaucratic effort was spent in attracting public submissions. The federal and departmental staff involved made an enormous effort to make the process work (pers. obs.). However, stakeholders remained highly critical that they were cut out of the actual decision-making process. Predictably, the result has been widespread condemnation of the process as having only tokenistic consultation. A number of conservation groups boycotted the process believing that participation would only be used for public relations output by the government to imply that there was widespread consultation. These concerns about consultation do not appear to be solely those of conservationists. A number of industry groups and other stakeholders were reported briefly in the public RFA documents as being highly critical of the consultation process.

Strong public debate is likely to continue over forests.

Appendix 3.2

Description and critique of the vegetation classifications used in the reserve gap analysis

Two vegetation classifications were used in the Review: 'Broad Vegetation Types' and 'Ecological Vegetation Classes'. Both these classification systems were devised by the Parks, Flora and Fauna Division of the Victorian Department of Natural Resources and Environment.

Neither methodologies or typologies (full lists and descriptions of the vegetation units in each classification system) have been formally published in a peer-reviewed journal.

Each classification system is therefore described here and briefly critiqued.

Broad Vegetation Types

Description and critique

Broad Vegetation Types (BVTs) are an 'artificial' generalised view of vegetation that was created in 1996 to help set vegetation protection priorities in Catchment Management Strategies that were being rapidly developed at that time (D. Parkes pers. comm.). At that time, the only useful and comprehensive statewide dataset on which vegetation mapping (particularly modelling pre-European patterns) could be based was 'Land System' mapping by Rowan (1990). The different land systems were defined on the basis of variation in land form patterns, soils and underlying geologies. To establish the BVT mapping, the vegetation type judged to be most common was labelled to each land system. The BVTs were themselves defined by botanists in DNRE by making generalisations from their personal knowledge and the available database information on vegetation communities. Mapping of the land systems used was at 1:250,000. A list and description of each BVT is given at the end of this appendix. Complete pre-European and current vegetation mapping has been completed for the state (DNRE 1997).

There are two key limitations with Broad Vegetation Types, both readily acknowledged by the authors of the system (D. Parkes pers. comm.). Firstly, because each land system is given a particular BVT, a designated BVT polygon on the ground usually contains a mixture of actual floristic vegetation types. Each BVT is essentially a mixture of vegetation types and there is consequently potential overlap, with individual Ecological Vegetation Classes or floristic vegetation communities being found in more than one BVT. Secondly, the land systems were mapped at 1:250,000, a coarse scale for vegetation mapping, which means that the use of BVTs for site specific work is inappropriate.

These problems greatly limit the way in which BVTs can be used. Use at a local level to identify actual on-ground vegetation types is potentially so inaccurate as to be meaningless. Use at a statewide or broad regional level is less problematic as long as the limitations of the dataset are acknowledged.

Ecological Vegetation Classes

Description and critique

Ecological Vegetation Classes (EVC) were devised in the mid-1990s by botanists in the Flora and Fauna Program of DNRE. The classification was devised to provide actual mapping of vegetation at a scale useable for catchment, forest, reserve or fire management planning.

EVCs are 'one or more floristic communities[1] which exist under a common regime of ecological processes and which are linked to broad landscape features' (Woodgate et al. 1994; Muir et al. 1995). The similarity of environmental regimes is manifested in comparable life forms, genera and vegetation structure. Any different floristic communities within an EVC will vary floristically due to geographic separation rather than ecological differences (Muir et al. 1995). For example, both Mountain Ash *Eucalyptus regnans* forest in the Otway Ranges, and Mountain Grey Gum *Eucalyptus cypellocarpa* forest in East Gippsland are classified as Wet Forest EVC. The two forests have quite different floristics. However, both have similar ecological processes, and are found in similar climatic and topographic regimes.

EVCs have been used as part of the Regional Forest Agreement process and also as part of Catchment Management planning. Most mapping of EVCs has been completed as part of the RFA process with some additional mapping in other areas for other government processes. Areas not mapped for both current extent and pre-European distribution at the time of writing are the northern Wimmera, parts of the Victorian Riverina and the Mallee. Mapping has been largely done at a 1:100,000 scale, with some areas at a 1:25,000 scale.

Ecological Vegetation Classes as *currently* delineated and described have some methodological problems and limitations.

- There are no published criteria for the classification and delineation of EVCs. EVC descriptions and definitional boundaries are made on the basis of the available information on ecological processes and floristic data as to what constitutes an EVC and whether a particular broad type of vegetation has one or more EVCs present. As the process relies at least partly on personal opinion the classification could be argued to be unrepeatable and therefore unscientific. It has been argued that some EVCs such as Wet Forest are extremely broad and incorporate too wide a range of life forms (J. Kirkpatrick pers. comm.).
- There is no complete written description of all EVCs. Some EVCs have been described in RFA documents and other references (e.g. Muir et al. 1995). Others in the database appear not to have been formally described in any published form. This is likely to be progressively improved as further work is completed. The published sources of all current typologies and descriptions of EVCs are listed at the end of this appendix.
- There has been a lack of consistency in definitions across regions by different botanists. While in general the same EVC definitions have been used in different bioregions there are some discrepancies. For example, in some regions very broad wetland EVCs have been described and mapped (e.g. 'Wetland Formation') while in others much more narrowly defined EVCs have been used (e.g. 'Plains Brackish Sedge Wetland'). This is likely to be progressively improved as the classification is improved and refined, and regional discrepancies are fixed.
- There may be limited correlation between the distribution of fauna and EVCs. In a study of the correlations between fauna and Box–Ironbark EVCs MacNally et al. (in prep.) found little correlation between the distribution of fauna groups and EVCs. However, this criticism probably also applies to the use of any vegetation-based ecological communities due to the broad distribution patterns of many animals and the importance to animals of variations in the age structure and local density of vegetation that are not included in most vegetation classifications.

Significant advantages of EVCs are:

- They provide a classification of vegetation that can be grasped and broadly identified on the ground by lay people more readily than more narrowly defined floristic communities which depend on identification of particular plant species.
- They are mapped at a scale appropriate for setting priorities at a regional and state scale.

Use of BVTs and EVCs in this report

As detailed above, there are limitations with the use of EVCs and BVTs. Possibly it would be preferable to use more detailed data on the current and previous extent of floristic communities as a basis for setting conservation targets. However, mapping of floristic communities is not available for all but very small areas and it is unlikely to be so in the foreseeable future due to the massive fieldwork that would be required to classify and map floristic communities. Determining the pre-European extent of narrowly defined floristic communities is probably impossible in many areas due to complete loss of remaining remnants.

At the time of this project BVTs and EVCs are the best available dataset on which to base conservation criteria and are therefore used here. As always with such data, care needs to be taken to ensure that the presence of numbers in tables and coloured areas on maps is not judged uncritically to represent a definite and absolute reality on the ground.

For this project it was judged that the BVT and EVC data is of sufficient accuracy at present to set priorities at a statewide level (which bioregions are most threatened and least reserved) and within bioregions (which vegetation types in the bioregions are most threatened and least reserved), as has already been completed in part through the Regional Forest Agreement processes. As the data is further refined by DNRE, or other institutions, new analyses will be required to further refine the conservation status of different areas and vegetation types, and their reservation status.

Pre-1750s vegetation types of Victoria

(Broad Vegetation Type (BVT) descriptions: Information provided by Parks, Flora and Fauna Division, Department Natural Resources and Environment)

1 Coastal Scrubs and Grasslands

This vegetation occurs in a narrow zone along the coast, mostly on sandy soils in association with dunes and rocky headlands that are directly exposed to salt spray and strong winds. It consists of both complexes and discrete ecological vegetation classes. The rainfall range is 700–1000 mm per annum. The vegetation is primarily composed of grasses (Prickly Spear Grass *Stipa stipoides*, Hairy Spinifex *Spinifex sericeus*, Australian Salt-grass *Distichlis distichophylla*), sedges (Club-rushes *Isolepis nodosus*, Coast Sword-sedge *Lepidosperma gladiatum*, Sandhill Sword-sedge *L. concavum*), salt tolerant herbs (Sea-celery *Apium prostratum*, Karkalla *Carpobrotus rossii* and Rounded Noon-flower *Disphyma crassifolium*, Austral Stork's-bill *Pelargonium australe*, Coast Groundsel *Senecio spathulatus*) and salt tolerant shrubs (Sea Box *Alyxia buxifolia*, Common Boobiallas *Myoporum insulare*, Coast Wattle *Acacia sophorae*, the Composites *Olearia* spp., *Helichrysum* spp., *Leucocephalus brownii*) that have adaptations to survive high levels of wind borne salt and droughty soils.

The predominant ecological vegetation classes in this BVT are Coastal Dune Scrubs Complex on dunes and Coastal Tussock Grasslands that occur on rocky headlands. Other vegetation sometimes represented in this category include Coast Banksia Woodland on older dunes, sedgelands in the damper swales and occasionally Coastal Lagoon Wetland and Saltmarshes. There are often extensive areas of bare sand in this category (particularly in the far west and the far east of the state).

2 Coastal Grassy Woodlands

Coastal Grassy Woodland is a BVT which occurs on damp loams that are derived from the sands of dunes and sand sheets that are leached of calcium and iron which have developed moderate levels of organic matter over time. The rainfall range is <600–700 mm per annum. These are usually restricted to near-coastal locations, although outliers can occur further inland where they are generally minor elements of other BVTs. The vegetation has a woodland formation generally of Coast Manna Gum *Eucalyptus pryoriana*, Coast Banksia *Banksia integrifolia*, Drooping Sheoke *Allocasuarina verticillata* and Black Sheoke *A. littoralis*, with few understorey shrubs of Black Wattle *Acacia mearnsii* and a variety of grasses (Wallaby Grasses *Danthonia* spp., Tussock Grasses *Poa* spp.), Bracken *Pteridium esculentum*, sedges (Spiney Mat-rush *Lomandra longifolia* var. *longifolia*, Club-rush *Isolepis nodosa*) and herbs (Pennyworts *Hydrocotyl* spp., Stone-crops *Crassula* spp., Starworts *Stellaria* spp. and various orchids) in the ground layer.

The most usual ecological vegetation class represented is Coastal Grassy Woodland, with smaller inliers within the BVT of Coast Banksia Woodland on soils of lower organic content with higher calcium and iron levels, Coastal Lagoon Wetlands, Saltmarshes, Heathy Woodlands and occasionally Plains Grassy Woodland where sand sheets overlay fertile plains.

3 Heathy Woodlands

This BVT develops on older Tertiary or Quaternary sand sheets and low dunes of aeolian origin to the south of the Great Divide on the coastal plains of the state under low to moderate rainfall regimes. The soils are deeply leached sands that may have a coffee rock horizon where the leached iron of upper soil horizons has reconsolidated. The soils are infertile and droughty and the rainfall range is 500–700 mm per annum. The predominant life-forms in this woodland formation are scattered overstorey trees (Shining Peppermint *Eucalyptus nitida* s.l.) heathy shrubs (Wattles *Acacia* spp., Parrot-peas *Dillwynia* spp., Tea-trees *Leptospermum* spp., Heaths *Epacris* sp., *Astroloma* spp., *Brachyloma* sp., Banksias *Banksia* spp., Cone Bush *Isopogon* sp., Hakeas *Hakea* spp., Sheokes *Allocasuarina* spp.) and restionaceous sedges (*Caustis* spp.), with the families of Proteaceae and Epacridaceae the most prominent. Herbs and grasses are uncommon or absent.

Heathy Woodland are by far the most common ecological vegetation class represented with smaller areas of Sand Heaths and Clay Heaths occurring where soil and/or drainage conditions do not favour the dominant ecological vegetation class. In East Gippsland the dominant ecological vegetation class in this BVT is Banksia Woodland which is floristically similar but extends as far north as southern Queensland where it is known as Wallum.

4 Lowland Forests

The lowland forest BVT in Victoria develops primarily on Tertiary geologies that produce moderately fertile clay or sandy clay loams under a moderate rainfall regime (700–1000 mm per annum) to the south of the Great Divide on the coastal plains of Victoria. These low to moderate height forests of Messmate *Eucalyptus obliqua*, Silvertop Ash *Eucalyptus sieberi*, White Stringybark *Eucalyptus globoidea*, Brown Stringybark *Eucalyptus baxteri* are not dominated by a single life-form category but instead have a wide range of life forms. The understorey has a variety of shrubs (Hakea *Hakea* spp., Banksia *Banksia* spp. Smooth Parrot-pea *Dillwynia glaberrima*, Pomaderris *Pomaderris* spp., Common Heath *Epacris impressa*, Wattles *Acacia* spp., Correa *Correa* sp., Lomatias *Lomatia* spp.), grasses (Tussock Grasses *Poa* spp. Bents *Deyeuxia* spp., Plume Grasses *Dichelacne* spp.), and herbs (Fan-flowers *Scaevola* spp., Raspworts *Gonocarpus* spp., Violets *Viola* spp., Pennyworts *Hydrocotyl* spp.), Bracken *Pteridium esculentum*, Purple-flags *Patersonia* spp., with the shrubs sometimes structurally dominant.

The most usual ecological vegetation class is Lowland Forest but there are usually also areas of Heathy Woodland\Banksia Woodland, Clay Heaths and Damp Forest on more sheltered aspects in higher rainfall zones.

5 Heaths

The Heath BVT develops on a variety of soil types that are often seasonally wet as the result of impeding layers in the soil such as iron pans or clay horizons under rainfall regimes generally <700 mm per annum. The soil fertility is low either because of the inherent qualities of the soil (sands), or, the nutrient availability is restricted by too little or too much water. Heath BVTs are generally dominated by small ericoid leaved shrubs (Heaths *Epacris* sp., *Astroloma* sp., *Brachyloma* sp., *Monotoca* sp., Cone Bush *Isopogon* spp., Wattles *Acacia* spp., Hakeas *Hakea* spp., Grevilleas *Grevillea* spp., Smoke-bush *Conospermum* spp.) and sedges (Sword-sedges *Lepidosperma* spp., Xanthorrhoea *Xanthorrhoea* spp., Tassel Rope-rush *Hypolaena fastigata*), as well as having a significant orchid flora particularly Spider Orchids *Caladenia* spp., and Sun Orchids *Thelymitra* spp. Trees are rarely present, although some specially adapted species such as Shining Peppermints *Eucalyptus nitida* s.l. and Swamp Stringybark *Eucalyptus conspicua* may characterise heaths.

The predominant ecological vegetation class present depends on the soil type. Sand Heaths and Wet Heaths are more common on sands (which is present depends on soil moisture status), whereas Clay Heaths are more common on clay soils. Other ecological vegetation classes that may be present include Heathy Woodlands, Banksia Woodlands or occasionally Lowland Forests on better soils nearby, with Riparian Scrubs present on the wettest sites in adjacent gullies.

6 Swamp Scrubs

Swamp Scrub Complex occurs on the fertile silty, often very peaty soils of river flats and swampy lowlands that are subject to regular inundation with the water table never far below the surface. At some locations this BVT abuts coastal lagoons. The rainfall regime is generally 700–1000 mm although it can be lower. Rainfall is not a significant determinant because of the well watered nature of the habitat. This BVT is almost invariably a closed scrub of Swamp Paperbark *Melaleuca ericifolia*, Tea-trees *Leptospermum* spp., Golden Spray *Viminaria juncea*, a few species of herbs (Australian Gypsy-wort *Lycopis australis*, Groundsels *Senecio* spp.) or occasionally specialised ferns (Soft Tree-fern *Dicksonia antarctica*, Ground-ferns *Hypolepis* spp.) or sedges (*Carex* spp., *Cyperus* spp., *Baumea* spp., *Lepidosperma* spp., Saw-sedges *Gahnia* spp., Common Reed *Phragmites australis)* and occasionally grasses such as *Poa* spp. or *Austrofestuca* spp.

Swamp Scrub is the usual ecological vegetation class represented, with Billabong Wetlands on old anabranches, reed swamps on wetter sites and Riparian Forest on slightly higher ground than the scrubs. Where the BVT abuts coastal lagoons or estuaries near river mouths the BVT may contain smaller areas of Grasslands, or Saltmarsh.

7 Box Ironbark Forests

The Box Ironbark BVTs occur on the gentle slopes and hills with sedimentary geology mostly north of the Great Divide, under a rainfall regime of 400–600 mm. The clayey soils are usually low in organic matter, hydrophobic, and of moderate to low fertility. The BVT is dominated by trees (Red-Ironbark *Eucalyptus tricarpa*, Mugga *E. sideroxylon*, Grey Box *E. microcarpa)* of moderate height and a shrubby understorey of Wattles *Acacia* spp. Guinea-flowers *Hibbertia* spp., Composites *Cassinia* spp. and *Ozothamnus* spp., Parrot Peas *Dillwynia* spp. and Bitter-peas *Daviesia* spp. with few grasses (Wallaby Grasses *Rhytidosperma* spp./*Chionocloa* spp.) and herbs.

Box Ironbark Forest is the dominant ecological vegetation class of this BVT with smaller areas of Metamorphic Slopes Shrubby Woodland on poorer soils, Heathy Dry Forest under higher rainfall regimes, Grassy Dry Forest on slightly better soils of steeper country and Low Rises Grassy Woodland on low relief sedimentary hills at the foot of the BVT where it meets the Northern Plains.

8 Inland Slopes Woodlands

This woodland BVT occurs predominantly in the same region as the Box Ironbark BVT but occupies sites that have sandier soils that are derived from sediments and granitic geology. Soils are infertile, and sandy with low levels of organic matter. The rainfall regime is 500–700 mm. Structurally the vegetation is low woodlands of Hill Red Gum *Eucalyptus blakelyi*, Red Stringybark *E. macrorhynca*, Black Cypress-pine *Callitris endlicheri* with a dense layer of heathy shrubs in the understorey (Grevilleas *Grevillea* spp., Epacrids *Monotoca* sp., *Brachyloma* sp., Heath Myrtle *Calytrix tetragona*, Nodding Blue Lily *Stypandra glauca*, Wattles *Acacia* spp.). Some sites may have a significant seasonal component of geophytes such as lilies and orchids.

The most common ecological vegetation class on sandy soils derived from sediments is Heathy Woodland and on granite derived soils it is Granite Hills Woodland. On the sandy extreme the BVT may have inliers of Sand Heath, whereas on the rockiest sites, the ecological vegetation class is Rocky Outcrop Scrub.

9 Sedge-Rich Woodlands

The Sedge-rich Woodland BVTs occur on poorly drained lateritic soils of the northern plains where the annual rainfall is 500–600 mm. Structurally this BVT consists of an open medium height woodland of Yellow Gum with a few low shrubs (Guinea-flower *Hibbertia* spp., Hakeas *Hakea* spp.), in the understorey and a diverse compliment of sedges (Scale-shedders *Lepidobolus* spp., Centrolepis *Centrolepis* spp., Sword-sedges *Lepidosperma* spp., Saw-sedges *Gahnia* spp., Bristle-sedges *Chorizandra* spp.), and some herbs. Grasses are uncommon.

The main ecological vegetation class in this BVT is Sedge-rich Woodland, with smaller areas of Heathy Woodland on sandier soils and Herb-rich Woodlands on drier laterites.

10 Dry Foothill Forests

This BVT is restricted to the foothills and mountain ranges of Victoria where rainfall is less than 800 mm and may be as low as 600 mm per annum. Soils are generally skeletal with moderate to low fertility and consists of clays or sandy clay loams. Aspect plays a significant part in the distribution of the BVT at the higher end of the rainfall gradient where it becomes restricted to northern or western slopes. The BVT is dominated by medium to low forests of Red Stringybark *Eucalyptus macrorhynca*, Red Box *E. polyanthemos*, Silvertop Ash *E. sieberi*, Broad-leaved Peppermint *E. dives*, with a generally shrubby understorey of Wattles *Acacia* spp., Bitter-peas *Daviesia* spp., Shrubby Composites *Ozothamnus* spp., *Cassinia* spp., or heathy understorey of Grevilleas *Grevillea* spp., Wattles *Acacia* spp., Peas Wedge-peas *Gompholobium* spp., Parrot-peas *Dillwynia* spp., Epacrids *Monotoca* spp., *Brachyloma* spp.. Occasionally the BVT may be grassy with Wallaby-grasses *Danthonia* spp., Wheat-grasses *Elymus* spp., Bents *Deyeuxia* spp. and Nodding Grass *Microlaena stipoides* on slightly more fertile damper sites. There is generally a significant shrub layer (except on fertile sites), although on frequently burnt sites the diversity declines and a few grasses become dominant. Herbs are uncommon and low in cover.

The most common ecological vegetation classes in this BVT are Shrubby Dry Forest, Heathy Dry Forest and sometimes Grassy Dry Forest. On more sheltered aspects Herb-rich Foothill Forest can be quite common especially north of the Divide, whereas to the south, Damp Forest occupies this niche. At lower elevations this BVT grades into Lowland Forest BVTs, Box Ironbark BVTs or one of the plains BVTs. At higher elevations this BVT merges with Montane Dry Woodland BVTs.

11 Moist Foothill Forests

This BVT is restricted to the foothills and mountain ranges of Victoria where rainfall exceeds 800 mm and may be as much as 1400 mm per annum. Soils are generally clay loams with moderate to high levels of organic matter. Cloud cover and aspect play a significant part in the distribution of the BVT at the lower end of the rainfall gradient. The BVT is dominated by medium to tall forests of Mountain Ash *Eucalyptus regnans*, Messmate *E. obliqua*, Gippsland Peppermint *E. croajingalensis*, Mountain Grey Gum *E. cypellocarpa*, Narrow-leaved Peppermint *E. radiata* s.s., Manna Gum *E. viminalis*, Brown Barrel *E. fastigata*, Shining Gum *E. nitens*, Silvertop *Ash E. sieberi*, with a herb-rich understorey of Pennyworts *Hydrocotyle* spp., Starworts *Stellaria* spp., Geraniums *Geranium* spp., Woodruffs *Asperula* spp., Tussock Grasses *Poa* spp.. Alternatively there may be a ferny understorey of Prickly Tree-fern *Cyathea australis*, Soft Tree-fern *Dicksonia antarctica*, Fishbone Ferns *Blechnum* spp., Rainbow Fern *Calochlaena dubia*, Mother Shield-fern *Polystichum proliferum*, Bat's Wing Fern *Histiopteris incisa*. There is generally a significant shrub layer of Blanket-leaf *Bedfordia arborescens*, Musk Daisy-bush *Olearia argophylla*, Snowy Daisy-bush *O. lirata*, Austral Mulberry *Hedycarya angustifolia* and understorey trees such as Blackwood *Acacia melanoxylon*, Frosted Wattle *A. frigescens*, Silver Wattle *Acacia dealbata* may be present as a consequence of the high environmental site quality.

The predominant ecological vegetation classes depend on the position on the rainfall gradient. Up to 900 mm the ecological vegetation class is Herb-rich Foothill Forest, 900–1000 mm it is Damp Forest and >1000 m the ecological vegetation class is Wet Forest. In the Otways, Central Highlands, Strezlecki Ranges and above 700 m in East Gippsland there are significant areas of Cool Temperate Rainforest, while in East Gippsland below this elevation there are substantial areas of Warm Temperate Rainforest present. At lower elevations this BVT grades into Lowland Forest BVTs or Dry Foothill Forest BVTs, whereas at higher altitudes the adjacent BVTs are Montane Moist Forest BVTs or Montane Dry BVTs.

12 Montane Dry Woodlands

Montane Dry Woodland BVTs develop at elevations of 1000–1200 m in areas with rainfall of 1000–1400 mm per annum and fogs are common. Snow falls are regular events every winter, although they generally only last for several weeks at a time. Soils are generally skeletal and moderate to low in fertility clays to sandy clay loams. Aspect plays a significant part in the distribution of the BVT at the higher end of the rainfall gradient where it becomes restricted to northern or western slopes. The overstorey is dominated by gum-barked species such as Mountain Gum *Eucalyptus dalrympleana*, Candlebark *E. rubida*, with smaller amounts of Snow Gum *E. pauciflora* and stunted Alpine Ash *E. delegetensis* that in undisturbed cases produces a woodland (frequent burning can produce a forest structure). The understorey is dominated by sclerophyllous shrubs (Prickly Bush-pea *Pultenaea juniperina*, Gorse Bitter-pea *Daviesia ulicifolia*, Rough Coprosma *Coprosma hirtella)*, and coarse grasses (Tussock\snow grasses such as *Poa hothamensis*, Red-anther Wallaby-grass *Chionocloa pallida*, Common Wheat Grass *Elymus scabrus*). Heathy species (Grevilleas *Grevillea* spp., Mountain Beard Heath *Leucopogon gelidus*, and Hooker's Beard Heath *Leucopogon hookeri*) may also be present but herbs are generally low in numbers and cover.

The most usual ecological vegetation class in this BVT is Montane Dry Woodland, with smaller areas of Montane Damp Forest on more sheltered aspects. Cold air drainage may produce Wet Heaths along the drainage lines and small outcrops of fertile geologies (particularly basalt and granodiorite) can give rise to Montane Grassy Woodlands. At higher elevations this BVT merges with Sub-alpine Woodland BVTs while at lower elevations it abuts Dry Foothill Forest BVTs.

13 Montane Moist Forests

(A)

Montane Moist Forest BVTs develop at elevations of 1000–1200 m in areas with rainfall of 1000–1400 mm per annum and fogs are common especially over winter and spring. Snow falls are regular events every winter, and they generally only last for many weeks at a time. Soils are generally well developed clay loams of moderate fertility with relatively good structure and organic content. Aspect plays a significant part in the distribution of the BVT at the lower end of the rainfall gradient where it becomes restricted to southern or eastern slopes and gullies.

The overstorey is dominated by Alpine Ash *Eucalyptus delegatensis* in damp habitats with Mountain Ash *E. regnans* and Shining Gum *E. nitens* becoming more prominent in the wetter areas, all of which are usually of good form. In damp areas the understorey is dominated by a diverse array of herbs (Bluebells *Wahlenbergia* spp., Sheep's Burrs *Acaena* spp. Forest Cotula *Leptinella filicula* and Woodruffs *Asperula* spp.) and grasses (Ledge Grass *Poa hothamensis*, Sword Tussock Grass *P. ensiformis)*, with ferns like Mother Shield-fern *Polystichum proliferum*, Soft Tree-fern *Dicksonia antarctica* more usual in wetter sites. Shrubs are uncommon except in the wettest end of this BVT or after fire, in either case they are never diverse. Sclerophyllous shrubs (Hop Bitter-pea *Daviesia latifolia*) may also be present but are generally low in numbers and cover, except after fire when they may temporarily dominate the understorey.

Montane Damp Forest is the predominant ecological vegetation class in this BVT with smaller areas of Montane Wet Forest and Montane Dry Woodland. At higher elevations this BVT merges with Sub-alpine Woodland BVT and at lower elevations it merges with Moist Foothill Forest BVTs.

(B) Riparian Woodlands and Thickets

These BVTs are restricted to riparian environments at montane elevations where soils are fertile silts that have high levels of organic matter and water is never limiting. The environment is subjected to frequent snow falls over winter which persist for many weeks at a time and fogs are often present. Cold air drainage from higher country keeps these valleys and gullies colder over summer than the surrounding ridges. The structure of the BVT varies according to the dominant ecological vegetation class, and may be a closed thicket or an open woodland with a diverse shrub layer. Ferns, sedges and herbs are common. Thickets are dominated by Mountain Tea-tree *Leptospermum grandifolium*, with a shrubby understorey of Mountain Peppers *Tasmannia* spp., and Dusty Daisy-bush *Olearia phlogopappa* with some herbs and ferns. The woodlands are dominated by Mountain Swamp Gum *Eucalyptus camphora*, Narrow-leaved Peppermint *E. radiata*, with an understorey of Hazel Pomaderris *Pomaderris aspera* Mountain Tea-tree *Leptospermum grandifolium*, and a diverse array of herbs (Self-heal *Prunella vulgaris*, Buttercups *Ranunculus* spp., Sheep's Burrs *Acaena* spp.).

This BVT is either dominated by Montane Riparian Woodland or Montane Riparian Thicket. The woodland is more usual on flat or undulating montane plateaus whereas the thickets are more usual in higher rainfall country on the margins of these plateaus where soils are somewhat more peaty and more poorly drained. The BVT may have smaller areas of Sub-alpine Wet Heaths where frosts and temperatures are more severe.

14 Sub-alpine Woodlands

(A) Treeless Sub-alpine

The unifying feature of the environment of Treeless Sub-alpine BVTs is the elevation (generally >1200 m) high levels of precipitation (>1400 mm per annum) and heavy snowfalls that last for many months. Snow may fall in any season and frosts are severe, even in summer with fogs frequently occurring. The soils are highly variable and can range from rock screes to peats depending on the topographic position and the parent geology. The structure can vary from closed to open shrublands, herblands or grasslands. Species are characterised by adaptations to long periods of sub-zero temperatures and include grasses (Ledge Grass *Poa hothamensis*, Alpine Wallaby Grass *Danthonia nudiflora*, Prickly Snow Grass *Poa costiniana*, shrubs Alpine Everlasting *Helichrysum alpinum*, Alpine Grevillea *Grevillea australis*, Mountain Plum Pine *Podocarpus lawrencei)* and herbs (particularly composites) Silver Daisy *Celmisia asteliifolia* spp. agg., Snow Daisy *Brachyscome nivalis*, Silver Carraway *Oreomyrrhis argentea*, Australian Buttercup *Ranunculus lappaceous* and Waxy Bluebell *Wahlenbergia ceracea.*

There is no dominant ecological vegetation class in this diverse vegetation BVT. Ecological vegetation classes represented include: Sub-alpine Wet Heaths, Podocarpus Closed Scrubs, Sub-alpine Meadows, Damp and Dry Sub-alpine Heaths and smaller areas of Sub-alpine Woodlands in more sheltered localities where frosts are not as severe as is usual for this BVT's habitat.

Sub-alpine Woodlands (B)

Sub-alpine Woodlands occur over an narrow altitudinal range (1200–1400 m) on a variety of geologies that generally produce a reasonably fertile clay or sandy clay loam that can occasionally be quite skeletal. Because the altitude is the principal environmental determinant, the BVT can occur on a wide range of topographies, such as mountain peaks, plains, plateaus or slopes where fogs are persistent. The precipitation regime is in excess of 1400 mm per annum, a great deal of which falls as snow over autumn, winter and spring. Snows may come at any time of year and frosts can occur during summer. Structurally the vegetation of this BVT is an open low woodland of Snow Gum *Eucalyptus pauciflora*, with a generally shrubby understorey of Rough Coprosma *Coprosma hirtella*, Prickly Bush-pea *Pultenaea juniperina*, Mountain Peppers *Tasmannia* spp., Mint-bushes *Prostanthera* spp. Heaths particularly *Leucopogon* spp. are prominent, with grasses (usually Snow Grasses *Poa* spp.) and these may or may not be an obvious component of the ground layer. Herbs however are often obvious with species like Caraways *Oreomyrrhis* spp., Violets Viola spp., Goodenias *Goodenia* spp. the most usual. Composites (Alpine Podolepis *Podolepis robust* and Brachyscomes *Brachyscome* spp.) are usually present.

Sub-alpine Woodlands are the most common ecological vegetation class present although Sub-alpine Wet Heaths are also present on the drainage lines, with Sub-alpine meadows and Outcrop Shrublands also occasionally present.

15 Plains Grasslands

Plains Grasslands BVTs occupy fertile plains under low rainfall regimes of 300–700 mm per annum but may be up to 1000 mm in Gippsland. The parent geologies of the plains varies with the Western Volcanic Plains being basalts, the Sale Plains being outwash clays, the Northern Plains, Wimmera and Western Port being riverine (alluvial) silts and clays. These BVTs are characterised by a very low density or complete absence of trees and shrubs, although the tree-form of Silver Banksia *Banksia marginata* may be present as may Drooping Sheoke *Allocasuarina verticillata*. The ground layer is dominated by perennial grasses (Kangaroo Grass *Themeda triandra*, Wallaby Grasses *Danthonia* spp., and Spear grasses such as Rough Spear Grass *Stipa scabra)* herbs (particularly composites) Brachyscomes *Brachyscome* spp., Blue Devil *Eryngium ovinum*, Common Everlasting *Chrysocephalum apiculatum* and perennial geophytes such as bulbines *Bulbine* spp. Annuals may be common in areas that are regularly grazed or burnt.

This BVT is characterised by extensive tracts of land with this vegetation. The dominant ecological vegetation class represented in this BVT varies according to biogeographic zone and parent geology: on the Western Volcanic Plains heavy clay basalt soils the ecological vegetation class is Western Plains Grassland, on the Sale Plains outwash clays the dominant ecological vegetation class is Gippsland Plains Grassland and on the Northern Plains with its riverine silts and clays, the dominant ecological vegetation class is Northern Plains Grassland. Within this BVT there are smaller marshes and areas of Grassy Wetlands and Grassy Woodlands.

16 Plains Grassy Woodlands

Plains Grassy Woodland BVTs occupy fertile plains under low rainfall regimes of 400–700 mm per annum. The original geologies of the plains varies, with the Western Volcanic Plains being basalts, the Sale Plains being outwash clays and the Northern Plains being riverine silts and clays. Other minor components includes sites with Tertiary outwash deposits (Dundas Tablelands) colluvial deposits localised in topography associated with valleys. These BVTs are characterised by a very low density cover of trees such as River Red Gum *Eucalyptus camaldulensis* on basalt and siltstone derived soils, Forest Redgum Eucalyptus tereticornis on gravel-clay outwash, Yellow Box *Eucalyptus melliodora* and White Box *Eucalyptus albens* on riverine silts and clays. Mixtures of Black Box *Eucalyptus largiflorens*, Yellow Gum *Eucalyptus leucoxylon* and Buloke *Allocasuarina luehmannii* are characteristic in the Wimmera north of the Little Desert. The most usual shrubs are Lightwood *Acacia implexa*, tree-form Silver Banksia *Banksia marginata*, Golden Wattle *Acacia pycnantha*, Cranberry Heath *Astroloma humifusum* and a ground layer dominated by perennial grasses, particularly Wallaby Grasses *Danthonia* spp., Spear Grasses *Stipa* spp., Kangaroo Grass *Themeda triandra*, Cane Wire Grass *Aristida ramosa*, herbs such as Scaly Buttons *Leptorhynchos squamatus* Kidney weed *Dichondra repens*, Solenogynes *Solenogyne* spp., Plantains *Plantago varia* and *P. debilis*, Cotton Fireweed *Senecio quadridentatus*, Austral Bear's Ear *Cymbonotus preissianus* and perennial geophytes especially orchids and lilies.

This BVT is characterised by extensive tracts of land with this vegetation. The dominant ecological vegetation class represented in this BVT varies according to biogeographic zone and parent geology: on the Western Volcanic Plains heavy clay basalt soils the ecological vegetation class is Western Plains Grassy Woodland, on the Sale Plains outwash clays the dominant ecological vegetation class is Gippsland Plains Grassy Woodland and on the Northern Plains with its riverine silts and clays, the dominant ecological vegetation class is Northern Plains Grassy Woodland. Within this BVT there are smaller areas of Wetlands and Grasslands. There are, however, smaller outliers of fertile geology that support this vegetation BVT such as the granodiorites around Mansfield and the limestones of the Buchan and Murrindal area.

17 Valley Grassy Forests

Valley Grassy Forest BVTs occur on the lower slopes of river valleys as they exit the foothills of the Divide, especially but not exclusively in northern Victoria. The rainfall is between 650–750 mm per annum and the soils are fertile silts and clay loams derived from old river flats or fertile geologies such as granodiorites. The BVT is dominated by a medium forest of Yellow Box *Eucalyptus melliodora*, Gippsland Grey Box *Eucalyptus bosistoana*, Southern Blue Gum *Eucalyptus globulus* and Candlebark *Eucalyptus rubida*, that has an open, nearly shrub free understorey and a ground layer that is characterised by an abundance and diversity of grasses, particularly Wallaby Grasses such as Slender Wallaby Grass *Danthonia pilosa*, Striped Wallaby Grass *Danthonia racemosa*, Weeping grass *Microlaena stipoides*, and tussock grasses such as Soft Tussock-grass *Poa morrisi*, Common Tussock-grass *Poa labillardieri*, herbs and geophytes such as lilies and orchids.

The most usual ecological vegetation class in this BVT is Valley Grassy Forest and this may have smaller areas of Riparian Forest, Riparian Swampy Woodland associated with drainage lines and Heathy Dry Forest or Grassy Dry Forest on the adjacent slopes of river valleys.

18 Herb-Rich Woodlands

Herb-rich Woodland BVTs occur on lateritic fertile clays and silty clay loams or the volcanic stony rises of the Western District under an annual rainfall regime of 500–600 mm. The vegetation usually occurs on gentle slopes or plains that represent past depositional or volcanic environments that today remain fairly damp. The BVT is characterised by an open medium woodland structure predominantly of Yellow Box *Eucalyptus melliodora*, River Red Gum *Eucalyptus camaldulensis* with Long-leaf Box *Eucalyptus goniocalyx* and an understorey almost devoid of shrubs and grasses. Tree-form Silver Banksia *Banksia marginata* and Black Wattle *Acacia mearnsii* are exceptions to this general rule, however. The dominant ground cover is perennial geophytes such Yellow Bulbine Lily *Bulbine bulbosa*, Nodding Chocolate Lily *Arthropodium fimbriatum*, Small Vanilla Lily *Arthropodium minus*, Yellow Star *Hypoxis hygrometrica*, Early Nancy *Wurmbea* spp., Trigger plants *Stylidium* spp., as orchids and lilies and a diverse array of herbs such as Solenogynes *Solenogyne* spp., Austral Bear's Ear *Cymbonotus preissianus* (both perennial and annual), with smaller numbers of grasses such as Wallaby Grass *Danthonia* spp., and minute sedges of the genus *Centrolepis* and a multitude of small annuals species.

The most usual ecological vegetation class is Herb-rich Woodland although there is often small Wetlands, areas of Box Ironbark Forest, Grassy Dry Forest or Western Plains Grassy Woodlands or Grasslands within the BVT or on its periphery. On current alluvial terraces the BVT merges with Riverine Plains Grassy Woodland and on more fertile, better drained sites Grassy Woodlands

19 Sub-alpine Grassy Woodlands

Sub-alpine Grassy Woodland BVTs are confined to altitudes of 1200–1400 m where fertile geologies such as basalts or granodiorites occur. The precipitation regime is in excess of 1400 mm per annum, a great deal of which falls as snow over autumn, winter and spring and fog cover is often present. Snows may come at any time of year and frosts can occur during summer. Structurally the vegetation of this BVT is an open low woodland of Snow Gum *Eucalyptus pauciflora* with a generally grassy ground layer of Snow grasses *Poa* spp. and Wallaby Grasses *Danthonia* spp., where shrubs are not an obvious component, but herbs are nearly always diverse and obvious, including Australian Carraway *Oreomyrrhis eriopoda*, Royal Bluebell *Wahlenbergia gloriosa*, Showy Violet *Viola betonicifolia* and Grass Trigger Plant *Stylidium graminifolium*.

The dominant ecological vegetation class in this vegetation BVT is Sub-alpine Grassy Woodland, with smaller areas of Sub-alpine Woodland and Sub-alpine Meadows. Sub-alpine heaths are uncommon.

20 Montane Grassy Woodlands

Montane Grassy Woodland BVTs are confined to altitudes of 1000–1200 m where fertile geologies such as basalts or granodiorites occur. The precipitation regime is in excess of 1400 mm per annum, a great deal of which falls as snow over autumn, winter and spring with fogs a common event. Snows may come at any time of year and frosts can occur during summer. Structurally the vegetation of this BVT is an open low woodland of Candlebark Eucalyptus rubida and Snow Gum Eucalyptus pauciflora with a generally grassy ground layer of Kangaroo Grass *Themeda triandra*, Common Tussock Grass *Poa labillardieri* and Wallaby Grass *Danthonia* spp., where shrubs are not an obvious component of the shrub-layer (with the exception of the tree-form of Silver Banksia *Banksia marginata* and Pale Fruit Ballart *Exocarpus strictus* and occasional heaths in the genus *Epacris*), but herbs like Common Everlasting *Chrysocephalum semipapposum*, Sheep's Burr *Acaena echinata*, Variable Plantain *Plantago varia* are nearly always present, diverse and obvious. Composites are usually present.

The dominant ecological vegetation class in this vegetation BVT is Montane Grassy Woodland, with smaller areas of Montane Dry Woodland. This vegetation merges into Sub-alpine Treeless BVTs at elevations of >1200 m, whereas at elevations of <1000 m the BVT merges into Moist Foothill Forest BVTs.

21 Riverine Grassy Woodlands

Riverine Grassy Woodland BVT grow on the flood plains of major rivers and streams in Victoria where the rainfall is 300–700 mm per annum. The soils are fertile silts and water is rarely a limiting factor. Floods are a regular feature usually happening at least once a year. The structure is a woodland of River Red Gum *Eucalyptus camaldulensis*, occasionally Black Box *Eucalyptus largiflorens* and on higher ground Grey Box *Eucalyptus microcarpa* and Yellow Box *Eucalyptus melliodora*, although timber harvesting can cause the structure to alter to a forest. The understorey has very few shrubs (often only the occasional wattle like Silver Wattle *Acacia dealbata*) and the ground layer is dominated by grasses such as Common Tussock Grass *Poa labillardieri*, Spiney Mud Grass *Pseudoraphis spinescens* and Warrego Summer Grass *Paspalidium jubiliflorum* and various sedges (usually *Carex* spp.) and rushes *Juncus* spp. Herbs are not always obvious but there are generally Water Peppers *Persicaria* spp. and Willow Herbs *Epilobium* spp. present.

The dominant ecological vegetation class is Riverine Grassy Woodland, with smaller areas of Riverine Grasslands, Billabong Wetlands and other aquatic and lake-bed communities. On more elevated sites on the flood plain Grassy Woodlands develop. This BVT merges into Grassy Woodlands BVT on older alluvial terraces.

22 Riparian Forests

This is a mosaic which occupies the currently flooded alluvial flats of major rivers and streams under an annual rainfall regime of 700–1000 mm. The soils are fertile, well watered silty loams often high in organic matter. The BVT is usually dominated by medium to tall forest with Manna Gum *Eucalyptus viminalis* usually present River Peppermint *Eucalyptus elata*, Bangalay *Eucalyptus botryoides* less common, with understorey trees Silver Wattle *Acacia dealbata*, Blackwood *Acacia melanoxylon*, tree-form Burgan *Kunzea ericoides*, (Warm Temperate Rainforest species in Eastern Victoria Lily Pilly *Acmena smithii* and Kanooka *Tristaniopsis laurina*). The dense tall shrub layer usually has Austral Mulberry *Hedycarya angustifolia*, Hazel Pomaderris *Pomaderris aspera*, Daisy-bushes *Olearia* spp., and Victorian Christmas Bush *Prostanthera lasianthos*. The understorey is characterised by a diverse and dense ground layer of herbs Austral Brooklime *Gratiola peruviana*, Pennyworts *Hydrocotyle* spp., Self-heal *Prunella vulgaris*, Forest Mints *Mentha* spp., Forest Nettle *Urtica incisa*, ferns such as Downy Ground-fern *Hypolepis glandulifera*, Common Ground-fern *Calochlaena dubia*, Soft Tree-fern *Dicksonia antarctica* and the sedge Leafy Flat-sedge *Cyperus lucidus* in particular. The density and diversity of life forms reflects the high environmental site quality of this BVTs' habitat.

The ubiquitous ecological vegetation class is Riparian Forest, with smaller areas of Swampy Riparian Woodland on wetter sites, Billabong Wetlands on old anabranches, occasionally Swamp Scrubs, and on the largest rivers, Riparian Shrubland on sands in the river bed proper. On its margins this BVT can merge with a wide variety of other BVTs but the most usual is Dry Foothill Forest BVTs and Lowland Forest BVTs. In some places in the east of the state, Warm Temperate Rainforest and Gallery Rainforest may be present.

23 Rainshadow Woodlands

Rainshadow Woodland BVTs are highly restricted in Victoria because they require rainfall of less than 700 mm and a fertile geology such as granodiorite. Soils are fertile but very free-draining sandy loams. The topography is generally gentle rolling hills. The BVT is usually a low open woodland predominantly of White Box *Eucalyptus albens* and Drooping Sheoke *Allocasuarina verticillata* with a sparse understorey shrub layer of wattles, for example, Deane's Wattle *Acacia deanii* and Sticky Hop-bush *Dodonea viscosa* and a ground layer of drought tolerant grasses such as common Wheat Grass *Elymus scabrus*, Wallaby Grasses *Danthonia* spp., and Niggerheads *Enneapogon nigricans*. The herbs include Kidney Weed *Dichondra repens*, Bear's Ear *Cymbonotus lawsonianus* and Large Tick-trefoil *Desmodium brachypodum*. Perennial geophytes like Bulbine Lilies *Bulbine* spp. and Vanilla Lilies *Arthropodium* spp. are often prominent in spring particularly. The vine Small-leaved Clematis *Clematis microphyll* var. *leptophylla* is diagnostic of this BVT.

The dominant ecological vegetation class is Rainshadow Woodland, while on the valley floors this may give way to Valley Grassy Forest and on the nearby ridges Grassy Dry Forest. The BVT can be characterised by extensive stands of Cypress Pine on the most exposed aspects.

24 Mallee

The Mallee BVTs develop on poor sandy soils under rainfall regimes of <350 mm. Organic matter is low and soil structure is poor and droughty. This BVT can occur on dunes and swales as well as on old lacustrine deposits provided these are sandy. The structure is variable although the overstorey is usually dominated by Mallee-form trees such as Yellow Mallee *Eucalyptus incrassata*, Slender-leaf Mallee *E. leptophylla*, Dumosa Mallee *E. dumosa* and Grey Mallee *E. socialis* that are low in height, occasionally heaths and also woodlands. The understorey is dominated by heathy shrubs like Desert Banksia *Banksia ornata*, Green Tea-tree *Leptospermum coriaceum*, Baeckias *Baeckia* spp., Scrub Cypress Pine *Callitris verrucosa* and Myrtles *Calytrix* spp. with few if any grasses except for Common *Triodia scariosa* and annual herbs (particularly composites). In Chenopod Mallees the understorey is dominated by Blue-bushes *Maireana* spp.

This BVT has one or a combination of: East\West Dune Mallees, Loamy Sand Mallees, Chenopod Mallees, Shallow Sand Mallees, Broombush Mallees, Red Swale Mallees, Big Mallees, Mallee Heaths, Yellow Gum Woodlands, Belah Woodlands, Sandstone-rise Broombush, Scrub Pine Woodlands.

25 Mallee Heaths

The Mallee Heath BVTs develop on deep siliceous sands associated with relatively recent dune formation, for example parabolic dune fields. These vegetation types occur under rainfall regimes of <350 mm. Organic matter is low and soil structure is poor and droughty. The structure is variable although the overstorey where present is usually dominated by Mallee-form trees such as Yellow Mallee *Eucalyptus incrassata*, Slender-leaf Mallee *E. leptophylla*, Dumosa Mallee *E. dumosa* and Desert Stringybark *Eucalyptus arenacea* that are low in height. The understorey is dominated by heathy shrubs like Desert Banksia *Banksia ornata*, Green Tea-tree *Leptospermum coriaceum*, Scrub Sheoke *Allocasuarina paludosa*, Baeckias *Baeckia* spp., Scrub Cypress Pine *Callitris verrucosa* and Myrtles *Calytrix* spp. with few if any grasses except for Common *Triodia scariosa*.

This BVT has one or a combination of: Dune-crest Tea-tree Heaths, Sandplain Heaths, Tea-tree Scrubs, Mallee Heaths, Shallow Sand Mallee-Heaths, Loamy Sand Mallees and Scrub-pine Woodlands.

26 Boinka-Raak

The Boinka-Raak BVTs develop on the heavy soils of old lacustrine deposits under rainfall regimes of <350 mm. Organic matter is moderately high. The structure is variable although mostly shrublands and occasionally a woodland, in which case the overstorey is usually dominated by Sugarwood *Myoporum platycarpum*. The understorey is dominated by salt tolerant species such as Samphire (Glassworts) *Halosarcia* spp., Bluebush *Maireana* spp., Saltbush *Atriplex* spp. and Twin-leaf *Zygophyllum* spp.

This BVT has one or a combination of: Saline Shrublands (Raak), Gypseous Plains Shrubland (bluebush, saltbush and Twin-leaf) and Gypseous Rise Woodlands.

27 Mallee Woodlands

The Mallee Woodland BVTs develop on moderately fertile heavy soils under rainfall regimes of <350 mm. This BVT occurs primarily on old lacustrine deposits. The structure is variable although the overstorey is usually dominated by a low woodland of Slender Cypress Pine *Callitris preissii*, Buloke *Allocasuarina* spp. and Oil Mallee *Eucalyptus oleosa* or occasionally grasslands. The understorey is dominated by grasses, Spear Grasses *Stipa* spp. and annuals, with few if any shrubs.

The BVT has one or a combination of Pine-Buloke Woodlands, Savannah Woodlands, Savannah Mallees, Grasslands or Sandplain Grasslands.

28 Wimmera Mallee Woodlands

This BVT has soils that are characterised as finely textured and unconsolidated often saline finely textured in nature occurring under a 300–500 mm rainfall regime. Structurally this BVT is a mosaic of Mallee, Big Mallee and Pine-Buloke Woodlands with occasional small areas of grasslands.

The BVT contains various combinations of Pine/Buloke Woodland, Alluvial Plains Shrubland, Savannah Woodland, Savannah Mallee, Chenopod Mallee, Red Swale Mallee, Black Box Chenopod-Woodland, Black Box Wetlands, Northern Plains Grasslands and Northern Plains Grassy Woodlands.

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1 ' For definiteness, floristic community was defined as 'an aggregation of one or more sub-communities that have floristic, structural and major environmental affinities' (Muir et al. 1995). This hierarchical structure culminates in the designation of 'floristic sub-communities': '[that are] based on groups of quadrats [544 30 m x 30 m quadrats] which have the highest similarity in floristic composition in the classification based on a two-way table. A sub-community represents subtle differences within a community which may be a result of microclimatic variations such as slope position, soil fertility and moisture levels, or of proximity to another community' (Muir et al. 1995).

Appendix 3.3

Conservation and reservation status of Ecological Vegetation Classes by Victorian bioregions

KEY

Conservation status:

X = Presumed Extinct
E = Endangered
V = Vulnerable
R = Rare
D = Depleted
LC = Least Concern

Note that listings of conservation status are based on the data available at the time of the study. Conservation status of Ecological Vegetation Classes in bioregions may therefore change as more accurate data becomes available.

Reservation status:

X = EVC does not reach reservation target set by the criteria
Y = EVC reaches reservation target set by the criteria

Note that the data may *not* be accurate to the hectare level. Reservation status of Ecological Vegetation Classes in bioregions may therefore change as more accurate data becomes available.

Tenures included as 'Reserved land' in the data:

Wilderness Areas
Wilderness Zone
Other Areas with Remote and Natural Attributes
National Parks
State Parks
Coastal Parks
Regional Parks (listed in National Parks Act)
Reference Areas
Nature Conservation Reserve
Flora Reserve
Flora and Fauna Reserve
Natural Catchment Area
Cave Reserve
Natural Features and Scenic Reserve
Scenic Reserve
Geological Reserve or Monument
Wildlife Reserve
Wildlife Management Co-operative Area
River Murray Reserve
Stream-side Reserve
Public Land Water Frontage Reserve
Stream Beds and Banks
Bushland Reserve
Heritage River

Note that reserves in the following figures include all those proposed and established by the RFA processes.

Appendix 3.3: 1

Bioregion	Ecological Veg. Class	Conservation status	Reservation status	Pre-1750 area (ha)	Total extant area (ha)	Extant/pre-1750	Private/pre-1750	Reserved/extant	Private/extant
Central Victorian Uplands	Plains Sedgy Woodland	X		246	0	0%	0%	0%	100%
Central Victorian Uplands	Alluvial Terraces Herb-rich Woodland	E	X	3738	632	17%	9%	12%	55%
Central Victorian Uplands	Basalt Escarpment Shrubland	E	X	1794	265	15%	14%	0%	96%
Central Victorian Uplands	Box Woodland	E	X	411	6	1%	1%	0%	100%
Central Victorian Uplands	Creekline Grassy Woodland	E	X	4633	364	8%	4%	0%	50%
Central Victorian Uplands	Creekline Herb-rich Woodland	E	X	8732	3418	39%	17%	10%	44%
Central Victorian Uplands	Damp Sands Herb-rich Woodland	E	X	9560	1031	11%	7%	29%	66%
Central Victorian Uplands	Floodplain Riparian Woodland	E	X	30318	2424	8%	3%	0%	44%
Central Victorian Uplands	Granitic Hills Woodland	E	X	1599	472	30%	10%	0%	34%
Central Victorian Uplands	Grassy Woodland	E	X	123679	5076	4%	4%	0%	93%
Central Victorian Uplands	Hillcrest Herb-rich Woodland	E	X	316	69	22%	16%	0%	73%
Central Victorian Uplands	Hills Herb-rich Woodland	E	X	7934	1768	22%	10%	44%	46%
Central Victorian Uplands	Plains Grassland	E	X	10490	219	2%	2%	0%	100%
Central Victorian Uplands	Plains Grassy Wetland	E	X	2403	114	5%	3%	0%	71%
Central Victorian Uplands	Plains Grassy Woodland	E	X	229745	8125	4%	3%	5%	75%
Central Victorian Uplands	Plains Sedgy Wetland	E	X	2062	68	3%	2%	12%	64%
Central Victorian Uplands	Red Gum Wetland	E	X	1658	242	15%	15%	0%	100%
Central Victorian Uplands	Riparian Shrubland	E	X	317	109	35%	3%	0%	9%
Central Victorian Uplands	Riparian Woodland	E	X	2626	165	6%	6%	0%	91%
Central Victorian Uplands	Riverine Escarpment Scrub	E	X	1484	12	1%	1%	0%	95%
Central Victorian Uplands	Riverine Grassy Forest	E	X	185	3	2%	1%	0%	61%
Central Victorian Uplands	Sand Forest	E	X	31	13	40%	40%	0%	100%
Central Victorian Uplands	Scoria Cone Woodland	E	X	2357	213	9%	9%	0%	100%
Central Victorian Uplands	Spring Soak Woodland	E	X	30	10	32%	32%	0%	100%
Central Victorian Uplands	Swamp Scrub	E	X	1334	105	8%	6%	0%	81%
Central Victorian Uplands	Swampy Riparian Woodland	E	X	6281	636	10%	8%	0%	84%
Central Victorian Uplands	Unclassified Foothill Forest	E	X	863	36	4%	4%	0%	100%
Central Victorian Uplands	Valley Heathy Forest	E	X	3170	310	10%	9%	4%	90%
Central Victorian Uplands	Wetland Formation	E	X	747	2	0%	0%	0%	100%
Central Victorian Uplands	Box Ironbark Forest	V	X	9391	4539	48%	25%	40%	51%
Central Victorian Uplands	Grassy Forest	V	X	8833	3107	35%	34%	0%	95%
Central Victorian Uplands	Riparian Forest	V	X	11162	5152	46%	12%	9%	25%
Central Victorian Uplands	Rocky Chenopod Woodland	V	X	1702	739	43%	21%	13%	48%
Central Victorian Uplands	Stream-bank Shrubland	V	X	4255	1866	44%	22%	22%	51%

Bioregion	Ecological Veg. Class	Conservation status	Reservation status	Pre-1750 area (ha)	Total extant area (ha)	Extant/pre-1750	Private/pre-1750	Reserved/extant	Private/extant
Central Victorian Uplands	Valley Grassy Forest	V	X	181624	21056	12%	8%	5%	71%
Central Victorian Uplands	Shrubby Woodland	R	Y	221	221	100%	0%	100%	0%
Central Victorian Uplands	Grassy Dry Forest	D	X	184577	80361	44%	20%	8%	46%
Central Victorian Uplands	Herb-rich Foothill Forest	D	X	195081	84962	44%	19%	5%	43%
Central Victorian Uplands	Damp Forest	LC	X	10230	8835	86%	16%	10%	18%
Central Victorian Uplands	Heathy Dry Forest	LC	X	125819	82297	65%	22%	22%	33%
Central Victorian Uplands	Heathy Woodland	LC	X	1358	942	69%	14%	42%	20%
Central Victorian Uplands	Lowland Forest	LC	X	4946	3363	68%	34%	29%	50%
Central Victorian Uplands	Sedgy Riparian Woodland	LC	X	3480	2333	67%	25%	2%	37%
Central Victorian Uplands	Shrubby Dry Forest	LC	X	13923	11658	84%	12%	44%	15%
Central Victorian Uplands	Shrubby Foothill Forest	LC	X	38763	35854	92%	11%	11%	12%
Central Victorian Uplands	Alluvial Terraces Herb-rich Woodland/Creekline Grassy Woodland Mosaic			370	34	9%	9%	0%	100%
Central Victorian Uplands	Alluvial Terraces Herb-rich Woodland/Plains Grassy Woodland Complex			1053	20	2%	2%	0%	92%
Central Victorian Uplands	Aquatic Herbland/Plains Sedgy Wetland Mosaic			2351	169	7%	7%	0%	91%
Central Victorian Uplands	Floodplain Riparian Woodland/Plains Grassy Woodland Mosaic			704	6	1%	1%	0%	100%
Central Victorian Uplands	Gilgai Plain Woodland/Wetland Mosaic			35	1	3%	3%	0%	100%
Central Victorian Uplands	Grassy Dry Forest/Heathy Dry Forest Complex			8429	2189	26%	7%	0%	25%
Central Victorian Uplands	Grassy Dry Forest/Rocky Outcrop Shrubland/Herbland Mosaic			115	7	6%	6%	0%	100%
Central Victorian Uplands	Grassy Woodland/Heathy Dry Forest Complex			21121	1008	5%	4%	0%	87%
Central Victorian Uplands	Grassy Woodland/Valley Grassy Forest Complex			157	0	0%	0%	0%	100%
Central Victorian Uplands	Heathy Dry Forest/Depapaurate Heathy Dry Forest Mosaic			1078	0	0%	0%	0%	0%
Central Victorian Uplands	Herb-rich Foothill Forest/Shrubby Foothill Forest Complex			6003	4102	68%	10%	0%	14%
Central Victorian Uplands	Low Rises Grassy Woodland/Alluvial Terraces Herb-rich Woodland Mosaic			3334	86	3%	2%	0%	93%
Central Victorian Uplands	Montane Grassy Woodland/Rock Outcrop Mosaic			9	7	80%	0%	0%	0%
Central Victorian Uplands	Montane Rocky Shrubland/Shrubby Foothill Forest Complex			1910	1547	81%	7%	49%	9%
Central Victorian Uplands	Perched Boggy Shrubland Complex			33	18	54%	54%	0%	100%
Central Victorian Uplands	Plains Grassland/Plains Grassy Woodland Mosaic			13527	248	2%	2%	0%	90%
Central Victorian Uplands	Plains Grassy Woodland/Creekline Grassy Woodland Mosaic			274	16	6%	6%	0%	100%
Central Victorian Uplands	Plains Grassy Woodland/Creekline Grassy Woodland/Floodplain Riparian Woodland			516	0	0%	0%	0%	100%
Central Victorian Uplands	Plains Grassy Woodland/Plains Grassland/Plains Grassy Wetland Mosaic			604	2	0%	0%	0%	100%
Central Victorian Uplands	Riparian Forest/Creekline Grassy Woodland Mosaic			114	2	2%	2%	0%	100%
Central Victorian Uplands	Riparian Forest/Swampy Riparian Woodland Mosaic			448	26	6%	6%	0%	100%
Central Victorian Uplands	Riparian Forest/Swampy Riparian Woodland/Riparian Shrubland/Riverine Escarpment Scrub			684	24	3%	1%	0%	19%
Central Victorian Uplands	Riparian Shrubland/Swampy Riparian Woodland Mosaic			128	11	9%	5%	0%	63%

Appendix 3.3: 3

Bioregion	Ecological Veg. Class	Conservation status	Reservation status	Pre-1750 area (ha)	Total extant area (ha)	Extant/pre-1750	Private/pre-1750	Reserved/extant	Private/extant
Central Victorian Uplands	Riverina Plains Grassy Woodland/Plains Grassland Mosaic			2799	241	9%	7%	0%	83%
Central Victorian Uplands	Rocky Outcrop Shrubland/Herbland Mosaic			750	612	81%	5%	63%	6%
Central Victorian Uplands	Shrubby Granitic-outwash Grassy Woodland/Plains Grassy Woodland Complex			17	0	0%	0%	0%	0%
Central Victorian Uplands	Slopes Box Grassy Woodland/Box Ironbark Forest Complex			1454	69	5%	5%	0%	100%
Central Victorian Uplands	Swampy Riparian Complex			11514	899	8%	6%	0%	82%
Central Victorian Uplands	Swampy Riparian Woodland/Spring Soak Woodland Mosaic			54	8	14%	14%	0%	100%
Central Victorian Uplands	Valley Grassy Forest/Box Ironbark Forest Complex			283	4	2%	2%	0%	100%
Central Victorian Uplands	Valley Grassy Forest/Grassy Dry Forest Mosaic			254	100	39%	39%	0%	100%
Central Victorian Uplands	Valley Grassy Forest/Plains Grassy Woodland Complex			629	3	1%	1%	0%	100%
Central Victorian Uplands	Valley Grassy Forest/Slopes Box Grassy Woodland Complex			44	3	7%	7%	0%	100%
Dundas Tablelands	Stony Knoll Shrubland	X		9	0	0%	0%	0%	0%
Dundas Tablelands	Alluvial Terraces Herb-rich Woodland	E	X	1398	342	24%	3%	45%	11%
Dundas Tablelands	Aquatic Herbland	E	X	228	19	9%	2%	0%	23%
Dundas Tablelands	Basalt Escarpment Shrubland	E	X	301	45	15%	10%	0%	70%
Dundas Tablelands	Creekline Grassy Woodland	E	X	23792	748	3%	2%	0%	77%
Dundas Tablelands	Creekline Sedgy Woodland	E	X	564	44	8%	1%	0%	9%
Dundas Tablelands	Dry Creekline Woodland	E	X	316	138	44%	24%	7%	55%
Dundas Tablelands	Lateritic Woodland	E	X	4232	252	6%	5%	1%	90%
Dundas Tablelands	Plains Grassy Woodland	E	X	220823	17376	8%	1%	7%	15%
Dundas Tablelands	Plains Sedgy Wetland	E	X	1101	8	1%	1%	0%	66%
Dundas Tablelands	Plains Woodland	E	X	6468	74	1%	1%	0%	85%
Dundas Tablelands	Riparian Woodland	E	X	2955	692	23%	15%	0%	66%
Dundas Tablelands	Sandy Stream Woodland	E	X	6430	593	9%	9%	0%	97%
Dundas Tablelands	Sedge Wetland	E	X	188	51	27%	0%	0%	2%
Dundas Tablelands	Shallow Freshwater Marsh	E	X	253	130	51%	7%	2%	14%
Dundas Tablelands	Damp Sands Herb-rich Woodland	V	X	27124	3254	12%	8%	1%	69%
Dundas Tablelands	Floodplain Riparian Woodland	V	X	11588	1811	16%	10%	0%	67%
Dundas Tablelands	Floodplain Thicket	V	X	873	529	61%	2%	38%	3%
Dundas Tablelands	Herb-rich Heathy Woodland	V	X	1636	840	51%	31%	0%	60%
Dundas Tablelands	Sand Heathland	V	X	590	380	64%	5%	48%	7%
Dundas Tablelands	Seasonally Inundated Shrubby Woodland	V	X	3884	1969	51%	8%	13%	16%
Dundas Tablelands	Shallow Sands Woodland	V	X	9721	1253	13%	4%	1%	29%
Dundas Tablelands	Sand Forest	R	X	42	42	100%	0%	0%	0%
Dundas Tablelands	Sedge-rich Wetland	R	X	244	235	96%	3%	12%	3%

Bioregion	Ecological Veg. Class	Conservation status	Reservation status	Pre-1750 area (ha)	Total extant area (ha)	Extant/pre-1750	Private/pre-1750	Reserved/extant	Private/extant
Dundas Tablelands	Shrubby Woodland	R	X	385	371	96%	27%	9%	28%
Dundas Tablelands	Hills Herb-rich Woodland	D	X	2990	1815	61%	36%	18%	59%
Dundas Tablelands	Plains Sedgy Woodland	D	X	1537	910	59%	4%	13%	6%
Dundas Tablelands	Heathy Woodland	LC	X	14129	10968	78%	16%	13%	21%
Dundas Tablelands	Aquatic Herbland/Plains Sedgy Wetland Mosaic			1890	10	1%	0%	0%	35%
Dundas Tablelands	Brackish Drainage Line Herbland/Sedgeland			700	13	2%	2%	0%	91%
Dundas Tablelands	Damp Sands Herb-rich Woodland / Heathy Woodland			28	3	10%	9%	9%	91%
Dundas Tablelands	Damp Sands Herb-rich Woodland / Plains Grassy Woodland			56653	562	1%	1%	0%	87%
Dundas Tablelands	Damp Sands Herb-rich Woodland / Seasonally Inundated Shrubby Woodland			14	11	79%	79%	0%	100%
Dundas Tablelands	Damp Sands Herb-rich Woodland / Shrubby Woodland			324	191	59%	40%	0%	67%
Dundas Tablelands	Floodplain Riparian Woodland / Plains Grassy Woodland			639	5	1%	1%	0%	94%
Dundas Tablelands	Freshwater Lake Mosaic			17	0	0%	0%	0%	0%
Dundas Tablelands	Grassy Dry Forest/Rocky Outcrop Shrubland/Herbland Mosaic			95	7	8%	8%	0%	100%
Dundas Tablelands	Grassy Woodland / Damp Sands Herb-rich Woodland			29669	546	2%	2%	0%	96%
Dundas Tablelands	Grassy Woodland / Hills Herb-rich Woodland / Damp Sands Herb-rich Woodland			13720	561	4%	4%	0%	94%
Dundas Tablelands	Heathy Woodland / Plains Grassy Woodland			1160	326	28%	28%	0%	99%
Dundas Tablelands	Heathy Woodland/Heathy Woodland Complex			82	82	100%	1%	16%	1%
Dundas Tablelands	Hills Herb-rich Woodland / Plains Grassy Woodland			5688	883	16%	7%	0%	44%
Dundas Tablelands	Montane Rocky Shrubland/Shrubby Foothill Forest Complex			795	688	87%	8%	15%	7%
Dundas Tablelands	Plains Grassy Woodland / Damp Sands Herb-rich Complex			27169	124	0%	0%	0%	94%
Dundas Tablelands	Plains Grassy Woodland / Shrubby Woodland			12	4	34%	29%	13%	87%
Dundas Tablelands	Plains Woodland/Plains Grassy Wetland			517	19	4%	4%	0%	100%
Dundas Tablelands	Riparian Shrubland / Escarpment Shrubland / Grassy Woodland			38	8	22%	11%	0%	53%
Dundas Tablelands	Rocky Outcrop Shrubland/Herbland / Heathy Woodland			42	41	96%	72%	0%	74%
Dundas Tablelands	Saline Lake Mosaic			59	0	0%	0%	0%	0%
Dundas Tablelands	Saline Lake Verge Herbland/Sedgeland			18	0	0%	0%	0%	0%
Dundas Tablelands	Seasonally Inundated Shrubby Woodland / Plains Sedgy Woodland			130	24	18%	9%	0%	52%
Dundas Tablelands	Shallow Sands Woodland / Plains Sedgy Woodland / Seasonally Inundated Shrubby Woodland			1010	62	6%	1%	0%	14%
Dundas Tablelands	Stony Rises Woodland / Stony Knoll Shrubland			2360	1967	83%	30%	0%	36%
Dundas Tablelands	Valley Grassy Forest / Lateritic Woodland			30	21	69%	68%	3%	97%
East Gippsland Lowlands	Deep Freshwater Marsh	X		129	0	0%	0%	0%	100%
East Gippsland Lowlands	Floodplain Reedbed	X		610	0	0%	0%	0%	100%
East Gippsland Lowlands	Dry Rainforest	E	X	12	7	62%	16%	28%	26%
East Gippsland Lowlands	Lagoon Wetland	E	X	288	9	3%	2%	0%	81%

Appendix 3.3: 5

Bioregion	Ecological Veg. Class	Conservation status	Reservation status	Pre-1750 area (ha)	Total extant area (ha)	Extant/pre-1750	Private/pre-1750	Reserved/extant	Private/extant
East Gippsland Lowlands	Limestone Pomaderris Shrubland	E	X	62	8	14%	13%	0%	93%
East Gippsland Lowlands	Plains Grassy Forest	E	X	18492	1248	7%	7%	0%	97%
East Gippsland Lowlands	Plains Grassy Woodland	E	X	3120	115	4%	4%	0%	98%
East Gippsland Lowlands	Sandy Flood Scrub	E	X	109	34	31%	10%	0%	31%
East Gippsland Lowlands	Swamp Scrub	E	X	1636	73	4%	3%	0%	70%
East Gippsland Lowlands	Brackish Sedgeland	V	Y	195	195	100%	0%	100%	0%
East Gippsland Lowlands	Coastal Vine-rich Forest	V	Y	76	74	98%	1%	90%	1%
East Gippsland Lowlands	Estuarine Wetland	V	X	706	463	66%	6%	12%	9%
East Gippsland Lowlands	Lowland Herb-rich Forest	V	X	13936	4304	31%	11%	0%	37%
East Gippsland Lowlands	Blackthorn Scrub	R	X	977	966	99%	6%	29%	6%
East Gippsland Lowlands	Coastal Lagoon Wetland	R	X	804	721	90%	3%	57%	4%
East Gippsland Lowlands	Coastal Sand Heathland	R	Y	677	677	100%	0%	100%	0%
East Gippsland Lowlands	Riparian Shrubland	R	X	240	236	98%	0%	13%	0%
East Gippsland Lowlands	Rocky Outcrop Shrubland	R	X	255	255	100%	0%	81%	0%
East Gippsland Lowlands	Shrubby Damp Forest	R	X	789	399	51%	15%	0%	30%
East Gippsland Lowlands	Warm Temperate Rainforest	R	X	3293	2973	90%	7%	25%	8%
East Gippsland Lowlands	Wet Swale Herbland	R	X	789	789	100%	0%	1%	0%
East Gippsland Lowlands	Dry Valley Forest	D	X	2127	1878	88%	14%	18%	15%
East Gippsland Lowlands	Limestone Box Forest	D	X	9324	6265	67%	15%	27%	22%
East Gippsland Lowlands	Banksia Woodland	LC	Y	40703	38934	96%	4%	56%	4%
East Gippsland Lowlands	Clay Heathland	LC	Y	1709	1425	83%	7%	68%	8%
East Gippsland Lowlands	Coast Banksia Woodland	LC	Y	3399	3329	98%	1%	80%	1%
East Gippsland Lowlands	Coastal Saltmarsh	LC	Y	1244	905	73%	1%	51%	2%
East Gippsland Lowlands	Damp Forest	LC	X	68210	67588	99%	3%	18%	3%
East Gippsland Lowlands	Grassy Dry Forest	LC	X	3653	3373	92%	19%	15%	20%
East Gippsland Lowlands	Lowland Forest	LC	X	287388	257132	89%	5%	19%	6%
East Gippsland Lowlands	Riparian Forest	LC	X	7944	7250	91%	8%	17%	9%
East Gippsland Lowlands	Shrubby Dry Forest	LC	X	43127	42849	99%	3%	12%	3%
East Gippsland Lowlands	Valley Grassy Forest	LC	X	6128	4688	77%	23%	4%	30%
East Gippsland Lowlands	Wet Forest	LC	X	1119	1119	100%	0%	21%	0%
East Gippsland Lowlands	Wet Heathland	LC	Y	9999	9660	97%	2%	51%	2%
East Gippsland Lowlands	Coastal Dune Scrub Mosaic			3094	3093	100%	0%	73%	0%
East Gippsland Lowlands	Dry Rainforest/Warm Temperate Rainforest/Gallery Rainforest/Riparian Scrub			19	19	98%	4%	0%	4%
East Gippsland Lowlands	Dry Valley Forest/Swamp Scrub/Warm Temperate Rainforest Mosaic			5730	1566	27%	9%	1%	32%

Bioregion	Ecological Veg. Class	Conservation status	Reservation status	Pre-1750 area (ha)	Total extant area (ha)	Extant/pre-1750	Private/pre-1750	Reserved/extant	Private/extant
East Gippsland Lowlands	Riparian Forest/Warm Temperate Rainforest Mosaic			7701	974	13%	3%	17%	24%
East Gippsland Lowlands	Riparian Scrub Complex			21151	17807	84%	4%	28%	5%
East Gippsland Lowlands	Swamp Scrub/Plains Sedgey Wetland Mosaic			8	0	0%	0%	0%	0%
East Gippsland Lowlands	Swamp Scrub/Warm Temperate Rainforest/Billabong Wetland Mosaic			22	0	0%	0%	0%	0%
East Gippsland Uplands	Gallery Rainforest	E	X	55	40	74%	54%	27%	73%
East Gippsland Uplands	Limestone Pomaderris Shrubland	E	X	31	20	64%	23%	0%	35%
East Gippsland Uplands	Plains Grassy Forest	E	X	2119	220	10%	10%	2%	96%
East Gippsland Uplands	Dry Rainforest	V	X	12	10	83%	4%	87%	5%
East Gippsland Uplands	Foothill Box-Ironbark Forest	V	X	603	603	100%	0%	0%	0%
East Gippsland Uplands	Valley Heathy Forest	V	X	837	837	100%	0%	0%	0%
East Gippsland Uplands	Blackthorn Scrub	R	Y	8050	8011	100%	2%	42%	2%
East Gippsland Uplands	Cool Temperate Rainforest	R	Y	2422	2422	100%	0%	43%	0%
East Gippsland Uplands	Montane Riparian Thicket	R	X	131	131	100%	3%	3%	3%
East Gippsland Uplands	Riparian Shrubland	R	X	892	872	98%	5%	48%	5%
East Gippsland Uplands	Riverine Escarpment Scrub	R	X	3333	3314	99%	3%	45%	3%
East Gippsland Uplands	Rocky Outcrop Shrubland	R	Y	1264	1264	100%	0%	96%	0%
East Gippsland Uplands	Valley Slopes Dry Forest	R	X	146	126	86%	17%	66%	15%
East Gippsland Uplands	Warm Temperate Rainforest	R	X	4769	4751	100%	2%	23%	2%
East Gippsland Uplands	Grassy Woodland	D	X	66051	35685	54%	19%	59%	36%
East Gippsland Uplands	Montane Grassy Woodland	D	X	11764	5109	43%	16%	20%	36%
East Gippsland Uplands	Montane Riparian Woodland	D	X	4269	1373	32%	13%	4%	40%
East Gippsland Uplands	Riparian Forest	D	X	5418	4583	85%	9%	12%	11%
East Gippsland Uplands	Valley Grassy Forest	D	X	21321	11178	52%	17%	11%	32%
East Gippsland Uplands	Clay Heathland	LC	X	1262	961	76%	23%	2%	30%
East Gippsland Uplands	Damp Forest	LC	X	179252	177686	99%	2%	27%	2%
East Gippsland Uplands	Dry Valley Forest	LC	X	12169	9628	79%	7%	13%	9%
East Gippsland Uplands	Grassy Dry Forest	LC	X	39985	30882	77%	26%	19%	34%
East Gippsland Uplands	Heathy Dry Forest	LC	X	6306	5790	92%	20%	12%	22%
East Gippsland Uplands	Herb-rich Foothill Forest	LC	X	6766	4477	66%	22%	0%	34%
East Gippsland Uplands	Lowland Forest	LC	X	55208	46659	85%	13%	22%	16%
East Gippsland Uplands	Lowland Herb-rich Forest	LC	X	14216	10321	73%	23%	7%	32%
East Gippsland Uplands	Montane Damp Forest	LC	Y	2278	2252	99%	0%	30%	0%
East Gippsland Uplands	Montane Dry Woodland	LC	X	26074	21667	83%	20%	15%	24%
East Gippsland Uplands	Montane Wet Forest	LC	Y	6084	6084	100%	0%	95%	0%

Appendix 3.3: 7

Bioregion	Ecological Veg. Class	Conservation status	Reservation status	Pre-1750 area (ha)	Total extant area (ha)	Extant/pre-1750	Private/pre-1750	Reserved/extant	Private/extant
East Gippsland Uplands	Shrubby Damp Forest	LC	X	14034	13900	99%	2%	10%	2%
East Gippsland Uplands	Shrubby Dry Forest	LC	Y	225128	219188	97%	5%	38%	5%
East Gippsland Uplands	Shrubby Foothill Forest	LC	X	3146	3109	99%	4%	19%	4%
East Gippsland Uplands	Sub-alpine Woodland	LC	X	1115	1056	95%	19%	43%	20%
East Gippsland Uplands	Tableland Damp Forest	LC	Y	5687	5657	99%	2%	31%	2%
East Gippsland Uplands	Wet Forest	LC	Y	85716	85614	100%	0%	32%	0%
East Gippsland Uplands	Cool/Temperate Rainforest Overlap			230	230	100%	0%	53%	0%
East Gippsland Uplands	Dry Rainforest/Warm Temperate Rainforest/Gallery Rainforest/Riparian Scrub			179	166	93%	4%	76%	4%
East Gippsland Uplands	Dry Valley Forest/Swamp Scrub/Warm Temperate Rainforest Mosaic			971	229	24%	12%	0%	50%
East Gippsland Uplands	Riparian Forest/Warm Temperate Rainforest Mosaic			188	46	24%	5%	0%	19%
East Gippsland Uplands	Rocky Outcrop Shrubland/Herbland Mosaic/Shrubby Foothill Forest Complex			3	0	n/a	n/a	n/a	n/a
East Gippsland Uplands	Valley Grassy Forest/Grassy Dry Forest Mosaic			7	2	33%	0%	0%	1%
Gippsland Plain (75%)	Creekline Herb-rich Woodland	X		1009	0	0%	0%	0%	0%
Gippsland Plain (75%)	Dry Rainforest	X		11	0	0%	0%	0%	0%
Gippsland Plain (75%)	Floodplain Reedbed	X		1001	0	0%	0%	0%	0%
Gippsland Plain (75%)	Limestone Pomaderris Shrubland	X		36	0	1%	1%	0%	100%
Gippsland Plain (75%)	Montane Riparian Thicket	X		90	0	0%	0%	0%	0%
Gippsland Plain (75%)	Plains Grassy Wetland	X		1081	0	0%	0%	0%	0%
Gippsland Plain (75%)	Seasonally Inundated Shrubby Woodland	X		131	0	0%	0%	0%	0%
Gippsland Plain (75%)	Floodplain Riparian Woodland	E	X	19068	1345	7%	4%	0%	53%
Gippsland Plain (75%)	Gallery Rainforest	E	X	214	9	4%	0%	0%	1%
Gippsland Plain (75%)	Grassy Forest	E	X	1608	12	1%	1%	0%	98%
Gippsland Plain (75%)	Lagoon Wetland	E	X	569	1	0%	0%	0%	100%
Gippsland Plain (75%)	Lowland Herb-rich Forest	E	X	497	72	14%	13%	0%	87%
Gippsland Plain (75%)	Plains Grassland	E	X	37327	291	1%	0%	0%	2%
Gippsland Plain (75%)	Plains Grassy Woodland	E	X	129084	2848	2%	1%	0%	61%
Gippsland Plain (75%)	Riparian Shrubland	E	X	2575	103	4%	1%	0%	29%
Gippsland Plain (75%)	Riparian Thicket	E	X	64	30	48%	2%	0%	4%
Gippsland Plain (75%)	Riverine Escarpment Scrub	E	X	395	77	20%	12%	0%	61%
Gippsland Plain (75%)	Sandy Flood Scrub	E	X	2346	360	15%	5%	0%	31%
Gippsland Plain (75%)	Swamp Scrub	E	X	81527	4371	5%	2%	10%	40%
Gippsland Plain (75%)	Swampy Riparian Woodland	E	X	12719	610	5%	1%	18%	26%
Gippsland Plain (75%)	Valley Heathy Forest	E	X	2299	120	5%	4%	0%	78%
Gippsland Plain (75%)	Warm Temperate Rainforest	E	X	176	10	6%	1%	71%	10%

Bioregion	Ecological Veg. Class	Conservation status	Reservation status	Pre-1750 area (ha)	Total extant area (ha)	Extant/pre-1750	Private/pre-1750	Reserved/extant	Private/extant
Gippsland Plain (75%)	Box Ironbark Forest	V	X	1256	145	12%	7%	36%	64%
Gippsland Plain (75%)	Damp Forest	V	X	17486	4895	28%	15%	4%	53%
Gippsland Plain (75%)	Damp Sands Herb-rich Woodland	V	X	40062	13763	34%	14%	9%	42%
Gippsland Plain (75%)	Deep Freshwater Marsh	V	X	8043	3978	49%	32%	0%	65%
Gippsland Plain (75%)	Herb-rich Foothill Forest	V	X	2208	679	31%	17%	17%	55%
Gippsland Plain (75%)	Limestone Box Forest	V	X	143	34	24%	0%	0%	0%
Gippsland Plain (75%)	Lowland Forest	V	X	153176	40481	26%	11%	7%	43%
Gippsland Plain (75%)	Plains Grassy Forest	V	X	57300	17863	31%	5%	0%	16%
Gippsland Plain (75%)	Riparian Forest	V	X	2448	1034	42%	12%	13%	28%
Gippsland Plain (75%)	Riparian Scrub	V	X	10837	1514	14%	6%	13%	43%
Gippsland Plain (75%)	Sedge Wetland	V	X	2149	912	42%	20%	12%	48%
Gippsland Plain (75%)	Shrubby Foothill Forest	V	X	8904	1230	14%	5%	0%	38%
Gippsland Plain (75%)	Wet Heathland	V	X	8210	1298	16%	7%	5%	47%
Gippsland Plain (75%)	Wetland Formation	V	X	1793	537	30%	74%	2%	22%
Gippsland Plain (75%)	Blocked Coastal Stream Swamp	R	Y	32	29	91%	0%	100%	0%
Gippsland Plain (75%)	Calcareous Swale Grassland	R	Y	558	310	55%	0%	100%	0%
Gippsland Plain (75%)	Clay Heathland	R	X	648	648	100%	12%	0%	12%
Gippsland Plain (75%)	Coastal Dune Grassland	R	X	32	32	100%	0%	0%	0%
Gippsland Plain (75%)	Coastal Headland Scrub	R	X	706	544	77%	29%	62%	38%
Gippsland Plain (75%)	Coastal Tussock Grassland	R	X	744	552	74%	19%	4%	26%
Gippsland Plain (75%)	Wet Swale Herbland	R	Y	121	99	82%	0%	100%	0%
Gippsland Plain (75%)	Coast Banksia Woodland	D	X	2857	952	33%	18%	36%	54%
Gippsland Plain (75%)	Calcarenite Dune Woodland	LC	Y	3796	3532	93%	0%	100%	0%
Gippsland Plain (75%)	Coastal Saltmarsh	LC	X	6053	5198	86%	30%	1%	35%
Gippsland Plain (75%)	Estuarine Wetland	LC	X	11187	7482	67%	61%	1%	41%
Gippsland Plain (75%)	Heathy Woodland	LC	X	45721	31698	69%	15%	28%	22%
Gippsland Plain (75%)	Mangrove Shrubland	LC	X	2030	1907	94%	9%	1%	10%
Gippsland Plain (75%)	Sand Heathland	LC	X	7454	6615	89%	4%	16%	5%
Gippsland Plain (75%)	Aquatic Herbland/Plains Sedgy Wetland Mosaic			1153	0	0%	0%	0%	0%
Gippsland Plain (75%)	Clay Heathland/Wet Heathland/Riparian Scrub Mosaic			2033	820	40%	11%	65%	28%
Gippsland Plain (75%)	Coast Banksia Woodland/ East Gippsland Coastal Warm Temperate Rainforest			12	12	100%	0%	0%	0%
Gippsland Plain (75%)	Coastal Dune Scrub Mosaic			9074	6879	76%	23%	37%	30%
Gippsland Plain (75%)	Damp Sands Herb-rich Woodland/Swamp Scrub Complex			5099	153	3%	0%	0%	4%
Gippsland Plain (75%)	Dry Valley Forest/Swamp Scrub/Warm Temperate Rainforest Mosaic			2908	5	0%	0%	0%	12%

Bioregion	Ecological Veg. Class	Conservation status	Reservation status	Pre-1750 area (ha)	Total extant area (ha)	Extant/pre-1750	Private/pre-1750	Reserved/extant	Private/extant
Gippsland Plain (75%)	Estuarine Wetland/Coastal Saltmarsh Mosaic			642	0	0%	0%	0%	0%
Gippsland Plain (75%)	Floodplain Riparian Woodland/Billabong Wetland Mosaic			3056	0	0%	0%	0%	100%
Gippsland Plain (75%)	Gippsland Plains Grassy Woodland/Gilgai Wetland Mosaic			30983	73	0%	0%	0%	100%
Gippsland Plain (75%)	Lowland Forest/Damp Sands Herb-rich Woodland Mosaic			24732	0	0%	0%	0%	0%
Gippsland Plain (75%)	Lowland Forest/Heathy Woodland Mosaic			9638	0	0%	0%	0%	0%
Gippsland Plain (75%)	Riparian Forest/Warm Temperate Rainforest Mosaic			181	0	0%	0%	0%	0%
Gippsland Plain (75%)	Riparian Scrub Complex			3505	280	8%	6%	16%	78%
Gippsland Plain (75%)	Sand Heathland/Wet Heathland Mosaic			220	74	34%	14%	95%	5%
Gippsland Plain (75%)	Shrubby Foothill Forest/Damp Forest Complex			223	176	79%	35%	0%	44%
Gippsland Plain (75%)	Swamp Scrub/Damp Sands Herb-rich Woodland/Wet Heathland			4	0	n/a	n/a	n/a	n/a
Gippsland Plain (75%)	Swamp Scrub/Plains Grassland Mosaic			22218	0	0%	0%	0%	0%
Gippsland Plain (75%)	Swamp Scrub/Plains Grassy Forest Mosaic			4136	147	4%	0%	0%	7%
Gippsland Plain (75%)	Swamp Scrub/Plains Sedgey Wetland Mosaic			19	0	0%	0%	0%	0%
Gippsland Plain (75%)	Swamp Scrub/Warm Temperate Rainforest/Billabong Wetland Mosaic			1783	5	0%	0%	0%	31%
Gippsland Plain (75%)	Swamp Scrub/Wet Heathland Mosaic			1128	0	0%	0%	0%	0%
Gippsland Plain (75%)	Swampy Riparian Complex			12797	935	7%	5%	0%	71%
Gippsland Plain (75%)	Swampy Riparian Woodland/Swamp Scrub Mosaic			4088	0	0%	0%	0%	0%
Gippsland Plain (75%)	Valley Grassy Forest/Swamp Scrub Mosaic			222	0	0%	0%	0%	0%
Gippsland Plain (75%)	Wet Heathland/Damp Heathland Mosaic			7055	0	0%	0%	0%	0%
Glenelg Plain	Coastal Heathland	X		33	0	0%	0%	0%	0%
Glenelg Plain	Aquatic Herbland	E	X	892	211	24%	5%	0%	21%
Glenelg Plain	Basalt Escarpment Shrubland	E	X	172	70	41%	35%	0%	85%
Glenelg Plain	Coastal Headland Scrub	E	X	465	206	44%	17%	62%	38%
Glenelg Plain	Coastal Mallee Scrub	E	X	596	302	51%	18%	64%	36%
Glenelg Plain	Creekline Sedgy Woodland	E	X	100	28	28%	21%	0%	77%
Glenelg Plain	Floodplain Riparian Woodland	E	X	3729	1069	29%	19%	1%	65%
Glenelg Plain	Freshwater Lignum Shrubland	E	X	51	8	16%	6%	0%	35%
Glenelg Plain	Freshwater Meadow	E	X	880	100	11%	6%	5%	53%
Glenelg Plain	Lunette Woodland	E	X	258	0	0%	0%	0%	0%
Glenelg Plain	Permanent Open Freshwater	E	Y	187	86	46%	3%	93%	7%
Glenelg Plain	Permanent Saline	E	Y	131	24	18%	0%	74%	2%
Glenelg Plain	Plains Grassy Woodland	E	X	46214	944	2%	1%	3%	65%
Glenelg Plain	Plains Sedgy Wetland	E	X	646	59	9%	4%	0%	43%
Glenelg Plain	Plains Swampy Woodland	E	X	457	55	12%	7%	0%	55%

Bioregion	Ecological Veg. Class	Conservation status	Reservation status	Pre-1750 area (ha)	Total extant area (ha)	Extant/pre-1750	Private/pre-1750	Reserved/extant	Private/extant
Glenelg Plain	Plains Woodland	E	X	4535	230	5%	2%	0%	33%
Glenelg Plain	Red Gum Wetland	E	X	7972	107	1%	1%	0%	40%
Glenelg Plain	Sandy Stream Woodland	E	X	715	194	27%	25%	0%	93%
Glenelg Plain	Seasonally Inundated Shrubby Woodland	E	X	501	115	23%	13%	0%	54%
Glenelg Plain	Sedgy Swamp Woodland	E	X	356	48	14%	8%	0%	56%
Glenelg Plain	Shallow Freshwater Marsh	E	X	1109	153	14%	6%	27%	42%
Glenelg Plain	Spray-zone Coastal Shrubland	E	Y	42	5	12%	0%	100%	0%
Glenelg Plain	Swamp Scrub	E	X	6461	1419	22%	12%	1%	56%
Glenelg Plain	Bird Colony Succulent Herbland	V		1	1	n/a	n/a	n/a	n/a
Glenelg Plain	Calcarenite Dune Woodland	V	X	13424	3929	29%	7%	69%	23%
Glenelg Plain	Damp Heathy Woodland	V	X	2490	741	30%	6%	0%	19%
Glenelg Plain	Damp Sands Herb-rich Woodland	V	X	104760	24374	23%	11%	20%	49%
Glenelg Plain	Herb-rich Foothill Forest	V	X	15421	3992	26%	9%	0%	35%
Glenelg Plain	Limestone Pomaderris Shrubland	V		4	4	n/a	n/a	n/a	n/a
Glenelg Plain	Plains Sedgy Woodland	V	X	91	33	36%	8%	0%	21%
Glenelg Plain	Riparian Woodland	V	X	1002	706	70%	24%	0%	34%
Glenelg Plain	Sedge Wetland	V	X	3273	1164	36%	7%	8%	20%
Glenelg Plain	Brackish Sedgeland	R	X	127	124	98%	9%	0%	10%
Glenelg Plain	Brackish Wetland	R	X	228	190	84%	0%	0%	0%
Glenelg Plain	Deep Freshwater Marsh	R	X	2413	764	32%	3%	78%	11%
Glenelg Plain	Lateritic Woodland	R	X	127	126	100%	0%	70%	0%
Glenelg Plain	Limestone Ridge Woodland	R	X	29	29	100%	22%	0%	22%
Glenelg Plain	Limestone Woodland	R	Y	69	69	100%	0%	100%	0%
Glenelg Plain	Sand Heathland	R	X	1387	1130	81%	1%	37%	2%
Glenelg Plain	Coastal Dune Scrub	D	Y	1011	443	44%	2%	95%	5%
Glenelg Plain	Herb-rich Heathy Woodland	D	X	31174	15431	49%	13%	6%	26%
Glenelg Plain	Lowland Forest	D	X	11131	7488	67%	9%	4%	14%
Glenelg Plain	Riparian Scrub	D	X	3229	2200	68%	16%	14%	23%
Glenelg Plain	Shallow Sands Woodland	D	X	2529	1188	47%	17%	40%	36%
Glenelg Plain	Damp Heathland	LC	X	7365	5339	72%	5%	21%	7%
Glenelg Plain	Heathy Woodland	LC	X	60588	47718	79%	6%	23%	7%
Glenelg Plain	Wet Heathland	LC	Y	4623	3847	83%	2%	77%	2%
Glenelg Plain	Aquatic Herbland/Plains Sedgy Wetland Mosaic			5001	164	3%	1%	0%	18%
Glenelg Plain	Brackish Drainage Line Herbland/Sedgeland			154	0	0%	0%	0%	0%

Appendix 3.3: 11

Bioregion	Ecological Veg. Class	Conservation status	Reservation status	Pre-1750 area (ha)	Total extant area (ha)	Extant/pre-1750	Private/pre-1750	Reserved/extant	Private/extant
Glenelg Plain	Damp Heathland / Damp Heathy Woodland			12162	3908	32%	5%	0%	16%
Glenelg Plain	Damp Heathland / Damp Heathy Woodland / Seasonally Inundated Shrubby Woodland			1480	11	1%	1%	0%	99%
Glenelg Plain	Damp Heathland / Damp Heathy Woodland / Wet Heathland			995	635	64%	6%	0%	10%
Glenelg Plain	Damp Heathland / Sand Heathland			813	648	80%	0%	0%	0%
Glenelg Plain	Damp Sands Herb-rich Woodland / Damp Heathland / Damp Heathy Woodland			31896	1884	6%	4%	0%	76%
Glenelg Plain	Damp Sands Herb-rich Woodland / Heathy Woodland			5681	4657	82%	10%	74%	12%
Glenelg Plain	Damp Sands Herb-rich Woodland / Heathy Woodland / Sand Heathland			1008	969	96%	0%	100%	0%
Glenelg Plain	Damp Sands Herb-rich Woodland / Herb-rich Foothill Forest			3003	404	13%	7%	0%	54%
Glenelg Plain	Damp Sands Herb-rich Woodland / Lowland Forest			1836	932	51%	8%	0%	16%
Glenelg Plain	Damp Sands Herb-rich Woodland / Plains Grassy Woodland			13918	751	5%	3%	0%	52%
Glenelg Plain	Damp Sands Herb-rich Woodland / Plains Grassy Woodland / Plains Sedgy Woodland			157	145	93%	17%	0%	18%
Glenelg Plain	Damp Sands Herb-rich Woodland / Plains Swampy Woodland / Aquatic Herbland			903	34	4%	2%	0%	59%
Glenelg Plain	Damp Sands Herb-rich Woodland / Riparian Woodland / Swamp Scrub			417	284	68%	1%	94%	2%
Glenelg Plain	Damp Sands Herb-rich Woodland / Seasonally Inundated Shrubby Woodland			114	111	98%	0%	0%	0%
Glenelg Plain	Escarpment Shrubland / Damp Sands Herb-rich Woodland / Riparian Woodland			275	170	62%	0%	100%	0%
Glenelg Plain	Escarpment Shrubland / Damp Sands Herb-rich Woodland / Swamp Scrub			152	88	58%	0%	95%	0%
Glenelg Plain	Grassy Woodland / Damp Sands Herb-rich Woodland			6631	385	6%	5%	0%	77%
Glenelg Plain	Heathy Herb-rich Woodland / Damp Sands Herb-rich Woodland			4546	240	5%	1%	0%	20%
Glenelg Plain	Heathy Woodland / Damp Heathy Woodland / Damp Heathland			23815	12001	50%	8%	2%	16%
Glenelg Plain	Heathy Woodland / Heathy Herb-rich Woodland / Damp Heathy Woodland			3466	2623	76%	0%	0%	0%
Glenelg Plain	Heathy Woodland / Limestone Woodland			3547	3215	91%	1%	87%	1%
Glenelg Plain	Heathy Woodland / Seasonally Inundated Shrubby Woodland			403	124	31%	0%	0%	1%
Glenelg Plain	Heathy Woodland/Sand Heath Mosaic			2684	738	27%	5%	0%	20%
Glenelg Plain	Lateritic Woodland / Heathy Woodland			29	27	92%	0%	0%	0%
Glenelg Plain	Limestone Rise Grassland / Limestone Rise Woodland			98	90	92%	0%	0%	0%
Glenelg Plain	Plains Grassy Woodland / Damp Sands Herb-rich Complex			4338	61	1%	1%	0%	100%
Glenelg Plain	Plains Grassy Woodland / Plains Swampy Woodland			5397	142	3%	2%	0%	78%
Glenelg Plain	Plains Swampy Woodland / Swamp Scrub			1712	57	3%	2%	0%	62%
Glenelg Plain	Seasonally Inundated Shrubby Woodland / Plains Sedgy Woodland			2570	616	24%	11%	3%	45%
Glenelg Plain	Shallow Sands Woodland / Plains Sedgy Woodland / Seasonally Inundated Shrubby Woodland			10631	2829	27%	5%	3%	18%
Glenelg Plain	Swamp Scrub / Plains Sedgy Wetland / Aquatic Herbland			96	33	35%	6%	0%	17%
Glenelg Plain	Wet Heathland / Heathy Woodland			4236	2461	58%	9%	83%	15%
Goldfields (99%)	Creekline Sedgy Woodland	X		120	0	0%	0%	0%	0%
Goldfields (99%)	Pine Box Woodland	X		323	0	0%	0%	0%	0%

Bioregion	Ecological Veg. Class	Conservation status	Reservation status	Pre-1750 area (ha)	Total extant area (ha)	Extant/pre-1750	Private/pre-1750	Reserved/extant	Private/extant
Goldfields (99%)	Brackish Lake	E	X	166	1	1%	0%	0%	0%
Goldfields (99%)	Creekline Grassy Woodland	E	X	36392	2769	8%	4%	0%	54%
Goldfields (99%)	Creekline Herb-rich Woodland	E	X	286	176	61%	38%	0%	63%
Goldfields (99%)	Deep Freshwater Marsh	E	X	327	8	2%	1%	0%	30%
Goldfields (99%)	Floodplain Riparian Woodland	E	X	15059	867	6%	4%	0%	63%
Goldfields (99%)	Freshwater Meadow	E	X	22	16	73%	70%	0%	96%
Goldfields (99%)	Grassy Woodland	E	X	420969	26947	6%	3%	14%	53%
Goldfields (99%)	Lignum Wetland	E	X	579	11	2%	2%	0%	100%
Goldfields (99%)	Plains Grassland	E	X	1560	0	0%	0%	0%	0%
Goldfields (99%)	Plains Grassy Woodland	E	X	305240	5940	2%	1%	0%	58%
Goldfields (99%)	Plains Sedgy Wetland	E	X	466	2	0%	0%	0%	100%
Goldfields (99%)	Plains Woodland	E	X	7516	47	1%	0%	0%	55%
Goldfields (99%)	Red Gum Wetland	E	X	2409	420	17%	9%	0%	54%
Goldfields (99%)	Riparian Scrub	E	X	914	111	12%	12%	0%	97%
Goldfields (99%)	Riparian Woodland	E	X	2911	131	5%	3%	0%	63%
Goldfields (99%)	Sand Forest	E	X	441	108	25%	24%	1%	98%
Goldfields (99%)	Scoria Cone Woodland	E	X	1044	21	2%	0%	0%	14%
Goldfields (99%)	Scrub-pine Woodland	E	X	5	2	41%	0%	0%	0%
Goldfields (99%)	Sedge-rich Woodland	E	X	259	155	60%	4%	0%	7%
Goldfields (99%)	Stream-bank Shrubland	E	X	2039	470	23%	16%	0%	68%
Goldfields (99%)	Swamp Scrub	E	X	3393	11	0%	0%	0%	81%
Goldfields (99%)	Swampy Riparian Woodland	E	X	745	26	4%	3%	0%	93%
Goldfields (99%)	Unclassified Lunette Woodland	E	X	59	0	0%	0%	0%	0%
Goldfields (99%)	Valley Heathy Forest	E	X	769	38	5%	2%	0%	42%
Goldfields (99%)	Wetland Formation	E	X	2508	133	5%	3%	0%	49%
Goldfields (99%)	Alluvial Terraces Herb-rich Woodland	V	X	22054	3541	16%	6%	1%	34%
Goldfields (99%)	Granitic Hills Woodland	V	X	13616	1493	11%	6%	0%	53%
Goldfields (99%)	Heathy Woodland	V	X	18562	5151	28%	17%	1%	62%
Goldfields (99%)	Hills Herb-rich Woodland	V	X	18560	7035	38%	18%	37%	46%
Goldfields (99%)	Lateritic Woodland	V	X	693	443	64%	18%	0%	29%
Goldfields (99%)	Shrubby Woodland	V	X	1460	221	15%	14%	1%	94%
Goldfields (99%)	Valley Grassy Forest	V	X	28451	4563	16%	9%	8%	58%
Goldfields (99%)	Box Ironbark Forest	D	X	355603	188712	53%	10%	2%	18%
Goldfields (99%)	Broombush Mallee	D	X	43272	24089	56%	15%	14%	27%

Bioregion	Ecological Veg. Class	Conservation status	Reservation status	Pre-1750 area (ha)	Total extant area (ha)	Extant/pre-1750	Private/pre-1750	Reserved/extant	Private/extant
Goldfields (99%)	Grassy Dry Forest	D	X	66434	20866	31%	8%	5%	25%
Goldfields (99%)	Herb-rich Foothill Forest	D	X	9691	4410	46%	12%	0%	27%
Goldfields (99%)	Hillcrest Herb-rich Woodland	D	X	13457	4311	32%	11%	0%	34%
Goldfields (99%)	Metamorphic Slopes Shrubby Woodland	D	X	5839	3211	55%	16%	11%	28%
Goldfields (99%)	Heathy Dry Forest	LC	X	89226	45937	51%	13%	5%	25%
Goldfields (99%)	Alluvial Terraces Herb-rich Woodland/ Plains Grassy Woodland Mosaic			212	19	9%	9%	0%	100%
Goldfields (99%)	Alluvial Terraces Herb-rich Woodland/Creekline Grassy Woodland Mosaic			13192	1143	9%	7%	0%	77%
Goldfields (99%)	Alluvial Terraces Herb-rich Woodland/Gilgai Plain Woodland/Wetland Mosaic			105	0	0%	0%	0%	0%
Goldfields (99%)	Alluvial Terraces Herb-rich Woodland/Plains Grassy Woodland Complex			7245	52	1%	1%	0%	72%
Goldfields (99%)	Box Ironbark Forest/Shrubby Granitic-outwash Grassy Woodland Mosaic			212	7	3%	3%	0%	100%
Goldfields (99%)	Broombush Mallee/Low Rises Grassy Woodland Mosaic			64	1	2%	2%	0%	100%
Goldfields (99%)	Damp Sands Herb-rich Woodland / Plains Grassy Woodland			2622	1	0%	0%	0%	100%
Goldfields (99%)	Damp Sands Herb-rich Woodland / Shrubby Woodland			362	33	9%	9%	0%	100%
Goldfields (99%)	Floodplain Riparian Woodland / Plains Grassy Woodland			188	0	0%	0%	0%	0%
Goldfields (99%)	Gilgai Plain Woodland/Wetland Mosaic			1259	72	6%	1%	0%	19%
Goldfields (99%)	Granitic Hills Woodland/Heathy Dry Forest Mosaic			12	0	0%	0%	0%	0%
Goldfields (99%)	Grassy Dry Forest/Granitic Hills Woodland Complex			339	54	16%	16%	0%	100%
Goldfields (99%)	Grassy Dry Forest/Heathy Dry Forest Complex			1460	109	7%	7%	0%	87%
Goldfields (99%)	Grassy Dry Forest/Rocky Outcrop Shrubland/Herbland Mosaic			168	37	22%	16%	0%	71%
Goldfields (99%)	Grassy Woodland / Alluvial Terraces Herb-rich Woodland			576	83	14%	0%	0%	3%
Goldfields (99%)	Grassy Woodland / Damp Sands Herb-rich Woodland			4746	0	0%	0%	0%	0%
Goldfields (99%)	Grassy Woodland / Heathy Woodland			357	120	34%	27%	0%	81%
Goldfields (99%)	Grassy Woodland / Hills Herb-rich Woodland / Damp Sands Herb-rich Woodland			6962	209	3%	3%	0%	100%
Goldfields (99%)	Grassy Woodland/Heathy Dry Forest Complex			9758	200	2%	2%	0%	90%
Goldfields (99%)	Gravelly Sediment Broombush Mallee/Heathy Woodland Mosaic			138	92	67%	0%	0%	0%
Goldfields (99%)	Gravelly-Sediment Broombush Mallee/Box Ironbark Forest Mosaic			4279	724	17%	15%	0%	91%
Goldfields (99%)	Low Rises Grassy Woodland/Alluvial Terraces Herb-rich Woodland Mosaic			98011	5002	5%	3%	3%	50%
Goldfields (99%)	Low Rises Grassy Woodland/Heathy Woodland Mosaic			1315	7	0%	0%	0%	100%
Goldfields (99%)	Montane Rocky Shrubland/Shrubby Foothill Forest Complex			274	121	44%	27%	20%	62%
Goldfields (99%)	Plains Grassland/Gilgai Plain Woodland/Wetland Mosaic			215	2	1%	0%	0%	12%
Goldfields (99%)	Plains Grassland/Plains Grassy Woodland Mosaic			8895	73	1%	1%	0%	92%
Goldfields (99%)	Plains Grassy Woodland/Creekline Grassy Woodland Mosaic			256	7	3%	3%	0%	100%
Goldfields (99%)	Plains Grassy Woodland/Plains Grassland/Plains Grassy Wetland Mosaic			6302	27	0%	0%	0%	100%
Goldfields (99%)	Plains Woodland/Plains Sedgy Woodland/Damp Sands Herb-rich Woodland			1202	675	56%	21%	0%	38%

Bioregion	Ecological Veg. Class	Conservation status	Reservation status	Pre-1750 area (ha)	Total extant area (ha)	Extant/pre-1750	Private/pre-1750	Reserved/extant	Private/extant
Goldfields (99%)	Riparian Forest/Creekline Grassy Woodland Mosaic			43	1	3%	3%	0%	79%
Goldfields (99%)	Riparian Shrubland/Swampy Riparian Woodland Mosaic			13	6	43%	22%	0%	52%
Goldfields (99%)	Riparian Woodland / Escarpment Shrubland			8	0	0%	0%	0%	0%
Goldfields (99%)	Riverina Plains Grassy Woodland/Plains Grassland Mosaic			1696	5	0%	0%	0%	100%
Goldfields (99%)	Riverina Plains Grassy Woodland/Plains Grassland/Gilgai Plain Woodland			11307	24	0%	0%	0%	100%
Goldfields (99%)	Rocky Outcrop Shrubland/Herbland Mosaic			1030	56	5%	3%	0%	50%
Goldfields (99%)	Shrubby Granitic-outwash Grassy Woodland/Plains Grassy Woodland Complex			60	1	2%	2%	0%	100%
Goldfields (99%)	Shrubby Granitic-outwash Grassy Woodland/Valley Grassy Forest Complex			152	7	4%	4%	0%	100%
Goldfields (99%)	Slopes Box Grassy Woodland/Box Ironbark Forest Complex			249	5	2%	2%	0%	100%
Goldfields (99%)	Valley Grass Forest / Creekline Grassy Woodland Mosaic			655	27	4%	1%	0%	14%
Goldfields (99%)	Valley Grassy Forest/Plains Grassy Woodland Complex			115	0	0%	0%	0%	100%
Goldfields (99%)	Valley Grassy Forest/Slopes Box Grassy Woodland Complex			3	1	n/a	n/a	n/a	n/a
Goldfields (99%)	Wimmera Plains Grassy Woodland/Plains Grassland Mosaic			90	4	4%	1%	0%	19%
Greater Grampians	Creekline Sedgy Woodland	E	X	63	3	5%	1%	0%	15%
Greater Grampians	Freshwater Meadow	E	X	37	1	2%	2%	0%	100%
Greater Grampians	Plains Grassy Wetland	E	X	1759	7	0%	0%	0%	1%
Greater Grampians	Plains Grassy Woodland	E	X	37492	2347	6%	3%	25%	41%
Greater Grampians	Plains Sedgy Wetland	E	X	797	3	0%	0%	0%	96%
Greater Grampians	Riparian Woodland	E	X	479	67	14%	1%	0%	7%
Greater Grampians	Sand Forest	E	X	954	172	18%	15%	12%	81%
Greater Grampians	Sedge Wetland	E	X	114	48	42%	9%	67%	22%
Greater Grampians	Shallow Sands Woodland	E	X	966	366	38%	2%	81%	5%
Greater Grampians	Dry Creekline Woodland	V	X	345	214	62%	15%	59%	24%
Greater Grampians	Lateritic Woodland	V	X	1714	377	22%	7%	1%	31%
Greater Grampians	Plains Sedgy Woodland	V	X	569	378	66%	47%	6%	71%
Greater Grampians	Shrubby Woodland	V	Y	8912	6990	78%	14%	80%	18%
Greater Grampians	Claypan Ephemeral Wetland	R		3	3	n/a	n/a	n/a	n/a
Greater Grampians	Heathland Thicket	R	Y	669	665	99%	1%	92%	1%
Greater Grampians	Herb-rich Heathy Forest	R	Y	431	431	100%	0%	100%	0%
Greater Grampians	Montane Rocky Shrubland	R	Y	1863	1863	100%	0%	100%	0%
Greater Grampians	Montane Wet Heathland	R	Y	54	54	100%	0%	100%	0%
Greater Grampians	Reed Swamp	R	X	52	28	54%	28%	24%	53%
Greater Grampians	Sedge-rich Wetland	R	X	238	237	99%	3%	84%	3%
Greater Grampians	Alluvial Terraces Herb-rich Woodland	D	Y	1687	934	55%	6%	87%	10%

Bioregion	Ecological Veg. Class	Conservation status	Reservation status	Pre-1750 area (ha)	Total extant area (ha)	Extant/pre-1750	Private/pre-1750	Reserved/extant	Private/extant
Greater Grampians	Shallow Freshwater Marsh	D	Y	1670	631	38%	1%	70%	3%
Greater Grampians	Damp Heath Scrub	LC	Y	1331	1331	100%	0%	98%	0%
Greater Grampians	Damp Sands Herb-rich Woodland	LC	Y	9937	6584	66%	16%	70%	24%
Greater Grampians	Floodplain Thicket	LC	Y	2350	2351	100%	0%	87%	0%
Greater Grampians	Grassy Dry Forest	LC	Y	2219	2097	94%	12%	72%	13%
Greater Grampians	Heathy Dry Forest	LC	Y	29944	29702	99%	1%	98%	1%
Greater Grampians	Heathy Woodland	LC	Y	57938	53175	92%	9%	79%	10%
Greater Grampians	Herb-rich Foothill Forest	LC	Y	1179	1156	98%	5%	94%	5%
Greater Grampians	Hills Herb-rich Woodland	LC	Y	11260	9204	82%	19%	74%	24%
Greater Grampians	Lowland Forest	LC	Y	8768	8730	100%	0%	100%	0%
Greater Grampians	Riparian Scrub	LC	Y	2279	2288	100%	2%	92%	2%
Greater Grampians	Rocky Outcrop Herbland	LC	Y	10016	10021	100%	0%	99%	0%
Greater Grampians	Rocky Outcrop Shrubland	LC	Y	13940	13924	100%	1%	90%	1%
Greater Grampians	Sand Heathland	LC	Y	11560	11368	98%	3%	89%	3%
Greater Grampians	Seasonally Inundated Shrubby Woodland	LC	Y	2502	2351	94%	14%	65%	14%
Greater Grampians	Sedgy Riparian Woodland	LC	Y	2432	2313	95%	1%	95%	1%
Greater Grampians	Shrubby Foothill Forest	LC	Y	4169	4169	100%	0%	100%	0%
Greater Grampians	Valley Grassy Forest	LC	Y	6152	5279	86%	18%	77%	22%
Greater Grampians	Wet Heathland	LC	Y	1346	1181	88%	4%	95%	4%
Greater Grampians	Aquatic Herbland/Plains Sedgy Wetland Mosaic			4988	1	0%	0%	0%	0%
Greater Grampians	Box Ironbark Forest/Heathy Woodland Complex			8	0	0%	0%	0%	0%
Greater Grampians	Damp Heathland / Sand Heathland			9	7	81%	81%	0%	100%
Greater Grampians	Damp Sands Herb-rich Woodland / Heathy Woodland			111	46	41%	41%	0%	100%
Greater Grampians	Damp Sands Herb-rich Woodland / Shrubby Woodland			370	81	22%	4%	0%	17%
Greater Grampians	Floodplain Riparian Woodland/Billabong Wetland Mosaic			1553	1	0%	0%	0%	100%
Greater Grampians	Floodplain Thicket / Shrubby Woodland			4	4	n/a	n/a	n/a	n/a
Greater Grampians	Grassy Dry Forest/Rocky Outcrop Shrubland/Herbland Mosaic			24	24	99%	0%	0%	0%
Greater Grampians	Heathy Dry Forest / Plains Grassy Woodland			40	30	75%	75%	0%	100%
Greater Grampians	Heathy Woodland/Heathy Dry Forest Complex			1374	1294	94%	1%	98%	2%
Greater Grampians	Heathy Woodland/Heathy Woodland Complex			651	651	100%	0%	85%	0%
Greater Grampians	Hills Herb-rich Woodland / Grassy Dry Forest			54	54	100%	0%	100%	0%
Greater Grampians	Hills Herb-rich Woodland / Heathy Woodland			12	8	67%	67%	0%	100%
Greater Grampians	Hills Herb-rich Woodland / Plains Grassy Woodland			186	7	4%	4%	0%	100%
Greater Grampians	Hills Herb-rich Woodland / Valley Grassy Forest			71	49	68%	63%	7%	93%

Bioregion	Ecological Veg. Class	Conservation status	Reservation status	Pre-1750 area (ha)	Total extant area (ha)	Extant/pre-1750	Private/pre-1750	Reserved/extant	Private/extant
Greater Grampians	Hills Herb-rich Woodland/Heathy Woodland Complex			829	737	89%	2%	97%	3%
Greater Grampians	Lateritic Woodland / Heathy Dry Forest			94	12	13%	n/a	n/a	n/a
Greater Grampians	Lateritic Woodland / Heathy Woodland			53	36	67%	55%	18%	82%
Greater Grampians	Lowland Forest/Heathy Dry Forest Complex			743	743	100%	0%	100%	0%
Greater Grampians	Lowland Forest/Valley Grassy Forest Complex			1318	1150	87%	11%	87%	13%
Greater Grampians	Montane Rocky Shrubland/Shrubby Foothill Forest Complex			7519	7457	99%	2%	94%	2%
Greater Grampians	Plains Grassy Woodland / Shrubby Woodland			6	3	56%	56%	0%	100%
Greater Grampians	Rocky Outcrop Shrubland/Herbland / Broombush Mallee			182	168	92%	25%	73%	27%
Greater Grampians	Rocky Outcrop Shrubland/Herbland / Heathy Woodland			408	360	88%	2%	85%	2%
Greater Grampians	Rocky Outcrop Shrubland/Herbland / Hills Herb-rich Woodland			9	16	170%	170%	0%	100%
Greater Grampians	Rocky Outcrop Shrubland/Herbland Mosaic			6041	5908	98%	2%	98%	2%
Greater Grampians	Scree-slope Grassland/Woodland			32	7	22%	0%	100%	0%
Greater Grampians	Sedgy Riparian Woodland / Damp Sands Herb-rich Woodland			4	4	n/a	n/a	n/a	n/a
Greater Grampians	Sedgy Riparian Woodland/Riparian Scrub Mosaic			193	0	0%	0%	0%	0%
Greater Grampians	Shallow Sands Woodland / Heathy Woodland			102	68	66%	0%	100%	0%
Greater Grampians	Shrubby Woodland / Lateritic Woodland			15	13	88%	50%	43%	57%
Greater Grampians	Shrubby Woodland/Riparian Scrub Mosaic			72	0	0%	0%	0%	0%
Greater Grampians	Valley Grassy Forest / Lateritic Woodland			8	8	100%	100%	0%	100%
Greater Grampians	Valley Grassy Forest/Plains Grassy Woodland Complex			14	11	80%	79%	1%	99%
Greater Grampians	Wet Heathland / Riparian Scrub			16	0	1%	0%	100%	0%
Highlands - Northern Fall	Dry Valley Forest	X		31	0	0%	0%	0%	0%
Highlands - Northern Fall	Floodplain Riparian Woodland	E	X	4041	392	10%	9%	1%	97%
Highlands - Northern Fall	Lake Bed Herbland	E	X	605	1	0%	0%	0%	0%
Highlands - Northern Fall	Montane Grassland	E	X	2013	52	3%	1%	0%	21%
Highlands - Northern Fall	Montane Swamp	E	X	702	219	31%	2%	0%	6%
Highlands - Northern Fall	Plains Grassy Woodland	E	X	4097	171	4%	4%	0%	99%
Highlands - Northern Fall	Spring Soak Woodland	E		4	1	n/a	n/a	n/a	n/a
Highlands - Northern Fall	Sub-alpine Grassy Shrubland	E	X	88	29	33%	28%	0%	86%
Highlands - Northern Fall	Valley Grassy Forest	E	X	60394	5972	10%	7%	8%	72%
Highlands - Northern Fall	Valley Heathy Forest	E	X	252	19	7%	7%	0%	100%
Highlands - Northern Fall	Montane Grassy Woodland	V	X	40652	17682	43%	13%	3%	30%
Highlands - Northern Fall	Riverine Escarpment Scrub	V	X	636	543	85%	7%	43%	8%
Highlands - Northern Fall	Sub-alpine Wet Heathland	V	X	822	421	51%	4%	5%	7%
Highlands - Northern Fall	Swampy Riparian Woodland	V	X	3925	1701	43%	11%	14%	24%

Appendix 3.3: 17

Bioregion	Ecological Veg. Class	Conservation status	Reservation status	Pre-1750 area (ha)	Total extant area (ha)	Extant/pre-1750	Private/pre-1750	Reserved/extant	Private/extant
Highlands - Northern Fall	Blackthorn Scrub	R	Y	306	212	69%	12%	83%	17%
Highlands - Northern Fall	Cool Temperate Rainforest	R	X	3279	3279	100%	0%	10%	0%
Highlands - Northern Fall	Montane Riparian Thicket	R	X	2442	2383	98%	1%	8%	1%
Highlands - Northern Fall	Montane Rocky Shrubland	R	Y	50	50	100%	0%	60%	0%
Highlands - Northern Fall	Riparian Shrubland	R	X	841	628	75%	3%	82%	4%
Highlands - Northern Fall	Riparian Thicket	R	X	796	497	62%	5%	0%	7%
Highlands - Northern Fall	Rocky Outcrop Shrubland	R	X	1032	1026	99%	2%	29%	2%
Highlands - Northern Fall	Sub-alpine Grassland	R	Y	879	879	100%	0%	100%	0%
Highlands - Northern Fall	Grassy Woodland	D	Y	7280	4126	57%	10%	78%	17%
Highlands - Northern Fall	Montane Riparian Woodland	D	X	6166	2115	34%	7%	33%	20%
Highlands - Northern Fall	Damp Forest	LC	X	101083	96344	95%	3%	18%	3%
Highlands - Northern Fall	Granitic Hills Woodland	LC	Y	5355	3813	71%	9%	80%	13%
Highlands - Northern Fall	Grassy Dry Forest	LC	X	147509	98961	67%	18%	19%	27%
Highlands - Northern Fall	Heathy Dry Forest	LC	Y	98312	91942	94%	7%	44%	7%
Highlands - Northern Fall	Herb-rich Foothill Forest	LC	X	588278	454771	77%	9%	21%	12%
Highlands - Northern Fall	Montane Damp Forest	LC	X	67209	65073	97%	1%	28%	1%
Highlands - Northern Fall	Montane Dry Woodland	LC	Y	127982	117654	92%	3%	33%	4%
Highlands - Northern Fall	Montane Herb-rich Woodland	LC	Y	15065	13729	91%	7%	42%	8%
Highlands - Northern Fall	Montane Wet Forest	LC	X	16538	16534	100%	0%	19%	0%
Highlands - Northern Fall	Riparian Forest	LC	X	22472	18211	81%	6%	15%	8%
Highlands - Northern Fall	Shrubby Dry Forest	LC	X	282789	256855	91%	3%	23%	3%
Highlands - Northern Fall	Shrubby Foothill Forest	LC	X	6026	3026	50%	26%	11%	52%
Highlands - Northern Fall	Sub-alpine Woodland	LC	Y	2227	2221	100%	0%	48%	0%
Highlands - Northern Fall	Wet Forest	LC	X	27836	27111	97%	2%	19%	2%
Highlands - Northern Fall	Granitic Hills Woodland/Rocky Outcrop Shrubland/Herbland Mosaic			94	6	7%	7%	0%	100%
Highlands - Northern Fall	Grassy Dry Forest/Heathy Dry Forest Complex			376	350	93%	0%	100%	0%
Highlands - Northern Fall	Grassy Dry Forest/Rocky Outcrop Shrubland/Herbland Mosaic			738	145	20%	16%	0%	81%
Highlands - Northern Fall	Heathy Dry Forest/Shrubby Granitic-outwash Grassy Woodland Complex			17	0	0%	0%	0%	0%
Highlands - Northern Fall	Montane Grassy Woodland/Montane Grassland Mosaic			1867	1	0%	0%	0%	0%
Highlands - Northern Fall	Perched Boggy Shrubland Complex			515	77	15%	15%	0%	98%
Highlands - Northern Fall	Plains Grassy Woodland/Creekline Grassy Woodland/Floodplain Riparian Woodland			1839	12	1%	1%	0%	100%
Highlands - Northern Fall	Plains Grassy Woodland/Floodplain Riparian Woodland Complex			796	55	7%	7%	0%	95%
Highlands - Northern Fall	Rainshadow Grassy Woodland /Valley Grassy Forest Mosaic			35	1	2%	2%	0%	100%
Highlands - Northern Fall	Riparian Forest/Swampy Riparian Woodland Mosaic			3767	362	10%	8%	1%	88%

Bioregion	Ecological Veg. Class	Conservation status	Reservation status	Pre-1750 area (ha)	Total extant area (ha)	Extant/pre-1750	Private/pre-1750	Reserved/extant	Private/extant
Highlands - Northern Fall	Riparian Forest/Swampy Riparian Woodland/Riparian Shrubland/Riverine Escarpment Scrub			6355	2645	42%	5%	14%	11%
Highlands - Northern Fall	Rocky Outcrop Shrubland/Herbland Mosaic			2021	1833	91%	8%	59%	9%
Highlands - Northern Fall	Sub-alpine Wet Heathland/Sub-alpine Grassland Mosaic			315	285	90%	4%	69%	5%
Highlands - Northern Fall	Swampy Riparian Complex			637	157	25%	19%	6%	76%
Highlands - Northern Fall	Swampy Riparian Woodland/Percherd Boggy Shrubland Mosaic			1354	347	26%	20%	0%	78%
Highlands - Southern Fall	Coast Banksia Woodland	X		75	0	0%	0%	0%	0%
Highlands - Southern Fall	Floodplain Riparian Woodland	E	X	2056	306	15%	7%	16%	50%
Highlands - Southern Fall	Grassy Forest	E	X	9938	2677	27%	25%	1%	92%
Highlands - Southern Fall	Plains Grassy Forest	E	X	8652	403	5%	5%	0%	97%
Highlands - Southern Fall	Plains Grassy Woodland	E	X	5806	564	10%	4%	0%	38%
Highlands - Southern Fall	Riverine Grassy Forest	E	X	24	1	2%	2%	0%	100%
Highlands - Southern Fall	Box Ironbark Forest	V	X	7696	3061	40%	19%	21%	48%
Highlands - Southern Fall	Clay Heathland	V	X	42	27	64%	51%	0%	80%
Highlands - Southern Fall	Dry Rainforest	V	X	7	7	88%	9%	0%	11%
Highlands - Southern Fall	Grassy Woodland	V	X	15303	6834	45%	22%	39%	49%
Highlands - Southern Fall	Swampy Riparian Woodland	V	Y	1813	563	31%	6%	61%	19%
Highlands - Southern Fall	Valley Grassy Forest	V	X	31054	7546	24%	17%	16%	68%
Highlands - Southern Fall	Valley Heathy Forest	V	X	1183	391	33%	14%	0%	43%
Highlands - Southern Fall	Valley Slopes Dry Forest	V	X	1869	1694	91%	11%	1%	12%
Highlands - Southern Fall	Blackthorn Scrub	R	X	3652	3636	100%	0%	5%	0%
Highlands - Southern Fall	Cool Temperate Rainforest	R	X	9724	9709	100%	0%	53%	0%
Highlands - Southern Fall	Limestone Pomaderris Shrubland	R	Y	43	43	100%	0%	100%	0%
Highlands - Southern Fall	Montane Riparian Thicket	R	X	1988	1984	100%	0%	17%	0%
Highlands - Southern Fall	Montane Rocky Shrubland	R	Y	1542	1542	100%	0%	90%	0%
Highlands - Southern Fall	Riverine Escarpment Scrub	R	X	5575	5239	94%	6%	13%	6%
Highlands - Southern Fall	Rocky Outcrop Shrubland	R	X	690	664	96%	1%	46%	1%
Highlands - Southern Fall	Sub-alpine Grassland	R	X	987	983	100%	0%	26%	0%
Highlands - Southern Fall	Sub-alpine Shrubland	R	Y	74	74	100%	0%	100%	0%
Highlands - Southern Fall	Sub-alpine Wet Heathland	R	X	232	214	92%	0%	25%	0%
Highlands - Southern Fall	Warm Temperate Rainforest	R	X	634	632	100%	0%	0%	0%
Highlands - Southern Fall	Heathy Woodland	D	X	12194	5754	47%	9%	49%	19%
Highlands - Southern Fall	Montane Grassy Woodland	D	X	14168	7879	56%	14%	42%	24%
Highlands - Southern Fall	Riparian Thicket	D	X	1202	516	43%	24%	2%	55%
Highlands - Southern Fall	Damp Forest	LC	X	217241	192326	89%	7%	17%	8%

Appendix 3.3: 19

Bioregion	Ecological Veg. Class	Conservation status	Reservation status	Pre-1750 area (ha)	Total extant area (ha)	Extant/pre-1750	Private/pre-1750	Reserved/extant	Private/extant
Highlands - Southern Fall	Dry Valley Forest	LC	X	14325	10864	76%	7%	16%	9%
Highlands - Southern Fall	Grassy Dry Forest	LC	Y	44598	33522	75%	24%	31%	32%
Highlands - Southern Fall	Heathy Dry Forest	LC	Y	51737	51121	99%	2%	33%	2%
Highlands - Southern Fall	Herb-rich Foothill Forest	LC	Y	121632	112368	92%	8%	40%	9%
Highlands - Southern Fall	Lowland Forest	LC	X	87313	62975	72%	23%	9%	32%
Highlands - Southern Fall	Lowland Herb-rich Forest	LC	X	7402	5771	78%	35%	0%	44%
Highlands - Southern Fall	Montane Damp Forest	LC	Y	54787	54318	99%	0%	40%	0%
Highlands - Southern Fall	Montane Dry Woodland	LC	Y	92165	87976	95%	4%	44%	4%
Highlands - Southern Fall	Montane Herb-rich Woodland	LC	X	6521	6331	97%	3%	23%	3%
Highlands - Southern Fall	Montane Riparian Woodland	LC	Y	1712	1002	59%	30%	36%	51%
Highlands - Southern Fall	Montane Wet Forest	LC	Y	41345	40693	98%	0%	39%	0%
Highlands - Southern Fall	Riparian Forest	LC	X	31599	26146	83%	8%	29%	10%
Highlands - Southern Fall	Riparian Shrubland	LC	X	1145	1032	90%	4%	15%	4%
Highlands - Southern Fall	Shrubby Damp Forest	LC	X	53893	53802	100%	1%	16%	1%
Highlands - Southern Fall	Shrubby Dry Forest	LC	X	235055	226667	96%	4%	29%	4%
Highlands - Southern Fall	Shrubby Foothill Forest	LC	X	66706	59002	88%	8%	21%	9%
Highlands - Southern Fall	Shrubby Wet Forest	LC	X	2078	2079	100%	0%	1%	0%
Highlands - Southern Fall	Sub-alpine Woodland	LC	Y	2792	2792	100%	0%	79%	0%
Highlands - Southern Fall	Tableland Damp Forest	LC	X	7196	7195	100%	0%	11%	0%
Highlands - Southern Fall	Wet Forest	LC	X	129387	125959	97%	4%	26%	4%
Highlands - Southern Fall	Clay Heathland/Wet Heathland/Riparian Scrub Mosaic			3768	2999	80%	10%	74%	12%
Highlands - Southern Fall	Cool/Temperate Rainforest Overlap			25	25	100%	0%	0%	0%
Highlands - Southern Fall	Grassy Dry Forest/Heathy Dry Forest Complex			154	153	100%	0%	100%	0%
Highlands - Southern Fall	Riparian Scrub Complex			6414	2357	37%	33%	0%	91%
Highlands - Southern Fall	Rocky Outcrop Shrubland/Herbland Mosaic			8496	8496	100%	1%	71%	1%
Highlands - Southern Fall	Shrubby Foothill Forest/Damp Forest Complex			7772	7533	97%	2%	0%	3%
Highlands - Southern Fall	Sub-alpine Wet Heathland/Sub-alpine Grassland Mosaic			696	696	100%	0%	91%	0%
Highlands - Southern Fall	Swampy Riparian Complex			24780	4366	18%	14%	3%	81%
Highlands - Southern Fall	Treeless Sub-alpine Mosaic			803	803	100%	0%	56%	0%
Murray Mallee (4%)	Black Box Chenopod Woodland			11831	11	0%	0%	0%	42%
Murray Mallee (4%)	Black Box Chenopod Woodland/Lignum Wetland Mosaic			9278	61	1%	0%	0%	49%
Murray Mallee (4%)	Broombush Mallee			3009	10	0%	0%	0%	97%
Murray Mallee (4%)	Broombush Mallee/Low Rises Grassy Woodland Mosaic			853	2	0%	0%	0%	100%
Murray Mallee (4%)	Cane Grass Wetland			4094	1	0%	0%	0%	38%

Bioregion	Ecological Veg. Class	Conservation status	Reservation status	Pre-1750 area (ha)	Total extant area (ha)	Extant/pre-1750	Private/pre-1750	Reserved/extant	Private/extant
Murray Mallee (4%)	Floodplain Riparian Woodland			1027	2	0%	0%	0%	100%
Murray Mallee (4%)	Grassy Woodland			17409	50	0%	0%	0%	35%
Murray Mallee (4%)	Lignum Wetland			3391	13	0%	0%	0%	100%
Murray Mallee (4%)	Metamorphic Slopes Shrubby Woodland			122	52	43%	1%	0%	2%
Murray Mallee (4%)	Pine Box Woodland			3997	6	0%	0%	0%	100%
Murray Mallee (4%)	Plains Grassland			7862	3	0%	0%	0%	100%
Murray Mallee (4%)	Plains Grassy Woodland			36540	65	0%	0%	0%	94%
Murray Mallee (4%)	Red Gum Wetland			1280	12	1%	0%	0%	12%
Murray Mallee (4%)	Riverina Plains Grassy Woodland/Low Rises Grassy Woodland Mosaic			13563	20	0%	0%	0%	86%
Murray Mallee (4%)	Riverina Plains Grassy Woodland/Plains Grassland Mosaic			12314	1	0%	0%	0%	100%
Murray Mallee (4%)	Wetland Formation			3073	100	3%	1%	0%	19%
Murray Mallee (4%)	Wimmera Plains Grassy Woodland/Plains Grassland Mosaic			2549	1	0%	0%	0%	100%
Northern Inland Slopes (99%)	Pine Box Woodland	X		842	0	0%	0%	0%	0%
Northern Inland Slopes (99%)	Alluvial Terraces Herb-rich Woodland	E	X	1708	43	3%	1%	0%	35%
Northern Inland Slopes (99%)	Creekline Grassy Woodland	E	X	4521	273	6%	4%	9%	68%
Northern Inland Slopes (99%)	Floodplain Riparian Woodland	E	X	21535	744	3%	3%	0%	91%
Northern Inland Slopes (99%)	Grassy Woodland	E	X	104314	5374	5%	3%	33%	57%
Northern Inland Slopes (99%)	Plains Grassy Woodland	E	X	59904	548	1%	1%	6%	75%
Northern Inland Slopes (99%)	Riparian Shrubland	E	X	455	184	40%	10%	74%	26%
Northern Inland Slopes (99%)	Spring Soak Woodland	E	X	177	27	16%	12%	12%	80%
Northern Inland Slopes (99%)	Swampy Riparian Woodland	E	X	592	241	41%	9%	52%	23%
Northern Inland Slopes (99%)	Valley Grassy Forest	E	X	96712	7936	8%	5%	33%	59%
Northern Inland Slopes (99%)	Wetland Formation	E	X	520	62	12%	7%	0%	55%
Northern Inland Slopes (99%)	Box Ironbark Forest	V	X	40078	7717	19%	5%	25%	26%
Northern Inland Slopes (99%)	Grassy Dry Forest	D	X	82591	33635	41%	21%	28%	52%
Northern Inland Slopes (99%)	Riverine Escarpment Scrub	D	X	130	49	38%	18%	0%	48%
Northern Inland Slopes (99%)	Granitic Hills Woodland	LC	X	32133	22275	69%	19%	60%	28%
Northern Inland Slopes (99%)	Heathy Dry Forest	LC	Y	28794	22026	76%	15%	50%	19%
Northern Inland Slopes (99%)	Herb-rich Foothill Forest	LC	X	29915	17873	60%	20%	23%	33%
Northern Inland Slopes (99%)	Shrubby Dry Forest	LC	X	14038	11944	85%	12%	38%	15%
Northern Inland Slopes (99%)	Alluvial Terraces Herb-rich Woodland/Creekline Grassy Woodland Mosaic			468	106	23%	6%	0%	27%
Northern Inland Slopes (99%)	Alluvial Terraces Herb-rich Woodland/Heathy Dry Forest Mosaic			149	126	85%	4%	0%	5%
Northern Inland Slopes (99%)	Alluvial Terraces Herb-rich Woodland/Plains Grassy Woodland Complex			1067	18	2%	0%	94%	6%
Northern Inland Slopes (99%)	Alluvial Terraces Herb-rich Woodland/Valley Grassy Forest Complex			916	21	2%	2%	7%	93%

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Northern Inland Slopes (99%)	Box Ironbark Forest/Shrubby Granitic-outwash Grassy Woodland Mosaic			1218	66	5%	5%	0%	99%
Northern Inland Slopes (99%)	Creekline Grassy Woodland/Red Gum Wetland Mosaic			132	21	16%	16%	0%	100%
Northern Inland Slopes (99%)	Floodplain Riparian Woodland/Plains Grassy Woodland Mosaic			2307	62	3%	3%	7%	93%
Northern Inland Slopes (99%)	Gilgai Plain Woodland/Wetland Mosaic			7346	241	3%	1%	9%	23%
Northern Inland Slopes (99%)	Granitic Hills Woodland/Rocky Outcrop Shrubland/Herbland Mosaic			3951	3114	79%	15%	72%	19%
Northern Inland Slopes (99%)	Pine Box Woodland/Riverina Plains Grassy Woodland Mosaic			1755	3	0%	0%	0%	95%
Northern Inland Slopes (99%)	Plains Grassy Woodland/Creekline Grassy Woodland/Wetland Mosaic			561	53	9%	7%	0%	72%
Northern Inland Slopes (99%)	Plains Grassy Woodland/Floodplain Riparian Woodland Complex			7084	218	3%	3%	0%	98%
Northern Inland Slopes (99%)	Plains Grassy Woodland/Gilgai Plains Woodland/Wetland Mosaic			6792	29	0%	0%	0%	90%
Northern Inland Slopes (99%)	Plains Grassy Woodland/Rainshadow Grassy Woodland Complex			2499	22	1%	0%	0%	49%
Northern Inland Slopes (99%)	Plains Grassy Woodland/Valley Grassy Forest Complex			1936	21	1%	1%	0%	100%
Northern Inland Slopes (99%)	Plains Grassy Woodland/Valley Grassy Forest/Rainshadow Grassy Woodland			2397	109	5%	1%	0%	21%
Northern Inland Slopes (99%)	Plains Saltmarsh Complex			42	4	10%	10%	0%	100%
Northern Inland Slopes (99%)	Rainshadow Grassy Woodland /Valley Grassy Forest Mosaic			1861	52	3%	1%	0%	38%
Northern Inland Slopes (99%)	Riparian Forest/Swampy Riparian Woodland Mosaic			691	28	4%	3%	15%	85%
Northern Inland Slopes (99%)	Riverina Plains Grassy Woodland/Shrubby Granitic-outwash Grassy Woodland			427	5	1%	1%	0%	100%
Northern Inland Slopes (99%)	Riverine Grassy Woodland/Riverine Sedgy Forest/Wetland Mosaic			12200	1418	12%	8%	0%	69%
Northern Inland Slopes (99%)	Rocky Outcrop Shrubland/Herbland Mosaic			1873	1258	67%	3%	78%	4%
Northern Inland Slopes (99%)	Shrubby Granitic-outwash Grassy Woodland/Valley Grassy Forest Complex			23	4	17%	0%	0%	0%
Northern Inland Slopes (99%)	Valley Grassy Forest/Box Ironbark Forest Complex			925	121	13%	13%	0%	100%
Otway Plain	Calcarenite Dune Woodland	E	X	4639	547	12%	6%	0%	47%
Otway Plain	Damp Heath Scrub	E	X	421	48	11%	11%	0%	100%
Otway Plain	Damp Sands Herb-rich Woodland	E	X	2364	433	18%	14%	11%	76%
Otway Plain	Floodplain Riparian Woodland	E	X	6027	337	6%	3%	0%	52%
Otway Plain	Grassy Forest	E	X	1597	139	9%	9%	0%	100%
Otway Plain	Grassy Woodland	E	X	80925	2050	3%	2%	0%	87%
Otway Plain	Lignum Wetland	E	X	79	2	3%	0%	0%	0%
Otway Plain	Plains Grassland	E	X	2064	76	4%	1%	0%	16%
Otway Plain	Plains Grassy Woodland	E	X	23832	257	1%	1%	0%	60%
Otway Plain	Plains Sedgy Wetland	E	X	560	2	0%	0%	0%	115%
Otway Plain	Scoria Cone Woodland	E	X	209	1	0%	0%	0%	100%
Otway Plain	Swamp Scrub	E	X	6064	183	3%	3%	0%	91%
Otway Plain	Swampy Riparian Woodland	E	X	2740	346	13%	12%	0%	96%
Otway Plain	Wetland Formation	E	X	233	55	23%	4%	0%	19%

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Otway Plain	Cane Grass-Lignum Halophyllic Herbland	V	X	137	89	65%	0%	0%	0%
Otway Plain	Coastal Headland Scrub	V	X	751	570	76%	7%	36%	9%
Otway Plain	Coastal Tussock Grassland	V	X	249	176	71%	5%	61%	7%
Otway Plain	Estuarine Wetland	V	X	221	119	54%	28%	0%	52%
Otway Plain	Plains Brackish Sedge Wetland	V	X	29	16	55%	0%	0%	0%
Otway Plain	Plains Freshwater Sedge Wetland	V	X	91	82	90%	0%	0%	0%
Otway Plain	Riparian Forest	V	X	2861	997	35%	23%	5%	67%
Otway Plain	Mangrove Shrubland	R	X	64	50	78%	11%	0%	14%
Otway Plain	Reed Swamp	R	X	565	517	92%	0%	0%	0%
Otway Plain	Seasonally-inundated Sub-saline Herbland	R	X	36	36	100%	0%	0%	0%
Otway Plain	Shrubby Wet Forest	R	X	578	482	83%	21%	23%	25%
Otway Plain	Wet Sands Thicket	R	X	516	503	97%	9%	18%	9%
Otway Plain	Lowland Forest	D	X	60587	28766	47%	17%	11%	36%
Otway Plain	Sedgy Riparian Woodland	D	X	2683	1376	51%	18%	14%	34%
Otway Plain	Heathy Woodland	LC	X	26724	21869	82%	13%	20%	16%
Otway Plain	Herb-rich Foothill Forest	LC	X	3849	1983	52%	15%	6%	29%
Otway Plain	Shrubby Dry Forest	LC	X	1290	969	75%	36%	48%	49%
Otway Plain	Shrubby Foothill Forest	LC	X	5716	3857	67%	17%	25%	26%
Otway Plain	Wet Heathland	LC	X	2184	1614	74%	8%	28%	10%
Otway Plain	Aquatic Herbland/Plains Sedgy Wetland Mosaic			517	4	1%	1%	0%	94%
Otway Plain	Coastal Dune Scrub Mosaic			1201	736	61%	4%	29%	7%
Otway Plain	Coastal Headland Scrub/Headland Coastal Tussock Grassland Mosaic			253	193	76%	9%	88%	12%
Otway Plain	Coastal Saltmarsh Complex			4823	2207	46%	1%	0%	2%
Otway Plain	Heathy Woodland/Sand Heath Mosaic			869	85	10%	10%	0%	100%
Otway Plain	Herb-rich Foothill Forest/Shrubby Foothill Forest Complex			1081	226	21%	16%	0%	78%
Otway Plain	Mangrove Shrubland/Coastal Saltmarsh/Berm Grassy Shrubland/Coastal Tussock Grassland			61	26	43%	0%	0%	0%
Otway Plain	Riparian Scrub Complex			5937	4394	74%	17%	18%	24%
Otway Ranges	Floodplain Reedbed	X		112	0	0%	0%	0%	0%
Otway Ranges	Swamp Scrub	E	X	1550	223	14%	5%	0%	36%
Otway Ranges	Coastal Tussock Grassland	V	Y	62	54	86%	16%	79%	18%
Otway Ranges	Wet Sands Thicket	V	X	779	763	98%	1%	31%	1%
Otway Ranges	Cool Temperate Rainforest	R	X	10174	8601	85%	16%	11%	18%
Otway Ranges	Sedgy Riparian Woodland	R	X	233	214	92%	16%	10%	17%
Otway Ranges	Coastal Headland Scrub	LC	Y	1774	1337	75%	25%	46%	34%

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Otway Ranges	Herb-rich Foothill Forest	LC	X	1442	1015	70%	18%	8%	26%
Otway Ranges	Lowland Forest	LC	Y	3524	2815	80%	23%	30%	29%
Otway Ranges	Riparian Forest	LC	X	2789	2155	77%	18%	23%	24%
Otway Ranges	Shrubby Foothill Forest	LC	Y	30488	24981	82%	18%	36%	22%
Otway Ranges	Shrubby Wet Forest	LC	X	37434	32015	86%	19%	16%	22%
Otway Ranges	Wet Forest	LC	X	50957	40799	80%	16%	18%	20%
Otway Ranges	Coastal Dune Scrub Mosaic			265	167	63%	1%	48%	2%
Otway Ranges	Herb-rich Foothill Forest/Shrubby Foothill Forest Complex			5025	3938	78%	11%	0%	14%
Strzelecki Ranges	Grassy Forest	X		304	0	0%	0%	0%	0%
Strzelecki Ranges	Swampy Riparian Woodland	X		3737	0	0%	0%	0%	0%
Strzelecki Ranges	Wet Sands Thicket	X		65	0	0%	0%	0%	0%
Strzelecki Ranges	Cool Temperate Rainforest	E	X	1888	579	31%	3%	4%	9%
Strzelecki Ranges	Damp Forest	E	X	80395	8239	10%	6%	3%	61%
Strzelecki Ranges	Plains Grassy Forest	E	X	1381	64	5%	4%	0%	96%
Strzelecki Ranges	Riparian Scrub	E	X	329	10	3%	2%	0%	57%
Strzelecki Ranges	Rocky Outcrop Shrubland	E	X	0	23	0%	0%	0%	80%
Strzelecki Ranges	Shrubby Foothill Forest	E	X	93080	2121	2%	1%	0%	61%
Strzelecki Ranges	Swamp Scrub	E	X	3207	102	3%	3%	4%	96%
Strzelecki Ranges	Warm Temperate Rainforest	E	X	3111	86	3%	1%	1%	43%
Strzelecki Ranges	Herb-rich Foothill Forest	V	X	7811	1396	18%	6%	13%	33%
Strzelecki Ranges	Lowland Forest	V	X	22454	5396	24%	16%	17%	67%
Strzelecki Ranges	Coastal Headland Scrub	R	Y	2	2	0%	0%	98%	2%
Strzelecki Ranges	Wet Forest	D	X	83337	41130	49%	21%	7%	42%
Strzelecki Ranges	Riparian Forest/Warm Temperate Rainforest Mosaic			1842	0	0%	0%	0%	0%
Strzelecki Ranges	Swamp Scrub/Plains Grassy Forest Mosaic			144	16	11%	0%	0%	4%
Strzelecki Ranges	Swampy Riparian Complex			8437	171	2%	2%	0%	88%
Victorian Alps	Montane Grassy Woodland	V	X	9189	7527	82%	6%	18%	8%
Victorian Alps	Cool Temperate Rainforest	R	Y	302	302	100%	0%	38%	0%
Victorian Alps	Montane Riparian Thicket	R	Y	2300	2277	99%	0%	44%	0%
Victorian Alps	Montane Riparian Woodland	R	Y	270	270	100%	0%	95%	0%
Victorian Alps	Montane Rocky Shrubland	R	Y	1552	1552	100%	0%	94%	0%
Victorian Alps	Rocky Outcrop Shrubland	R	X	187	187	100%	0%	21%	0%
Victorian Alps	Sub-alpine Shrubland	R	Y	238	238	100%	0%	98%	0%
Victorian Alps	Sub-alpine Wet Heathland	D	X	1053	597	57%	0%	33%	0%

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Victorian Alps	Heathy Dry Forest	LC	Y	1744	1744	100%	0%	79%	0%
Victorian Alps	Herb-rich Foothill Forest	LC	Y	2009	2008	100%	0%	74%	0%
Victorian Alps	Montane Damp Forest	LC	Y	56701	55407	98%	0%	47%	0%
Victorian Alps	Montane Dry Woodland	LC	Y	104095	104378	100%	0%	54%	0%
Victorian Alps	Montane Herb-rich Woodland	LC	Y	3135	2341	75%	1%	48%	1%
Victorian Alps	Montane Wet Forest	LC	Y	11565	11489	99%	0%	52%	0%
Victorian Alps	Sub-alpine Grassland	LC	Y	13925	13492	97%	3%	91%	3%
Victorian Alps	Sub-alpine Woodland	LC	Y	82710	82485	100%	0%	73%	0%
Victorian Alps	Tableland Damp Forest	LC	X	3245	3240	100%	0%	11%	0%
Victorian Alps	Rocky Outcrop Shrubland/Herbland Mosaic			489	489	100%	0%	100%	0%
Victorian Alps	Sub-alpine Wet Heathland/Sub-alpine Grassland Mosaic			2643	2437	92%	12%	22%	13%
Victorian Alps	Treeless Sub-alpine Mosaic			23186	22630	98%	0%	91%	0%
Victorian Riverina (77%)	Brackish Lake	X		1089	0	0%	0%	0%	100%
Victorian Riverina (77%)	Cane Grass Wetland	X		195	0	0%	0%	0%	0%
Victorian Riverina (77%)	Riverine Escarpment Scrub	X		257	0	0%	0%	0%	0%
Victorian Riverina (77%)	Spring Soak Woodland	X		5	0	7%	7%	0%	100%
Victorian Riverina (77%)	Black Box Chenopod Woodland	E	X	14161	379	3%	2%	0%	74%
Victorian Riverina (77%)	Granitic Hills Woodland	E	X	1367	64	5%	4%	0%	87%
Victorian Riverina (77%)	Grassy Woodland	E	X	45918	1190	3%	2%	0%	76%
Victorian Riverina (77%)	Lagoon Wetland	E	X	567	54	10%	3%	16%	33%
Victorian Riverina (77%)	Lignum Wetland	E	X	5869	316	5%	5%	0%	89%
Victorian Riverina (77%)	Pine Box Woodland	E	X	20327	208	1%	1%	0%	96%
Victorian Riverina (77%)	Plains Grassland	E	X	168816	579	0%	0%	0%	91%
Victorian Riverina (77%)	Plains Grassy Wetland	E	X	8326	220	3%	2%	0%	92%
Victorian Riverina (77%)	Plains Grassy Woodland	E	X	829044	8238	1%	1%	3%	73%
Victorian Riverina (77%)	Red Gum Wetland	E	X	5860	933	16%	8%	0%	49%
Victorian Riverina (77%)	Sand Ridge Woodland	E	X	4845	229	5%	3%	0%	57%
Victorian Riverina (77%)	Sedge-rich Woodland	E	X	39	3	7%	7%	0%	100%
Victorian Riverina (77%)	Unclassified Lunette Woodland	E	X	2265	133	6%	0%	79%	1%
Victorian Riverina (77%)	Valley Grassy Forest	E	X	3158	129	4%	4%	0%	96%
Victorian Riverina (77%)	Valley Heathy Forest	E	X	354	33	9%	9%	0%	100%
Victorian Riverina (77%)	Wetland Formation	E	X	31879	1243	4%	2%	0%	60%
Victorian Riverina (77%)	Alluvial Terraces Herb-rich Woodland	V	X	1039	130	13%	1%	6%	11%
Victorian Riverina (77%)	Box Ironbark Forest	V	X	11884	3963	33%	7%	13%	20%

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Victorian Riverina (77%)	Creekline Grassy Woodland	V	X	21660	2949	14%	5%	0%	37%
Victorian Riverina (77%)	Floodplain Riparian Woodland	V	X	17866	3376	19%	13%	0%	67%
Victorian Riverina (77%)	Grassy Dry Forest	V	X	1026	132	13%	13%	0%	100%
Victorian Riverina (77%)	Riverine Grassy Woodland	V	X	16455	2345	14%	2%	3%	17%
Victorian Riverina (77%)	Reed Swamp	R	X	464	395	85%	0%	83%	0%
Victorian Riverina (77%)	Moira Plain Wetland	LC	Y	2294	2038	89%	0%	65%	0%
Victorian Riverina (77%)	Alluvial Terraces Herb-rich Woodland/Creekline Grassy Woodland Mosaic			1431	67	5%	4%	0%	91%
Victorian Riverina (77%)	Alluvial Terraces Herb-rich Woodland/Gilgai Plain Woodland/Wetland Mosaic			1015	0	0%	0%	0%	0%
Victorian Riverina (77%)	Alluvial Terraces Herb-rich Woodland/Heathy Dry Forest Mosaic			607	408	67%	3%	0%	4%
Victorian Riverina (77%)	Black Box Chenopod Woodland/Lignum Wetland Mosaic			29087	551	2%	1%	0%	26%
Victorian Riverina (77%)	Broombush Mallee/Low Rises Grassy Woodland Mosaic			247	4	2%	2%	0%	100%
Victorian Riverina (77%)	Creekline Grassy Woodland/Red Gum Wetland Mosaic			425	52	12%	8%	0%	65%
Victorian Riverina (77%)	Drainage-Line Complex			12226	641	5%	3%	5%	55%
Victorian Riverina (77%)	Floodplain Riparian Woodland/Floodplain Wetland Mosaic			307	63	20%	14%	0%	69%
Victorian Riverina (77%)	Floodplain Riparian Woodland/Plains Grassy Woodland Mosaic			219	0	0%	0%	0%	0%
Victorian Riverina (77%)	Gilgai Plain Woodland/Wetland Mosaic			26361	1513	6%	2%	1%	38%
Victorian Riverina (77%)	Gilgai Plain Woodland/Wetland/Plains Grassy Wetland Mosaic			1499	0	0%	0%	0%	0%
Victorian Riverina (77%)	Gilgai Plain Woodland/Wetland/Shrubby Riverina Plains Grassy Woodland			7	0	0%	0%	0%	0%
Victorian Riverina (77%)	Grassy Dry Forest/Granitic Hills Woodland Complex			54	10	19%	19%	0%	100%
Victorian Riverina (77%)	Gravelly-Sediment Broombush Mallee/Box Ironbark Forest Mosaic			310	11	4%	3%	0%	84%
Victorian Riverina (77%)	Heathy Dry Forest/Shrubby Granitic-outwash Grassy Woodland Complex			170	2	1%	1%	0%	100%
Victorian Riverina (77%)	Lagoon Wetland/Red Gum Wetland Mosaic			340	72	21%	21%	0%	100%
Victorian Riverina (77%)	Low Rises Grassy Woodland/Alluvial Terraces Herb-rich Woodland Complex			37	1	4%	0%	0%	0%
Victorian Riverina (77%)	Pine Box Woodland/Riverina Plains Grassy Woodland Mosaic			112684	718	1%	1%	0%	87%
Victorian Riverina (77%)	Plains Grassland/Gilgai Plain Woodland/Wetland Mosaic			16180	87	1%	1%	0%	96%
Victorian Riverina (77%)	Plains Grassy Woodland/Box Ironbark Forest Complex			81	33	41%	24%	0%	59%
Victorian Riverina (77%)	Plains Grassy Woodland/Creekline Grassy Woodland Mosaic			48	0	0%	0%	0%	0%
Victorian Riverina (77%)	Plains Grassy Woodland/Creekline Grassy Woodland/Floodplain Riparian Woodland			1525	42	3%	3%	0%	100%
Victorian Riverina (77%)	Plains Grassy Woodland/Creekline Grassy Woodland/Wetland Mosaic			7844	343	4%	4%	0%	95%
Victorian Riverina (77%)	Plains Grassy Woodland/Floodplain Riparian Woodland Complex			184	0	0%	0%	0%	0%
Victorian Riverina (77%)	Plains Grassy Woodland/Gilgai Plains Woodland/Wetland Mosaic			65612	767	1%	1%	0%	51%
Victorian Riverina (77%)	Plains Grassy Woodland/Rainshadow Grassy Woodland Complex			231	0	0%	0%	0%	0%
Victorian Riverina (77%)	Plains Saltmarsh Complex			1743	42	2%	2%	0%	92%
Victorian Riverina (77%)	Red Gum Wetland/Plains Grassy Wetland Mosaic			4308	420	10%	9%	0%	94%

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Victorian Riverina (77%)	Riverina Plains Grassy Woodland/Lignum Wetland Mosaic			1251	2	0%	0%	0%	100%
Victorian Riverina (77%)	Riverina Plains Grassy Woodland/Low Rises Grassy Woodland Mosaic			1350	6	0%	0%	0%	59%
Victorian Riverina (77%)	Riverina Plains Grassy Woodland/Plains Grassland Mosaic			6808	16	0%	0%	0%	100%
Victorian Riverina (77%)	Riverina Plains Grassy Woodland/Plains Grassland/Gilgai Plain Woodland			415	0	0%	0%	0%	100%
Victorian Riverina (77%)	Riverina Plains Grassy Woodland/Red Gum Wetland Mosaic			1020	0	0%	0%	0%	0%
Victorian Riverina (77%)	Riverina Plains Grassy Woodland/Shrubby Granitic-outwash Grassy Woodland			91	0	0%	0%	0%	0%
Victorian Riverina (77%)	Riverine Grassy Woodland/Black Box Chenopod Woodland/Wetland Mosaic			6098	62	1%	1%	0%	90%
Victorian Riverina (77%)	Riverine Grassy Woodland/Gilgai Plain Woodland/Wetland/Riverina Plains			11433	671	6%	4%	0%	63%
Victorian Riverina (77%)	Riverine Grassy Woodland/Riverina Plains Grassy Woodland Complex			5296	216	4%	3%	0%	75%
Victorian Riverina (77%)	Riverine Grassy Woodland/Riverina Plains Grassy Woodland/Black Box Che			14924	859	6%	3%	1%	53%
Victorian Riverina (77%)	Riverine Grassy Woodland/Riverine Sedgy Forest/Wetland Mosaic			81153	51332	63%	9%	10%	15%
Victorian Riverina (77%)	Rocky Outcrop Shrubland/Herbland Mosaic			94	10	11%	2%	0%	23%
Victorian Riverina (77%)	Shrubby Granitic-outwash Grassy Woodland/Plains Grassy Woodland Complex			1244	33	3%	3%	0%	96%
Victorian Riverina (77%)	Valley Grassy Forest/Box Ironbark Forest Complex			430	6	1%	1%	0%	100%
Victorian Volcanic Plain	Brackish Wetland	X		786	0	0%	0%	0%	0%
Victorian Volcanic Plain	Creekline Tussock Grassland	X		2591	0	0%	0%	0%	0%
Victorian Volcanic Plain	Damp Heathland	X		117	0	0%	0%	0%	100%
Victorian Volcanic Plain	Freshwater Lignum Shrubland	X		26	0	0%	0%	0%	0%
Victorian Volcanic Plain	Lignum Cane Grass Swamp	X		414	0	0%	0%	0%	0%
Victorian Volcanic Plain	Stony Knoll Shrubland	X		89	0	0%	0%	0%	0%
Victorian Volcanic Plain	Basalt Creekline Shrubby Woodland	E	X	4001	1	0%	0%	0%	0%
Victorian Volcanic Plain	Basalt Escarpment Shrubland	E	X	676	72	11%	10%	0%	94%
Victorian Volcanic Plain	Basalt Shrubby Woodland	E	X	70150	72	0%	0%	0%	93%
Victorian Volcanic Plain	Box Woodland	E	X	59	1	2%	2%	0%	100%
Victorian Volcanic Plain	Brackish Lake	E	X	1114	2	0%	0%	0%	0%
Victorian Volcanic Plain	Cane Grass Wetland	E	X	282	0	0%	0%	0%	0%
Victorian Volcanic Plain	Cinder Cone Woodland	E	X	487	215	44%	0%	0%	0%
Victorian Volcanic Plain	Creekline Grassy Woodland	E	X	25800	1024	4%	1%	0%	28%
Victorian Volcanic Plain	Creekline Herb-rich Woodland	E	X	320	17	5%	5%	6%	92%
Victorian Volcanic Plain	Floodplain Riparian Woodland	E	X	15277	863	6%	4%	0%	76%
Victorian Volcanic Plain	Freshwater Meadow	E	X	290	21	7%	1%	0%	17%
Victorian Volcanic Plain	Grassy Forest	E	X	1332	143	11%	10%	0%	97%
Victorian Volcanic Plain	Grassy Woodland	E	X	33352	852	3%	2%	0%	63%
Victorian Volcanic Plain	Hills Herb-rich Woodland	E	X	5477	146	3%	2%	0%	70%

Appendix 3.3: 27

Bioregion	Ecological Veg. Class	Conservation status	Reservation status	Pre-1750 area (ha)	Total extant area (ha)	Extant/pre-1750	Private/pre-1750	Reserved/extant	Private/extant
Victorian Volcanic Plain	Lunette Woodland	E	X	679	0	0%	0%	0%	0%
Victorian Volcanic Plain	Mangrove Shrubland	E	X	29	8	29%	8%	0%	27%
Victorian Volcanic Plain	Permanent Open Freshwater	E	X	290	13	4%	0%	0%	0%
Victorian Volcanic Plain	Permanent Saline	E	X	31	2	6%	0%	0%	0%
Victorian Volcanic Plain	Plains Grassland	E	X	220073	2291	1%	0%	0%	36%
Victorian Volcanic Plain	Plains Grassy Wetland	E	X	39166	159	0%	0%	0%	37%
Victorian Volcanic Plain	Plains Grassy Woodland	E	X	612871	6804	1%	1%	1%	67%
Victorian Volcanic Plain	Plains Sedgy Wetland	E	X	27962	315	1%	1%	0%	66%
Victorian Volcanic Plain	Plains Swampy Woodland	E	X	15150	21	0%	0%	0%	94%
Victorian Volcanic Plain	Riparian Woodland	E	X	11828	488	4%	3%	0%	69%
Victorian Volcanic Plain	Riverine Escarpment Scrub	E	X	561	90	16%	1%	0%	7%
Victorian Volcanic Plain	Rocky Chenopod Woodland	E	X	50	20	40%	23%	0%	58%
Victorian Volcanic Plain	Sand Forest	E	X	85	48	56%	56%	0%	100%
Victorian Volcanic Plain	Scoria Cone Woodland	E	X	12117	845	7%	4%	3%	50%
Victorian Volcanic Plain	Seasonally Inundated Shrubby Woodland	E	X	123	1	1%	1%	0%	69%
Victorian Volcanic Plain	Shallow Freshwater Marsh	E	X	744	76	10%	4%	25%	43%
Victorian Volcanic Plain	Stream-bank Shrubland	E	X	2578	642	25%	12%	3%	50%
Victorian Volcanic Plain	Swamp Scrub	E	X	27206	581	2%	1%	0%	35%
Victorian Volcanic Plain	Swampy Riparian Woodland	E	X	2827	71	3%	2%	0%	69%
Victorian Volcanic Plain	Coastal Tussock Grassland	V	X	30	20	68%	0%	0%	0%
Victorian Volcanic Plain	Damp Heathy Woodland	V	X	118	92	78%	6%	54%	7%
Victorian Volcanic Plain	Damp Sands Herb-rich Woodland	V	X	5916	2002	34%	12%	0%	35%
Victorian Volcanic Plain	Deep Freshwater Marsh	V	X	1642	519	32%	5%	0%	17%
Victorian Volcanic Plain	Grassy Dry Forest	V	X	3376	435	13%	12%	6%	92%
Victorian Volcanic Plain	Heathy Dry Forest	V	X	4120	761	18%	14%	0%	76%
Victorian Volcanic Plain	Herb-rich Foothill Forest	V	X	66855	12678	19%	8%	15%	42%
Victorian Volcanic Plain	Stoney Rises Herb-rich Woodland	V	X	106503	19026	18%	9%	46%	50%
Victorian Volcanic Plain	Valley Grassy Forest	V	X	4440	425	10%	9%	6%	91%
Victorian Volcanic Plain	Reed Swamp	R	X	27	24	88%	73%	8%	82%
Victorian Volcanic Plain	Seasonally-inundated Sub-saline Herbland	R	X	23	23	100%	0%	0%	0%
Victorian Volcanic Plain	Sedgy Riparian Woodland	R	X	509	320	63%	4%	0%	6%
Victorian Volcanic Plain	Wet Heathland	R	Y	651	573	88%	0%	99%	0%
Victorian Volcanic Plain	Heathy Woodland	LC	X	1309	1211	93%	7%	48%	8%
Victorian Volcanic Plain	Lowland Forest	LC	X	34353	32120	93%	3%	11%	3%

Bioregion	Ecological Veg. Class	Conservation status	Reservation status	Pre-1750 area (ha)	Total extant area (ha)	Extant/pre-1750	Private/pre-1750	Reserved/extant	Private/extant
Victorian Volcanic Plain	Alluvial Terraces Herb-rich Woodland/Plains Grassy Woodland Complex			1501	6	0%	0%	0%	58%
Victorian Volcanic Plain	Aquatic Herbland/Plains Sedgy Wetland Mosaic			15704	212	1%	0%	0%	35%
Victorian Volcanic Plain	Basalt Shrubby Woodland / Herb-rich Foothill Forest			1237	0	0%	0%	0%	0%
Victorian Volcanic Plain	Brackish Drainage Line Herbland/Sedgeland			572	0	0%	0%	0%	0%
Victorian Volcanic Plain	Coastal Saltmarsh Complex			1514	563	37%	1%	0%	4%
Victorian Volcanic Plain	Damp Heathland / Damp Heathy Woodland			807	35	4%	4%	0%	86%
Victorian Volcanic Plain	Damp Sands Herb-rich Woodland / Damp Heathland / Damp Heathy Woodland			3709	235	6%	4%	38%	64%
Victorian Volcanic Plain	Damp Sands Herb-rich Woodland / Heathy Woodland			50	48	96%	2%	98%	2%
Victorian Volcanic Plain	Damp Sands Herb-rich Woodland / Herb-rich Foothill Forest			115	0	0%	0%	0%	0%
Victorian Volcanic Plain	Damp Sands Herb-rich Woodland / Plains Grassy Woodland			17229	8	0%	0%	5%	94%
Victorian Volcanic Plain	Damp Sands Herb-rich Woodland / Plains Swampy Woodland / Aquatic Herbland			1937	15	1%	1%	0%	100%
Victorian Volcanic Plain	Escarpment Shrubland / Grassy Woodland / Riparian Woodland			65	0	0%	0%	0%	0%
Victorian Volcanic Plain	Floodplain Riparian Woodland / Plains Grassy Woodland			2070	8	0%	0%	0%	0%
Victorian Volcanic Plain	Freshwater Lake Mosaic			410	0	0%	0%	0%	0%
Victorian Volcanic Plain	Grassy Woodland / Damp Sands Herb-rich Woodland			1539	1	0%	0%	0%	0%
Victorian Volcanic Plain	Grassy Woodland / Hills Herb-rich Woodland / Damp Sands Herb-rich Woodland			336	0	0%	0%	0%	0%
Victorian Volcanic Plain	Grassy Woodland/Heathy Dry Forest Complex			1107	2	0%	0%	0%	100%
Victorian Volcanic Plain	Grey Clay Drainage Line Complex			2181	0	0%	0%	0%	39%
Victorian Volcanic Plain	Heathy Woodland / Damp Heathy Woodland / Damp Heathland			1820	783	43%	6%	0%	15%
Victorian Volcanic Plain	Plains Grassland / Stony Knoll Shrubland			761	0	0%	0%	0%	0%
Victorian Volcanic Plain	Plains Grassland/Plains Grassy Woodland Mosaic			456163	3336	1%	0%	0%	64%
Victorian Volcanic Plain	Plains Grassy Woodland / Damp Sands Herb-rich Complex			3546	0	0%	0%	0%	100%
Victorian Volcanic Plain	Plains Grassy Woodland / Stony Knoll Shrubland			1798	3	0%	0%	0%	0%
Victorian Volcanic Plain	Plains Swampy Woodland / Swamp Scrub			951	20	2%	1%	0%	41%
Victorian Volcanic Plain	Riparian Shrubland / Escarpment Shrubland / Grassy Woodland			2603	21	1%	1%	0%	61%
Victorian Volcanic Plain	Riparian Woodland / Escarpment Shrubland			554	22	4%	2%	0%	60%
Victorian Volcanic Plain	Riverina Plains Grassy Woodland/Plains Grassland Mosaic			8873	333	4%	3%	0%	91%
Victorian Volcanic Plain	Saline Lake Mosaic			2923	0	0%	0%	0%	0%
Victorian Volcanic Plain	Stony Knoll Shrubland / Basalt Shrubby Woodland			223	0	0%	0%	0%	0%
Victorian Volcanic Plain	Stony Knoll Shrubland / Plains Grassy Woodland / Plains Grassy Wetland			57515	10	0%	0%	0%	0%
Victorian Volcanic Plain	Stony Rises Woodland / Stony Knoll Shrubland			1227	47	4%	3%	12%	88%
Victorian Volcanic Plain	Swamp Scrub / Aquatic Herbland			391	13	3%	1%	0%	42%
Victorian Volcanic Plain	Swamp Scrub / Plains Sedgy Wetland / Aquatic Herbland			8742	39	0%	0%	19%	57%
Victorian Volcanic Plain	Swampy Riparian Complex			1805	12	1%	0%	0%	73%

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Bioregion	Ecological Veg. Class	Conservation status	Reservation status	Pre-1750 area (ha)	Total extant area (ha)	Extant/pre-1750	Private/pre-1750	Reserved/extant	Private/extant
Victorian Volcanic Plain	Wet Heathland / Heathy Woodland			2114	2028	96%	4%	37%	4%
Warrnambool Plain	Plains Swampy Woodland	X		3610	0	0%	0%	0%	0%
Warrnambool Plain	Shallow Freshwater Marsh	X		1253	0	0%	0%	0%	100%
Warrnambool Plain	Aquatic Herbland	E	X	217	3	1%	0%	0%	2%
Warrnambool Plain	Deep Freshwater Marsh	E	X	700	18	3%	3%	0%	100%
Warrnambool Plain	Estuarine Wetland	E	X	954	314	33%	13%	5%	40%
Warrnambool Plain	Freshwater Meadow	E	X	392	8	2%	2%	0%	100%
Warrnambool Plain	Permanent Saline	E	X	471	54	11%	0%	0%	4%
Warrnambool Plain	Plains Grassy Woodland	E	X	3819	124	3%	3%	0%	100%
Warrnambool Plain	Reed Swamp	E	X	39	2	6%	6%	0%	100%
Warrnambool Plain	Riparian Forest	E	X	2286	575	25%	16%	0%	62%
Warrnambool Plain	Scoria Cone Woodland	E	X	314	15	5%	5%	0%	100%
Warrnambool Plain	Swamp Scrub	E	X	10641	286	3%	3%	1%	93%
Warrnambool Plain	Bird Colony Succulent Herbland	V	X	9	8	82%	0%	0%	0%
Warrnambool Plain	Coastal Dune Scrub	V	X	3065	911	30%	10%	5%	34%
Warrnambool Plain	Damp Heath Scrub	V	X	15900	2010	13%	5%	25%	44%
Warrnambool Plain	Damp Sands Herb-rich Woodland	V	X	11927	1257	11%	7%	28%	62%
Warrnambool Plain	Heathy Woodland	V	X	1544	284	18%	5%	37%	30%
Warrnambool Plain	Herb-rich Foothill Forest	V	X	39710	8330	21%	8%	0%	37%
Warrnambool Plain	Lowland Forest	V	X	47057	6820	14%	6%	3%	39%
Warrnambool Plain	Sedgy Riparian Woodland	V	X	2475	402	16%	6%	0%	40%
Warrnambool Plain	Wet Heathland	V	X	2716	336	12%	4%	0%	34%
Warrnambool Plain	Coast Gully Thicket	R	Y	344	196	57%	6%	87%	11%
Warrnambool Plain	Coastal Tussock Grassland	R	Y	198	160	81%	1%	99%	1%
Warrnambool Plain	Coastal Headland Scrub	LC	Y	2234	1252	56%	3%	93%	5%
Warrnambool Plain	Shrubby Foothill Forest	LC	X	2008	1029	51%	17%	34%	33%
Warrnambool Plain	Aquatic Herbland/Plains Sedgy Wetland Mosaic			530	3	0%	0%	0%	100%
Warrnambool Plain	Coastal Dune Scrub Mosaic			1141	818	72%	2%	86%	3%
Warrnambool Plain	Coastal Headland Scrub/Headland Coastal Tussock Grassland Mosaic			1094	490	45%	1%	97%	2%
Warrnambool Plain	Damp Heath Scrub/Heathy Woodland Complex			16	16	100%	0%	0%	0%
Warrnambool Plain	Damp Heathland / Damp Heathy Woodland			16766	68	0%	0%	10%	90%
Warrnambool Plain	Damp Sands Herb-rich Woodland / Damp Heathland / Damp Heathy Woodland			48729	822	2%	1%	1%	78%
Warrnambool Plain	Damp Sands Herb-rich Woodland / Plains Swampy Woodland / Aquatic Herbland			5301	150	3%	3%	0%	92%
Warrnambool Plain	Riparian Scrub Complex			711	214	30%	7%	0%	24%

Bioregion	Ecological Veg. Class	Conservation status	Reservation status	Pre-1750 area (ha)	Total extant area (ha)	Extant/pre-1750	Private/pre-1750	Reserved/extant	Private/extant
Warrnambool Plain	Stony Knoll Shrubland / Plains Grassy Woodland / Plains Grassy Wetland			669	0	0%	0%	0%	0%
Warrnambool Plain	Swamp Scrub / Aquatic Herbland			2044	91	4%	2%	0%	50%
Warrnambool Plain	Swamp Scrub / Plains Sedgy Wetland / Aquatic Herbland			153	0	0%	0%	0%	0%
Wilsons Promontory	Coast Banksia Woodland	R	Y	286	285	100%	0%	100%	0%
Wilsons Promontory	Coastal Headland Scrub	R	Y	268	267	100%	0%	98%	0%
Wilsons Promontory	Coastal Lagoon Wetland	R	Y	59	59	100%	0%	100%	0%
Wilsons Promontory	Coastal Sand Heathland	R	Y	19	19	100%	0%	69%	0%
Wilsons Promontory	Cool Temperate Rainforest	R	Y	142	142	100%	0%	100%	0%
Wilsons Promontory	Estuarine Wetland	R	Y	140	140	100%	0%	100%	0%
Wilsons Promontory	Montane Rocky Shrubland	R	Y	115	115	100%	0%	100%	0%
Wilsons Promontory	Sand Heathland	R	Y	761	762	100%	0%	100%	0%
Wilsons Promontory	Sedge Wetland	R	Y	72	70	97%	0%	100%	0%
Wilsons Promontory	Warm Temperate Rainforest	R	Y	1107	1008	91%	0%	100%	0%
Wilsons Promontory	Wet Rocky Outcrop Scrub	R	Y	516	516	100%	0%	100%	0%
Wilsons Promontory	Wet Swale Herbland	R	Y	75	75	100%	0%	100%	0%
Wilsons Promontory	Damp Forest	LC	Y	3880	3670	95%	0%	100%	0%
Wilsons Promontory	Granitic Hills Woodland	LC	Y	3922	3920	100%	0%	100%	0%
Wilsons Promontory	Heathy Woodland	LC	Y	3273	3274	100%	0%	100%	0%
Wilsons Promontory	Lowland Forest	LC	Y	3842	3841	100%	0%	100%	0%
Wilsons Promontory	Riparian Scrub	LC	Y	2181	2182	100%	0%	100%	0%
Wilsons Promontory	Shrubby Foothill Forest	LC	Y	3783	3770	100%	0%	100%	0%
Wilsons Promontory	Wet Forest	LC	Y	3948	3850	98%	0%	100%	0%
Wilsons Promontory	Wet Heathland	LC	Y	5922	5919	100%	0%	100%	0%
Wilsons Promontory	Coastal Dune Scrub Mosaic			1328	1315	99%	0%	100%	0%
Wilsons Promontory	Rocky Outcrop Shrubland/Herbland Mosaic			225	224	100%	0%	100%	0%
Wilsons Promontory	Sand Heathland/Wet Heathland Mosaic			3316	3315	100%	0%	100%	0%
Wimmera (41%)	Alluvial Terraces Herb-rich Woodland			375	36	10%	5%	0%	57%
Wimmera (41%)	Aquatic Herbland			1164	43	4%	2%	0%	65%
Wimmera (41%)	Black Box Chenopod Woodland			11814	212	2%	1%	0%	41%
Wimmera (41%)	Black Box Chenopod Woodland/Lignum Wetland Mosaic			2453	17	1%	1%	0%	92%
Wimmera (41%)	Black Box Chenopod Woodland/Plains Grassland Mosaic			190	0	0%	0%	0%	0%
Wimmera (41%)	Black Box Lignum Woodland			348	65	19%	7%	0%	35%
Wimmera (41%)	Box Ironbark Forest			4642	2100	45%	7%	0%	15%
Wimmera (41%)	Brackish Drainage Line Herbland/Sedgeland			105	0	0%	0%	0%	0%

Bioregion	Ecological Veg. Class	Conservation status	Reservation status	Pre-1750 area (ha)	Total extant area (ha)	Extant/pre-1750	Private/pre-1750	Reserved/extant	Private/extant
Wimmera (41%)	Brackish Lake			2503	49	2%	0%	0%	0%
Wimmera (41%)	Brackish Sedgeland			419	25	6%	1%	0%	20%
Wimmera (41%)	Brackish Wetland			63	3	6%	0%	0%	0%
Wimmera (41%)	Broombush Mallee			1707	189	11%	0%	98%	1%
Wimmera (41%)	Broombush Mallee/Low Rises Grassy Woodland Mosaic			63	0	0%	0%	0%	0%
Wimmera (41%)	Cane Grass Wetland			1213	96	8%	3%	3%	38%
Wimmera (41%)	Creekline Grassy Woodland			1378	57	4%	2%	0%	56%
Wimmera (41%)	Creekline Sedgy Woodland			2046	293	14%	4%	0%	27%
Wimmera (41%)	Damp Heathland			126	103	82%	17%	10%	21%
Wimmera (41%)	Damp Heathland / Seasonally Inundated Shrubby Woodland			63	62	98%	49%	0%	50%
Wimmera (41%)	Damp Sands Herb-rich Woodland			8632	3981	46%	19%	0%	42%
Wimmera (41%)	Damp Sands Herb-rich Woodland / Heathy Woodland			71	70	99%	99%	0%	100%
Wimmera (41%)	Damp Sands Herb-rich Woodland / Plains Swampy Woodland / Aquatic Herbland			1182	29	2%	2%	0%	100%
Wimmera (41%)	Damp Sands Herb-rich Woodland / Seasonally Inundated Shrubby Woodland			569	220	39%	23%	0%	59%
Wimmera (41%)	Damp Sands Herb-rich Woodland / Shallow Sands Woodland			2202	474	22%	11%	35%	51%
Wimmera (41%)	Damp Sands Herb-rich Woodland / Shrubby Woodland			39	8	21%	0%	0%	1%
Wimmera (41%)	Deep Freshwater Marsh			1561	2	0%	0%	0%	60%
Wimmera (41%)	Drainage-Line Woodland			4433	166	4%	2%	8%	46%
Wimmera (41%)	Dune Soak Woodland			121	47	39%	18%	0%	47%
Wimmera (41%)	Floodplain Riparian Woodland			2382	149	6%	2%	0%	35%
Wimmera (41%)	Freshwater Lake Mosaic			2598	0	0%	0%	0%	0%
Wimmera (41%)	Freshwater Lignum Shrubland			989	1	0%	0%	0%	0%
Wimmera (41%)	Freshwater Meadow			79	5	7%	7%	0%	100%
Wimmera (41%)	Grassy Dry Forest / Heathy Woodland			240	191	80%	15%	0%	19%
Wimmera (41%)	Grassy Woodland			20205	952	5%	1%	0%	30%
Wimmera (41%)	Grassy Woodland / Alluvial Terraces Herb-rich Woodland			384	32	8%	1%	0%	17%
Wimmera (41%)	Grassy Woodland / Heathy Woodland			2468	371	15%	13%	0%	88%
Wimmera (41%)	Heathy Herb-rich Woodland / Damp Sands Herb-rich Woodland			797	477	60%	22%	11%	37%
Wimmera (41%)	Heathy Woodland			48941	40925	84%	19%	15%	23%
Wimmera (41%)	Heathy Woodland / Heathy Herb-rich Woodland			332	188	57%	22%	61%	39%
Wimmera (41%)	Heathy Woodland / Seasonally Inundated Shrubby Woodland			55	55	100%	5%	0%	5%
Wimmera (41%)	Heathy Woodland/Sand Heath Mosaic			4812	3850	80%	21%	25%	27%
Wimmera (41%)	Herb-rich Heathy Woodland			8629	5482	64%	29%	16%	45%
Wimmera (41%)	Hills Herb-rich Woodland			1001	260	26%	24%	9%	91%

Bioregion	Ecological Veg. Class	Conservation status	Reservation status	Pre-1750 area (ha)	Total extant area (ha)	Extant/pre-1750	Private/pre-1750	Reserved/extant	Private/extant
Wimmera (41%)	Inland Saltmarsh			363	4	1%	0%	0%	0%
Wimmera (41%)	Lateritic Woodland			472	223	47%	44%	0%	94%
Wimmera (41%)	Lignum Cane Grass Swamp			128	34	27%	0%	0%	0%
Wimmera (41%)	Lignum Wetland			780	0	0%	0%	0%	0%
Wimmera (41%)	Low Rises Grassy Woodland/Alluvial Terraces Herb-rich Woodland Mosaic			2984	296	10%	1%	0%	7%
Wimmera (41%)	Low Rises Grassy Woodland/Riverina Grassy Chenopod Woodland Mosaic			929	0	0%	0%	0%	0%
Wimmera (41%)	Lunette Woodland			1441	57	4%	3%	11%	67%
Wimmera (41%)	Permanent Open Freshwater			196	1	1%	0%	0%	5%
Wimmera (41%)	Permanent Saline			143	0	0%	0%	0%	0%
Wimmera (41%)	Plains Grassland			24612	3	0%	0%	0%	82%
Wimmera (41%)	Plains Grassy Woodland			97915	2017	2%	1%	24%	39%
Wimmera (41%)	Plains Riparian Shrubby Woodland			416	281	68%	5%	0%	8%
Wimmera (41%)	Plains Sedgy Wetland			271	15	6%	2%	0%	38%
Wimmera (41%)	Plains Sedgy Woodland			2135	981	46%	11%	11%	23%
Wimmera (41%)	Plains Sedgy Woodland / Shallow Sands Woodland / Heathy Woodland			371	366	99%	15%	0%	16%
Wimmera (41%)	Plains Swampy Woodland			369	10	3%	3%	0%	100%
Wimmera (41%)	Plains Woodland			419689	4038	1%	1%	2%	56%
Wimmera (41%)	Plains Woodland/Damp Sands Herb-rich Woodland			219	109	50%	2%	0%	4%
Wimmera (41%)	Plains Woodland/Plains Grassy Wetland			7234	2015	28%	4%	1%	14%
Wimmera (41%)	Plains Woodland/Plains Sedgy Woodland/Damp Sands Herb-rich Woodland			4327	299	7%	7%	0%	99%
Wimmera (41%)	Red Gum Wetland			21152	1006	5%	3%	5%	55%
Wimmera (41%)	Red Gum Wetland / Aquatic Herbland			1260	149	12%	2%	8%	14%
Wimmera (41%)	Riparian Woodland			3482	1084	31%	13%	0%	41%
Wimmera (41%)	Riverina Plains Grassy Woodland/Low Rises Grassy Woodland Mosaic			4765	4	0%	0%	0%	100%
Wimmera (41%)	Riverina Plains Grassy Woodland/Plains Grassland Mosaic			3607	3	0%	0%	0%	100%
Wimmera (41%)	Riverine Grassy Woodland / Riverine Sedgy Forest / Aquatic Herbland			1199	213	18%	10%	0%	57%
Wimmera (41%)	Saline Lake Mosaic			1438	0	0%	0%	0%	0%
Wimmera (41%)	Salt Paperbark Woodland			188	50	26%	9%	0%	35%
Wimmera (41%)	Salt Paperbark Woodland / Inland Saltmarsh			232	17	7%	0%	0%	0%
Wimmera (41%)	Sand Heathland			1614	1407	87%	7%	10%	8%
Wimmera (41%)	Sand Ridge Woodland			981	91	9%	5%	0%	54%
Wimmera (41%)	Sand Ridge Woodland / Damp Sands Herb-rich Woodland			428	86	20%	6%	0%	28%
Wimmera (41%)	Sandy Stream Woodland			31	6	20%	20%	0%	100%
Wimmera (41%)	Seasonally Inundated Shrubby Woodland			1801	1042	58%	15%	36%	25%

Appendix 3.3: 33

Bioregion	Ecological Veg. Class	Conservation status	Reservation status	Pre-1750 area (ha)	Total extant area (ha)	Extant/pre-1750	Private/pre-1750	Reserved/extant	Private/extant
Wimmera (41%)	Seasonally Inundated Shrubby Woodland / Plains Sedgy Woodland			782	613	78%	15%	17%	19%
Wimmera (41%)	Sedge Wetland			365	67	18%	0%	0%	2%
Wimmera (41%)	Sedge-rich Wetland			14	14	100%	27%	73%	27%
Wimmera (41%)	Semi-permanent Saline			1215	40	3%	1%	0%	16%
Wimmera (41%)	Shallow Freshwater Marsh			58	43	74%	20%	9%	27%
Wimmera (41%)	Shallow Sands Woodland			31794	5688	18%	6%	23%	32%
Wimmera (41%)	Shallow Sands Woodland / Heathy Herb-rich Woodland			69	62	90%	90%	0%	100%
Wimmera (41%)	Shallow Sands Woodland / Heathy Woodland			855	719	84%	7%	69%	8%
Wimmera (41%)	Shallow Sands Woodland / Plains Sedgy Woodland			3241	1871	58%	8%	26%	13%
Wimmera (41%)	Shallow Sands Woodland / Plains Sedgy Woodland / Seasonally Inundated Shrubby Woodland			12794	3711	29%	8%	9%	29%
Wimmera (41%)	Wetland Formation			2318	77	3%	3%	0%	84%
Wimmera (41%)	Wimmera Plains Grassy Woodland/Plains Grassland Mosaic			6739	2	0%	0%	0%	100%

Appendix 3.4

Conservation and reservation status of Broad Vegetation Types in the Murray–Darling Depression

KEY

Conservation status:

X = Presumed Extinct
E = Endangered
V = Vulnerable
R = Rare
D = Depleted
LC = Least Concern

Reservation status:

X = BVT does not reach reservation target set by the criteria
Y = BVT reaches reservation target set by the criteria

Murray–Darling Depression	Conservation status	Reservation status	Pre-1750 area (ha)	Total extant area (ha)	Extant/pre-1750	Private/pre-1750	Reserved/extant	Private/extant
DRY FOOTHILL FOREST COMPLEXES	D	Y	3082	1271	41%	1%	90%	2%
MALLEE COMPLEXES	D	X	2690543	1002521	37%	3%	80%	7%
GRASSLAND COMPLEXES	E	X	381249	1235	0%	0%	54%	38%
HERB-RICH WOODLAND COMPLEXES	E	X	78045	4762	6%	4%	19%	62%
PLAINS GRASSY WOODLAND COMPLEXES	E	X	942508	26274	3%	2%	7%	59%
SEDGE-RICH WOODLAND COMPLEXES	E	X	25726	2309	9%	5%	38%	56%
WIMMERA MALLEE/WOODLAND COMPLEXES	E	X	859492	2386	0%	0%	28%	68%
HEATHY WOODLAND COMPLEXES	LC	X	106210	61074	58%	20%	21%	34%
MALLEE HEATH COMPLEXES	LC	Y	553745	502628	91%	4%	79%	5%
BOINKA-RAAK COMPLEXES	V	X	167443	39277	23%	1%	74%	5%
BOX IRONBARK FOREST COMPLEXES	V	X	8006	2255	28%	9%	42%	31%
INLAND SLOPES WOODLAND COMPLEXES	V	X	16916	2122	13%	5%	8%	36%
MALLEE WOODLAND COMPLEXES	V	X	224256	60780	27%	4%	74%	13%
RIVERINE GRASSY WOODLAND COMPLEXES	V	X	377735	84166	22%	3%	62%	15%

forests that have been clearfelled and replanted with indigenous species are not counted as 'plantations'. However, this appears to have occurred in the Strzeleckis. Local conservation groups estimate that around 7000 hectares of land on the Hancocks leasehold is actually native forest, and not plantation as is claimed (K. Devenish pers. comm.).

Prior to the 1999 Gippsland Regional Forest Agreement (RFA), ecologists from the Department of Natural Resources and Environment (DNRE) classified areas of 'hardwood reforestation' as Wet Forest EVC . However, this classification was subsequently removed and the final RFA map labels the hardwood reafforestation as plantation, along with pine plantations (K. Devenish pers. comm.). Moreover, the entire area of 48,000 hectares of public land leased to Amcor and Hancocks was removed from the RFA.

In practice, incorrect designation of areas of native forest as plantations has two very significant consequences:

- It potentially allows areas to be clearfelled and replaced with non-indigenous vegetation (ie. Radiata Pine, non-indigenous eucalypts) without requiring permits under the State Planning Act for clearing (i.e. the permanent removal) of native vegetation. This means that illegal clearing of vegetation may be currently occurring in the eastern Strzeleckis if areas of native forest, incorrectly designated as plantations, are clearfelled and replaced with non-indigenous species.
- It removes areas for consideration for further protection in conservation reserves, such has occurred already during the RFA process.

Careful examination and definition of plantation and native forest, and their identification on the ground, is key to determining the situation legally in the eastern Strzelecki Ranges. In addition to any legal definitions, there needs to be a focus on determining what is required to maintain ecological processes and species in the Strzeleckis. Some species (e.g. Satin Bowerbird, Leadbeaters Possum, and possibly Sooty Owl) have already become extinct, or are highly threatened in the Strzelecki Ranges. Management of the area's forests as an intensive plantation zone may accelerate losses of other sensitive forest species in the bioregion.

In the final Gippsland RFA consultation paper, the raising of this issue by residents was acknowledged and it was noted that the Victorian Government proposed to refer the issues to the new Environmental Assessment Council.

The above information is based largely on research by Julie Constable and Kim Devenish. Further details are provided on the website:http://members.dcsi.net.au/kimjulie