Biodiversity Assessment

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East Melbourne VIC 3002
Ph: (03) 9637 8325

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Requests should be addressed to:
Commonwealth and Victorian RFA Steering Committee
C/o - Commonwealth Forests Taskforce
Department of the Prime Minister and Cabinet
3-5 National Circuit
Barton ACT 2600
Ph: (02) 6271 5181.

Foreword

This report provides details of the biodiversity assessment component of the West Comprehensive Regional Assessment (CRA). A summary version of this document has been published as part of a West CRA report, obtainable from the address given above.

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Victoria

Department of Natural Resources and Environment

Coordination and editing:
Rod Anderson, Kylie White.

Flora chapters:
Writers: Cathy Molnar, Alison Oates, Annette Muir
Technical advice: Simon Cropper (Botanicus Australia P/L), Doug Frood (Pathways Experiences), David Parkes, Bill Peel.

Fauna chapters:
Writers: Jenny Nelson, Tim Doeg, Phoebe Macak.
Technical Advice: Tarmo Raadik, Kim Lowe, Richard Loyn, Graeme Newell, Andrew Corrick.

GIS analysis and Technical advice:
Petina Pert, Rolf Willig and Nadia Marine, Steve Farrell, Susanne Thulin.

Commonwealth

Environment Australia:
Environment Forests Taskforce

Editorial advice:
Felix Schlager, Geoff Dyne.

Technical advice and assistance:
Jason Passioura, Ron Wardman, Gaston Rozenbilds.

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1.1 Background

The National Forest Policy Statement (NFPS) establishes the concept of the Comprehensive Regional Assessment (CRA) process, and lists the protection of biological diversity under *The Convention on Biological Diversity* as one of the Commonwealth obligations to be included in the assessment. Strategies for conserving biodiversity, as outlined under the NFPS, are:

- establishment of a dedicated forest reserve system on public land based on the principles of comprehensiveness, adequacy and representativeness;
- complementary management of public native forests outside conservation reserves which assists biodiversity conservation; and
- promotion of the management of private forests in sympathy with nature conservation goals (Commonwealth of Australia 1992a).

The NFPS identifies the following objectives of biodiversity conservation:

- to maintain ecological processes and the dynamics of forest ecosystems in their landscape context;
- to maintain viable examples of forest ecosystems throughout their natural ranges;
- to maintain viable populations of native forest species throughout their natural ranges; and
- to maintain the genetic diversity of native forest species.

To achieve these objectives, a set of national criteria has been developed to guide the establishment of a Comprehensive, Adequate and Representative (CAR) forest reserve system (JANIS 1997). The criteria relating specifically to biodiversity are outlined in Box 1.

Box 1 Summary of the JANIS biodiversity criteria

1. As a general criterion, 15% of the pre-1750 distribution of each forest ecosystem should be protected in the CAR reserve system with flexibility considerations applied according to regional circumstances, and recognising that as far as possible and practicable, the proportion of dedicated reserves should be maximised.
2. Where forest ecosystems are recognised as vulnerable, (eg. approaching a reduction in areal extent of 70% within a bioregional context or subject to continuing and significant threatening processes), then at least 60% of their remaining extent should be reserved. (Vulnerable ecosystems include those where threatening processes have caused significant changes in species composition, loss or significant decline in species that play a major role within the ecosystem, or significant alteration to ecosystem processes.)
3. All remaining occurrences of rare and endangered forest ecosystems should be reserved or protected by other means as far as is practicable.
4. Reserved areas should be replicated across the geographic range of the forest ecosystem to decrease the likelihood that chance events such as wildfire or disease will cause the forest ecosystem to decline.
5. The reserve system should seek to maximise the area of high quality habitat for all known elements of biodiversity wherever practicable, but with particular reference to:

- the special needs of rare, vulnerable or endangered species;
- special groups of organisms, for example species with complex habitat requirements, or migratory or mobile species;
- areas of high species diversity, natural refugia for flora and fauna, and centres of endemism; and
- those species whose distributions and habitat requirements are not well correlated with any particular forest ecosystem.

6. Reserves should be large enough to sustain the viability, quality and integrity of populations.
7. To ensure representativeness, the reserve system should, as far as possible, sample the full range of biological variation within each forest ecosystem, by sampling the range of environmental variation typical of its geographic range and sampling its range of successional stages.
8. In fragmented landscapes, remnants that contribute to sampling the full range of biodiversity are vital parts of a forest reserve system. The areas should be identified and protected as part of the development of integrated regional conservation strategies.

The Scoping Agreement for the Victoria–Commonwealth Regional Forest Agreement requires that elements of biodiversity at the species and ecosystem levels be identified and threatening processes be reviewed.

The results of this assessment are to be used in identifying a comprehensive, adequate and representative (CAR) reserve system that protects forest biodiversity in accordance with nationally agreed criteria. The strategy for conserving biodiversity relies not just on a CAR reserve system, but also on the application of

ecologically sustainable forest management practices in off-reserve areas. The assessment provides a benchmark for monitoring the efficacy of these practices.

1.2 Elements of biodiversity

Biological diversity is usually considered at three levels:

- 'Genetic diversity' refers to the variety of genetic information contained in all individual plants, animals and micro-organisms. It occurs within and between populations of species as well as between species.
- 'Species diversity' refers to the variety of living species.
- 'Ecosystem diversity' refers to the variety of habitats, biotic communities and ecological processes, as well as the diversity present between and within ecosystems.

1.2.1 Genetic diversity

Empirical data on genetic variation within and between species is sparse and generally restricted to a small number of species, primarily vertebrates and vascular plants. The time and cost of analyses to incorporate a full consideration of genetic variation is beyond the scope of the RFA process.

The national criteria state that "The reserve system should seek to maximise the area of high quality habitat for all known elements of biodiversity "(criterion 5). The agreed approach to address the genetic component of this diversity in the assessment has been to analyse the spatial and environmental spread in the representation of vegetation classes and species populations within the Region. Threatened species or groups of species that require targeted assessments to ensure their survival *in situ* will have a particular dependence on the maintenance of genetic variation.

As knowledge of intra-specific variation and techniques for assessing it improve, it will be necessary to review the strategies for ensuring preservation of genetic variation.

1.2.2 Species diversity

Under the National Forest Policy Statement (Commonwealth of Australia 1992a), Australian governments agreed to manage for the conservation of all species of Australia's indigenous forest fauna and flora throughout those species' ranges and to maintain the native forest cover where a reduction in this cover would compromise regional conservation objectives, consistent with ecologically sustainable management. The national forest reserve criteria, jointly agreed by the Commonwealth and the States, identify objectives in relation to species conservation (see Box 1 above, point 5).

In particular, assessment of species-level biodiversity in the West forests for the CRA required a review of the conservation status of threatened taxa, their susceptibility to decline and extinction and an evaluation of the effects of disturbance on each of these taxa. Existing or proposed management actions are also addressed.

1.2.3 Ecosystem diversity

Ecosystem diversity encompasses the broad differences between and within ecosystem types in relation to the diversity of habitats and ecological processes. It is more difficult to define than species or genetic diversity because the 'boundaries' of communities (associations of species) and ecosystems are often indistinct. The ecosystem concept is dynamic and thus variable, and it can also be applied at different scales.

Forest ecosystems are defined in the nationally agreed criteria for a CAR reserve system for forests and in Victoria it has been agreed that Ecological Vegetation Classes (EVCs) are equivalent to forest ecosystems for the purposes of the CRA assessments. This assumes a correlation between the occurrence of entities defined by certain structural, floristic and environmental features and the occurrence of particular suites of fauna.

1.3 Conservation of biodiversity

1.3.1 National and State obligations and actions

The Commonwealth and Victorian governments have a number of legislative and international responsibilities in connection with the conservation of biodiversity. Of particular relevance are the Convention on Biological Diversity, the Commonwealth *Endangered Species Protection Act* 1992 and Victorian *Flora and Fauna Guarantee Act* 1988.

The Convention on Biological Diversity

Conservation of biodiversity is a foundation of ecologically sustainable development and one of the three principal objectives of the National Strategy for Ecologically Sustainable Development (Commonwealth of Australia 1992b).

The Convention on Biological Diversity, ratified by Australia on 18 June 1993, deals at a global level with the full range of the conservation of biological diversity, its sustainable use, and the fair and equitable sharing of the

benefits arising from this use. The National Strategy for the Conservation of Australia's Biological Diversity, signed by the Commonwealth and all State and Territory governments, provides the framework for giving effect to Australia's international obligations (Commonwealth of Australia 1996). Under the Strategy, governments in Australia have undertaken to identify the terrestrial, marine and other aquatic components of biodiversity that are important for biodiversity conservation and ecologically sustainable use.

Commonwealth Endangered Species Protection Act

Under the *Endangered Species Protection Act* 1992, the Commonwealth is responsible for identifying endangered species and their habitats for the purpose of analysis of threats and potential for recovery and for developing measures to ensure their future viability.

The primary purpose of the Act is to promote the recovery of species and ecological communities that are endangered or vulnerable and to prevent other species and communities from becoming endangered or vulnerable. The Act aims to reduce conflict in land management, to provide for public involvement and better understanding, and to encourage cooperative management for the conservation of endangered species and communities.

Provision is made under the Act for a scientifically based listing process that identifies nationally endangered and vulnerable species, endangered ecological communities and key threatening processes of national importance. Those species, communities and threatening processes are listed in Schedules to the Act.

The Act promotes the use of 'Recovery Plans', to help in the recovery of endangered species and ecological communities, and 'threat-abatement plans', for reducing the impact of threatening processes.

Note: The objects of the Environment Protection and Biodiversity Conservation Act 1999 are met through the Regional Forest Agreement Process for each region. Accordingly, the Act does not apply to forestry operations in RFA regions except where such operations are in a property included in the World Heritage list or in a wetland designated under the Ramsar Convention or are incidental to a purpose other than forestry.

Victorian Flora and Fauna Guarantee Act

The *Flora and Fauna Guarantee Act* 1988 provides a framework for the legal protection of Victoria's flora and flora, and for a major program of State Government and community action. The aim is to ensure that Victoria's native flora and fauna survive, flourish and retain their potential for evolutionary development.

The Act provides for native species or biological communities, which have been identified as being threatened, to be listed in one of its schedules.

It also allows for the listing of threatening processes which may affect the long term survival and evolutionary development of flora and fauna.

When a listing occurs, an Action Statement must be prepared as soon as possible detailing what measures are needed for the management of the listed species, biological community or potentially threatening process. Action Statements take into account social and economic considerations.

Interim Conservation Orders (ICOs) can also be made in cases where the threat to the critical habitat of a listed species or biological community is considered so urgent that immediate action is required.

Victoria's Biodiversity Strategy

In December 1997 Victoria published its Biodiversity Strategy which sets a strategic framework to enable the Victorian community to better understand, value and protect its biodiversity assets. The Strategy embraces broad-based responsibility for action within an adaptive management framework, and outlines priorities for action, monitoring and reporting at a bioregional scale. In addition, the Strategy fulfils a legislative requirement under the *Flora and Fauna Guarantee Act* 1988 to produce a Flora and Fauna Guarantee Strategy.

Victorian National Parks Act

The *National Parks Act* 1975 provides for the establishment, protection, management and use of National, State, and Wilderness Parks, as well as other parks and reserves. Under the Act, the Director is required to ensure that each National, State and Wilderness Park is controlled and managed in a manner that will preserve and protect the natural condition of the park and its indigenous flora and fauna. The Act requires a management plan to be prepared for each park.

Forest Management

Forest management plans are prepared in accord with the relevant legislation such as the *Flora and Fauna Guarantee Act* 1998 to address the full range of values and uses in State forest. These management plans provide protection of environmental, cultural and resource values at the regional level and for the long term.

In accordance with the Code of Forest Practices for Timber Production (Code), forest management plans and associated local prescriptions consider:

- representative conservation and minimum levels of protection of all forest ecosystems;
- special protection for communities of limited distribution;
- strategies for conserving rare and threatened plant and animal species;
- protection and provision for recruitment of old trees;
- protection of old-growth forest; and
- strategies for maintaining a mosaic of corridors, regrowth stages and zones which incorporate high flora and fauna value so as to enhance conservation values and biodiversity.

A forest management plan for the West Region is in preparation.

The purpose of the Code is to ensure that commercial timber growing and timber harvesting activities are carried out in such a way that promotes an internationally competitive forest industry, is compatible with the conservation of the wide range of environmental values, and ecological sustainable forest management. The Code provides Statewide goals, guidelines and minimum standards to be applied to timber production operations.

Other relevant legislation includes the *Forests Act* 1958, *Crown Land (Reserves) Act* 1978 and the *Heritage Rivers Act* 1992.

A list and description of key Commonwealth and State legislation relating to RFAs in Victoria is provided in Appendix 1 of the West CRA Report (VicRFASC 1999) and in the statewide assessment of Ecologically Sustainable Forest Management (VicRFASC 1997).

1.4 Biodiversity assessment methods

1.4.1 Methodological approaches: an overview

The Comprehensive Regional Assessment (CRA) provides information about individual flora and fauna species and their habitats, forest ecosystems and communities, and threatening processes. It reviews existing information and the results of additional studies of priority taxa and communities.

The review of existing information has two main elements: an audit of biological records data so as to identify any major gaps in biodiversity information; and a review of information on species and forest ecosystems, the effects of threatening processes and existing or proposed management actions which address these. Chapter 3 discusses the approach to the data audit which was undertaken.

A major, systematic program of fauna survey has been undertaken during the preparation of this CRA. This survey was considered necessary because of the lack of fauna survey data which was revealed in an initial data audit. A data audit following this survey is also included in the CRA for comparison.

Analysis of data involves the following:

- information identifying survey intensity for flora and selected fauna groups in relation to different environmental strata across the Region;
- generation of maps of the current distribution of Ecological Vegetation Classes (EVCs) in the West and analysis of their reservation status in relation to modelled pre-1750 distributions and current tenures; and
- analysis of species and ecosystem responses to disturbance.

The CRA has focused primarily on the ecosystem and species levels of biodiversity because information about genetic variation within species is limited. Ecosystem biodiversity has been dealt with for flora only, because there is, at present, no well-developed understanding of faunal ecosystems. Floristic ecosystems are dealt with in detail in the EVC mapping component of the CRA (see Chapter 3).

The biodiversity information presented here is intended to reflect the best understanding of the available information, including information obtained through data audit, expert scientific opinion, and analysis of available data. It also points to deficiencies in existing information.

The data presented will be used in the development of the West RFA, including configuration of the CAR forest reserve system, and in the formulation of management recommendations.

1.4.2 Limits to reliability of information

The utility of all scientific information is constrained by the reliability inherent in the method of its collection. The limitations imposed by incompleteness and/or a lack of replication of biological data sets are largely unavoidable, but their impact can be minimised if deficiencies are acknowledged and well circumscribed. The Chapter on data audit deals with a number of these issues. The following are other important factors relating to the reliability of assessment of biodiversity in the West CRA. Many are generally applicable to forested regions of Australia as a whole:

For species assessments,

- A lack of data of the biology, population and life history characteristics of taxa can lead to uncertainty in identifying the status of specific threatening processes and identifying remedial action.
- The dearth of knowledge about the distribution and characteristics of invertebrate and non-vascular plant species, many of which remain undescribed, means that assessments are necessarily weighted towards the less cryptic elements of flora and fauna (ie. vascular flora and vertebrate fauna).

For Ecological Vegetation Class (EVC) mapping,

- The digital coverages were produced at a scale of 1:100 000. The minimum polygon size defined is approximately 0.25 hectares.
- Vegetation associations tend to merge along a continuum, so that a line on the vegetation map often represents an ecotone rather than a discrete boundary. Discrete boundaries do, however, occur in some situations; for example, the boundary between closed forest and sedgelands.
- Most of the vegetation boundaries can be clearly derived from aerial photo interpretation based on canopy height and cover. Dominant floristics are attributed to each polygon on the basis of the site data present, expert knowledge, aerial photo-interpretation of forest types, and extensive field validation.
- The pre-1750 vegetation reconstruction was conducted using the best available environmental modelling, remnant site data, reference to historical information, and expert knowledge. This component of the assessment was, however, impossible to validate in the field in most places.

2. AUDIT OF EXISTING BIOLOGICAL DATA

2.1 Introduction

Biodiversity assessment relies on having adequate information about the distribution of species. It is important to know whether or not surveys undertaken for species or groups of species have been adequately distributed across the range of environments represented within the region. As part of this assessment, analyses were undertaken to determine where surveys for flora and fauna had been carried out in the West region, which species were targeted, and whether survey sites are reasonably distributed to detect most species in most geographic or environmental components. The results of these analyses highlight gaps in information and identify those areas that require further survey work. Some gaps were identified early in the assessment and revealed the need for further fauna survey work. This work has been carried out during the preparation of the CRA. It covered 122 sites and has resulted in a more complete distribution of vertebrate fauna information for the West region. The survey, which is reported on in Chapter 5, also collected an amount of invertebrate fauna information.

Site selection for the fauna survey was developed through a process of using statewide environmental stratification to ensure an even spread of sites across the region. A separate regional stratification has been developed to verify the site selection for fauna survey and assess the adequacy of flora survey. The data review process involves systematically working through databases to determine the adequacy of existing site-based biological data for identifying priority areas and data gaps to be filled through additional survey work. The data review relies on expert knowledge and professional judgment but is supplemented by explicit analyses where appropriate.

The first step in the data review process is to select only those survey data that meet required standards of accuracy, precision and reliability. This allows a degree of confidence when analysing the distribution of species.

The next step is to stratify the region. This enables an assessment of the environmental and geographic representation by sites from accredited data sets. A regional environmental stratification should be based on variables that either directly or indirectly influence the spatial distribution of species. These include solar radiation, temperature, terrain wetness, nutrient status, ground water, rainfall, elevation, slope, aspect and geology. The strata developed may represent either classes of single variables, such as temperature or rainfall, or may consist of environmental units developed from the integration of variables using objective or intuitive multivariate classification analyses.

The distribution of flora and fauna survey sites among strata can initially be analysed in terms of the size of each stratum and its geographic distribution. The density of survey sites in each stratum is calculated and strata with no sites or low site densities are identified as possibly requiring future field work. Ideally, the density of survey sites in each stratum should be a function of the stratum's total species richness and spatial heterogeneity. These parameters can be examined by using species data from existing sites to derive species accumulation curves and associated statistics for each stratum. Species accumulation curves are frequently used to assess sampling adequacy in a given area by graphically illustrating the rate of addition of new species to a sampling unit with repeated sampling events. Curves that show an asymptote indicate the full complement of species in the area being investigated has been sampled, assuming an unbiased distribution of adequately sampled sites.

Because most, if not all, strata will be made up of numerous geographically discrete areas (substrata), it is necessary to also examine the distribution of sites between substrata within strata. Sites should be replicated across the geographic extent of each stratum. Where this is not the case, a geographically representative sample of substrata may be identified for further survey work (Cocks and Baird 1991). In the case of very large substrata, the distribution of existing flora and fauna survey sites should be examined for spatial biases resulting from the design and objectives of the original surveys and logistic constraints (for example, sampling along roads).

2.1.1 Methods

A data audit methodology tool kit was developed by the Environment Forest Group within Environment Australia to assist assessment of the quality of data to be used in regional biodiversity assessments. The tool kit has been developed as an ARC/INFO geographic information system application with a menu interface that incorporates ARC/INFO advanced macro language scripts menus and functions, in addition to system scripts and other programs. The methodology helps users to:

- ascertain the resolution and reliability of species site-survey records,
- identify spatial, environmental and temporal biases in the survey data, and
- ascertain sampling adequacy for species groups within a region.

The tool kit is designed to perform the following tasks:

- develop a regional environmental stratification;
- create ARC/INFO point coverages from site text files and add species attributes;
- intersect sites with a regional environmental stratification and calculate statistics;
- generate cumulative species curves and predicted species richness statistics;
- create a histogram showing the proportion of total land area and the proportion of total sites of each stratum;
- produce maps of the regional environmental stratification and survey intensity; and view and print graphs and maps.

Process of developing the stratification

Environmental variables suitable for developing stratifications for CRA data audits in Victoria were identified in a joint State-Commonwealth Workshop involving both flora and fauna specialists. These variables include 35 climatic attributes and one substrate attribute (lithology). The stratification process works best when a small number of environmental attributes, which most accurately reflect the environmental gradients across the region, are combined to produce environmental strata. As more variables are combined to develop the stratification, the process becomes more complex and the output becomes more difficult to interpret. It is therefore important to select variables that provide the best surrogates for the range of factors influencing species distribution. The stratification of the West region was based on three climatic variables which best reflect the range, seasonality and extremes of climate of the region. A fourth variable, lithology, provides an acceptable surrogate for variations in fertility, drainage and landform which are key factors influencing vegetation distribution. The sources and derivation of these data are outlined below.

Climate

Methods have been developed to estimate climate at any point in a landscape, given the availability of topographic and meteorological data. 'Climate surfaces' fitted to a Digital Elevation Model provide spatially reliable estimates of mean monthly climate attributes derived from long-term meteorological station records for any given longitude, latitude and elevation (Hutchinson and Bischof, 1983; Hutchinson *et al*., 1984; Hutchinson, 1989, 1991a, 1991b). Currently, the estimated standard errors are 0.5° Celsius for monthly mean temperature and less than 10% for mean monthly precipitation (Hutchinson 1984; Hutchinson *et al*., 1992).

Key climatic attributes which describe the range, seasonality and extremes of climate (temperature, precipitation and radiation) of Victoria have been calculated for each cell in the nine second elevation grid using the software package ANUCLIM (McMahon *et al*., 1995). Of the climatic variables available for the West region, mean annual precipitation (with a range of 411 to 1912 mm), mean maximum temperature of the warmest month (21 to 30°C) and mean minimum temperature of the coldest month (- 0.1 to + 6.3°C) were selected for use in the stratification of the region. These variables were used to develop the stratification in the Central Highlands, North East and Gippsland RFA regions and were considered the most appropriate group of environmental variables for the West stratification. Each of these climatic variables was then divided into intervals which most accurately reflect the bioclimatic variation within the West region (Table 2.1).

Table 2.1 Climatic attributes and classes used in the West environmental stratification

Variable	Classes
mean annual precipitation West range = 411 to 1912 mm	Low = 411 - 700mm Moderate =701 - 1100mm High = 1101 - 1912mm
mean minimum temperature of coldest month West range = minus 0.1 to 6.3°C	Low = minus 0.1- 3.0°C Moderate = 3.1 - 4.7°C High = 4.8 - 6.3°C
mean maximum temperature of warmest month West range = 21 to 30°C	Low = 21 - 25°C Moderate = 25 .1- 27°C High = 27.1 - 30°C

Lithology (rock type)

Lithology influences soil fertility, drainage and landform which in turn influence vegetation distribution. Lithology (rock type) has been mapped for Victoria at 1:250,000 scale and was considered to be the most suitable surrogate for these variables in the stratification process. Of the 26 lithological types described in the Land Systems coverage of Victoria at a 1:250,000 scale, 16 are represented in the West. From these 16 types, 7 generalised classes of lithology were derived by aggregating lithology classes with similar characteristics (Table 2.2). These classes were used to derive an environmental stratification.

Table 2.2 Aggregations of lithology types used in the West environmental stratification

Class	Lithology types
1	• undescribed
2	• coarsely textured unconsolidated deposits: low fertility • coarsely textured unconsolidated deposits/finely textured unconsolidated deposits: low fertility
3	• finely textured unconsolidated deposits: highest fertility • finely textured unconsolidated deposits/coarsely textured unconsolidated deposits: moderate fertility • finely textured unconsolidated deposits/coarsely textured unconsolidated deposits/limestone • finely textured unconsolidated deposits/limestone • finely textured unconsolidated deposits/volcanic rock • saline finely textured deposits/ coarsely textured unconsolidated deposits/ coarsely textured unconsolidated deposits
4	• granites and gneisses: moderate to low fertility
5	• limestone/coarsely textured unconsolidated deposits
6	• sedimentary rock: low fertility (except where rainfall is high)
7	• volcanic rock (acid volcanics): low fertility • volcanic rock/ finely textured unconsolidated deposits • volcanic/sedimentary rock: high fertility • volcanic/sedimentary rock/granites and gneisses/ finely textured unconsolidated deposits

Deriving the regional stratification

The environmental stratification was based on the three climatic attributes and lithology as described above, and estimated for each 250 x 250 metre grid cell. A total of 189 individual units or strata are possible when the three classes of annual precipitation, three classes of minimum temperature of the coldest month, three classes of maximum temperature of the warmest month and seven classes of lithology are combined. Clipping strata classes with an overlay of a forest/non-forest classified coverage (TREE 100 tree cover of Victoria) reduced the number of forested strata which occurred in the West to 86 ranging in size from 96,470 to 3 ha. Twenty-three strata were less than 500 ha, and for the purpose of this analysis, these strata (comprising only 0.3 % of the forest cover) were not evaluated. The spatial arrangement of strata across the Region is shown in Map 1. This environmental stratification was subsequently used for the analyses of flora and fauna databases presented here.

Of the 86 strata represented in the area under forest cover (1,206,045 ha) the 27 largest strata (>10,000 ha) occupied 87% of the forested land area. Thirty-nine strata were smaller than 5,000 hectares. These small strata (56,242 ha) represented only 5% of the forested land of the region.

2.2 Flora survey data review

2.2.1 Methods

For flora, the site-based biological data sets used in this assessment were drawn from the Flora Information System of Victoria. The flora core data fields extracted were: reference (quadrat) number; date; latitude longitude; and species code. The latitude/longitude is accurate to 100 metres. Flora survey intensity was evaluated both for the total area of the West Region (including non- forested areas) and separately for the area under forest cover.

3522 sites (quadrats) have been sampled for vascular plants on forested land in the West. The sites sampled have been collected in a consistent manner as part of a range of studies including region-wide studies, intensive sampling of experimental areas and other studies based on targeted sampling of particular habitats. The quadrat sampling has been largely undertaken by NRE for the purpose of classifying and describing the variation in native vegetation.

Summary information for each stratum, along with figures relating to the flora site density analysis discussed below, is presented in Appendix A. The flora survey intensity is shown in Map 4 and is discussed below in relation to the environmental strata of the region (Map 1)

Of the 86 strata generated from the stratification, the 23 strata which occupied less than 500 hectares have not been evaluated in the following discussion. The remaining 46 strata were classified on the basis of flora survey intensity (none, low, moderate, high - see Map 4). The geographic locations referred to in the discussion below relate primarily to the Forest Management Areas that comprise the West region.

2.2.2 Results and discussion

Strata under forest cover with high flora survey site density (> 40 sites per 10,000 hectares)

Eighteen strata in the West fell into this category. These strata occupy 251,719 hectares or 21% of the total forested land area. Six of these strata, 82, 63, 36, 76, 80, and 84, are large. Strata 82, 80 and 84 are located wholly in the Otways FMA. The majority of stratum 76 is also located in the Otways. Stratum 63 is located in Portland and Otway FMAs while the majority of stratum 36 is located in Horsham and Midlands FMAs.

Strata under forest cover with moderate flora survey site density (10-40 sites per 10,000 hectares)
Strata with moderate site densities comprise 643,088 hectares or 53% of the total forested land area. Fifteen of the 27 strata in this group, 8, 14, 1, 62, 28, 11, 35, 79, 3, 37, 26, 6, 32, 24 and 38, are large and comprise 643,088 hectares. Strata 8 and 14, 96,470 hectares and 95,549 hectares respectively, are the two largest strata in the region. These two strata are mostly located in the Horsham and Midlands FMAs.

Strata under forest cover with low flora survey site density (>0-10 sites per 10,000 hectares)
Strata with low site densities comprise 297,782 hectares or 25% of the forested area of the region. Of the 11 strata in this category, six are large (2, 66, 64, 41, 50, 40). Strata 64, 41 and 50 and the majority of stratum 64 are located in the Portland FMA. Stratum 2 is mostly located in the Horsham FMA while stratum 40 is located in the Midlands FMA.

Strata without flora survey sites
Seven strata greater than 500 hectares do not contain flora survey sites. These strata, 34, 42, 67, 18, 47, 56 and 16, comprise 10,030 hectares or 0.83% of the total forested land area. These strata are generally small and scattered, and with the exception of stratum 16, which is partly located in the Central FMA, are located in the Midlands and Portland FMAs.

Cumulative species curves
The results of the cumulative species curve analysis were expressed as a probability that the next species encountered for a stratum would not have already been encountered. A high probability therefore generally reflected relatively low sampling densities, while a low probability generally reflected relatively high sampling densities.

Although the results of the cumulative species curve analysis tended to mirror those of the site density analysis, the probability also strongly reflected the absolute number of samples collected. Thus a relatively small (in area) stratum with high sampling density but only a small number of samples would be likely to have a higher probability that the next species would be new than a large stratum with the same sampling density but many more samples. Unevenness in sampling of extensive and/or floristically diverse strata is also likely to produce higher probabilities.

Probability that next species is 'new' (%)	Percentage of Area included (%)	Number of strata included
sample too small to calculate	3%	9
< 10	66%	24
10 - 20	23%	15

The results obtained in the cumulative species curve analysis suggest an adequate survey effort with 66% of the forested area of the region (24 strata) having probabilities of <10% that the next species is 'new' (previously unrecorded). If this threshold is raised to 20%, then 89% of the region (39 strata) is included.

2.2.3 Summary
The majority of forested land in the West region (74%) has either a high (21%) or moderate survey intensity (53%). Twenty-five percent of the forested land in the region has a low (25%) survey intensity. This region has been relatively well surveyed compared with the North East RFA region and has an overall similar survey intensity to Gippsland. When a cumulative species curve analysis is carried out, 89% of the West region has a probability of $\leq$ 20% that the next species recorded will be new. This is similar to the results of the species curve analysis of the Gippsland region where 84% of the region has a probability of $\leq$ 20% that the next species recorded will be new.

2.3 Fauna survey data review

2.3.1 Methods
In Victoria, much of the existing site data for fauna has come from individual records from a range of sources supplemented by information from systematic surveys. A lack of species records in certain strata does not necessarily mean that the strata have not been sampled, but that the information might not have been appropriate for use in this analysis. All biological records over an area as large and diverse as the West are to some extent artefacts of differential collecting effort and subject to the sampling bias arising from the relative ease with which the occurrence of certain groups (such as birds) can be scored. A lack of systematic survey for specific faunal groups weakens the power of the audit tool to expose under-sampled environmental strata for those groups, but it is not without value.

To ensure an adequate database of systematic survey records for terrestrial fauna, a general survey covering 122 sites was undertaken in the West region. The records from this survey were entered onto the Atlas of Victorian Wildlife to supplement the existing data sets.

The site-based biological data sets used in the fauna assessment were drawn from the Atlas of Victorian Wildlife and the Victorian Freshwater and Estuarine Fish Database.

The fauna core data fields extracted were: reference number, date, latitude, longitude, survey method, survey effort and species code.

The Atlas of Victorian Wildlife covers birds, mammals, reptiles, amphibians, threatened invertebrates and threatened fish. Of these, the following groups were excluded from the study: marine birds, waders (except Latham's Snipe), marine mammals and marine reptiles. Records with less geographic precision (ie. greater than two minutes of latitude or longitude), were also excluded. Invertebrate fauna were also not included in the review because of lack of survey information.

The data audit only includes data from formal surveys, incidental records were excluded from the analysis. The fauna data audit only includes strata under forest cover. The flora data analysis was undertaken across the entire region including non-forested areas.

In preparation for further analysis, the data were collated into discrete data sets to cover the following species groups:

- Arboreal mammals
- Large mammals
- Small ground mammals
- Bats
- Diurnal birds
- Nocturnal birds
- Large forest owls
- Reptiles
- Amphibians

As was done for flora information, the distribution and density of survey site records were used to evaluate the adequacy of sampling of the environmental variation in the region. Strata and large polygons with low densities of sites were identified. The probability of the next species recorded for a particular stratum being new (ie. not previously recorded in surveys for that fauna group in that stratum) was used as an indication of the adequacy of sampling effort. The analysis was mostly confined to the 27 most extensive strata (>10,000 ha.), totalling 87 % of the forested area.

2.3.2 Results and discussion

The results of the survey site analysis for each fauna functional group are shown in Table 2.3, Maps 5-13 and in Appendix B. Incidental records were not included in the analysis but are shown on the maps referred to above.

Arboreal Mammal Surveys

A total of 902 sites in 47 strata have been surveyed for arboreal mammals in the West region. All the most extensive strata (> 10,000 ha) have been surveyed for arboreal mammals. The majority of large strata have either a low (1-5 sites per 10,000 ha, 12 strata) or moderate (5-10 sites per 10,000 ha, 7 strata) survey intensity. Eighteen large strata have a low (≤ 5%) probability of new species being detected by further survey. Stratum 38, a 10,163 ha stratum located in the Midlands FMA, has a very high survey intensity (> 20 sites per 10, 000 ha) and a 1% probability of detecting new species with further survey. Two strata (26, 76) had too few samples for accurate calculation of a probability statistic. The majority of stratum 26 is located in the Horsham FMA, while stratum 76 is located in the Otway FMA.

Large Mammal Surveys

A total of 3017 sites in 48 strata have been surveyed for large mammals in the West. Of the 27 most extensive strata, all have been surveyed and include 89% of all large mammal survey sites in the region. Most large strata had either a very high (> 20 sites per 10,000 ha, 15 strata) or high (10-20 sites per 10,000 ha, 9 strata) survey intensity. The most intensely surveyed large stratum is 38. This stratum has 145 sites per 10,000 ha and a 2% probability that the next species detected by further survey, will be new. Eleven large strata had low (≤ 5%) probabilities of new species being detected with further survey; six of these, 66, 28, 50, 32, 76, 24, had a zero probability of detecting new species. Despite a high survey intensity, no large mammals have been recorded by survey in stratum 41 located in the Portland FMA. Consequently this stratum has a 100% chance that the next species detected is new.

Small Ground Mammal Surveys

Small ground mammals have been surveyed at 2719 sites in 52 strata in the West. Twenty-six of the 27 largest strata have been surveyed and include 88% of all survey sites. The unsurveyed large stratum, 6 is an 18,430 ha stratum located in the Midlands, Central and Horsham FMAs. The majority of large strata have either very high (>20 sites per 10, 000 ha, 11 strata) or high (10-20 sites per 10,000 ha, 13 strata) survey intensities. Thirteen of the largest strata have a low probability (≤ 5%) of the next species detected being new. Although stratum 24 has a high survey intensity with 17 sites per 10,000 ha, it has a 94% chance that further survey will detect new species. To date, survey has recorded only one species of small mammal from this 14,044 ha stratum located in the Horsham and Midlands FMAs. Statum 11 had too few survey sites to calculate a probability statistic.

Table 2.3 Terrestrial vertebrate fauna survey data, by species group

Faunal group	Arb-oreal Mamm	Large Mamm.	Small Ground Mamm.	Bats	Diurnal Birds	Noc-turnal Birds	Large Forest Owls	Rep-tiles	Amph-ibians
Number of the 86 strata with survey sites	47	48	52	45	44	47	39	43	27
Number of the 27 largest strata with survey sites	27	27	26	27	27	27	26	27	16
Number of the largest strata with low probability (≤5%) of new species in next survey	18	11	13	19	24	12	17	13	3

Bat Surveys

A total of 1417 sites in 45 strata have been surveyed for bats in the West region. All 27 of the largest strata include bat survey sites. Fifty-two have been surveyed for bats, including all of the 27 large strata. The majority of large strata have either a high (10-20 sites per 10, 000 ha, 9 strata) or moderate (5-10 sites per 10,000 ha, 10 strata) survey intensity. Nineteen of the largest strata have a low probability (≤ 5%) of the next species detected being new. Two of the large strata, 27 and 6, have a very low (0-1 sites per 10,000 ha) survey intensity. Both strata had too few sites to calculate a probability statistic.

Diurnal Birds

Forty-four strata have been surveyed for diurnal birds in the West region. All of the 27 largest strata have been surveyed and include 87% (1418 sites) of all survey sites (1635 sites). The majority of these strata have either a high (10-20 sites per 10,000 ha, 10 strata) or moderate (5-10 sites per 10,000 ha, 10 strata) survey intensity and have a low probability (≤ 5%) of the next species detected being new (24 strata). Ten large strata have a zero probability that further survey will record new species.

Nocturnal Birds

Nocturnal birds have been surveyed at 692 sites in 47 strata in the West. All of the large strata have been surveyed for nocturnal birds and overall include the majority of survey sites (86%). However, the majority of these large strata have low (1-5 sites per 10, 000 ha, 14 strata) or moderate (5-10 sites per 10,000 ha, 9 strata) survey intensities. One stratum, 38, has a very high survey intensity (>20 sites per 10,000 ha). This stratum has 52 sites per 10,000 ha and a zero probability that further survey will detect new species. Of the large strata, 12 have low probabilities (≤ 5%) of detecting new species with further survey. Four strata, 62, 37, 24, 40 had a 100% chance of detecting new species with further survey as to date, no nocturnal birds have been detected by survey in these strata. Three strata (41, 26, 76) had too few survey sites to calculate a probability statistic. Stratum 76 has a very low survey intensity with less than one site per 10,000 ha. These three poorly surveyed strata are mostly located in the Horsham (stratum 26), Portland (stratum 41) and Otway (stratum 76) FMAs.

Large Forest Owls

A total of 698 sites in 54 strata have been surveyed for large forest owls. All of the large strata, with the exception of stratum 80 a 13,805 ha stratum located in the Otways FMA, have owl survey sites. These 26 large strata include 90% of all owl survey sites in the West region. The majority of surveyed large strata have either a low (1-5 sites per 10, 000 ha, 11 strata) or moderate (5-10 sites per 10,000 ha, 12 strata) survey intensity. Seventeen large strata have low probabilities (≤ 5%) that the next species recorded is new. Stratum 38 located in the Midlands FMA, has a very high survey intensity with 24 sites per 10,000 ha and a zero probability of detecting new species with further survey. Six strata, 2, 62 64, 28, 41, 35, have a 100% chance of detecting new species with further survey. These six strata have low survey intensities (5-10 sites per 10,000 ha) and no survey records of large forest owls. Four large strata, 37, 26, 76 and 84, had too few survey sites to calculate probabilities.

Reptiles

A total of 3056 sites in 43 strata have been surveyed for reptiles. All of the large strata include reptile survey sites with the majority having very high (>20 sites per 10,000 ha, 14 strata) or high (10-20 sites per 10,000 ha, 10 strata) survey intensities. Thirteen of these strata have been surveyed sufficiently to reduce the probability of detecting a new species to 5% or less. No reptile species have been recorded from five large strata, despite three of these strata having either very high (41) or high survey intensities (77, 36). The other two strata without reptile records, strata 6 and 41 have a low (0-5 sites per 10,000 ha) and moderate (5-10 sites per 10,000 ha) survey intensity respectively. Stratum 6 is located in the Midlands, Central and Horsham FMAs and stratum 41 in the Portland FMA. Eight large strata have a zero probability that further surveys will detect new species.

Amphibians

Amphibians have been surveyed at 164 sites in 27 strata in the West. Amphibian survey sites are present in 16 of the 27 largest strata. The 11 large strata without amphibian survey sites include: 66, 41, 11, 35, 79, 50, 26, 6, 84, 40 and 38. For most of the large surveyed strata, survey intensity is very low (0-1 sites per 10,000 ha, 20 strata). Three strata, 8, 2 and 1, had been surveyed sufficiently to reduce the probability of detecting new

species with further survey to zero. Stratum 8 is the largest stratum in the region occupying 96,470 ha located in the Midlands and Horsham FMAs. Eleven of the largest strata had too few survey sites to calculate a probability statistic.

2.3.3 Summary

Of the largest strata generated by the stratification of the West region, the majority have been surveyed for each of the fauna groups considered. Large mammals, small ground mammals and reptiles have mostly very high or high survey intensities for the largest strata. For nocturnal birds, arboreal mammals and large forest owls, survey intensity is either low or moderate, and for amphibians most of the large strata have a very low survey intensity. Diurnal birds are the group most comprehensively surveyed across the region, based on them having the most large strata with low probabilities of new species being detected. Arboreal mammals, bats and large forest owls have also been well surveyed with between 63-70% of the surveyed large strata having a low probability of detecting new species with further survey. Amphibians have been poorly surveyed within the region. Future surveys for this group as well as large mammals and nocturnal birds are most likely to detect species not previously recorded in formal surveys.

3. FOREST ECOSYSTEM ASSESSMENT

3.1 Introduction

The forest ecosystem assessment provides an analysis of information to determine whether viable examples of forest ecosystems are maintained throughout their natural ranges, and whether ecological processes and the dynamics of forest ecosystems are provided for in their landscape context. The assessment contributes to an evaluation against the national reserve criteria, particularly criteria (1), (2), (3), (4), (5) and (7), and complementary off-reserve management as part of ecologically sustainable forest management (ESFM).

To meet these objectives the following assessment outputs are required:

- maps of both the current and pre-1750 distributions of forest ecosystems;
- determination of the current reservation status for forest ecosystems;
- a description of forest ecosystems which are endangered, vulnerable or rare; and
- a description of disturbances and management actions relevant to forest ecosystems.

3.1.1 Ecological Vegetation Classes

Ecological vegetation classes (EVCs) are the basic mapping unit used for forest ecosystem assessments, biodiversity planning and conservation management at the regional scale in Victoria. The concept of ecological vegetation classes (EVCs) was introduced and used in the *Old growth study of East Gippsland* (Woodgate *et al.* 1994).

EVCs are derived from underlying large scale forest type and floristic community mapping. Floristic, structural, and environmental attributes are used to define EVCs. The relationship of each EVC to floristic vegetation communities and floristic sub-communities and forest types (Land Conservation Council studies) is discussed in Woodgate *et. al.* 1994.

A description of the methodology used to derive EVCs can be found in Commonwealth and NRE (1996), Appendix G.

Descriptions of EVCs occurring in the West is given in Appendix C.

3.2 Pre-1750 extent of Ecological Vegetation Classes

EVCs have been mapped on all public land in the West region at a scale of 1:100 000 (Map 2). For the purposes of this assessment the pre-1750 extent of each EVC on both private and public land has been mapped to allow a comparison of the extant distribution and area of each EVC with that estimated prior to European settlement within the region (Map 3).

3.2.1 Methods

Mapping

In cleared or heavily disturbed areas, existing remnant vegetation and a variety of physical environmental attributes were employed to map the estimated pre-1750 extent of EVCs. This process relied heavily on subjective assessments by experts with extensive field knowledge of the area surveyed and the vegetation mapped. The attributes used to predict presence were specific to each EVC being mapped and include aspect, elevation, exposure, floodplain, flood sevirity, geography, gradient, hydrology, inundation regime, landform, landsystems, morphology, rainfall, salinity, slope, soils, stream order and topography.

Where indigenous vegetation currently exists in the region it was assumed that the pre-1750 vegetation type and extent is the same as the existing vegetation.

Mapping Reliability

The inherent reliability of mapping at 1:100 000 scale using current technology is adequate for the assessment. The certainty and reliability of this mapping is related to the quality and understanding of the underlying data sets used to define the vegetation types, the extent of ground-truthing undertaken and the quality of extant vegetation visited during that ground-truthing. This reliability pertains to both the identity (label) and the boundaries of the vegetation types mapped.

Reliability of pre-1750 mapping was determined using four components: ground truthing, remnants (quality and observation), EVC determination and linkage of EVCs to and quality of available environmental data sets. Table 3.1 lists these components and the characteristics that define them. Pre-1750 mapping reliability ratings were determined for all pre-1750 mapping and will be stored in the Departmental Corporate Geographic Data Library to be accessed by 1:100 000 map sheet.

Table 3.1 Components used to determine mapping reliability and their characteristics

Component	Characteristics
Ground truthing	• density of tracks available • proportion of tracks driven during ground-truthing • applies to EVC identity only (not to line work or EVC boundary)
Remnants	• number of remnants or sites visited that contain an EVC, this will limit the ability to characterise and determine the EVC • vegetation quality/level of disturbance within those remnants visited, this will limit the ability to characterise and determine the EVC • applies to EVC label only (not to line work or EVC boundary)
EVC determination	• quality of the definition and description, this limits the ability to accurately determine and EVC (components include the number of samples taken, quality and type of floristic analyses and floristic vegetation and habitat description and characterisation) • applies to EVC label and to line work or boundary of EVC
Environmental data sets - attributes for modelling	• quality, scale and availability of environmental information available (geology, soils and topography mapping, rainfall data, aerial photographs etc) • environmental correlation of an EVC to these parameters, ie. how useful are the perameters as environmental surrogates for the determination of EVC type and boundary • applies to EVC label and to line work or boundary of EVC

3.2.2 Results

The results of the Pre-1750 EVC analysis are presented in Table 3.2. These data have also been used to ascertain the rarity and threatened status of EVCs within the study area.

Table 3.2 Representative conservation (percentage reservation status) of EVCs in the West study area based on Pre-1750s vegetation mapping

EVC No	Ecological Vegetation Classes	Area (ha)		Percent Remaining	Regional Conservation Status	Area (ha) and percent of EVC (Pre 1750 extent) in each land tenure category							
		Pre 1750	Current			Conservation Reserves		State Forest		Other Public Land		Private Land	
						ha	%	ha	%	ha	%	ha	%
1	Coastal Dune Scrub Mosaic	2752	1786	65	-	1618	59	60	2	75	3	32	1
3	Damp Sands Herb-rich Woodland	180525	43072	24	V	14019	8	7480	4	2289	1	19284	11
6	Sand Heathland	15422	14486	94	R, V	12375	80	1408	9	153	1	549	4
7	Clay Heathland	32	32	100	R	2	5			30	95		0
8	Wet Heathland	11657	7493	64	R, V	5581	48	1553	13	138	1	222	2
9	Coastal Saltmarsh	30	15	49	R	14	45			0	0	1	4
10	Estuarine Wetland	1697	632	37	R, V	129	8	2	0	360	21	140	8
13	Brackish Sedgeland	575	153	27	R, V, E	124	22	11	2	1	0	17	3
16	Lowland Forest	170710	86605	51	-	22598	13	46964	28	2688	2	14354	8
17	Riparian Scrub Complex	6780	4327	64	R	1361	20	1414	21	841	12	711	10
18	Riparian Forest	10431	4815	46	R, V	1535	15	1790	17	128	1	1362	13
19	Riparian Shrubland	213	116	54	R, V, E	98	46	0	0	1	0	17	8
20	Heathy Dry Forest	151087	95824	63	-	47760	32	24293	16	2295	2	21476	14
21	Shrubby Dry Forest	11531	8732	76	-	5896	51	1623	14	46	0	1167	10
22	Grassy Dry Forest	130697	46753	36	-	10237	8	20505	16	637	0	15373	12
23	Herb-rich Foothill Forest	233085	65131	28	V	7360	3	32285	14	1104	0	24381	10
28	Rocky Outcrop Shrubland	14139	14012	99	R, E	12682	90	1232	9	12	0	85	1
29	Damp Forest	2596	2128	82	R, V	1057	41	708	27	1	0	362	14
30	Wet Forest	51953	40732	78	-	9355	18	23960	46	171	0	7246	14
37	Montane Grassy Woodland	14	14	100	R	14	100				0		0
45	Shrubby Foothill Forest	81030	68109	84	-	18789	23	38924	48	511	1	9886	12
47	Valley Grassy Forest	66811	15754	24	R, V	5454	8	2017	3	341	1	7941	12
48	Heathy Woodland	221763	179068	81	-	75668	34	72036	32	6314	3	25050	11
50	Coastal Heathland	33			na								
52	Coastal Saltmarsh Complex	6652	3549	53	-	2143	32	3	0	1403	21		0
53	Swamp Scrub	53649	2415	5	E	618	1	357	1	205	0	1235	2
55	Plains Grassy Woodland	1215141	36605	3	V, E	5673	0	15858	1	4086	0	10988	1
56	Floodplain Riparian Woodland	40727	4359	11	R, V, E	1415	3	109	0	705	2	2130	5
61	Box Ironbark Forest	27008	8440	31	R, V	1701	6	3749	14	589	2	2401	9
64	Rocky Chenopod Woodland	1752	673	38	R	375	21			17	1	281	16
65	Sedge-rich Woodland	179	155	86	R, V		0	143	80		0	11	6
67	Alluvial Terraces Herb-rich Woodland	22592	3806	17	E	1309	6	1688	7	41	0	768	3
68	Creekline Grassy Woodland	66594	2468	4	R, V, E	1107	2	205	0	207	0	949	1
69	Metamorphic Slopes Shrubby Woodland	79	8	10	R, E		0				0	8	10
70	Hillcrest Herb-rich Woodland	821	482	59	R	70	9	308	38		0	104	13
71	Hills Herb-rich Woodland	36430	17183	47	-	9599	26	798	2	651	2	6135	17
72	Granitic Hills Woodland	6703	250	4	R, E	226	3	2	0		0	23	0
73	Rocky Outcrop Shrubland/Herbland Mosaic	6925	6423	93	R, E	6162	89	94	1	4	0	163	2
74	Wetland Formation	868	119	14	R, V, E	73	8	37	4	2	0	8	1
76	Low Rises Grassy Woodland/Alluvial Terraces Herb-rich Woodland Mosaic	18424	635	3	E	26	0	113	1	22	0	474	3
80	Spring Soak Woodland	4			na								
81	Alluvial Terraces Herb-rich Woodland/Creekline Grassy Woodland Mosaic	293			na								
83	Swampy Riparian Woodland	11184	444	4	R, V, E	11	0	8	0	52	0	372	3
84	Riparian Forest/Swampy Riparian Woodland/Riparian Shrubland/Riverine Escarpment Scrub/Disturbed Mosaic	115			na								

Table 3.2 (cont.) Representative conservation (percentage reservation status) of EVCs in the West study area based on Pre-1750s vegetation mapping

EVC No	Ecological Vegetation Classes	Area (ha)		Percent Remaining	Regional Conservation Status	Area (ha) and percent of EVC (Pre 1750 extent) in each land tenure category							
		Pre 1750	Current			Conservation Reserves		State Forest		Other Public Land		Private Land	
						ha	%	ha	%	ha	%	ha	%
93	Broombush Mallee	1441	209	15	R, V	187	13				0	22	1
103	Riverine Grassy Chenopod Woodland	10130	199	2	R, E	95	1			23	0	81	1
104	Lignum Wetland	162	23	14	R, V, E	1	1			22	14		0
124	Grey Clay Drainage Line Complex	1665	0	0	na		0			0	0		0
125	Plains Grassy Wetland	44362	213	0	R, E	43	0	19	0	109	0	42	0
126	Swampy Riparian Complex	512	0	0	na		0			0	0		0
127	Valley Heathy Forest	1460	70	5	R, E	11	1				0	58	4
128	Grassy Forest	12625	2946	23	V		0	83	1	27	0	2836	22
132	Plains Grassland	242334	3507	1	V, E	77	0			3349	1	82	0
133	Limestone Pomaderris Shrubland	4	4	94	R	4	94				0		0
134	Sand Forest	1553	374	24	R, V, E	22	1	54	3		0	299	19
136	Sedge Wetland	3983	1354	34	R, V	314	8	775	19	16	0	248	6
140	Mangrove Shrubland	93	49	53	R	44	47			5	5	0	0
152	Alluvial Terraces Herb-rich Woodland/Plains Grassy Woodland Complex	9800	172	2	R, V, E		0	8	0	16	0	148	2
155	Bird Colony Succulent Herbland	2	1	25	R	0	21				0	0	4
160	Coastal Dune Scrub	4972	1407	28	V	1109	22			15	0	282	6
161	Coastal Headland Scrub	5511	3301	60	R	2755	50			30	1	516	9
162	Coastal Headland Scrub/Headland Coastal Tussock Grassland Mosaic	1448	383	26	R	361	25				0	22	2
163	Coastal Tussock Grassland	771	506	66	R	487	63			19	2		0
164	Creekline Herb-rich Woodland	9055	2097	23	R, V	547	6	446	5	67	1	1037	11
165	Damp Heath Scrub	24773	2988	12	V, E	2472	10	52	0	32	0	432	2
174	Grassy Dry Forest/Rocky Outcrop Shrubland/Herbland Mosaic	185	31	17	R	24	13				0	7	4
175	Grassy Woodland	258067	6439	2	E	717	0	977	0	922	0	3823	1
177	Valley Slopes Dry Forest	14	14	100	R	14	100				0		0
178	Herb-rich Foothill Forest/Shrubby Foothill Forest Complex	12112	7995	66	-	15	0	6700	55	111	1	1169	10
179	Herb-rich Heathy Woodland	41475	21792	53	-	5160	12	8674	21	1065	3	6894	17
181	Coast Gully Thicket	345	178	52	R	174	50			4	1		0
184	Montane Wet Heathland	54	54	100	R	54	100				0		0
191	Riparian Scrub	6679	4809	72	R	2848	43	1018	15	216	3	727	11
192	Montane Rocky Shrubland	1863	1863	100	R	1863	100				0		0
193	Rocky Outcrop Herbland	10021	10026	100	R	9899	99	86	1	0	0	41	0
195	Seasonally Inundated Shrubby Woodland	8830	5490	62	R, V	2181	25	1183	13	1146	13	981	11
196	Seasonally-inundated Sub-saline Herbland	58	58	100	R	58	100				0		0
198	Sedgy Riparian Woodland	12000	6166	51	-	2587	22	2371	20	340	3	869	7
200	Shallow Freshwater Marsh	5123	1063	21	R, V, E	667	13	167	3	83	2	145	3
201	Shrubby Wet Forest	38047	31835	84	-	5722	15	19394	51	107	0	6612	17
203	Stoney Rises Herb-rich Woodland	111676	18838	17	E	9310	8	48	0	307	0	9172	8
233	Wet Sands Thicket	1299	1264	97	R	448	35	757	58	12	1	47	4
235	Gilgai Plain Woodland/Wetland Mosaic	451			na								
237	Riparian Forest/Swampy Riparian Woodland Mosaic	262	14	5	R, E		0				0	14	5
241	Valley Grassy Forest/Plains Grassy Woodland Complex	181	11	6	R, E	0	0			0	0	11	6
247	Box Ironbark Forest/Shrubby Granitic-outwash Grassy Woodland Mosaic	1			na								
261	Plains Grassy Woodland/Creekline Grassy Woodland Mosaic	489			na								
262	Slopes Box Grassy Woodland/Box Ironbark Forest Complex	1703	1	0	R, E	1	0				0		0

Table 3.2 (cont.) Representative conservation (percentage reservation status) of EVCs in the West study area based on Pre-1750s vegetation mapping

EVC No	Ecological Vegetation Classes	Area (ha)		Percent Remaining	Regional Conservation Status	Area (ha) and percent of EVC (Pre 1750 extent) in each land tenure category							
		Pre 1750	Current			Conservation Reserves		State Forest		Other Public Land		Private Land	
						ha	%	ha	%	ha	%	ha	%
263	Plains Grassy Woodland/Plains Grassland/Plains Grassy Wetland Mosaic	6892	8	0	R, E	8	0				0		0
264	Sand Ridge Woodland	996	91	9	R, E	33	3	8	1		0	49	5
268	Valley Grassy Forest/Slopes Box Grassy Woodland Complex	47			na								
269	Riparian Shrubland/Swampy Riparian Woodland Mosaic	142	11	8	R, E	11	8				0		0
271	Grassy Woodland/Valley Grassy Forest Complex	157			na								
272	Swampy Riparian Woodland/Spring Soak Woodland Mosaic	54			na								
278	Herb-rich Heathy Forest	431	431	100	R	430	100			1	0		0
279	Heathland Thicket	667	677	101	R	614	92	47	7	9	1	6	1
280	Floodplain Thicket	3223	2880	89	-	2272	70	486	15	96	3	26	1
281	Sedge-rich Wetland	488	495	101	R, V	241	49	234	48	2	0	18	4
282	Shrubby Woodland	11081	7907	71	R	6050	55	269	2	30	0	1558	14
283	Plains Sedgy Woodland	4592	2281	50	R, E	324	7	1422	31	3	0	532	12
284	Claypan Ephemeral Wetland	3	3	100	R	3	100				0		0
285	Dry Creekline Woodland	660	352	53	R	135	20	89	14		0	127	19
291	Cane Grass Wetland	1495	159	11	R, V, E	34	2	0	0	88	6	37	2
292	Red Gum Wetland	32634	1508	5	R, V, E	409	1	339	1	20	0	740	2
293	Riparian Forest/Creekline Grassy Woodland Mosaic	157	12	8	R, E	12	8				0		0
300	Reed Swamp	682	569	83	R, E	535	78			0	0	34	5
320	Grassy Dry Forest/Heathy Dry Forest Complex	3928	1837	47	R, V		0	1542	39	0	0	295	8
333	Red Gum Wetland/Plains Grassy Wetland Mosaic	100			na								
336	Grampian Ranges Mosaics (includes EVCs 336-350, 352-381, 384-400, 402-471, 475-480, 484-634)	8238	8421	102	na	7321	89	660	8	180	2	260	3
351	Rocky Outcrop Shrubland/Herbland Mosaic/Grassy Dry Forest Complex	2131	1603	75	R	779	37	665	31	6	0	154	7
382	Lowland Forest/Heathy Dry Forest Complex	743	743	100	R	743	100				0		0
383	Lowland Forest/Valley Grassy Forest Complex	1318	1150	87	R	1005	76				0	145	11
401	Hills Herb-rich Woodland/Heathy Woodland Complex	737	738	100	R	718	97				0	19	3
472	Heathy Woodland/Heathy Woodland Complex	734	734	100	R	567	77	163	22		0	3	0
481	Heathy Woodland/Heathy Dry Forest Complex	1294	1294	100	R	1274	98				0	20	2
636	Brackish Lake	3659	37	1	R, V, E	5	0	1	0	30	1	0	0
640	Creekline Sedgy Woodland	2893	368	13	R, V	250	9	6	0	4	0	108	4
641	Riparian Woodland	25135	3125	12	R, V, E	1397	6	156	1	104	0	1468	6
642	Basalt Shrubby Woodland	70899	78	0	R, E	2	0			3	0	73	0
643	Brackish Drainage Line Herbland/Sedgeland Mosaic	1114	24	2	R, E	12	1				0	12	1
644	Cinder Cone Woodland	487	214	44	R,E	203	42			11	2		0
645	Wet Heathland / Heathy Woodland Mosaic	6350	4489	71	R, V	2824	44	1211	19	10	0	444	7
646	Heathy Woodland / Plains Grassy Woodland Mosaic	1162	327	28	E	0	0	2	0		0	325	28
647	Plains Sedgy Wetland	33983	474	1	R, E	104	0	51	0	210	1	109	0
648	Saline Lake Verge Herbland/Sedgeland Mosaic	18			na								
649	Stony Knoll Shrubland	175			na								
650	Heathy Woodland / Damp Heathy Woodland / Damp Heathland Mosaic	25812	12836	50	V	1948	8	8788	34	177	1	1923	7
651	Plains Swampy Woodland	19707	87	0	R, E	1	0	25	0	0	0	61	0
652	Lunette Woodland	2378	55	2	R, E	14	1	0	0	3	0	38	2
653	Aquatic Herbland	2512	273	11	R, V	100	4	85	3	12	0	77	3
654	Creekline Tussock Grassland	2563			na								

Table 3.2 (cont.) Representative conservation (percentage reservation status) of EVCs in the West study area based on Pre-1750s vegetation mapping

EVC No	Ecological Vegetation Classes	Area (ha)		Percent Remaining	Regional Conservation Status	Area (ha) and percent of EVC (Pre 1750 extent) in each land tenure category							
		Pre 1750	Current			Conservation Reserves		State Forest		Other Public Land		Private Land	
						ha	%	ha	%	ha	%	ha	%
655	Lignum Cane Grass Swamp	542	34	6	R, E	8	1			26	5		0
656	Brackish Wetland	1080	194	18	R, V	185	17	6	1	4	0		0
657	Freshwater Lignum Shrubland	1076	22	2	R, E	8	1	5	0	0	0	8	1
658	Riverine Grassy Woodland / Riverine Sedgy Forest / Aquatic Herbland Mosaic	1199	212	18	R, V	89	7			2	0	121	10
659	Plains Riparian Shrubby Woodland	416	281	68	R, V	250	60			10	2	22	5
660	Plains Woodland/Plains Grassy Wetland Mosaic	7911	2234	28	E	865	11	1000	13		0	370	5
662	Escarpment Shrubland / Grassy Woodland / Riparian Woodland Mosaic	65			na								
663	Black Box Lignum Woodland	348	65	19	R, V, E	28	8			15	4	23	7
664	Limestone Ridge Woodland	29	29	100	R	22	78				0	6	22
665	Coastal Mallee Scrub	597	302	51	R, V	194	32				0	109	18
666	Riparian Shrubland / Escarpment Shrubland / Grassy Woodland Mosaic	2641	29	1	R, E	12	0				0	17	1
668	Riparian Woodland / Escarpment Shrubland Mosaic	491	22	4	R, E		0			9	2	13	3
669	Escarpment Shrubland / Damp Sands Herb-rich Woodland / Riparian Woodland / Swamp Scrub Mosaic	275	169	62	R, E	122	44			48	17		0
670	Limestone Woodland	69	69	100	R	69	100				0		0
672	Damp Sands Herb-rich Woodland / Shrubby Woodland Mosaic	1094	312	29	V	82	7	55	5		0	175	16
673	Dune Soak Woodland	121	47	39	R, E	5	4	19	16	1	1	22	18
674	Sandy Stream Woodland	7321	792	11	R, V	10	0	13	0	8	0	761	10
675	Escarpment Shrubland / Damp Sands Herb-rich Woodland / Swamp Scrub Mosaic	152	88	58	R, E	63	41			25	16	0	0
676	Salt Paperbark Woodland	188	49	26	R, V	21	11	7	4	3	2	18	9
677	Inland Saltmarsh	363	3	1	R, E	3	1			0	0		0
679	Drainage Line Woodland	3818	372	10	R, E	193	5	44	1	6	0	129	3
680	Freshwater Meadow	1705	150	9	R, E	6	0	55	3	4	0	85	5
681	Deep Freshwater Marsh	6639	1307	20	V	795	12	310	5	11	0	190	3
682	Permanent Open Freshwater	673	99	15	na	37	5			56	8	6	1
683	Semi-permanent Saline	1226	40	3	na	11	1	6	1	16	1	8	1
684	Permanent Saline	657	80	12	na	42	6			35	5	2	0
685	Box Ironbark Forest/Heathy Woodland Complex	8			na								
690	Floodplain Riparian Woodland/Billabong Wetland Mosaic	1558	1	0	R, E		0				0	1	0
691	Aquatic Herbland/Plains Sedgy Wetland Mosaic	30988	1197	4	R, V	112	0	55	0	865	3	165	1
692	Mangrove Shrubland/Coastal Saltmarsh/Berm Grassy Shrubland/Coastal Tussock Grassland Mosaic	61	26	42	R		0			26	42		0
693	Riverina Plains Grassy Woodland/Plains Grassland Mosaic	11672	338	3	R, E		0			70	1	268	2
697	Grassy Woodland / Alluvial Terraces Herb-rich Woodland Mosaic	970	119	12	E	4	0	110	11		0	5	0
704	Lateritic Woodland	7266	1423	20	V	103	1	634	9	7	0	681	9
705	Basalt Creekline Shrubby Woodland	3998	1	0	R, E		0			1	0		0
707	Sedgy Swamp Woodland	356	48	14	R, V		0	9	2	13	4	27	8
709	Scree-slope Grassland/Woodland	32	7	22	R, V	7	22				0		0
710	Damp Heathland	7641	5466	72	-	1900	25	2973	39	148	2	445	6
711	Shallow Sands Woodland / Plains Sedgy Woodland Mosaic	3264	1878	58	V	1320	40	308	9		0	250	8
713	Damp Sands Herb-rich Woodland / Damp Heathland / Damp Heathy Woodland Mosaic	84334	2930	3	V	108	0	600	1	5	0	2217	3
714	Stony Knoll Shrubland / Plains Grassy Woodland / Plains Grassy Wetland Mosaic	58184	9	0	E	5	0			4	0		0
715	Plains Grassland / Stony Knoll Shrubland Mosaic	853			na								
716	Plains Grassy Woodland / Stony Knoll Shrubland Mosaic	1629	3	0	E		0			3	0		0

Table 3.2 (cont.) Representative conservation (percentage reservation status) of EVCs in the West study area based on Pre-1750s vegetation mapping

EVC No	Ecological Vegetation Classes	Area (ha)		Percent Remaining	Regional Conservation Status	Area (ha) and percent of EVC (Pre 1750 extent) in each land tenure category							
		Pre 1750	Current			Conservation Reserves		State Forest		Other Public Land		Private Land	
						ha	%	ha	%	ha	%	ha	%
719	Grassy Woodland / Damp Sands Herb-rich Woodland Mosaic	43875	919	2	E	18	0	63	0	21	0	817	2
720	Swamp Scrub / Aquatic Herbland Mosaic	2435	99	4	E	48	2			4	0	47	2
724	Plains Woodland/Plains Sedgy Woodland/Damp Sands Herb-rich Woodland Mosaic	5531	966	17	E	0	0	277	5	146	3	544	10
725	Damp Sands Herb-rich Woodland / Riparian Woodland / Swamp Scrub Mosaic	417	284	68	R, V	187	45	2	0	89	21	6	1
726	Rocky Outcrop Shrubland/Herbland Mosaic / Heathy Woodland Mosaic	450	401	89	R	337	75			26	6	38	8
727	Hills Herb-rich Woodland / Heathy Woodland Mosaic	9	8	87	R		0				0	8	87
729	Sand Ridge Woodland / Damp Sands Herb-rich Woodland Mosaic	428	86	20	V	62	15				0	24	6
730	Plains Grassy Woodland / Shrubby Woodland Mosaic	18	8	42	E	1	3				0	7	39
732	Damp Sands Herb-rich Woodland / Plains Swampy Woodland / Aquatic Herbland Mosaic	9400	228	2	V	12	0	14	0		0	202	2
733	Swamp Scrub / Plains Sedgy Wetland / Aquatic Herbland Mosaic	8982	72	1	R, V	41	0			2	0	28	0
734	Damp Heathland / Damp Heathy Woodland / Wet Heathland Mosaic	995	635	64	V	19	2	552	55		0	64	6
736	Limestone Rise Grassland / Limestone Rise Woodland	98	90	92	R		0	90	91		0	0	0
737	Heathy Woodland / Limestone Woodland Mosaic	3547	3215	91	-	3003	85	162	5	5	0	44	1
738	Damp Sands Herb-rich Woodland / Plains Grassy Woodland / Plains Sedgy Woodland Mosaic	157	145	93	V, E		0	119	76		0	26	17
739	Plains Grassy Woodland / Plains Swampy Woodland Mosaic	5396	136	3	E	0	0	22	0	8	0	106	2
740	Damp Sands Herb-rich Woodland / Heathy Woodland / Sand Heathland Mosaic	1008	969	96	V	966	96			1	0	1	0
741	Salt Paperbark Woodland / Inland Saltmarsh Mosaic	232	16	7	R, V	13	5	0	0	3	1		0
742	Basalt Shrubby Woodland / Herb-rich Foothill Forest Mosaic	1237			na								
744	Stony Knoll Shrubland / Basalt Shrubby Woodland Mosaic	223			na								
745	Hills Herb-rich Woodland / Plains Grassy Woodland Mosaic	5875	889	15	E	26	0	467	8		0	395	7
746	Damp Heathland / Damp Heathy Woodland Mosaic	22588	4008	18	V	639	3	2531	11	123	1	714	3
748	Shallow Sands Woodland / Heathy Woodland Mosaic	958	788	82	V	502	52	228	24		0	58	6
749	Shallow Sands Woodland / Plains Sedgy Woodland / Seasonally Inundated Shrubby Woodland Mosaic	4167	905	22	V	56	1	644	15		0	204	5
750	Shallow Sands Woodland / Plains Sedgy Woodland / Seasonally Inundated Shrubby Woodland Mosaic / Damp Sands Herb-rich Woodland Mosaic	20275	5697	28	V	342	2	3989	20	4	0	1361	7
751	Seasonally Inundated Shrubby Woodland / Plains Sedgy Woodland Mosaic	3483	1252	36	R, V	75	2	770	22	3	0	404	12
752	Grassy Woodland / Hills Herb-rich Woodland / Damp Sands Herb-rich Woodland Mosaic	20083	807	4	E	37	0	21	0	0	0	749	4
753	Rocky Outcrop Shrubland/Herbland / Broombush Mallee Mosaic	182	168	92	E	122	67				0	46	25
754	Damp Heathland / Seasonally Inundated Shrubby Woodland Mosaic	63	62	98	R, V		0	31	50		0	31	49
756	Heathy Woodland / Seasonally Inundated Shrubby Woodland Mosaic	457	178	39	R, V		0	174	38		0	4	1
757	Damp Sands Herb-rich Woodland / Seasonally Inundated Shrubby Woodland Mosaic	697	342	49	V	187	27	1	0	13	2	142	20
758	Rocky Outcrop Shrubland/Herbland / Hills Herb-rich Woodland Mosaic	25	16	66	E		0				0	16	66
759	Hills Herb-rich Woodland / Valley Grassy Forest Mosaic	71	49	68	R	3	5				0	45	64
760	Lateritic Woodland / Heathy Dry Forest Mosaic	116	95	82	V	3	2				0	92	80
761	Hills Herb-rich Woodland/ Lateritic Woodland Mosaic	151	1	1	V		0				0	1	1
762	Damp Heathland / Sand Heathland Mosaic	822	655	80	R, V	252	31	396	48		0	7	1
763	Damp Heathland / Damp Heathy Woodland / Seasonally Inundated Shrubby Woodland Mosaic	1481	10	1	V		0				0	10	1
764	Lateritic Woodland / Heathy Woodland Mosaic	83	63	76	V	7	8	27	33		0	29	36
765	Heathy Dry Forest / Plains Grassy Woodland Mosaic	40	30	75	E		0				0	30	75
766	Shrubby Woodland / Lateritic Woodland Mosaic	15	13	87	R, V	6	38				0	7	50
768	Wet Heathland / Riparian Scrub Mosaic	16	0	1	na	0	1				0		0
770	Damp Sands Herb-rich Woodland / Lowland Forest Mosaic	1836	932	51	V	169	9	577	31	36	2	150	8
771	Heathy Dry Forest/Sand Heathland Mosaic	5	3	62	R, V	1	16				0	2	46

Table 3.2 (cont.) Representative conservation (percentage reservation status) of EVCs in the West study area based on Pre-1750s vegetation mapping

EVC No	Ecological Vegetation Classes	Area (ha)		Percent Remaining	Regional Conservation Status	Area (ha) and percent of EVC (Pre 1750 extent) in each land tenure category							
		Pre 1750	Current			Conservation Reserves		State Forest		Other Public Land		Private Land	
						ha	%	ha	%	ha	%	ha	%
772	Heathy Dry Forest/Hill Herb-rich Woodland/Lateritic Woodland Mosaic	5			na								
773	Hills Herb-rich Woodland / Shrubby Woodland Mosaic	2	2	100	R		0				0	2	100
774	Sedgy Riparian Woodland / Damp Sands Herb-rich Woodland Mosaic	4	4	92	V	2	51				0	2	41
775	Floodplain Thicket / Shrubby Woodland Mosaic	4	4	85	R		0				0	4	85
776	Plains Swampy Woodland / Swamp Scrub Mosaic	2664	77	3	R, E	7	0	12	0	15	1	44	2
779	Damp Sands Herb-rich Woodland / Shallow Sands Woodland Mosaic	2202	474	22	V	13	1	219	10		0	242	11
780	Plains Sedgy Woodland / Shallow Sands Woodland / Heathy Woodland Mosaic	371	366	99	R, E		0	309	83		0	57	15
781	Damp Sands Herb-rich Woodland / Herb-rich Foothill Forest Mosaic	3119	404	13	V		0	188	6		0	216	7
783	Grassy Dry Forest / Heathy Woodland Complex	240	191	80	-	98	41	57	24		0	37	15
785	Heathy Herb-rich Woodland / Damp Sands Herb-rich Woodland Mosaic	5343	717	13	V	357	7	100	2	37	1	223	4
786	Heathy Woodland / Heathy Herb-rich Woodland / Damp Heathy Woodland Mosaic	3466	2622	76	V		0	1873	54	741	21	9	0
787	Plains Woodland/Damp Sands Herb-rich Woodland Mosaic	219	109	50	E	105	48			0	0	4	2
788	Shallow Sands Woodland / Heathy Herb-rich Woodland Mosaic	69	62	90	V		0				0	62	90
789	Hills Herb-rich Woodland / Grassy Dry Forest Complex	54	54	100	-	54	100				0		0
790	Heathy Woodland / Heathy Herb-rich Woodland Mosaic	332	188	57	-		0	115	35		0	73	22
791	Plains Grassy Woodland / Damp Sands Herb-rich Complex / Damp Sands Herb-rich Woodland / Plains Grassy Woodland Complex / Damps Sands Herb-rich Woodland Mosaic	35053	184	1	E	7	0				0	177	1
792	Stony Rises Woodland / Stony Knoll Shrubland Complex	3587	2016	56	E	5	0	1266	35		0	744	21
793	Damp Heathy Woodland	2608	833	32	V	110	4	515	20	63	2	145	6
794	Floodplain Riparian Woodland / Plains Grassy Woodland Mosaic	2896	13	0	E	8	0				0	5	0
796	Valley Grassy Forest / Lateritic Woodland Mosaic	38	29	76	R, V	1	1				0	28	74
797	Coastal Landfill / Sand Accretion	86	5	6	na	5	6			0	0		0
798	Sedgy Riparian Woodland/Riparian Scrub Mosaic	193			na								
799	Shrubby Woodland/Riparian Scrub Mosaic	72			na								
802	Grassy Woodland / Heathy Woodland Mosaic	2825	520	18	E	49	2			17	1	454	16
803	Plains Woodland	440084	4379	1	E	841	0	980	0	211	0	2348	1
836	Damp Heath Scrub/Heathy Woodland Complex	16	16	100	R	16	100				0		0
851	Stream-bank Shrubland	6609	1599	24	R, V	618	9	188	3	287	4	506	8
858	Calcarenite Dune Woodland	18177	4286	24	R, V	3012	17	230	1	62	0	982	5
859	Montane Grassy Woodland/Rock Outcrop Mosaic	9	9	100	R	6	65			3	35		0
863	Floodplain Reedbed	112	112	100	R	0	0			112	100		0
876	Spray-zone Coastal Shrubland	77	9	11	R, V	9	11				0		0
881	Damp Sands Herb-rich Woodland / Heathy Woodland Mosaic	5941	4824	81	V	3475	58	371	6	285	5	693	12
882	Shallow Sands Woodland	45204	8576	19	V	1975	4	3987	9	132	0	2483	5
885	Damp Sands Herb-rich Woodland / Plains Grassy Woodland Complex	91497	1441	2	V, E	31	0	365	0	36	0	1009	1
886	Red Gum Wetland / Aquatic Herbland Mosaic	1280	147	12	R, E	54	4	68	5	5	0	21	2
890	Valley Grassy Forest/Creekline Grassy Woodland Mosaic	428			na								
891	Plains Brackish Sedge Wetland	29	16	55	R	16	55			0	0		0
892	Heathy Woodland/Sand Heath Mosaic	8401	4643	55	R, V	1729	21	1632	19	54	1	1227	15
894	Scoria Cone Woodland	15519	689	4	R, V, E	229	1	1	0	188	1	271	2
895	Escarpment Shrubland	3560	272	8	R, V, E	19	1			41	1	212	6
896	Grassy Woodland/Heathy Dry Forest Complex	31987	820	3		9	0	44	0	70	0	697	2
897	Plains Grassland/Plains Grassy Woodland Mosaic	480749	1951	0	E	846	0	6	0	715	0	384	0
898	Cane Grass-Lignum Halophytic Herbland	137	89	65	R	89	65			0	0		0

Table 3.2 (cont.) Representative conservation (percentage reservation status) of EVCs in the West study area based on Pre-1750s vegetation mapping

EVC No	Ecological Vegetation Classes	Area (ha)		Percent Remaining	Regional Conservation Status	Area (ha) and percent of EVC (Pre 1750 extent) in each land tenure category							
		Pre 1750	Current			Conservation Reserves		State Forest		Other Public Land		Private Land	
						ha	%	ha	%	ha	%	ha	%
899	Plains Freshwater Sedge Wetland	91	82	90	R	82	90				0		0
987	Plantation - Undefined		14692		na	69		417		1153		13052	
988	Quarry		81		na	41		39		0			
989	Cleared/Severely Disturbed Due To Power Easement		6		na	2		5					
991	Water Body-Salt	54836	43328	79	na	2293		6	0	40910	75	118	
992	Water Body-Fresh	14884	13331	90	na	237		74	0	12918	87	102	
995	Water - Ocean	408			na								
997	Cleared areas		4329698		na	21868		9246		31588		4266995	
998	Water Body - Natural or man made		5869		na	186		64		5620		0	
999	Unknown/Unclassified	1443	153744	10657	na	5400	374	6016	417	3090	214	139238	9651
57	Plantation - Softwood		85451		na	696		1864		47991		34900	
58	Cleared / Severely Disturbed		44111		na	13865		2784		26570		891	
121	Plantation - Hardwood		816		na	655						161	

A vegetation *mosaic* consists of discrete floristic entities (EVCs) which were unable to be distinguished in the mapping due to the scale used (ie. 1:100 000).

A vegetation *complex* occurs where floristic entities are unable to be distinguished in an area but are known to exist discretely elsewhere. In the West region complexes were mapped as part of the pre-1750 mapping exercise on private land where sufficient information was available to determine that a group of EVCs occurred in a particular area but there was insufficient information was available to accurately map the boundaries between them.

R=Rare, V=Vulnerable, E=Endangered (see Table 3.5)

3.3 Reservation status of Ecological Vegetation Classes

A reserve system that is comprehensive, adequate and representative in its regional coverage of forest ecosystems is an important component of the Regional Forest Agreement for the West. The extent of representation of EVCs in conservation reserves has been used as the basis for evaluating the current reservation status of forest ecosystems in the region.

Information on the current reservation status of EVCs for the West is provided in Table 3.2. The reservation level of each EVC can be assessed against the national reserve criteria. For those EVCs that are not endangered, vulnerable or rare, the criteria establish a reservation target of 15 per cent of the pre-1750 extent. If an EVC is vulnerable, then 60 per cent of its remaining extent should be reserved. All remaining occurrences of rare and endangered EVCs should be protected.

Table 3.2 shows the distribution of EVCs across all land tenures in the West. Descriptions the land tenure categories represented in the table are as follows:

Conservation Reserves: includes National Parks, State Parks, Wilderness Parks, Reference Areas, Regional Parks (where timber harvesting does not occur), Flora and Fauna Reserves, Flora Reserves, Natural Features Reserves, Heritage Rivers and Natural Catchment Areas established under the Heritage Rivers Act, and Remote and Natural Areas not available for timber harvesting.

Other Public Land: includes Bushland Reserves and land managed by water supply authorities.

Private Land: includes freehold land and land leased or licensed for plantation purposes.

A total of 378 EVC units have been identified as currently occurring in the West region. These EVCs have been mapped across all land in the region at a scale of 1:100,000 and are listed in Table 3.2. A description of each EVC is available in Appendix C

For those EVCs in the Midlands and Otways FMAs that are not endangered, vulnerable or rare, the national reserve criteria reservation target of 15 per cent of the pre-1750 extent has been met for all EVCs except for Lowland Forest, Riparian Forest, Heathy Dry Forest, Grassy Dry Forest, Sedgy Riparian Woodland and Stream-bank Shrubland. For those EVCs in the Portland and Horsham FMAs that are not endangered, vulnerable or rare, the national reserve criteria reservation target of 15 per cent of the pre-1750 extent has been met for all EVCs. For many of the EVCs which are endangered, vulnerable or rare as a result of depletion (Table 3.2), the only occurrence outside conservation reserves is on private land or in State Forest. This reflects the effects of disturbances discussed in Chapter 6. Table 6.1 lists threatening processes associated with EVCs determined to be endangered, vulnerable or rare.

3.3.1 Sub-regional reservation of Ecological Vegetation Classes

The West region has not been divided into Geographic Representation Units because of the highly fragmented nature of the region's remnant forest. Sub-regional representation of EVCs is considered on a Forest Management Area (FMA) basis (Table 3.3). These FMAs are shown on Map 1.

Table 3.3a Representative conservation (% reservation status) of EVCs in the West region (Midlands and Otways) by FMA

Ecological Vegetation Class	Total Area (ha)		Midlands		Otways		Central / Dandenong	
	pre1750	current	Ha Remaining	% pre1750 Protected	Ha Remaining	% pre1750 Protected	Ha Remaining	% pre1750 Protected
Plains Grassy Woodland	561442	9712	7245	0.5	1076	0.2%	1391	0.3
Plains Grassland/Plains Grassy Woodland Mosaic	345163	1886	1460	0.3	420	0.2%	6	0.0
Grassy Woodland	228025	5199	4230	0.3	817	0.2%	152	0.2
Plains Grassland	171604	3508	2541	0.0	0	0.0%	967	0.1
Herb-rich Foothill Forest	155448	44636	37263	4.6	7029	3.2%	343	1.7
Grassy Dry Forest	128313	44613	44295	9.1	262	53.8%	56	0.1
Heathy Dry Forest	120736	65733	65660	18.9	7	0.0%	65	0.9
Lowland Forest	114027	37695	5785	12.1	31909	8.0%	1	0.2
Stoney Rises Woodland	90614	5770	141	0.5	5628	0.5%	0	0.0
Shrubby Foothill Forest	76861	63932	34857	23.1	29074	30.5%	1	100.0
Valley Grassy Forest	60239	10394	10252	4.0	0	0.0%	142	0.6
Wet Forest	51777	40551	483	22.4	40068	21.2%	0	0.0
Shrubby Wet Forest	38047	31831	0	0.0	31831	17.8%	0	0.0
Heathy Woodland	33684	23155	7386	11.0	15768	53.5%	0	0.0
Grassy Woodland/Heathy Dry Forest Complex	31987	821	821	0.0	0	0.0%	0	0.0
Swamp Scrub	31453	583	21	0.1	562	0.9%	0	0.0
Damp Heath Scrub	23437	1652	0	0.0	1651	5.1%	1	0.9
Plains Sedgy Wetland	22491	371	224	0.4	130	0.4%	17	0.0
Floodplain Riparian Woodland	22009	1357	580	0.7	0	0.0%	672	14.8
Box Ironbark Forest	18530	4741	4653	17.7	0	0.0%	88	0.8

Ecological Vegetation Class	Total Area (ha)		Midlands		Otways		Central / Dandenong	
	pre1750	current	Ha Remaining	% pre1750 Protected	Ha Remaining	% pre1750 Protected	Ha Remaining	% pre1750 Protected
Low Rises Grassy Woodland/Alluvial Terraces Herb-rich Woodland Mosaic	18414	635	635	0.0	0	0.0%	0	0.1
Plains Grassy Wetland	18175	187	126	0.0	61	0.9%	0	0.0
Alluvial Terraces Herb-rich Woodland	17985	2148	2148	2.4	0	0.0%	0	0.0
Creekline Grassy Woodland	16481	1151	932	4.8	64	10.1%	156	3.8
Hills Herb-rich Woodland	16168	3572	2406	9.1	0	0.0%	1166	0.5
Scoria Cone Woodland	14123	635	247	0.0	372	1.9%	15	2.0
Damp Sands Herb-rich Woodland	13265	2255	794	9.7	1443	20.2%	18	0.0
Riparian Woodland	12124	350	306	1.1	26	0.0%	18	0.0
Herb-rich Foothill Forest/Shrubby Foothill Forest Complex	12112	7994	3910	3.6	4083	6.7%	0	0.0
Grassy Forest	11764	2943	2854	0.0	89	0.0%	0	0.0
Riverina Plains Grassy Woodland/Plains Grassland Mosaic	11672	338	338	0.0	0	0.0%	0	0.0
Shrubby Dry Forest	11531	8730	7258	55.8	1391	75.1%	81	6.8
Cool Temperate Rainforest	10174	8298	0	0.0	8298	68.6%	0	0.0
Alluvial Terraces Herb-rich Woodland/Plains Grassy Woodland Complex	9800	172	172	0.0	0	0.0%	0	0.0
Riparian Forest	9210	4037	733	38.2	3258	13.3%	45	12.1
Swampy Riparian Woodland	9159	440	331	0.1	108	0.0%	0	0.0
Aquatic Herbland/Plains Sedgy Wetland Mosaic	9127	1001	363	0.0	637	0.6%	0	0.0
Creekline Herb-rich Woodland	9004	2066	2066	7.4	0	0.0%	0	0.0
Sedgy Riparian Woodland	8886	3460	2080	10.9	1379	7.7%	0	0.0
Plains Grassy Woodland/Plains Grassland/Plains Grassy Wetland Mosaic	6892	8	0	0.0	0	0.0%	8	0.1
Riparian Scrub Complex	6780	4327	817	6.7	3510	32.9%	0	0.0
Granitic Hills Woodland	6703	250	250	0.0	0	0.0%	0	0.0
Coastal Saltmarsh Complex	6652	3549	3305	33.0	2	100.0%	243	23.3
Stream-bank Shrubland	6609	1598	1520	10.4	15	0.0%	62	20.9
Wet Heathland	5036	1893	0	0.0	1893	29.6%	0	0.0

Table 3.3b Representative conservation (percentage reservation status) of EVCs in the West region (Portland and Horsham) by FMA

EVC	Ecological Vegetation Class	Total Area (ha)		Horsham		Portland	
		Pre1750	Current	Ha Remaining	% Pre1750 Protected	Ha Remaining	% Pre1750 Protected
55	Plains Grassy Woodland	656,082	26,934	23,250	1.8	3,355	0.1
803	Plains Woodland	440,062	4,433	4,417	0.2	0	0.0
48	Heathy Woodland	188,079	155,886	105,604	41.1	50,133	26.2
3	Damp Sands Herb-rich Woodland	167,260	40,826	12,099	22.7	28,727	5.3
897	Plains Grassland/Plains Grassy Woodland Mosaic	135,652	71	0	0.0	71	0.0
885	Damp Sands Herb-rich Woodland / Plains Grassy Woodland	91,497	1,450	164	0.1	1,285	0.0
713	Damp Sands Herb-rich Woodland / Damp Heathland / Damp Heathy Woodland	84,334	2,935	0	-	2,935	0.1
23	Herb-rich Foothill Forest	78,142	20,514	1,157	92.5	19,357	2.8
132	Plains Grassland	72,011	1	1	0.0	1	0.0
642	Basalt Shrubby Woodland	70,899	79	0	0.0	79	0.0
714	Stony Knoll Shrubland / Plains Grassy Woodland / Plains Grassy Wetland	58,184	10	0	-	10	0.0
16	Lowland Forest	57,013	48,989	8,729	99.3	40,260	10.4
68	Creekline Grassy Woodland	50,221	1,324	637	3.8	619	0.1
882	Shallow Sands Woodland	45,204	8,599	7,075	2.5	1,524	19.1
719	Grassy Woodland / Damp Sands Herb-rich Woodland	43,875	933	11	0.2	922	0.0
179	Heathy Herb-rich Woodland	41,475	21,784	7,132	4.0	14,652	15.7
791	Plains Grassy Woodland / Damp Sands Herb-rich Complex / Dam	35,053	186	0	-	186	0.0
292	Red Gum Wetland	30,808	1,453	1,351	1.8	102	0.0
20	Heathy Dry Forest	30,349	30,073	30,073	96.3	0	-
175	Grassy Woodland	30,065	1,238	1,118	0.3	0	0.0
125	Plains Grassy Wetland	26,358	27	3	0.0	24	0.0
650	Heathy Woodland / Damp Heathy Woodland / Damp Heathland	25,812	12,833	2,368	2.4	10,465	8.3
746	Damp Heathland / Damp Heathy Woodland	22,766	4,009	0	-	4,009	2.8
53	Swamp Scrub	22,209	1,839	19	0.0	1,820	1.7
691	Aquatic Herbland/Plains Sedgy Wetland Mosaic	21,862	200	4	0.0	196	0.5
203	Stoney Rises Woodland	21,065	13,055	0	0.0	13,055	42.1
750	Shallow Sands Woodland / Plains Sedgy Woodland / Seasonally Inundated Shrubby Wo	20,275	5,700	4,286	1.0	1,414	3.1
71	Hills Herb-rich Woodland	20,261	13,600	12,737	43.3	739	5.6
752	Grassy Woodland / Hills Herb-rich Woodland / Damp Sands Herb-rich Woodland	20,083	814	276	0.5	538	0.1
651	Plains Swampy Woodland	19,707	87	25	0.0	62	0.0
56	Floodplain Riparian Woodland	18,818	3,003	931	12.5	2,072	3.9

EVC	Ecological Vegetation Class	Total Area (ha)		Horsham		Portland	
		Pre1750	Current	Ha Remaining	% Pre1750 Protected	Ha Remaining	% Pre1750 Protected
6	Sand Heathland	15,220	14,310	12,888	84.9	1,423	46.2
28	Rocky Outcrop Shrubland	14,072	14,012	13,896	90.5	116	61.4
641	Riparian Woodland	13,852	2,781	1,559	14.8	1,196	6.3
858	Calcarenite Dune Woodland	13,438	3,933	0	-	3,933	20.7
647	Plains Sedgy Wetland	11,496	105	20	0.7	85	0.0
282	Shrubby Woodland	10,860	7,684	7,591	54.1	92	24.4
103	Riverine Grassy Chenopod Woodland	10,130	207	207	1.0	0	-
193	Rocky Outcrop Herbland	10,021	10,026	10,023	98.8	3	100.0
732	Damp Sands Herb-rich Woodland / Plains Swampy Woodland / Aquatic Herbland	9,400	228	0	0.0	228	0.1
733	Swamp Scrub / Plains Sedgy Wetland / Aquatic Herbland	8,982	72	0	-	72	0.5
195	Seasonally Inundated Shrubby Woodland	8,820	5,481	5,230	29.5	250	0.6
61	Box Ironbark Forest	8,478	3,697	3,697	5.7	0	-
660	Plains Woodland/Plains Grassy Wetland	7,911	2,228	2,228	1.6	0	0.0
710	Damp Heathland	7,641	5,468	227	0.5	5,241	25.8
892	Heathy Woodland/Sand Heath Mosaic	7,532	4,603	4,385	32.2	218	0.0
674	Sandy Stream Woodland	7,321	792	65	0.0	727	0.2
704	Lateritic Woodland	7,266	1,421	1,258	0.2	163	37.5
191	Riparian Scrub	6,679	4,810	2,449	66.1	2,361	20.5
681	Deep Freshwater Marsh	6,639	1,312	10	0.0	1,301	16.8
8	Wet Heathland	6,621	5,601	1,176	82.9	4,425	68.2
47	Valley Grassy Forest	6,572	5,351	5,351	62.3	0	-
645	Wet Heathland / Heathy Woodland	6,350	4,489	0	-	4,489	44.5
73	Rocky Outcrop Shrubland/Herbland Mosaic	6,120	5,925	5,924	94.5	2	9.5
881	Damp Sands Herb-rich Woodland / Heathy Woodland	5,941	4,824	82	0.2	4,742	60.0
745	Hills Herb-rich Woodland / Plains Grassy Woodland	5,875	890	824	0.4	67	1.1
724	Plains Woodland/Plains Sedgy Woodland/Damp Sands Herb-rich Woodland	5,531	965	965	0.0	0	-
739	Plains Grassy Woodland / Plains Swampy Woodland	5,396	142	0	-	142	0.0
785	Heathy Herb-rich Woodland / Damp Sands Herb-rich Woodland	5,343	717	477	25.4	240	3.4
200	Shallow Freshwater Marsh	5,113	1,060	837	29.3	222	2.0
160	Coastal Dune Scrub	4,973	1,412	0	-	1,412	22.4

3.3.2 Endangered, vulnerable and rare forest ecosystems

The conservation status of EVCs in the region has been assessed against a number of national reserve criteria (JANIS 1997). The criteria have been applied to ecological vegetation classes as the appropriate level of resolution for forest ecosystems.

Table 3.4 The National Reserve criteria used to assess the conservation status of EVCs

Status of EVC	Criteria
Rare	R1. Total range generally less than 10,000 ha. R2. Total area generally less than 1,000 ha. R3. Patch sizes generally less than 100 ha.
Vulnerable	V1. Approaching greater than 70 per cent lost (depletion) and remains subject to threatening processes. V2. Includes EVCs where threatening processes have caused: • significant changes in species composition, • loss or significant decline in species that play a major role within the ecosystem, or • significant alteration to ecosystem processes. V3. Not depleted but subject to continuing threatening processes which may reduce its extent.
Endangered	E1. Distribution has contracted to less than 10 per cent of original range. E2. Less than 10 per cent of original area remaining. E3. 90 per cent of area is in small patches subject to threatening processes and unlikely to persist.

A Regional assessment of EVCs which are classified as rare, vulnerable or endangered according to the national reserve criteria are presented in Table 3.2. This assessment is relevant to JANIS Criteria 2 and 3 (see Box 1—Chapter 1) which specify reservation targets for EVCs classified as endangered, vulnerable or rare. As outlined previously, all remaining occurrences of rare and endangered EVCs should be reserved or protected by other means as far as is practicable, and at least 60 percent of the remaining extent of vulnerable EVCs should be reserved.

Information on the threatening processes and relevant management mechanisms applying to these EVCs is given in Chapter 6. A sub-regional assessment of EVCs classified as Rare, Vulnerable, and Endangered has previously been published in the CRA (Volumes 1 and 2).

Most of the EVCs classified as Rare, Vulnerable or Endangered are largely confined to private land in the region (see also Section 3.2).

Several relatively common EVCs are subject to a variety of threatening processes but are not judged to be impacted to a sufficiently significant degree (ie. in extent and/or severity) to be considered endangered, vulnerable or rare in accordance with the JANIS criteria. For example, EVCs with heathy and herb-rich understories (Heathy Woodland, Hills Herb-rich Woodland and Heathy Herb-rich Woodland) are particularly sensitive to altered fire regimes and weed invasion. Management of these EVCs needs to consider ways of minimising any long-term impacts.

4. VASCULAR FLORA ASSESSMENT

4.1 Introduction

Assessment of the West region flora has involved an analysis of the distribution and viability of individual taxa and their populations within the region. The purpose of this assessment is to assist in determining whether:

- viable populations of all terrestrial and aquatic plant taxa are maintained throughout their natural range in the region;
- representative populations of each taxon are included in the reserve system; and
- populations and their habitats both within and outside the reserve system are subject to management appropriate for their long-term maintenance.

Rare or threatened plants are often at the forefront of the debate regarding the balance between conservation and resource utilisation. They are significant because of their intrinsic value as unique forms of life and the higher likelihood of their permanent loss. In addition, the fate of rare or threatened plants may also indicate the health of the ecosystems and communities on which they depend and the direct or indirect impact of human activities on these ecosystems and communities.

4.1.1 Priority flora

A total of approximately 2,900 vascular plants have been recorded for the West region, including 519 taxa of conservation significance and 850 exotic taxa. Of the 519 taxa of conservation significance known to have occurred within the West region, only 366 have post-1950 records that can be substantiated.

Taxa not included in the analysis were taxa that are rare, or extinct, or taxa where the conservation status was not known or taxa not known to occur within woodland or forest communities – leaving 101 plants that were, in the context of this report, treated as priority flora.

Rare or threatened plants exhibit a range of life histories, life forms, reproductive strategies, distribution patterns and ecological dependencies. Included among the plants considered priority flora within the West region are:

- 19 short-lived herbs and 65 long-lived herbs or shrubs;
- 4 annuals and 13 long-lived trees;
- 58 herbs, 24 shrubs, 3 grasses, 1 sedge, 9 trees, 3 ferns, 2 epiphytes and 1 climber;
- 45 perennial taxa that do not disperse seeds over long distances and persist in an area by virtue of a substantial soil seedbank;
- 42 orchids and ferns that produce large quantities of short-lived seeds or spores that are dispersed by wind over large distances;
- 51 taxa categorised as Facultative Root Resprouters -26 Obligate Seed Regenerators, 12 Obligate Seed Regenerators and 5 Obligate Root Resprouters. Three taxa occurred in habitats not affected by fire and insufficient information was available for 4 taxa to categorise their response to fire;
- Rare plants that may be locally abundant but occur in a restricted area and those which occur over a large area but are rarely common; and
- montane, lowland, swamp and coastal taxa.

Priority taxa were not evenly distributed throughout the higher taxonomic groups with certain families and genera being represented by numerous taxa. The most common families represented were Orchidaceae with 33 plants, followed by Asteraceae with 13 plants, Fabaceae with 9, Myrtaceae with 7 and Proteaceae with 5. The remaining taxa were evenly distributed throughout another 29 families. The most common genera encountered within the list of priority taxa were *Caladenia*, *Thelymitra*, *Eucalyptus*, *Grevillea* and *Prasophyllum* with 13, 8, 7, 5 and 5 taxa respectively.

This review of the conservation of rare or threatened taxa in the West region addresses:

- plants listed as threatened under the Victorian *Flora and Fauna Guarantee Act* 1988 (FFG Act);
- plants listed as endangered or vulnerable under the Commonwealth *Endangered Species Protection Act* 1992 (ESP Act);
- threatened plants included in the Victorian Rare or Threatened Species list for plants (VROTS);
- threatened plants included in the national list of Rare or Threatened Australian Plants (ROTAP) (Briggs and Leigh 1995); and
- any other threatened plants recommended for addition to the ROTAP list by the Australian and New Zealand Environment and Conservation Council (ANZECC).

Non-vascular plants have not been considered in this assessment, nor have those taxa whose continuing occurrence within the West region could not be confirmed because of (a) difficulties in confirming identification

or location, (b) the absence of recent (post-1950) records, or (c) where they are hybrids. The full list of 101 priority taxa is listed in Table 4.1.

4.2 Life history and population parameters for priority flora

4.2.1 Assessment methods

For each of the plants evaluated in this review, questions relating to the following topics were answered using the best information available from the databases maintained by NRE, the available literature and expert opinion:

- the conservation status of each taxon;
- the regional distribution and demographic attributes of each taxon;
- the habitat attributes of each taxon;
- the life history attributes of each taxon, and;
- the response of each taxon to various forms of disturbance or common environmental conditions found in different land-use categories or management regimes.

The greatest effort went into compiling information on the distribution, abundance and demography of all priority taxa so that a detailed assessment of the reservation status and vulnerability of each taxon could be conducted. Some of the more important information collated included:

- the approximate proportion of each taxon's Australian distribution, or population when this is known, that occurs within the West region;
- the reservation status of known populations within the West region;
- the number of populations and/or individuals known to occur in the West region;
- the number of populations and/or individuals known to occur in protected areas or land free from processes causing sudden and irreversible loss of habitat within the West region;
- the area of occupancy and/or the extent of occurrence of each taxon within the West region;
- any trends that may be apparent in the demography of each taxon; and
- any trends that may be apparent or threats to the habitat of each species.

Some of these data are presented in Table 4.1. More details for plants listed under the *Flora and Fauna Guarantee Act* 1988 or *Endangered Species Protection Act* 1992 can be found in Appendix E.

4.2.2 Patterns of abundance, distribution and habitat

Spatial analysis of the distribution and abundance of priority taxa and review of their habitat identified distinct groups of plants that appeared to correlate with particular regions or habitats present throughout the region. These include plants endemic to the West region and plants localised to natural regions (e.g. Otway Plain, Otway Ranges, etc). In addition, those Ecological Vegetation Classes (e.g. Plains Grassland, Plains Grassy Woodland, etc) or Conservation Reserves with the greatest number of priority taxa were identified. Each habitat, region, EVC or reserve and the plants associated with them are discussed in the sections below.

Plants endemic to the West region

Of the threatened species identified as priority taxa, 19 were found to be endemic to the West region. These are Limestone Spider-orchid *Caladenia calcicola,* Tawny Spider-orchid *Caladenia fulva,* Mellblom's Spider-orchid *Caladenia hastata,* Grampians Bitter-pea *Daviesia laevis,* Swamp Flax-lily *Dianella callicarpa,* Otway Grey Gum *Eucalyptus* aff. *cypellocarpa* (Anglesea), Coast Gum *Eucalyptus diversifolia* ssp. *megacarpa,* Gellibrand Midge-orchid *Genoplesium* sp. aff. *nudiscapum,* Enfield Grevillea *Grevillea bedggoodiana,* Drooping Grevillea *Grevillea floripendula,* Anglesea Grevillea *Grevillea infecunda,* Langi Ghiran Grevillea *Grevillea montis-cole* ssp. *brevistyla,* Mt. William Grevillea *Grevillea williamsonii,* Square Raspwort *Haloragis exalata* ssp. *exalata* var. *exalata,* Wrinkled Buttons *Leptorhynchos gatesii,* Gorae Leek-orchid *Prasophyllum diversiflorum,* Pomonal Leek-orchid *Prasophyllum subbisectum,* Williamson's Bush-pea *Pultenaea williamsoniana* and Anglesea Sun-orchid *Thelymitra* sp. aff. *pauciflora* (Anglesea). Seven other taxa that are endemic to Victoria also occur within the West region. These are Tall Astelia *Astelia australiana,* Ornate Pink Fingers *Caladenia carnea* var. *ornata*, Black Gum *Eucalyptus aggregata,* Yellow Gum *Eucalyptus leucoxylon* ssp. *connata,* Floodplain Rustyhood *Pterostylis cheraphila,* Scented Bush-pea *Pultenaea graveolens* and Brilliant Sun-orchid *Thelymitra mackibbinii.* Of these taxa Black Gum *Eucalyptus aggregata,* Scented Bush-pea *Pultenaea graveolens* and Brilliant Sun-orchid *Thelymitra mackibbinii* had the largest proportion of their Australian distribution occurring within the West region.

Plants localised to natural regions occurring within the West region

Geology, topography and rainfall were used to identify the boundaries of natural regions occurring throughout the West region. The greatest weight when defining regions in this analysis was placed on geology since little

variation existed in the topography and rainfall except in those areas already well defined by geological features, viz. Otway Ranges and Victorian Midlands. In general, a significant proportion of these natural regions correlated well with existing biogeographical regions recognised by Thackway and Cresswell (1995), Conn (1993) and NRE (1997c). The Otway Ranges, Otway Plain and Volcanic Plain were all clearly identified although some historically well recognized bioregions like the Greater Grampians, Glenelg Plain and Wimmera Bioregions (NRE 1997c) were clearly stratified into distinct zones. For example, the Greater Grampians Bioregion (NRE 1997c) was stratified into two distinct zones, viz. a central mountainous area formed of Silurian-Devonian Sandstone and peripheral plain formed from more recent fluvial deposits. These natural regions were retained to better correlate known plant distributions with variation in geology, rainfall and topography throughout the West region. All post-1950 records of priority taxa were superimposed on the natural regions using GIS technology and natural regions supporting the greatest number of priority taxa identified.

Five natural regions, as defined in this report, contained the greatest number of priority taxa. These were (1) the Otway Ranges, (2) the coastal and inland dunes found in the southwest of the region, (3) the fluvial deposits surrounding the Grampians Ranges, (4) the Otway Plain and (5) the volcanic plain.

Otway Ranges

The Otway Ranges occur close to the coast along the southern edge of the West region. It is formed from volcanolithic sandstone and siltstone laid down and elevated in the Cretaceous. The terrain is deeply dissected throughout most of the range with the altitude varying from sea-level to 670 m ASL. The proximity to the coast and steep terrain result in high rainfall with up to 2000 mm being recorded. Eight priority taxa have over 80% of their regional population within the Otway Ranges. These are Tall Astelia *Astelia australiana,* Slender Tree-fern *Cyathea cunninghamii,* Snow-berry *Gaultheria hispida,* Beech Finger-fern *Grammitis magellanica* ssp. *nothofageti,* Long Clubmoss *Huperzia varia,* Merran's Sun-orchid *Thelymitra merraniae,* Wrinkled Buttons *Leptorhynchos gatesii* and Slender Fork-fern *Tmesipteris elongata* ssp. *elongata.* Wrinkled Buttons *Leptorhynchos gatesii* is endemic to this natural region.

Coastal and inland dunes

Throughout the southwest of the West region a series of parallel dunes can be found extending from the coast inland for several hundred kilometres. These extensive sand deposits have been laid down by wind and waves as the sea level has receded since the Pleistocene. The extensive lagoon and swamp deposits that alternate with these dunes are not included in this natural region. The annual rainfall ranges from 500 mm inland to 1000 mm near the coast and the altitude ranges from sea level to 200 m ASL further inland. Eight priority taxa have over 80% of their regional population within this natural region. These are Limestone Spider-orchid *Caladenia calcicola*, Scented Spider-orchid *Caladenia fragrantissima* ssp. *fragrantissima*, Coast Gum *Eucalyptus diversifolia* ssp. *megacarpa*, Green-leaf Mallee *Eucalyptus phenax*, Small Nut-heads *Haegiela tatei*, Sweet Quandong *Santalum acuminatum*, Coast Dandelion *Taraxacum cygnorum* and Heathy Guinea-flower *Hibbertia sessiliflora*. Limestone Spider-orchid *Caladenia calcicola* and Coast Gum *Eucalyptus diversifolia* ssp. *megacarpa* are endemic to this natural region. Twenty-one other priority taxa have been recorded within this natural region.

Fluvial deposits surrounding the Grampians Ranges

The characteristic sandstone escarpments associated with the mountainous regions of the Grampians form the focal point for the surrounding plains that form this natural region. For the most part the altitude varies between 100m to 200m ASL and the rainfall ranges between 500 and 750 mm. The region extends for up to 20km east of the Serra Range and 40km north of the Mount Difficult Range. Fluvial deposits also occur in the Victoria Valley that were formed by the erosion of softer siltstones and sandstones, these areas support extensive forested areas that have in the past been heavily harvested. All harvesting in the Grampians National Park ceased in June 1994. Seven priority taxa have over 80% of their regional population within this natural region. These are Rigid Spider-orchid *Caladenia tensa,* Candy Spider-orchid *Caladenia versicolor*, Yellow-lip Spider-orchid *Caladenia xanthochila*, Umbrella Grass *Digitaria divaricatissima*, Clustered Daisy-bush *Olearia suffruticosa,* Floodplain Rustyhood *Pterostylis cheraphila* and Swamp Buttercup *Ranunculus undosus.* Twenty-seven other priority taxa have been recorded within this natural region.

The Otway Plain

The Otway Plain occurs northwest of the Otway Ranges and extends from the Bellarine Peninsula through to Warrnambool, with a small outlier between Bessiebelle and Kirkstall. The plain extends between 10 km and 40 km inland and has been derived from both Tertiary marine sediments and outwash sediments from the Otway Ranges. The rainfall throughout the bulk of the natural region varies between 500 mm and 1000 mm and the altitude between sea level and 200 m ASL. Six priority taxa have over 80% of their regional population within this natural region. These are Wine-lipped Spider-orchid *Caladenia lindleyana*, Robust Spider-orchid *Caladenia valida,* Long Rope-rush *Calorophus elongatus,* Otway Grey Gum *Eucalyptus* aff. *cypellocarpa* (Anglesea), Anglesea

Grevillea *Grevillea infecunda* and Anglesea Sun-orchid *Thelymitra* sp. aff. *pauciflora* (Anglesea). The last three taxa are endemic to this natural region and 40 other priority taxa have been recorded within this natural region.

The Volcanic Plain

This natural region is clearly defined by geology and landform. A result of 'recent' volcanic activity, the plain consists of basalt and scoria that forms reddish brown or sometimes black fertile soils. Due to very low rainfall, the bulk of the plain is only able to support grasslands dominated by Kangaroo Grass *Themeda tri*and*ra*, Wallaby-grasses *Austrodanthonia* spp., Tussock-grasses *Poa* spp. and Spear-grasses *Austrostipa* spp. Trees are limited to the edge of watercourses or the moist environments that are associated with stony rises or the moister margins of the Plain to the west. The rainfall mostly varies between 500 mm and 750 mm although it can reach up to 1500 mm in the foothills. The volcanic plains vary in altitude between sea-level in the far southwest to 800 m ASL in the Victorian Midlands. Six priority taxa have over 80% of their regional population within this natural region. These are Kidney Saltbush *Atriplex stipitata,* Tough Scurf-pea *Cullen tenax*, Pale Flax-lily *Dianella longifolia* var. *grandis*, Hairy Anchor Plant *Discaria pubescens*, Pale Swamp Everlasting *Helichrysum* aff. *rutidolepis* (Lowland Swamps) and Leafless Bluebush *Maireana aphylla*. Thirty-two other priority taxa have been recorded within this natural region.

Ecological Vegetation Classes and priority taxa

Due to the absence of spatial data for Ecological Vegetation Classes in the West region, it was not possible to allocate all known populations of the priority taxa to a particular vegetation type. Where sufficient historical data was available to identify habitat preferences, this was collated and analysed in an attempt to identify those habitat types with the greatest numbers of threatened plants. Five EVCs were identified as having an unusually high number of priority taxa. These are Plains Grassy Woodland, Plains Grassland, Cool Temperate Rainforest, Heathy Woodland and Shallow Sand Woodland. Plains Grassy Woodland and Plains Grassland are currently considered to be endangered, while Cool Temperate Rainforest is threatened.

Plains Grassy Woodland

Plains Grassy Woodland was once widespread across the West region but has been heavily grazed and cleared for agriculture. Plains Grassy Woodland occurs on fertile, flat or gently undulating basalt plains, associated volcanic cones of the Victorian Volcanic Plains and the Tertiary clays and Cretaceous sediments of the Dundas Tableland where rainfall is greater than 650 mm per annum. The dominant trees include River Red Gum *Eucalyptus camaldulensis*, Yellow Gum *Eucalyptus leucoxylon*, Swamp Gum *Eucalyptus ovata*, Yellow Box *Eucalyptus melliodora* and Manna Gum *Eucalyptus viminalis*. The understorey consists primarily of perennial grasses and a range of annual herbs. Fourteen priority taxa are known to occur within this EVC. These are Buloke *Allocasuarina luehmannii,* Buloke Mistletoe *Amyema linophylla* ssp. *orientale,* Australian Piert *Aphanes australiana,* Small Milkwort *Comesperma polygaloides,* Swamp Billy-buttons *Craspedia paludicola,* Bent-grass *Deyeuxia imbricata,* Trailing Hop-bush *Dodonaea procumbens,* Turkey-bush *Eremophila deserti,* Clover Glycine *Glycine latrobeana,* Hairy Tails *Ptilotus erubescens,* Button Wrinklewort *Rutidosis leptorhynchoides,* Large-fruit Fireweed *Senecio macrocarpus,* Downy Swainson-pea *Swainsona swainsonioides* and Leafy Templetonia *Templetonia stenophylla.*

Plains Grassland

Plains Grassland is a tussock grassland, usually dominated by Kangaroo Grass *Themeda triandra* and occurs on fertile, usually heavy loam or clay soils derived from basalt. Previously widespread throughout the West region, it is now largely cleared and restricted to degraded sites along road reserves. When intact, Plains Grassland is typically rich in perennial herbs. Eleven priority taxa are known to occur within this EVC. These are Buloke *Allocasuarina luehmannii,* Small Milkwort *Comesperma polygaloides,* Swamp Billy-buttons *Craspedia paludicola,* Small Scurf-pea *Cullen parvum*, Tough Scurf-pea *Cullen tenax*, Clover Glycine *Glycine latrobeana,* Pale Swamp Everlasting *Helichrysum* aff. *rutidolepis* (Lowland Swamps), Leafless Bluebush *Maireana aphylla*, Hairy Tails *Ptilotus erubescens,* Button Wrinklewort *Rutidosus leptorhynchoides* and Large-fruit Fireweed *Senecio macrocarpus*.

Cool Temperate Rainforest

Cool Temperate Rainforest is highly localised in Victoria and is restricted (within the West region) to steeply dissected gullies and valleys in the Otway Ranges where the wettest and most sheltered niches occur. The overstorey is dominated by Myrtle Beech *Nothofagus cunninghamii*, with Soft Tree-fern *Dicksonia antarctica*, Prickly Currant-bush *Coprosma quadrifida*, Austral Mulberry *Hedycarya angustifolia*, Banyalla *Pittosporum bicolor*, Musk Daisy-bush *Olearia argophylla* and Blackwood *Acacia melanoxylon* forming a dense understorey. This Ecological Vegetation Class is characterised by a diversity and abundance of obligate epiphytes. Eight priority taxa are known to occur within this EVC. These are Tall Astelia *Astelia australiana,* Slender Tree-fern *Cyathea cunninghamii,* Beech Finger-fern *Grammitis magellanica* ssp. *nothofageti,* Long Clubmoss *Huperzia varia,* Slender

Fork-fern *Tmesipteris elongata* ssp. *elongata,* Slender Tree-fern *Cyathea cunninghamii,* Beech Finger-fern *Grammitis magellanica* ssp. *nothofageti* and Long Clubmoss *Huperzia varia.*

Heathy Woodland

Heathy Woodland is a common and variable Ecological Vegetation Class with numerous floristic communities identified. Dominated by eucalypts it lacks a secondary tree layer and generally supports a diverse array of narrow or ericoid-leaved shrubs. Although it occurs on a variety of geological types, it is generally associated with nutrient poor soils including deep sands or quartzite gravel. Twelve priority taxa are known to occur within this EVC. These are Buloke *Allocasuarina luehmannii,* Downy Star-Bush *Asterolasia phebalioides,* Small Milkwort *Comesperma polygaloides,* Trailing Hop-bush *Dodonaea procumbens,* Otway Grey Gum *Eucalyptus* aff. *cypellocarpa* (Anglesea), Heathy Guinea-flower *Hibbertia sessiliflora,* Wrinkled Buttons *Leptorhynchos gatesii,* Scented Bush-pea *Pultenaea graveolens,* Williamson's Bush-pea *Pultenaea williamsoniana,* Leafy Templetonia *Templetonia stenophylla,* Blotched Sun-orchid *Thelymitra benthamiana* and Anglesea Sun-orchid *Thelymitra* sp. aff. *pauciflora* (Anglesea).

Shallow Sand Woodland

Shallow Sand Woodland is defined as woodland or open-forest growing on shallow sands over poorly-drained clays. A sparse shrub layer of heathy, ericoid shrubs is generally present and, in relatively intact remnants, a species-rich ground cover dominated by grasses, annuals and geophytes usually persists. The ground cover is often visually dominated by Clustered Sword-sedge *Lepidosperma congestum*. This EVC has been extensively cleared for agriculture and remnants have been subject to timber production and grazing. Eleven priority taxa are known to occur within this EVC. These are Buloke *Allocasuarina luehmannii,* Australian Piert *Aphanes australiana,* Small Milkwort *Comesperma polygaloides,* Bent-grass *Deyeuxia imbricata,* Trailing Hop-bush *Dodonaea procumbens,* Clover Glycine *Glycine latrobeana,* Slender Club-sedge *Isolepis congrua,* Green Leek-orchid *Prasophyllum lindleyanum,* Hairy Tails *Ptilotus erubescens,* Large-fruit Fireweed *Senecio macrocarpus* and Leafy Templetonia *Templetonia stenophylla.*

Riparian habitats and wetlands

As part of the review of the biological and ecological data for each priority taxa, plants were identified as occurring within shallow depressions or swamps, riparian habitats or in poorly drained soil. The purpose of this assessment was to identify species that are dependent on being infrequently or regularly inundated in order to successfully reproduce. The analysis showed that 14 priority taxa were confined to seasonal or perennial swamps, 7 taxa to riparian habitats and 12 to poorly drained soils.

Seasonal or perennial swamps

Seasonal or perennial swamps can be found in all shapes and sizes throughout the West region. Due to the restricted nature of this habitat it is rarely sampled or mapped. For example, gilgai - shallow depressions in clay soils caused by expansion and contraction of the clay - are rarely over a 1 m wide and yet can be quite floristically and structurally distinct from adjacent grassland areas. These areas provide important microhabitat for water-dependent species in otherwise dry landscapes. Fourteen priority taxa are known to occur within shallow depressions or swamps. These are Purple Diuris *Diuris punctata* var. *punctata*, Small Nut-heads *Haegiela tatei*, Slender Club-sedge *Isolepis congrua*, Gorae Leek-orchid *Prasophyllum diversiflorum*, Swamp Buttercup *Ranunculus undosus*, Downy Swainson-pea *Swainsona swainsonioides*, Naked Sun-orchid *Thelymitra circumsepta*, Floodplain Rustyhood *Pterostylis cheraphila*, Ornate Pink Fingers *Caladenia carnea* var. *ornata*, Swamp Billy-buttons *Craspedia paludicola*, Pale Swamp Everlasting *Helichrysum* aff. *rutidolepis* (Lowland Swamps), Swamp Fireweed *Senecio psilocarpus*, Swamp Flax-lily *Dianella callicarpa* and Gellibrand Midge-orchid *Genoplesium* sp. aff. *nudiscapum*.

Riparian habitats

Seven priority taxa are known to occur within riparian habitats. These are Tall Astelia *Astelia australiana*, Mountain Bertya *Bertya findlayi*, Candy Spider-orchid *Caladenia versicolor*, Long Rope-rush *Calorophus elongatus*, Square Raspwort *Haloragis exalata* ssp. *exalata* var. *exalata*, Button Immortelle *Leptorhynchos waitzia* and Lime Fern *Pneumatopteris pennigera*.

Poorly drained soil

Twelve priority taxa are known to occur on poorly drained soils. These are Swamp Diuris *Diuris palustris*, Metallic Sun-orchid *Thelymitra epipactoides*, Golden Cowslips *Diuris behrii*, Pink Gum *Eucalyptus fasciculosa*, Heathy Guinea-flower *Hibbertia sessiliflora*, Leafless Bluebush *Maireana aphylla*, Small Scurf-pea *Cullen parvum*, Clustered Daisy-bush *Olearia suffruticosa*, Yellow-lip Spider-orchid *Caladenia xanthochila*, Weak Daisy *Brachyscome debilis*, Long Clubmoss *Huperzia varia* and Slender Tree-fern *Cyathea cunninghamii*.

Conservation reserves with the greatest number of priority taxa

Although not representing natural units within the environment, Conservation Reserves represent readily identifiable units that contain representative and related ecosystems. As management units they also provide a focus for the conservation of rare and threatened plants and the allocation of funds for the monitoring and management of these plants. As part of reviewing the reservation status of each taxon (described in full in the next section) it was possible to establish which reserves had the highest concentration of priority taxa. The reserve with the most priority taxa was the Grampians National Park with 22 taxa being represented within the reserve. This was followed by Deep Lead Flora and Fauna Reserve, Mount Arapiles-Tooan State Park, Lower Glenelg National Park, Brisbane Ranges National Park and Angahook-Lorne State Park with 11, 9, 7, 6 and 6 taxa respectively.

Grampians National Park

Twenty-two priority taxa are known to occur in the Grampians National Park. These are Buloke *Allocasuarina luehmannii*, Australian Piert *Aphanes australiana*, Downy Star-Bush *Asterolasia phebalioides*, Elegant Spider-orchid *Caladenia formosa*, Veined Spider-orchid *Caladenia reticulata* s.s., Grampians Duck-orchid *Caleana* sp. aff. *nigrita* (Horsham), Small Milkwort *Comesperma polygaloides*, Bent-grass *Deyeuxia imbricata*, Swamp Flax-lily *Dianella callicarpa*, Trailing Hop-bush *Dodonaea procumbens*, Clover Glycine *Glycine latrobeana*, Mt. William Grevillea *Grevillea williamsonii*, Slender Club-sedge *Isolepis congrua*, Lanky Buttons *Leptorhynchos elongatus*, Clustered Daisy-bush *Olearia suffruticosa*, Green Leek-orchid *Prasophyllum lindleyanum*, Hairy Tails *Ptilotus erubescens*, Scented Bush-pea *Pultenaea graveolens*, Williamson's Bush-pea *Pultenaea williamsoniana*, Slender Swainson-pea *Swainsona brachycarpa*, Blotched Sun-orchid *Thelymitra benthamiana* and Spiral Sun-orchid *Thelymitra matthewsii*. Swamp Flax-lily *Dianella callicarpa,* Mt. William Grevillea *Grevillea williamsonii* and Williamson's Bush-pea *Pultenaea williamsoniana* are all endemic to the West region. Williamson's Bush-pea *Pultenaea williamsoniana* is only known from Grampians National Park.

Deep Lead Flora and Fauna Reserve

Eleven priority taxa are known to occur in the Deep Lead Flora and Fauna Reserve. These are Buloke *Allocasuarina luehmannii*, Tawny Spider-orchid *Caladenia fulva*, Small Milkwort *Comesperma polygaloides*, Bent-grass *Deyeuxia imbricata*, Trailing Hop-bush *Dodonaea procumbens*, Purple Eyebright *Euphrasia collina* ssp. *muelleri*, Slender Club-sedge *Isolepis congrua*, Fitzgerald's Leek-orchid *Prasophyllum fitzgeraldii*, Green Leek-orchid *Prasophyllum lindleyanum*, Large-fruit Fireweed *Senecio macrocarpus* and Leafy Templetonia *Templetonia stenophylla*. Tawny Spider-orchid *Caladenia fulva* is endemic to the West region.

Mount Arapiles - Tooan State Park

Nine priority taxa are known to occur in the Mount Arapiles-Tooan State Park. These are Buloke *Allocasuarina luehmannii*, Buloke Mistletoe *Amyema linophylla* ssp. *orientale*, Weak Daisy *Brachyscome debilis*, White Cypress-pine *Callitris glaucophylla*, Small Milkwort *Comesperma polygaloides*, Umbrella Grass *Digitaria divaricatissima*, Green-leaf Mallee *Eucalyptus phenax*, Hairy Tails *Ptilotus erubescens* and Leafy Templetonia *Templetonia stenophylla.*

Lower Glenelg National Park

Seven priority taxa are known to occur in the Lower Glenelg National Park. These are Mellblom's Spider-orchid *Caladenia hastata*, Square Raspwort *Haloragis exalata* ssp. *exalata* var. *exalata*, Lime Fern *Pneumatopteris pennigera*, Glenelg Pomaderris *Pomaderris halmaturina* ssp. *continentis*, Coast Dandelion *Taraxacum cygnorum*, Blotched Sun-orchid *Thelymitra benthamiana* and Metallic Sun-orchid *Thelymitra epipactoides*. Mellblom's Spider-orchid *Caladenia hastata* and Square Raspwort *Haloragis exalata* ssp. *exalata* var. *exalata* are both endemic to the West region.

Angahook - Lorne State Park

Six priority taxa are known to occur in the Angahook-Lorne State Park. These are Otway Grey Gum *Eucalyptus* aff. *cypellocarpa* (Anglesea), Anglesea Grevillea *Grevillea infecunda*, Wrinkled Buttons *Leptorhynchos gatesii*, Blotched Sun-orchid *Thelymitra benthamiana*, Spiral Sun-orchid *Thelymitra matthewsii* and Merran's Sun-orchid *Thelymitra merraniae*. Otway Grey Gum *Eucalyptus* aff. *cypellocarpa* (Anglesea), Anglesea Grevillea *Grevillea infecunda* and Wrinkled Buttons *Leptorhynchos gatesii* are all endemic to the West region.

Brisbane Ranges National Park

Six priority taxa are known to occur in the Brisbane Ranges National Park. These are Ornate Pink Fingers *Caladenia carnea* var. *ornata*, Yellow Gum *Eucalyptus leucoxylon* ssp. *connata*, Clover Glycine *Glycine latrobeana*, Velvet Daisy-bush *Olearia pannosa* ssp. *cardiophylla*, Scented Bush-pea *Pultenaea graveolens* and Naked Sun-orchid *Thelymitra circumsepta*.

Table 4.1 Conservation Status and Distribution of Rare or Threatened Plants in the West Regional Forest Agreement Region.

(a) Plants listed (or recommended for listing) as threatened under either the Commonwealth *Endangered Species Protection Act* 1992, the *Flora and Fauna Guarantee Act* 1988, or both.

Species Name	Common Name	Conservation Status				% of Australian	Tenure		
		ESP	ROTAP	FFG	VROTS	Range	bcr (%)	opl (%)	pri (%)
Acacia glandulicarpa	Hairy-pod Wattle	V	V	listed	v	0-25%	20	-	80
Allocasuarina luehmannii	Buloke	-	-	listed	v	0-25%	30	20	50
Aphanes australiana	Australian Piert	V	V	-	-	0-25%	30	30	40
Astelia australiana	Tall Astelia	V	V	listed	v	26-50%	-	100	-
Asterolasia phebalioides	Downy Star-Bush	V	V	listed	v	76-100%	50	30	20
Caladenia calcicola	Limestone Spider-orchid	V	V	listed	e	100%	50	-	50
Caladenia concolor	Crimson Spider-orchid	V	V	listed	e	0-25%	-	100	-
Caladenia formosa	Elegant Spider-orchid	V	V	listed	v	51-75%	20	-	80
Caladenia fulva	Tawny Spider-orchid	E	E	listed	e	100%	50	50	-
Caladenia hastata	Mellblom's Spider-orchid	E	E	listed	e	100%	50	-	50
Caladenia tensa	Rigid Spider-orchid	E	E	-	e	0-25%	-	100	-
Caladenia versicolor	Candy Spider-orchid	V	V	-	v	0-25%	-	100	-
Caladenia xanthochila	Yellow-lip Spider-orchid	E	E	listed	e	26-50%	-	-	100
Caleana sp. aff. *nigrita* (Horsham)	Grampians Duck-orchid	-	-	prelim. rec.	e	k	100	-	-
Comesperma polygaloides	Small Milkwort	-	-	listed	v	26-50%	20	20	60
Cullen parvum	Small Scurf-pea	E	E	listed	e	0-25%	-	-	100
Cullen tenax	Tough Scurf-pea	-	-	listed	e	0-25%	-	-	100
Cyathea cunninghamii	Slender Tree-fern	-	R	listed	v	0-25%	50	50	-
Daviesia laevis	Grampians Bitter-pea	V	V	-	v	100%	10	60	30
Discaria pubescens	Hairy Anchor Plant	-	R	listed	v	0-25%	-	100	-
Diuris palustris	Swamp Diuris	-	-	final rec.	v	26-50%	10	30	60
Diuris punctata var. *punctata*	Purple Diuris	-	-	listed	v	26-50%	-	70	30
Dodonaea procumbens	Trailing Hop-bush	V	V	-	v	0-25%	20	50	30
Eucalyptus aff. *cypellocarpa* (Anglesea)	Otway Grey Gum	-	-	not eligible	v	100%	80	20	-
Eucalyptus aggregata	Black Gum	-	-	listed	e	51-75%	-	30	70
Eucalyptus leucoxylon ssp. *connata*	Yellow Gum	-	-	not eligible	v	76-100%	10	10	80
Euphrasia collina ssp. *muelleri*	Purple Eyebright	E	-	final rec.	e	0-25%	50	-	50
Glycine latrobeana	Clover Glycine	V	V	listed	v	51-75%	30	10	60
Grevillea floripendula	Drooping Grevillea	-	R	final rec.	v	100%	20	50	30
Grevillea infecunda	Anglesea Grevillea	V	V	-	v	100%	60	30	10
Grevillea williamsonii	Mt. William Grevillea	E	E	-	e	100%	50	-	50
Isolepis congrua	Slender Club-sedge	-	-	final rec.	v	0-25%	80	20	-
Leptorhynchos gatesii	Wrinkled Buttons	V	V	final rec.	v	100%	50	20	30
Olearia pannosa ssp. *cardiophylla*	Velvet Daisy-bush	-	R	listed	v	26-50%	60	10	30
Prasophyllum diversiflorum	Gorae Leek-orchid	E	E	listed	e	100%	-	-	100
Prasophyllum fitzgeraldii	Fitzgerald's Leek-orchid	-	-	final rec.	e	51-75%	70	-	30
Prasophyllum frenchii	Maroon Leek-orchid	V	V	final rec.	e	26-50%	-	10	90
Prasophyllum lindleyanum	Green Leek-orchid	-	-	rejected	v	51-75%	40	10	50
Prasophyllum subbisectum	Pomonal Leek-orchid	E	E	listed	e	100%	100	-	-
Pterostylis cheraphila	Floodplain Rustyhood	-	R	listed	v	26-50%	-	-	100
Ptilotus erubescens	Hairy Tails	-	-	listed	0	26-50%	20	20	60
Pultenaea graveolens	Scented Bush-pea	-	-	listed	v	76-100%	10	-	90

Species Name	Common Name	Conservation Status				% of Australian Range	Tenure		
		ESP	ROTAP	FFG	VROTS		bcr (%)	opl (%)	pri (%)
Rutidosis leptorhynchoides	Button Wrinklewort	E	E	listed	e	26-50%	-	20	80
Senecio macrocarpus	Large-fruit Fireweed	V	V	listed	e	51-75%	10	10	80
Swainsona brachycarpa	Slender Swainson-pea	-	-	listed	v	26-50%	70	30	-
Swainsona swainsonioides	Downy Swainson-pea	-	-	prelim. rec.	e	26-50%	-	-	100
Taraxacum cygnorum	Coast Dandelion	V	V	listed	e	51-75%	100	-	-
Thelymitra epipactoides	Metallic Sun-orchid	E	E	listed	e	76-100%	80	20	-
Thelymitra mackibbinii	Brilliant Sun-orchid	V	V	-	e	51-75%	50	50	-
Thelymitra matthewsii	Spiral Sun-orchid	V	V	listed	v	51-75%	60	20	20
Thelymitra merraniae	Merran's Sun-orchid	-	-	listed	e	0-25%	k	k	k
Thelymitra sp. aff. *pauciflora* (Anglesea)	Anglesea Sun-orchid	-	-	rejected	v	100%	-	80	20

(b) Other Priority Taxa

Species Name	Common Name	Conservation Status				% of Australian Range	Tenure		
		ESP	ROTAP	FFG	VROTS		bcr (%)	opl (%)	pri (%)
Amyema linophylla ssp. *orientale*	Buloke Mistletoe	-	-	-	v	0-25%	10	-	90
Atriplex stipitata	Kidney Saltbush	-	-	-	v	0-25%	-	-	100
Bertya findlayi	Mountain Bertya	-	R	-	v	26-50%	-	100	-
Brachyscome debilis	Weak Daisy	-	-	-	v	0-25%	50	20	30
Caladenia carnea var. *ornata*	Ornate Pink Fingers	-	-	-	v	26-50%	100	-	-
Caladenia fragrantissima ssp. *fragrantissima*	Scented Spider-orchid	-	R	-	e	26-50%	-	-	100
Caladenia lindleyana	Wine-lipped Spider-orchid	-	K	-	v	0-25%	-	100	-
Caladenia reticulata s.s.	Veined Spider-orchid	-	-	-	v	0-25%	70	30	-
Caladenia valida	Robust Spider-orchid	-	R	-	e	0-25%	-	-	100
Callitris glaucophylla	White Cypress-pine	-	-	-	v	0-25%	30	-	70
Calorophus elongatus	Long Rope-rush	-	-	-	v	0-25%	k	k	k
Craspedia paludicola	Swamp Billy-buttons	-	-	-	v	26-50%	20	-	80
Deyeuxia imbricata	Bent-grass	-	-	-	v	0-25%	30	50	20
Dianella callicarpa	Swamp Flax-lily	-	-	-	v	100%	30	60	10
Dianella longifolia var. *grandis*	Pale Flax-lily	-	-	-	v	0-25%	-	-	100
Digitaria divaricatissima	Umbrella Grass	-	-	-	v	0-25%	100	-	-
Dipodium campanulatum	Bell-flower Hyacinth-orchid	-	K	-	e	26-50%	40	-	60
Diuris behrii	Golden Cowslips	-	-	-	v	26-50%	-	-	100
Eremophila deserti	Turkey-bush	-	-	-	v	0-25%	30	10	60
Eucalyptus diversifolia ssp. *megacarpa*	Coast Gum	-	-	-	v	100%	-	30	70
Eucalyptus fasciculosa	Pink Gum	-	-	-	v	0-25%	10	40	50
Eucalyptus leucoxylon ssp. *megalocarpa*	Yellow Gum	-	-	-	e	26-50%	-	20	80
Eucalyptus phenax	Green-leaf Mallee	-	-	-	v	0-25%	100	-	-
Gaultheria hispida	Snow-berry	-	-	-	e	0-25%	-	100	-
Genoplesium sp. aff. *nudiscapum*	Gellibrand Midge-orchid	-	-	-	e	100%	100	-	-
Grammitis magellanica ssp. *nothofageti*	Beech Finger-fern	-	-	-	v	51-75%	20	80	-
Grevillea bedggoodiana	Enfield Grevillea	-	R	-	v	100%	-	40	60
Grevillea montis-cole ssp. *brevistyla*	Langi Ghiran Grevillea	-	R	-	v	100%	70	-	30
Haegiela tatei	Small Nut-heads	-	K	-	v	0-25%	100	-	-
Haloragis exalata ssp. *exalata* var. *exalata*	Square Raspwort	-	-	-	v	100%	40	-	60
Helichrysum aff. *rutidolepis* (Lowland Swamps)	Pale Swamp Everlasting	-	-	-	v	51-75%	-	-	100
Hibbertia sessiliflora	Heathy Guinea-flower	-	-	-	v	51-75%	100	-	-

Species Name	Common Name	Conservation Status				% of Australian Range	Tenure		
		ESP	ROTAP	FFG	VROTS		bcr (%)	opl (%)	pri (%)
Huperzia varia	Long Clubmoss	-	-	-	v	0-25%	80	20	-
Leptorhynchos elongatus	Lanky Buttons	-	-	-	e	0-25%	40	30	30
Leptorhynchos waitzia	Button Immortelle	-	-	-	v	0-25%	50	-	50
Maireana aphylla	Leafless Bluebush	-	-	-	v	0-25%	-	-	100
Olearia suffruticosa	Clustered Daisy-bush	-	-	-	v	0-25%	50	50	-
Pneumatopteris pennigera	Lime Fern	-	-	-	v	51-75%	70	10	20
Pomaderris halmaturina ssp. *continentis*	Glenelg Pomaderris	-	R	-	v	51-75%	50	30	20
Pultenaea williamsoniana	Williamson's Bush-pea	-	R	-	v	100%	100	-	-
Ranunculus undosus	Swamp Buttercup	-	-	-	v	0-25%	50	50	-
Santalum acuminatum	Sweet Quandong	-	-	-	v	0-25%	100	-	-
Senecio psilocarpus	Swamp Fireweed	-	-	-	v	k	-	40	60
Sporobolus creber	Western Rat-tail Grass	-	-	-	v	0-25%	-	100	-
Templetonia stenophylla	Leafy Templetonia	-	-	-	v	26-50%	30	20	50
Thelymitra benthamiana	Blotched Sun-orchid	-	-	-	v	26-50%	70	10	20
Thelymitra circumsepta	Naked Sun-orchid	-	-	-	v	26-50%	80	-	20
Thelymitra ixioides var. *subdifformis*	Green Sun-orchid	-	-	-	e	51-75%	-	100	-
Tmesipteris elongata ssp. *elongata*	Slender Fork-fern	-	-	-	v	51-75%	30	70	-

ESP, *Endangered Species Protection Act* 1992 (E = endangered, V = vulnerable). **ROTAP**, Rare or Threatened Australian Plant (E = endangered, V = vulnerable, R = rare). **FFG**, *Flora and Fauna Guarantee Act* 1988 (listed = taxon listed under Schedule 2 of the FFG Act, prelim. rec. = taxon has received the Scientific Advisory Committee's preliminary recommendation to be listed under Schedule 2 of the FFG Act, final rec. = taxon has received the Scientific Advisory Committee's final recommendation to be listed under Schedule 2 of the FFG Act, not eligible = recommended but considered by the Scientific Advisory Committee to be ineligible for listing, rejected = taxon nominated but rejected by the Scientific Advisory Committee, delisted = taxon delisted from FFG Act). **VROTS**, Victorian Rare or Threatened Species (x = extinct, e = endangered, v = vulnerable). **Tenure**, Tenure of populations (**bcr** = % of regional population occurring in biological conservation reserves, **opl** = % of regional population occurring in other public land, **pri** = % of regional population occurring in private land, **k**=unknown).

4.3 Review of the reservation status of priority flora

4.3.1 Assessment methods

The purpose of this review is to examine the tenure of rare or threatened plant populations within the West region. In this review, plant location data from statewide flora databases and the National Herbarium of Victoria was intersected with land tenure using a geographic information system (GIS). This data was then updated and augmented with current knowledge of the historical and contemporary distribution and abundance of each taxon.

The land tenure categories used are biological conservation reserves (National Parks, State Parks, Reference Areas, Wilderness Park, Flora Reserves, Flora and Fauna Reserves, Wildlife Reserve), other public land (State Forest, uncommitted Crown land and public land reserved for other purposes) and private land. It should be noted that these land tenure categories differ from those used in other analyses in this report.

This review is based on a qualitative rather than quantitative analysis, due to the lack of accurate, verified information on the current size and location of populations. It relies on a combination of recent records and judgement by experts. Each taxon was evaluated according to the proportion of its Australian distribution that occurs within the West region (0-25%, 26-50%, 51-75%, 76-100%) and the proportion, to the nearest decile, that occurs in biological conservation reserves, other public land and private property. Results are presented in Table 4.1.

Plants for which their regional occurrence forms a major part of their distribution

Of the 101 rare or threatened plants in the West region, 61 have more than 25% of their geographic range within the Region. For 39 of these taxa, over half their Australian distribution occurs within the West region and conservation within this area is critical for their long-term survival.

Of the 61 taxa with more than 25% of their geographic range within the region, 25 have at least 50% of their regional population occurring in biological conservation reserves. Eleven of the 19 taxa endemic to the West region fall into this category. These are Limestone Spider-orchid *Caladenia calcicola,* Tawny Spider-orchid *Caladenia fulva,* Mellblom's Spider-orchid *Caladenia hastata,* Otway Grey Gum *Eucalyptus* aff. *cypellocarpa* (Anglesea), Anglesea Grevillea *Grevillea infecunda,* Mt. William Grevillea *Grevillea williamsonii,* Wrinkled Buttons *Leptorhynchos gatesii,* Pomonal Leek-orchid *Prasophyllum subbisectum,* Gellibrand Midge-orchid *Genoplesium* sp. aff. *nudiscapum,* Langi Ghiran Grevillea *Grevillea montis-cole* ssp. *brevistyla* and Williamson's Bush-pea *Pultenaea williamsoniana*. Of these, 3 taxa, viz. Mellblom's Spider-orchid *Caladenia hastata,* Pomonal Leek-orchid *Prasophyllum subbisectum* and Mt. William Grevillea *Grevillea williamsonii,* are listed as endangered and 3 taxa, viz. Anglesea Grevillea *Grevillea infecunda,* Limestone Spider-orchid *Caladenia calcicola* and Wrinkled Buttons *Leptorhynchos gatesii*, are listed as vulnerable, on the *Endangered Species Protection Act* 1992. Limestone Spider-orchid *Caladenia calcicola,* Mellblom's Spider-orchid *Caladenia hastata* and Pomonal Leek-orchid *Prasophyllum subbisectum* are all listed on the *Flora and Fauna Guarantee Act* 1988.

Of the remaining 36 taxa with more than 25% of their geographic range within the region, 9 have greater than 50% of their regional population and 3 an equal highest proportion of their regional population occurring on other public land. Three of these taxa, viz. Anglesea Sun-orchid *Thelymitra* sp. aff. *pauciflora* (Anglesea), Grampians Bitter-pea *Daviesia laevis* and Swamp Flax-lily *Dianella callicarpa*, are endemic to the region. Grampians Bitter-pea *Daviesia laevis* is listed on the *Endangered Species Protection Act* 1992. One taxon, Drooping Grevillea *Grevillea floripendula*, a regional endemic, has 50% of its regional population occurring on other public land.

Twenty-four taxa, or 39% of the 61 taxa with more than 25% of their geographic range within the region, have greater than 50% of their regional population occurring on private land. Seven of these taxa are known to occur only on private land and one of these, Gorae Leek-orchid *Prasophyllum diversiflorum,* is endemic to the region. This taxon is listed as endangered on the *Endangered Species Protection Act* 1992 and is listed on the *Flora and Fauna Guarantee Act* 1988. Another 17 taxa occur predominantly on private land. Of these, Coast Gum *Eucalyptus diversifolia* ssp. *megacarpa,* Square Raspwort *Haloragis exalata* ssp. *exalata* var. *exalata* and Enfield Grevillea *Grevillea bedggoodiana* are endemic to the region. None are listed under the *Endangered Species Protection Act* 1992 or the *Flora and Fauna Guarantee Act* 1988. Two taxa, viz. Leafy Templetonia *Templetonia stenophylla* and Green Leek-orchid *Prasophyllum lindleyanum*, have 50% of their regional population occurring on private land.

The nature of the tenure of two taxa, Merran's Sun-orchid *Thelymitra merraniae* and Long Rope-rush *Calorophus elongatus* remain undetermined. The former taxon is listed on the *Flora and Fauna Guarantee Act* 1988.

4.4 Vulnerability analysis of priority flora

4.4.1 Assessment methods

The vulnerability assessment is designed to identify those rare or threatened plants that are at greatest risk of further significant decline and potential extinction as a result of activities, ongoing threatening processes and catastrophic events in the West region. Note that this assessment is confined to each taxon's West region distribution and does not necessarily accord with its overall vulnerability, which is generally reflected by its status at a national or statewide level (see Table 4.1)

Quantitative criteria such as those endorsed by the IUCN (IUCN 1994) provide a recognised and internationally accepted set of criteria with which to assess the risk of extinction. The criteria are most appropriately applied to taxa at a global scale but can be used at a regional or national scale. For rating as Critically Endangered (CR), Endangered (EN) or Vulnerable (VU) there is a range of quantitative criteria: RULES A to E (IUCN 1994). Meeting any one of these criteria qualifies a taxon for rating at that level of threat. The different criteria are derived from a wide review aimed at detecting risk factors across the broad range of organisms and the diverse life histories they exhibit. A taxon is considered Lower Risk (LR) when it has been evaluated but does not satisfy the criteria for any of the Critically Endangered, Endangered or Vulnerable categories. A taxon is considered Data Deficient (DD) when there is inadequate information to make a direct or indirect assessment of its risk of extinction based on its distribution and/or population status (IUCN 1994).

The IUCN criteria were developed primarily for fauna and there are several difficulties in applying them to flora (IUCN 1994). Recently, Keith (1998) critically reviewed the IUCN Red List criteria and developed a modified system called 'RARE' (Rules for the Assessment of the Risk of Extinction in vascular plants). The modifications included smaller distributional thresholds appropriate to sessile organisms, inclusion of life-history and land-based attributes, an amendment to account for skewed metapopulation structure and inclusion of an additional rule (RULE F) to address number of populations and qualitatively define classes of threatening processes. For the West region vulnerability assessment, the vulnerability for priority taxa was evaluated using both the IUCN and RARE rule sets. Precedence is given to the IUCN rating in this assessment because RARE has just recently been published and has not been discussed within the broader scientific community.

As a means of improving the efficiency of evaluating a large number of plants for both the IUCN and RARE rule sets, the rules were re-interpreted as a series of explicit questions to avoid collecting the same data twice and a series of decision trees developed so that each rule could be evaluated using a computer. A software package, called ConStat98, was then developed to allow large data sets to be imported, analysed and presented quickly. Data output was in two forms: Taxon Assessment Sheets or a summary table. Taxon Assessment Sheet lists a taxon's overall rating, the rating for each rule and the sub-criteria used to establish the overall rating for both the IUCN and RARE rule sets. A modified version of the summary table is presented in Table 4.2.

4.4.2 Overview of vulnerability analysis

Of the 101 priority taxa considered in this study, sufficient information was available to analyse 100 taxa. Thirty-two taxa were rated as Critically Endangered, 38 rated as Endangered, 29 rated as Vulnerable (Table 4.2) and 1, viz. Clover Glycine *Glycine latrobeana*, rated as Lower Risk. Rating using the IUCN rule set (IUCN 1994) was primarily based on satisfying RULES D, B, A AND C in that order. Rating using the RARE rule set (Keith 1998) was based on satisfying RULES A, E, C, B and D in that order. All plants were rated as Data Deficient for RULE E using the IUCN rule set, as there was insufficient information available to satisfy any one of the criteria.

RULE D rates taxa based on the estimated number of mature individuals alone, RULE B rates taxa based on a combination of extent of occurrence or area of occupancy with indicators of population variability, RULE A rates taxa based on an observed, estimated, inferred or suspected past or future reduction in the regional population, RULE C rates taxa based on the estimated number of mature individuals in combination with estimates of continuing decline in numbers of mature individuals and RULE F rates taxa based on how concentrated the populations of a species are and their exposure to different forms of threat.

For taxa rated as Critically Endangered or Endangered their overall rating was based primarily on satisfying RULE B (IUCN 1994). This contrasts significantly from the Vulnerable taxa for which the overall rating was based almost exclusively on satisfying RULE D. For further details on the categorisation of threatened taxa using the IUCN or RARE rule sets see IUCN (1994) and Keith (1998).

4.4.3 Plants rated 'Critically Endangered' in the West region

The 'Critically Endangered' category signifies the highest risk of extinction in the wild. Thirty-two of the rare or threatened plant taxa evaluated during this assessment were categorised as Critically Endangered according to the IUCN Red List Criteria (IUCN 1994). Most of these have been rated Critically Endangered based on their

very small extent of occurrence or area of occupancy and fragmented population or continuing decline in habitat.

Sixteen of the 32 taxa rated Critically Endangered have more than 25% of their geographic range within the West region, which forms an important part of their distribution. These are Mountain Bertya *Bertya findlayi*, Elegant Spider-orchid *Caladenia formosa*, Scented Spider-orchid *Caladenia fragrantissima* ssp. *fragrantissima*, Mellblom's Spider-orchid *Caladenia hastata*, Yellow-lip Spider-orchid *Caladenia xanthochila*, Golden Cowslips *Diuris behrii*, Purple Diuris *Diuris punctata* var. *punctata*, Otway Grey Gum *Eucalyptus* aff. *cypellocarpa* (Anglesea), Gellibrand Midge-orchid *Genoplesium* sp. aff. *nudiscapum*, Fitzgerald's Leek-orchid *Prasophyllum fitzgeraldii*, Pomonal Leek-orchid *Prasophyllum subbisectum*, Floodplain Rustyhood *Pterostylis cheraphila*, Button Wrinklewort *Rutidosis leptorhynchoides*, Slender Swainson-pea *Swainsona brachycarpa*, Downy Swainson-pea *Swainsona swainsonioides* and Brilliant Sun-orchid *Thelymitra mackibbinii*.

4.4.4 Plants rated 'Endangered' in the West region

The 'Endangered' category signifies that a taxon is facing a very high risk of extinction in the wild. Thirty-eight of the rare or threatened plant taxa evaluated during this assessment were categorised as Endangered according to the IUCN Red List Criteria (1994). Most of these taxa have been rated Endangered based on their low population numbers or their low extent of occurrence with a continuing decline in habitat.

Twenty-five of the 38 taxa rated Endangered have more than 25% of their geographic range within the West region, which forms an important part of their distribution. These are Limestone Spider-orchid *Caladenia calcicola*, Tawny Spider-orchid *Caladenia fulva*, Small Milkwort *Comesperma polygaloides*, Swamp Billy-buttons *Craspedia paludicola*, Swamp Flax-lily *Dianella callicarpa*, Bell-flower Hyacinth-orchid *Dipodium campanulatum*, Swamp Diuris *Diuris palustris*, Black Gum *Eucalyptus aggregata*, Yellow Gum *Eucalyptus leucoxylon* ssp. *megalocarpa*, Beech Finger-fern *Grammitis magellanica* ssp. *nothofageti*, Mt. William Grevillea *Grevillea williamsonii*, Pale Swamp Everlasting *Helichrysum* aff. *rutidolepis* (Lowland Swamps), Lime Fern *Pneumatopteris pennigera*, Gorae Leek-orchid *Prasophyllum diversiflorum*, Maroon Leek-orchid *Prasophyllum frenchii*, Green Leek-orchid *Prasophyllum lindleyanum*, Hairy Tails *Ptilotus erubescens*, Scented Bush-pea *Pultenaea graveolens*, Large-fruit Fireweed *Senecio macrocarpus*, Coast Dandelion *Taraxacum cygnorum*, Blotched Sun-orchid *Thelymitra benthamiana*, Naked Sun-orchid *Thelymitra circumsepta*, Metallic Sun-orchid *Thelymitra epipactoides*, Spiral Sun-orchid *Thelymitra matthewsii* and Anglesea Sun-orchid *Thelymitra* sp. aff. *pauciflora* (Anglesea).

4.4.5 Plants rated as 'Vulnerable' in the West region

The 'Vulnerable' category signifies that a taxon is facing a high risk of extinction in the wild in the medium-term future. Twenty-nine of the rare or threatened plants evaluated during this assessment were categorised as Vulnerable according to the IUCN Red List Criteria (1994). Most of these have been rated as Vulnerable based on their low population numbers or their low area of occupancy.

Eighteen of the 29 taxa rated Vulnerable have more than 25% of their geographic range within the West region, which forms an important part of their distribution. These are Tall Astelia *Astelia australiana*, Downy Star-Bush *Asterolasia phebalioides*, Ornate Pink Fingers *Caladenia carnea* var. *ornata*, Grampians Bitter-pea *Daviesia laevis*, Coast Gum *Eucalyptus diversifolia* ssp. *megacarpa*, Yellow Gum *Eucalyptus leucoxylon* ssp. *connata*, Enfield Grevillea *Grevillea bedggoodiana*, Drooping Grevillea *Grevillea floripendula*, Anglesea Grevillea *Grevillea infecunda*, Langi Ghiran Grevillea *Grevillea montis-cole* ssp. *brevistyla*, Square Raspwort *Haloragis exalata* ssp. *exalata* var. *exalata*, Heathy Guinea-flower *Hibbertia sessiliflora*, Velvet Daisy-bush *Olearia pannosa* ssp. *cardiophylla*, Glenelg Pomaderris *Pomaderris halmaturina* ssp. *continentis*, Williamson's Bush-pea *Pultenaea williamsoniana*, Leafy Templetonia *Templetonia stenophylla*, Green Sun-orchid *Thelymitra ixioides* var. *subdifformis* and Slender Fork-fern *Tmesipteris elongata* ssp. *elongata*.

Table 4.2 The results of the vulnerability analysis carried out by ConStat 98.

(a) Plants rated as Critically Endangered in the West region according to the IUCN Red List Categories (IUCN 1994).

TAXON	IUCN	RARE
Allocasuarina luehmannii	CR	EN
Bertya findlayi	CR	CR
Caladenia concolor	CR	CR
Caladenia formosa	CR	EN
Caladenia fragrantissima ssp. *fragrantissima*	CR	CR
Caladenia hastata	CR	VU
Caladenia lindleyana	CR	CR
Caladenia reticulata s.s.	CR	VU
Caladenia tensa	CR	CR
Caladenia valida	CR	CR

TAXON	IUCN	RARE
Eucalyptus aff. *cypellocarpa* (Anglesea)	CR	EN
Euphrasia collina ssp. *muelleri*	CR	VU
Gaultheria hispida	CR	CR
Genoplesium sp. aff. *nudiscapum*	CR	CR
Haegiela tatei	CR	EN
Leptorhynchos elongatus	CR	VU
Maireana aphylla	CR	CR
Prasophyllum fitzgeraldii	CR	VU
Prasophyllum subbisectum	CR	CR
Pterostylis cheraphila	CR	CR

TAXON	IUCN	RARE
Caladenia versicolor	CR	CR
Caladenia xanthochila	CR	CR
Caleana sp. aff. *nigrita* (Horsham)	CR	CR
Discaria pubescens	CR	VU
Diuris behrii	CR	VU
Diuris punctata var. *punctata*	CR	VU

TAXON	IUCN	RARE
Rutidosis leptorhynchoides	CR	DD
Sporobolus creber	CR	CR
Swainsona brachycarpa	CR	EN
Swainsona swainsonioides	CR	EN
Thelymitra mackibbinii	CR	VU
Thelymitra merraniae	CR	EN

(b) Plants rated as Endangered in the West region according to the IUCN Red List Categories (IUCN 1994).

TAXON	IUCN	RARE
Acacia glandulicarpa	EN	VU
Aphanes australiana	EN	DD
Atriplex stipitata	EN	VU
Caladenia calcicola	EN	VU
Caladenia fulva	EN	EN
Callitris glaucophylla	EN	DD
Calorophus elongatus	EN	VU
Comesperma polygaloides	EN	LR
Craspedia paludicola	EN	LR
Cullen parvum	EN	VU
Cullen tenax	EN	VU
Deyeuxia imbricata	EN	VU
Dianella callicarpa	EN	VU
Dipodium campanulatum	EN	VU
Diuris palustris	EN	DD
Dodonaea procumbens	EN	VU
Eucalyptus aggregata	EN	LR
Eucalyptus leucoxylon ssp. *megalocarpa*	EN	VU
Grammitis magellanica ssp. *nothofageti*	EN	CR

TAXON	IUCN	RARE
Grevillea williamsonii	EN	VU
Helichrysum aff. *rutidolepis* (Low. Swps.)	EN	VU
Huperzia varia	EN	VU
Olearia suffruticosa	EN	EN
Pneumatopteris pennigera	EN	VU
Prasophyllum diversiflorum	EN	VU
Prasophyllum frenchii	EN	DD
Prasophyllum lindleyanum	EN	DD
Ptilotus erubescens	EN	VU
Pultenaea graveolens	EN	VU
Ranunculus undosus	EN	EN
Senecio macrocarpus	EN	VU
Senecio psilocarpus	EN	DD
Taraxacum cygnorum	EN	EN
Thelymitra benthamiana	EN	LR
Thelymitra circumsepta	EN	VU
Thelymitra epipactoides	EN	VU
Thelymitra matthewsii	EN	VU
Thelymitra sp. aff. *pauciflora* (Anglesea)	EN	VU

(c) Plants rated as vulnerable in the West region according to the IUCN Red List Categories (IUCN 1994).

TAXON	IUCN	RARE
Amyema linophylla ssp. *orientale*	VU	VU
Astelia australiana	VU	CR
Asterolasia phebalioides	VU	DD
Brachyscome debilis	VU	VU
Caladenia carnea var. *ornata*	VU	VU
Cyathea cunninghamii	VU	VU
Daviesia laevis	VU	DD
Dianella longifolia var. *grandis*	VU	CR
Digitaria divaricatissima	VU	VU
Eremophila deserti	VU	DD
Eucalyptus diversifolia ssp. *megacarpa*	VU	VU
Eucalyptus fasciculosa	VU	VU
Eucalyptus leucoxylon ssp. *connata*	VU	DD
Eucalyptus phenax	VU	VU
Grevillea bedggoodiana	VU	EN

TAXON	IUCN	RARE
Grevillea floripendula	VU	VU
Grevillea infecunda	VU	VU
Grevillea montis-cole ssp. *brevistyla*	VU	VU
Haloragis exalata ssp. *exalata* var. *exalata*	VU	VU
Hibbertia sessiliflora	VU	LR
Isolepis congrua	VU	VU
Leptorhynchos waitzia	VU	VU
Olearia pannosa ssp. *cardiophylla*	VU	VU
Pomaderris halmaturina ssp. *continentis*	VU	VU
Pultenaea williamsoniana	VU	LR
Santalum acuminatum	VU	VU
Templetonia stenophylla	VU	DD
Thelymitra ixioides var. *subdifformis*	VU	VU
Tmesipteris elongata ssp. *elongata*	VU	EN

CR = Critically Endangered by either the IUCN or the RARE rule sets. **EN** = Endangered by either the IUCN or the RARE rule sets. **VU** = vulnerable by either the IUCN or the RARE rule sets. **LR** = Lower Risk by either the IUCN or the RARE rule sets. **DD** = inadequate information available to make an assessment of its risk of extinction (Data Deficient).

4.4.6 Conclusion

Taxa with a high priority for management in the West region based on this vulnerability assessment are listed in Table 4.3. Taxa have been included in this list if the Region represents a major part of their distribution (i.e. >25% of Australian distribution occurs within West region) and they have been rated Critically Endangered, Endangered, or Vulnerable in the Region using the criteria published by the IUCN. In total, 63 plants have been identified as having a high regional priority.

As shown in Table 4.1, 7 of these taxa occur solely within a biological conservation reserve and another 11 have more than half their regional distribution within a reserve. Important conservation reserves for these taxa within the West region are the Grampians National Park, Deep Lead Flora and Fauna Reserve, Mount Arapiles-Tooan State Park, Lower Glenelg National Park, Brisbane Ranges National Park, Angahook-Lorne State Park, Melba Gully State Park and Otway National Park Six of these taxa have been listed on the *Flora and Fauna Guarantee Act* 1988. None have an Action Statement prepared. Five taxa, Pomonal Leek-orchid, *Prasophyllum subbisectum*, Anglesea Grevillea *Grevillea infecunda*, Coast Dandelion *Taraxacum cygnorum*, Metallic Sun-orchid *Thelymitra epipactoides* and Spiral Sun-orchid *Thelymitra matthewsii*, are listed on the *Endangered Species Protection Act* 1992.

Three plants are only known from other public land. These are Mountain Bertya *Bertya findlayi*, Tall Astelia *Astelia australiana* and Green Sun-orchid *Thelymitra ixioides* var. *subdifformis*. Tall Astelia *Astelia australiana* is listed on the *Flora and Fauna Guarantee Act* 1998 and *Endangered Species Protection Act* 1992, and has a published Action Statement and draft Recovery Plan. Two other taxa have over half their regional distribution within other public land. These include Purple Diuris *Diuris punctata* var. *punctata* and Anglesea Sun-orchid *Thelymitra*

sp. aff. *pauciflora* (Anglesea). The former has been listed on the *Flora and Fauna Guarantee Act* (1998) but an Action Statement has not been prepared for this taxon.

Seven taxa are known only from private land. These are Scented Spider-orchid *Caladenia fragrantissima* ssp. *fragrantissima,* Yellow-lip Spider-orchid *Caladenia xanthochila*, Golden Cowslips *Diuris behrii*, Pale Swamp Everlasting *Helichrysum* aff. *rutidolepis* (Lowland Swamps), Gorae Leek-orchid *Prasophyllum diversiflorum*, Floodplain Rustyhood *Pterostylis cheraphila* and Downy Swainson-pea *Swainsona swainsonioides*. Floodplain Rustyhood *Pterostylis cheraphila*, Gorae Leek-orchid *Prasophyllum diversiflorum* and Yellow-lip Spider-orchid *Caladenia xanthochila*, are listed on the *Flora and Fauna Guarantee Act* 1998. Gorae Leek-orchid *Prasophyllum diversiflorum* and Yellow-lip Spider-orchid *Caladenia xanthochila*, are also listed on the *Endangered Species Protection Act* 1992. The former taxon has a draft Recovery Plan.

Eighteen further plants have over half their regional distribution occurring on private land. These include Maroon Leek-orchid *Prasophyllum frenchii*, Scented Bush-pea *Pultenaea graveolens,* Yellow Gum *Eucalyptus leucoxylon* ssp. *megalocarpa*, Button Wrinklewort *Rutidosis leptorhynchoides*, Spider-orchid *Caladenia formosa*, Swamp Billy-buttons *Craspedia paludicola*, Yellow Gum *Eucalyptus leucoxylon* ssp. *connata*, Large-fruit Fireweed *Senecio macrocarpus*, Black Gum *Eucalyptus aggregata*, Coast Gum *Eucalyptus diversifolia* ssp. *megacarpa,* Enfield Grevillea *Grevillea bedggoodiana* Fireweed *Senecio psilocarpus*, Bell-flower Hyacinth-orchid *Dipodium campanulatum*, Raspwort *Haloragis exalata* ssp. *exalata* var. *exalata*, Clover Glycine *Glycine latrobeana*, Small Milkwort *Comesperma polygaloides*, Hairy Tails *Ptilotus erubescens*, Swamp Diuris *Diuris palustris*. Eight of these, viz. Scented Bush-pea *Pultenaea graveolens*, Clover Glycine *Glycine latrobeana*, Small Milkwort *Comesperma polygaloides*, Elegant Spider-orchid *Caladenia formosa*, Hairy Tails *Ptilotus erubescens*, Button Wrinklewort *Rutidosis leptorhynchoides*, Large-fruit Fireweed *Senecio macrocarpus* and Black Gum *Eucalyptus aggregata*, have been listed on the *Flora and Fauna Guarantee Act* (1998) and the last three have had an Action Statement prepared. Five taxa, viz. Maroon Leek-orchid *Prasophyllum frenchii*, Button Wrinklewort *Rutidosis leptorhynchoides*, Elegant Spider-orchid *Caladenia formosa*, Large-fruit Fireweed *Senecio macrocarpus* and Clover Glycine *Glycine latrobeana* are listed on the *Endangered Species Protection Act* 1992. The Recovery Plan for Button Wrinklewort *Rutidosis leptorhynchoides* was adopted in 1998.

Of the 19 taxa endemic to the West region only one, viz. Wrinkled Buttons *Leptorhynchos gatesii*, had insufficient information to be categorised. Two taxa were ranked as Critically Endangered, viz. Pomonal Leek-orchid *Prasophyllum subbisectum* and Limestone Spider-orchid *Caladenia calcicola.* Pomonal Leek-orchid *Prasophyllum subbisectum* is only known from the Three Jacks Flora and Fauna Reserve near Stawell. Limestone Spider-orchid *Caladenia calcicola* is only known from the Bats Ridge Wildlife Reserve and adjacent private property. Both taxa are listed on the *Flora and Fauna Guarantee Act* 1988 and the *Endangered Species Protection Act* 1992. An Action Statement has been prepared for Limestone Spider-orchid *Caladenia calcicola*.

Six other endemic taxa were ranked as Endangered. These are Tawny Spider-orchid *Caladenia fulva*, Anglesea Sun-orchid *Thelymitra* sp. aff. *pauciflora* (Anglesea), Anglesea Grevillea *Grevillea infecunda*, Enfield Grevillea *Grevillea bedggoodiana*, Gorae Leek-orchid *Prasophyllum diversiflorum* and Mt. William Grevillea *Grevillea williamsonii*. Three of these taxa, Anglesea Sun-orchid *Thelymitra* sp. aff. *pauciflora* (Anglesea), Enfield Grevillea *Grevillea bedggoodiana* and Gorae Leek-orchid *Prasophyllum diversiflorum,* are not found within biological conservation reserves. Gorae Leek-orchid *Prasophyllum diversiflorum* is listed on the *Flora and Fauna Guarantee Act* 1988 and the *Endangered Species Protection Act* 1992.

The remaining 10 taxa were ranked as Vulnerable. These are Gellibrand Midge-orchid *Genoplesium* sp. aff. *nudiscapum,* Swamp Flax-lily *Dianella callicarpa,* Otway Grey Gum *Eucalyptus* aff. *cypellocarpa* (Anglesea), Langi Ghiran Grevillea *Grevillea montis-cole* ssp. *brevistyla,* Grampians Bitter-pea *Daviesia laevis,* Mellblom's Spider-orchid *Caladenia hastata,* Williamson's Bush-pea *Pultenaea williamsoniana,* Square Raspwort *Haloragis exalata* ssp. *exalata* var. *exalata,* Drooping Grevillea *Grevillea floripendula,* Coast Gum *Eucalyptus diversifolia* ssp. *megacarpa*. Less than half of the distribution of five of these taxa, viz. Swamp Flax-lily *Dianella callicarpa,* Drooping Grevillea *Grevillea floripendula,* Grampians Bitter-pea *Daviesia laevis*, Coast Gum *Eucalyptus diversifolia* ssp. *megacarpa* and Square Raspwort *Haloragis exalata* ssp. *exalata* var. *exalata,* was within biological conservation reserves. Of these only Grampians Bitter-pea *Daviesia laevis* is listed on the *Endangered Species Protection Act* 1992.

Management

Both the Commonwealth *Endangered Species Protection Act* 1992 (ESP Act) and the Victorian *Flora and Fauna Guarantee Act* 1988 (FFG Act) include provisions for the preparation of management plans for listed taxa. Recovery Plans and Action Statements outline the actions necessary to maximise the long-term prospects for survival of the taxon in the wild. It should be noted that the implementation of management actions is dependent on available resourcing and priorities within and between taxa.

The Department of Natural Resources and Environment has developed a simple monitoring form and database (VROTPop) for rare and threatened plant populations. It is envisaged that the use of this form and database will expand to the point where the major populations of all threatened plants will be regularly monitored. Active habitat management (environmental weed control, exclusion of predators or browsers and ecological burning) is the most common form of management being implemented for taxa whose habitat is degrading or where direct external threats are operating. Where populations have declined to critical levels, active population management techniques (population reinforcement, reintroduction, translocation and artificial pollination) are sometimes recommended. Table 4.3 summarises the status of management planning for high priority listed taxa, further specific information on management planning, monitoring and habitat and population management for these and other listed plant taxa is available in Appendix E.

Table 4.3 Plant Taxa with high Regional priority for management action.

TAXON	IUCN	RARE	ESP	ROTAP	FFG	VROTS	Action Statement	Recovery Plan
Astelia australiana	VU	CR	V	V	listed	v	publ. 1991	Completed
Asterolasia phebalioides	VU	DD	V	V	listed	v	-	-
Bertya findlayi	CR	CR	-	R	-	v	-	-
Caladenia calcicola	CR	CR	V	V	listed	e	publ. 1992	-
Caladenia carnea var. *ornata*	VU	EN	-	-	-	v	-	-
Caladenia formosa	VU	EN	V	V	listed	v	-	To be prepared
Caladenia fragrantissima ssp. *fragrantissima*	VU	EN	-	R	-	e	-	-
Caladenia fulva	EN	VU	E	E	listed	e	-	-
Caladenia hastata	VU	EN	E	E	listed	e	-	Completed
Caladenia xanthochila	VU	EN	E	E	listed	e	-	To be prepared
Caleana sp. aff. *nigrita* (Horsham)	VU	EN	-	-	prelim. rec.	e	-	-
Comesperma polygaloides	EN	LR	-	-	listed	v	-	-
Craspedia paludicola	VU	EN	-	-	-	v	-	-
Daviesia laevis	VU	EN	V	V	-	v	-	-
Dianella callicarpa	VU	EN	-	-	-	v	-	-
Dipodium campanulatum	VU	EN	-	K	-	e	-	-
Diuris behrii	CR	VU	-	-	-	v	-	-
Diuris palustris	EN	DD	-	-	final rec.	v	-	-
Diuris punctata var. *punctata*	CR	VU	-	-	listed	v	-	-
Eucalyptus aff. *cypellocarpa* (Anglesea)	VU	EN	-	-	not eligible	v	-	-
Eucalyptus aggregata	EN	LR	-	-	listed	e	publ. 1997	-
Eucalyptus diversifolia ssp. *megacarpa*	VU	VU	-	-	-	v	-	-
Eucalyptus leucoxylon ssp. *connata*	VU	EN	-	-	not eligible	v	-	-
Eucalyptus leucoxylon ssp. *megalocarpa*	VU	EN	-	-	-	e	-	-
Genoplesium sp. aff. *nudiscapum*	VU	EN	-	-	-	e	-	-
Glycine latrobeana	LR	LR	V	V	listed	v	-	-
Grammitis magellanica ssp. *nothofageti*	EN	VU	-	-	-	v	-	-
Grevillea bedggoodiana	EN	VU	-	R	-	v	-	-
Grevillea floripendula	VU	VU	-	R	final rec.	v	-	-
Grevillea infecunda	EN	VU	V	V	-	v	-	-
Grevillea montis-cole ssp. *brevistyla*	VU	EN	-	R	-	v	-	-
Grevillea williamsonii	EN	VU	E	E	-	e	-	Completed
Haloragis exalata ssp. *exalata* var. *exalata*	VU	VU	-	-	-	v	-	-
Helichrysum aff. *rutidolepis* (Lowland Swamps)	VU	EN	-	-	-	v	-	-
Hibbertia sessiliflora	VU	LR	-	-	-	v	-	-
Leptorhynchos gatesii	DD	LR	V	V	final rec.	v	-	-
Olearia pannosa ssp. *cardiophylla*	VU	VU	-	R	listed	v	-	-
Pneumatopteris pennigera	EN	VU	-	-	-	v	-	-
Pomaderris halmaturina ssp. *continentis*	EN	VU	-	R	-	v	-	-
Prasophyllum diversiflorum	EN	VU	E	E	listed	e	-	Draft completed
Prasophyllum fitzgeraldii	VU	EN	-	-	final rec.	e	-	-
Prasophyllum frenchii	EN	DD	V	V	final rec.	e	-	-
Prasophyllum lindleyanum	EN	DD	-	-	rejected	v	-	-
Prasophyllum subbisectum	CR	CR	E	E	listed	e	-	-
Pterostylis cheraphila	EN	VU	-	R	listed	v	-	-
Ptilotus erubescens	EN	VU	-	-	listed	0	-	-
Pultenaea graveolens	EN	VU	-	-	listed	v	-	-
Pultenaea williamsoniana	VU	LR	-	R	-	v	-	-
Rutidosis leptorhynchoides	CR	DD	E	E	listed	e	publ. 1992	Adopted 1998
Senecio macrocarpus	EN	VU	V	V	listed	e	publ. 1996	-
Senecio psilocarpus	VU	EN	-	-	-	v	-	-
Swainsona brachycarpa	CR	EN	-	-	listed	v	-	-
Swainsona swainsonioides	CR	EN	-	-	prelim. rec.	e	-	-
Taraxacum cygnorum	EN	EN	V	V	listed	e	-	-

TAXON	IUCN	RARE	ESP	ROTAP	FFG	VROTS	Action Statement	Recovery Plan
Templetonia stenophylla	VU	DD	-	-	-	v	-	-
Thelymitra benthamiana	EN	VU	-	-	-	v	-	-
Thelymitra circumsepta	EN	VU	-	-	-	v	-	-
Thelymitra epipactoides	EN	VU	E	E	listed	e	-	-
Thelymitra ixioides var. *subdifformis*	VU	EN	-	-	-	e	-	-
Thelymitra mackibbinii	CR	VU	V	V	-	e	-	-
Thelymitra matthewsii	EN	VU	V	V	listed	v	-	-
Thelymitra sp. aff. *pauciflora* (Anglesea)	EN	VU	-	-	rejected	v	-	-
Tmesipteris elongata ssp. *elongata*	VU	EN	-	-	-	v	-	-

IUCN, Regional conservation status based on IUCN rule set (CR=Critically Endangered, EN=Endangered, VU=vulnerable). **RARE**, Regional conservation status based on RARE rule set (CR=Critically Endangered, EN=Endangered, VU=vulnerable). **ESP**, Taxon listed on Schedule 1 of the *Endangered Species Protection Act* 1992 (E=endangered, V=vulnerable). **ROTAP**, Rare or Threatened Australian Plant Conservation Status (E=endangered, V=vulnerable, R=rare, K=unknown). **FFG**, Taxon listed on Schedule 2 of the *Flora and Fauna Guarantee Act* 1988. **VROTS**, Victorian Rare or Threatened Plant Species Conservation Status (e=endangered, v=vulnerable).

5. TERRESTRIAL FAUNA SPECIES ASSESSMENT

5.1 Introduction

Assessment of terrestrial fauna in the West involved the collation of all relevant information on the distribution, biology and life history characteristics of priority species, the known threates to these species and current management actions that may affect them. This assessment will assist in determining the status of priority forest dependent fauna in the region and provide sufficient information to ensure the legislative and policy requirements for fauna conservation are met in the development of the West Regional Forest Agreement.

Data were gathered from an extensive search of the literature, existing data sets, experts and from new information generated by specialist projects inluding a broad scale regional survey of terrestrial fauna and a series of projects targeted at key threatened fauna (see sections 5.3 And 5.5). Critical life history attributes and population parameters were developed with the assistance of local and national experts in the field of population ecology. The information collected fell into two categories:

- life history attributes, population parameters and habitat components; and
- responses to disturbance.

This information is presented fully in Appendix F. It can be incorporated into databases and modelling tools to assist in predicting species' responses to various impacts and disturbances, allow appraisal and refinement of management action and the development of medium and long-term monitoring programs.

5.1.1 Priority species

The assessment of fauna in the West has focused on a selected group of priority species. These species are classified as threatened in Victoria and listed in *Threatened Fauna in Victoria* (NRE 1999a), listed under the Victorian *Flora and Fauna Guarantee Act* 1988 (FFG Act) and the Commonwealth *Endangered Species Protection Act* 1992 (ESP Act). The majority of these priority species are either forest dependent or require a component of their habitat to be within forest or woodland and may be affected by forestry or related activities.

To provide a broader assessment of the status of fauna in the region, a number of species were included because they are representative of taxa at risk from other management activities (not necessarily forestry related) on public or private land. A number of these species are either poorly known and their status in the West is unclear, or are known to be declining.

The terrestrial species included in this assessment are shown in Table 5.1 with conservation status as classified in *Threatened Fauna in Victoria* (NRE 1999a), the existence of Action Statements (for species listed under the FFG Act) and Recovery Plans (for species listed under the ESP Act), and whether the species is secure based on other listings.

The categories and definitions used to describe the threatened status of fauna included on the list are largely based on those developed by the World Conservation Union (IUCN), and are defined as follows:

Threatened: a collective term used to denote taxa that are Critically Endangered, Endangered or Vulnerable. Additional categories used in this list are Lower Risk - near threatened and Data Deficient.

(C) Critically Endangered: A taxon is Critically Endangered when it is facing an extremely high risk of extinction in the wild in the immediate future.

(E) Endangered: A taxon is Endangered when it is not Critically Endangered but is facing a very high risk of extinction in the wild in the near future.

(V) Vulnerable: A Taxon is Vulnerable when it is not Critically Endangered or Endangered but is facing a high risk of extinction in the wild in the medium-term future.

(R) Rare: Taxa with small Victorian populations that are not at present Endangered or Vulnerable but are at risk. These taxa are usually localised within restricted geographical areas or habitats or are thinly distributed over a more extensive range.

(LR) Lower Risk - near threatened: A taxon is Lower Risk - near threatened when it has been evaluated, does not satisfy the criteria for any of the threatened categories, but which is close to qualifying for Vulnerable. In practice, these species are most likely to move into a threatened category should current declines continue or catastrophes befall the species.

(D) Data Deficient: A taxon is Data Deficient when there is inadequate information to make a direct or indirect assessment of its risk of extinction based on its distribution or population status. Listing of taxa in this category indicates that more information is required and acknowledges the possibility that future investigation will show that a threatened classification is appropriate.

In practice, these threat categories may include species whose populations are beginning to recover as a result of remedial action, but whose recovery is insufficient to justify their transfer to another category.

Other listings include the threatened species lists or legislated lists of all States and Territories, other than Victoria, where the species occur. Where species are not listed as threatened, rare, insufficiently known or restricted in these States/Territories, they are indicated as secure.

Table 5.1: Terrestrial fauna species included in the assessment

Species Name	Common Name	TFV 1999	FFG Status	Action Statement (Vic)	ESP Status	Recovery Plan (C'wlth)	Secure in Other States
Mammals							
Priority species							
Mastacomys fuscus	Broad-toothed Rat	L					No
Dasyurus maculatus	Spot-tailed Quoll	E	L	Yes	V	No	No
Miniopteris schreibersii oceanensis	Eastern Bent-wing Bat	V	L	In prep			Yes
Myotis macropus	Southern Myotis	L					No
Phascogale tapoatafa	Brush-tailed Phascogale	V	L	In prep			No
Petaurus norfolcensis	Squirrel Glider	E	L	In prep			No
Sminthopsis murina	Common Dunnart	D					Yes
Pseudomys fumeus	Smoky Mouse	E	R				No
Pseudomys shortridgei	Heath Mouse	L	L	In prep	E	No	No
Antechinus minimus	Swamp Antechinus	L					Yes
Indicator species							
Potorous tridactylus	Long-nosed Potoroo						Yes
Antechinus flavipes	Yellow-footed Antechinus						Yes
Petaurus australis	Yellow-bellied Glider						No
Sminthopsis leucopus	White-footed Dunnart						No
Scotorepens balstoni	Inland Broad-nosed Bat						Yes
Falsistrellus tasmaniensis	Eastern False Pipistrelle						Yes
Birds							
Priority species							
Xanthomyza phrygia	Regent Honeyeater	C	L	Yes	E	Yes	No
Grantiella picta	Painted Honeyeater	V	L	No			No
Lathamus discolor	Swift Parrot	E	L	In prep	V	Yes	No
Calyptorhynchus banksii graptogyne	Red-tailed Black-Cockatoo	E	L	Yes	E	Yes	No
Dasyornis broadbenti	Rufous Bristlebird	V	L	Yes			No
Burhinus grallarius	Bush Stone-curlew	V	L	In prep			No
Pomatostomus temporalis	Grey-crowned Babbler	E	L	Yes			No
Lophoictinia isura	Square-tailed Kite	E					No
Accipiter novaehollandiae	Grey Goshawk	L					No
Haliaeetus leucogaster	White-bellied Sea-eagle	E	L	Yes			No
Ninox connivens	Barking Owl	E	R	No			No
Ninox strenua	Powerful Owl	E	L	In prep			No
Tyto novaehollandiae	Masked Owl	E	L	In prep			No
Hylacola pyrrhopygia	Chestnut-rumped Heathwren	D					Yes
Chthonicola sagittata	Speckled Warbler	V					Yes
Indicator species							
Alecedo azurea	Azure Kingfisher						No
Melanodryas cucullata	Hooded Robin						Yes
Pachycephala inornata	Gilbert's Whistler						No
Chrysococcyx osculans	Black-eared Cuckoo						Yes
Reptiles							
Priority species							
Aprasia striolata	Striped Worm-lizard	L					?
Varanus varius	Lace Monitor	D					Yes
Egernia coventryi	Swamp Skink	V					Yes
Ramphotyphlops proximus	Woodland Blind Snake	V					Yes
Tympanocryptis diemensis	Anglesea Mountain Dragon	C					No
Indicator species							
Pygopus lepidopodus	Common Scaly-foot						Yes
Amphibians							
Priority species							
Litoria raniformis	Warty Bell Frog	V	X				Yes

Notes: Threatened Fauna in Victoria - 1999 (NRE 1999) - C- critically endangered, E- Endangered, V-vulnerable, L-lower risk near threatened, D-data deficient

***Flora and Fauna Guarantee Act* 1988 (FFG Act):** L-Listed, R-recommended for listing, X-rejected from listing
Commonwealth Endangered Species Protection Act (ESP): E = Endangered; V = Vulnerable.

5.2 Life history and population parameters for fauna species

A number of biological characteristics may predispose a species or population to extinction. These are rarity, population dynamics, spatial dynamics, and life history parameters.

1. Rarity refers to the static qualities of a population: geographic range, abundance and habitat specificity. Species or populations most predisposed to extinction are those that have small geographic ranges, low abundance and narrow habitat specificity.
2. Population dynamics are the dynamic qualities of a population, that is, whether it is increasing, stable or decreasing in size.
3. Spatial dynamics, or metapopulation dynamics, is the interaction between colonisation and extinction of sub-populations that make up a population. The parameters that contribute to the potential risk of extinction of a species through metapopulation collapse are the variability in abundance of individual populations and dispersal ability.
4. Life history parameters are aspects of biology that may predispose a species to the threat of extinction under particular circumstances. The two most important parameters identified are reproductive output and longevity.

Each species listed in Table 5.1 was assigned a rating for the parameters associated with rarity, population dynamics, spatial dynamics, and life history, based on the scores for the contributing factors. A full explanation of the derivation of the parameters is contained in Dexter (1996). Each rating indicates the relative magnitude of the contribution of each parameter to the probability of extinction, as described below.

For the parameters associated with rarity, range size within the West was classified for each species as large, medium or small, based on the geographic coverage of records within the region. Range size was large if the records were located over the majority of the region, medium if the area covered by the records was equal to or less than 50%, and small if records were clustered or confined within a limited area of the region. This parameter was designed to give an indication of the recorded geographic range size of the species within the region. Abundance within the West was classified as high, medium or low, based the number of records on the Atlas of Victorian Wildlife and on expert opinion of the density of individuals within the West. A species may have a large geographic range while at the same time have a low abundance if there is low number of records spread over a large area of the region. Habitat specificity was classified as narrow or wide, based on expert opinion and literature studies of critical habitat components and/or habitat types likely to be used.

When considering the parameters associated with rarity, species or populations with small geographic range, low abundance and narrow habitat specificity are considered more predisposed to the threat of extinction than species with large geographic ranges, high abundance and wide habitat specificity.

Population dynamics were assessed by identifying those species whose numbers have been relatively stable or increased, and those which have declined over a recent time period (the last 10 years). Past population dynamics (from discovery by Europeans until 10 years ago) were also classified for all species as either having increased, declined or remained stable. Stable species and populations are considered to be at a lower risk of extinction as species and populations that are declining. It is also assumed that species that have declined in abundance since their discovery by Europeans, but have had stable abundance in the last 10 years, would have a higher risk of extinction than species that have maintained a stable abundance since their discovery by Europeans. Population trends since European settlement were classified by experts and from relevant literature, and were generally based on the change in the amount of each species' habitat within the West.

Spatial dynamics describes the interaction between colonisation and extinction of sub-populations, and can be assessed using estimates of population variability and dispersal ability. Species were classified as having high or low population variability, based on measures or estimates of changes in abundance over time. Species that have high population variability are more likely to be under threat of extinction than species that have low population variability. Species were classified as having high or low dispersal ability, based on measured dispersal distances or inferences from anatomy (e.g. wings developed for flying long distances). Species with high mobility are more likely to colonise new patches of habitat and are less likely to be threatened by extinction than species that have low mobility.

The two life history parameters considered in this assessment were reproductive output and longevity. Species were classified as having high, medium or low reproductive output, based on measures or estimates of litter or clutch sizes or rates of increase, and as being long or short-lived based on measures or estimates of longevity or inferred from body size. Species that have high reproductive outputs are more likely to recover quickly from major declines in abundance than species with low reproductive outputs. Species that are long-lived tend to be

less susceptible to extinction due to catastrophic events, such as fire and flooding, when abundance is low because of their low adult mortality (compared to species with high adult mortality).

For some species the biological information available for a number of parameters was so limited, classifications could not be made. Parameters with no information were either classified as unknown, or a classification was assigned by experts, based on the most likely estimate.

Results and Discussion

Detailed information on the life history and population dynamics for each species are included in Appendix F. Summarised information for the species included in this review is presented in Table 5.2. The intention of this assessment is to provide a basis for prioritising those species requiring management action to improve the prospects for their long-term survival. This assessment should also be considered in conjunction with the information relating to threatening processes.

Table 5.2: Summary of life history and population dynamics information.

Species	Pop^{n} trend in the last 10 years	Rarity Scores			Spatial Dynamics Score		Life History Parameters Score	
		Geog. Range	Abun-dance	Habitat Specificity	Pop^{n} Varia-bility	Powers of Disper-sal	Repro-ductive Output	Longevity
Mammals								
Broad-toothed Rat	*declined	small	low	medium	*low	unknown	medium	long-lived
Spot-tailed Quoll	declined	large	low	wide	low	*high	medium	unknown
Common Bent-wing Bat	*declined	medium	low	narrow	low	high	low	long-lived
Large-footed Myotis	unknown	large	low	narrow	low	unknown	low	long-lived
Brush-tailed Phascogale	declined	large	low	wide	high	high	high	short-lived
Squirrel Glider	*declined	small	low	wide	unknown	high	low	short-lived
Common Dunnart	*declined	large	low	narrow	unknown	unknown	high	short-lived
Heath Mouse	*declined	small	low	narrow	high	unknown	medium	long-lived
Swamp Antechinus	unknown	medium	low	narrow	high	low	high	short-lived
Long-nosed Potoroo	declined	medium	low	wide	low	unknown	medium	long-lived
Yellow-footed Antechinus	*stable	medium	low	wide	high	unknown	high	short-lived
Yellow-bellied Glider	*declined	medium	low	wide	low	high	low	long-lived
White-footed Dunnart	declined	medium	unknown	wide	unknown	high	high	short-lived
Inland Broad-nosed Bat	unknown	medium	low	wide	low	high	low	long-lived
Eastern False Pipistrelle	unknown	large	low	narrow	low	high	low	long-lived
Birds								
Regent Honeyeater	declined	large	low	narrow	high	high	low	unknown
Painted Honeyeater	*declined	medium	low	narrow	high	high	high	unknown
Swift Parrot	declined	large	low	narrow	high	high	high	*long-lived
Red-tailed Black-Cockatoo	*declined	small	low	narrow	high	high	low	long-lived
Rufous Bristlebird	declined	small	low	narrow	*low	low	low	unknown
Bush Stone-curlew	declined	large	low	narrow	low	*low	low	long-lived
Grey-crowned Babbler	declined	medium	low	wide	low	low	low	short-lived
Square-tailed Kite	unknown	medium	low	wide	unknown	high	low	*long-lived
Grey Goshawk	unknown	large	low	narrow	unknown	high	low	*long-lived
White-bellied Sea-Eagle	unknown	large	low	wide	low	high	low	long-lived
Barking Owl	unknown	large	low	narrow	low	high	low	*long-lived
Powerful Owl	stable	large	low	wide	low	high	low	long-lived
Masked Owl	*declined	medium	low	medium	unknown	high	low	long-lived
Chestnut-rumped Heathwren	unknown	large	low	narrow	unknown	low	low	short-lived
Speckled Warbler	declined	medium	medium	wide	high	low	medium	short-lived
Azure Kingfisher	declined	large	low	narrow	high	unknown	medium	*long-lived
Hooded Robin	declined	large	low	wide	*low	low	low	long-lived
Gilbert's Whistler	declined	medium	low	wide	low	high	low	*long-lived
Black-eared Cuckoo	declined	large	low	medium	high	high	low	unknown
Reptiles								
Striped Worm-lizard	unknown	medium	low	narrow	unknown	low	low	unknown
Lace Monitor	unknown	medium	medium	wide	unknown	unknown	low	*long-lived
Swamp Skink	unknown	large	low	narrow	unknown	low	low	*long-lived
Woodland Blind Snake	unknown	small	low	medium	unknown	low	low	unknown
Mountain Dragon Anglesea form	*declined	small	low	narrow	unknown	low	low	unknown
Common Scaly-foot	unknown	small	low	unknown	unknown	low	low	unknown
Amphibians								
Warty Bell Frog	declined	large	unknown	wide	unknown	unknown	unknown	unknown

* denotes unknown, but most likely classification

The majority of the species assessed have either large or medium geographic ranges within the West (Table 5.2). Eight species had small geographic ranges: Broad-toothed Rat, Squirrel Glider, Heath Mouse, Red-tailed Black-

Cockatoo, Rufous Bristlebird, Woodland Blind Snake, Anglesea Mountain Dragon, and Common Scaly-foot. Species with a small geographic range are more prone to regional extinction as a result of localised disturbance.

As expected for a group of species selected because there is some documented concern for their status, most species have a low abundance. Of the threatened species the Lace Monitor is the only exception; its abundance is classified as medium within the West. Twelve threatened species recorded a low abundance with a large geographic range: Spot-tailed Quoll, Southern Myotis, Brush-tailed Phascogale, Common Dunnart, Regent Honeyeater, Swift Parrot, Bush Stone-curlew, Grey Goshawk, White-bellied Sea-Eagle, Barking Owl, Masked Owl, Chestnut-rumped Heathwren and Swamp Skink. Many of these species have a scattered distribution throughout the region. The Common Dunnart is represented by less than 48 records and was most recently recorded in 1995. Records of the Spot-tailed Quoll, although dotted around the region, are mainly within two areas (Mt Eccles-Lake Condah and the Otway Ranges) (Atlas of Victorian Wildlife).

The majority of non-threatened species covered by this review also have a low abundance (Table 5.2). The Inland Broad-nosed Bat has been recorded from three widely separate locations from the north-east to the north-west of the region and is considered an uncommon species (Lumsden and Bennett 1995). The Hooded Robin, although having a widespread distribution, has disappeared from a number of areas within the West region. This species is declining; particularly from woodland and agricultural areas (Robinson 1993). The Common Scalyfoot has only been recorded from a single location in the West region, west of Dadswell's Bridge (Atlas of Victorian Wildlife).

Many of the species covered by the review were rated as habitat specific. These species often depend on a combination of certain habitat components; the Southern Myotis is always associated with permanent water bodies and requires caves and tree hollows for roosting (Lumsden and Menkhorst 1995); the Regent Honeyeater appears to rely on nectar from a few key eucalypt species and needs this food source to be produced in copious amounts (Franklin *et al.* 1989); the Swamp Skink requires dense ground level vegetation and a humid micro-environment (Clemann 1997). As a result, loss or reduction of a critical habitat component is likely to lead to population declines. Although some species rated a wide habitat specificity, due to their ability to inhabitat a range of forest types, many of these animals require particular componants to be present to be able to survive. A number of species, for example, depend on tree hollows for dens such as the Brush-tailed Phascogale, Inland Broad-nosed Bat, Yellow-bellied Glider and Powerful Owl. The Lace Monitor appears to depend largely on termite nests as egg-laying sites (P. Robertson pers. comm.).

A total of 4 species, Heath Mouse, Red-tailed Black-Cockatoo, Rufous Bristlebird, and Anglesea Mountain Dragon, rate a small geographic range size, a low abundance and have narrow habitat requirements. Consequently, of the species assessed, these species are more predisposed to the threat of extinction within the West based on the rarity parameter. Many of these species exist in small isolated populations making them particularly vulnerable to disturbances, especially stochastic events such as wildfire which can cause local extinctions. Large populations with widespread distributions are better buffered against environmental changes (Bennett *et al.* 1991).

Factors limiting distribution of species can include habitat availability which is especially important when a species has specific habitat requirements. The Broad-toothed Rat is restricted to areas where the annual rainfall exceeds 1000mm (Watts and Aslin 1981) and lives in habitat characterised by the presence of a dense ground layer of grasses, sedges and herbs (Menkhorst 1995f). This species is found only within the Otway Ranges in the West region (Atlas of Victorian Wildlife). The Red-tailed Black-Cockatoo feeds almost exclusively upon the seeds of Brown Stringybark eucalypts (*Eucalyptus baxteri*) and most of its known nest sites are in large deep hollows of dead River Red Gums (*E. camaldulensis*). Most known nesting habitat is on private land (Joseph *et al.* 1991, Venn and Fisher 1993). The Anglesea Mountain Dragon inhabitats coastal heath and heathy woodland; there are eight records of this species in the West region (P. Robertson pers. comm., Atlas of Victorian Wildlife).

Species with high population variability and low powers of dispersal are more prone to metapopulation collapse. Low powers of dispersal limits the ability of species to recolonise areas where local population extinctions have occurred. Species with low powers of dispersal include most of the reptiles, the Swamp Antechinus, and some bird species; the Bush Stone-curlew, Grey-crowned Babbler, Rufous Bristlebird, Chestnut-rumped Heathwren, Hooded Robin and Speckled Warbler. A high population variability and low powers of dispersal in conjunction with either a low reproductive rate or low longevity increases the risk of decline. There are two species with a combination of these parameters; the Swamp Antechinus and Speckled Warbler are both short-lived species. Species with a high reproductive rate can increase from low abundance following disturbances more rapidly than those with low reproductive outputs. Long-lived species are more buffered against sudden population declines than short-lived species as individuals with a longer lifespan are less likely to die due to age (Dexter 1996). The Brush-tailed Phascogale and Yellow-footed Antechinus both have a very short lifespan (about 1 year) which is partially off-set by a high reproductive output (many young are born once a year). However, the short lifespan means it is particularly important that breeding is successful

each year or local populations will become extinct. There are many species for which a number of these parameters are unknown, highlighting a lack of information and a need for species-specific research.

Population trends are the clearest indicators of a species likelihood of extinction. The population trends since European settlement for each species is detailed in Appendix F. The majority of species are thought to have declined in abundance since European settlement, usually as a result of loss of habitat through clearing for agriculture and urban development. Species such as the Squirrel Glider, Bush Stone-curlew and Grey-crowned Babbler are now largely confined to roadside and remnant patches of woodland habitat on private land as a result of widespread clearing of habitat.

For a range of species, the population trend in the past 10 years could not be determined (Table 5.2). This parameter was unknown for all of the reptile species assessed with the exception of the Anglesea Mountain Dragon where a most likely estimate was assigned. This highlights the need for monitoring of populations; the effectiveness of management cannot be assessed if population changes are not recorded. Of the species whose population trend in the past 10 years could be determined, the majority have declined, including a number of the non-threatened species such as the Black-eared Cuckoo and Warty Bell Frog. Although Powerful Owl numbers are thought to have decreased since European settlement (see Appendix F), they appear to have become stable over the past 10 years.

When considering current knowledge of the life history and population parameters presented in Table 5.2, the Heath Mouse, Red-tailed Black-Cockatoo, Rufous Bristlebird and Anglesea Mountain Dragon appear to have combinations of characteristics which indicate a higher risk of extinction. These species have declined in the last 10 years, have small geographic ranges, low abundance and are habitat specific. Population variability is high for the Heath Mouse although its powers of dispersal are unknown. This species has a medium reproductive output and is long-lived. The Rufous Bristlebird has low powers of dispersal and a low reproductive output; longevity is unknown. The Red-tailed Black-Cockatoo has high population variability and a low reproductive output although it is long-lived with high powers of dispersal. The Anglesea Mountain Dragon has low powers of dispersal and a low reproductive output; population variability and longevity are unknown. Based on these parameters these species have the highest management priority. Table 5.2 also highlights gaps in published knowledge of various aspects of these priority species.

5.3 Fauna Survey

A major fauna survey of the West Region has been carried out in preparation for this CRA. A comprehensive report of the study is in preparation; it is reported on briefly here.

Objectives for the study included:

- To provide up-to-date and systematic information on distribution of terrestrial fauna (vertebrates and selected invertebrates), by conducting systematic and stratified surveys and producing a database that is suitable for habitat modelling and will facilitate informed management decisions on conservation of forest wildlife.
- To provide data on wildlife distribution and habitat for completion of Forest Management Plans and to facilitate the completion of Regional Forest Agreements.

5.3.1 Summary

Field surveys for all major fauna groups were conducted throughout the West Victoria RFA region. A total of 122 survey sites were pre-selected in a randomized manner across the study area. Sites were surveyed intensively during the 1998-99 summer period (late October to March), and diurnal birds were also to be assessed during the 1999 winter. These surveys and associated incidental observations detected a total of 215 vertebrates species (146 bird, 24 reptile, 11 amphibian, 21 terrestrial mammal and 13 bat species), and a further 127 species of ants, which were the primary invertebrate group investigated.

Important range extensions were identified for several species, including the Swamp Skink and Southern Freetail Bat. A new population of the little-known Striped Worm-lizard was also identified. These surveys represent the broadest scale regional fauna surveys ever executed in the region, and the data obtained may be very useful in modelling the distribution of specific taxa as an aid to their conservation.

Background

Much of the fauna data that has been used in the CRA process has come from the 'Atlas of Victorian Wildlife'. This data is extensive, and has been compiled over a long period of time, with considerable amounts of data being derived fauna surveys conducted mainly during the 1970s or early 1980s. While this data is useful for detailing the distribution of fauna necessary for the Regional Forest Agreement (RFA) process, contemporary information that has been collected in a systematic manner is also required. For this reason, the biodiversity of West Victoria RFA region was assessed with a series of randomized and stratified fauna surveys targeted to all major vertebrate groups across the whole region.

5.3.2 Site Randomization and Allocation

Sites for fauna surveys were randomly selected using a Data Audit Methodology toolkit developed by 'Environment Australia'. Four environmental variables were used in this stratification process, lithology, mean annual rainfall, mean coldest temperature, and mean warmest temperature. The spatial intersection of these variables and their classes created 56 potentially unique strata that were to be sampled across the West Victoria region. Fauna survey sites were allocated with 23 strata that each covered an area greater than 10,000 ha.

Potential survey sites were identified within these strata using ARC-INFO system by intersecting the strata with forest cover layer. Random sites were allocated within the polygons created by the intersection. The criteria for these sites were that adjacent sites were at least 2 km distant from each other, and no greater than 200 m from a road or track. A total of 894 potential sites were identified within the 23 strata. The number of sites allocated for sampling was proportional to the area of that strata under forest cover. A further five sites were also randomly selected for sampling in forest areas in the Maryborough-Avoca district, as this area was not intensively sampled during the recent 'Box-Ironbark' study. A total of 122 sites were identified across the region to be sampled, where possible, for all fauna groups. One site was not sampled for all taxa, as it was severely disturbed by a wildfire in the Wartok area of the Grampians in January 1999.

Broad Vegetation Types

Although the strata sampled were derived from mapped variables and were capable of being mapped independently, the interpretation of these strata in the field can be problematic. Since plants and vegetation communities respond directly to these same factors (e.g. soil type, temperature, aspect, etc.), and are inherently more tangible and detectable by an observer on-site, the distribution of plant communities was used as a surrogate for the suite of environmental factors. Ideally Ecological Vegetation Classes (EVCs) would have been available, however the coverage for the West region was incomplete at the time the study commenced. Consequently, site allocation took place blind to the distribution and representation of EVCs. Broad Vegetation Types were however available, and groupings of these (Broad Vegetation Communities – BVC) were used as the primary factor in categorizing the distribution of sites in the region and the fauna that were recorded at survey sites.

For a clearer appreciation of the broad distribution of fauna, survey sites were broadly grouped into sub-regions (Wimmera, Grampians, Portland, Midland, and Otway). The allocation of sites within different BVC groupings across these sub-regions is shown in Table 5.3.

Table 5.3 Number of pre-selected survey sites sampled within Broad Vegetation Communities across sub-regions in the Western RFA zone.

BVC grouping	Wimmera	Grampians	Midlands	Otways	Portland	Total
Box - Ironbark Forest		2	5			7
Dry Foothill Forest		8	20			28
Grassy Woodland	4	5	2			11
Heathy Woodland	18	8	2	2	11	41
Lowland Forest				5	11	16
Moist Foothill Forest			5	10		15
Riparian Forest		2	1	1		4
TOTAL	22	25	35	18	22	122

5.3.3 Fauna Assessment

While attempts were made to sample each site for each vertebrate group at each site, this was not always possible. Fauna surveys were conducted at most sites for the following taxonomic groups:

- diurnal birds: spring surveys (winter surveys to be completed by end of June 1999)
- reptiles and amphibians
- terrestrial mammals
- bats
- owls and arboreal mammals
- epigeal invertebrates

Diurnal Birds

Timed 20-minute surveys for diurnal bird were conducted over a six week period between late October and early December 1998 at the 122 pre-selected sites. A total of 109 native bird species and two alien species were recorded at survey sites from counts over a defined 2 ha study plot (Table 5.4). A further ten species were recorded 'off-site' (within similar habitat) and 'far off-site' (sometimes different habitat). These included several raptors recorded on-site (Australian Hobby, Collared Sparrowhawk) and open country birds recorded off-site (Stubble Quail, Brown Falcon, Pallid Cuckoo). Other species (e.g. waterbirds) observed while travelling between RFA sites of western Victoria were recorded as incidental observations.

Spring bird surveys were conducted during a year following a severe two-year drought, and it is likely that this event may have still been exerting some residual effect on certain bird species. Populations of most migrants (e.g. Olive-backed Oriole, cuckoos) appeared lower than expected, and several other species (e.g. White-winged Triller) arrived a month later than normal and were consequently missed at several sites from which they would have been expected to occur.

Table 5.4 Abundance of birds from pre-selected sites within broad BVC groups censused during spring 1998.

Species	Riparian Forest	Moist Foothill Forest	Dry Foothill Forest	Lowland Forest	Grassy Woodland	Heathy Woodland	Box Ironbark Forest	Totals
Emu					2	14		16
Stubble Quail						1		1
Painted Button-quail						1		1
Peaceful Dove					1	1		2
Common Bronzewing			1	3	2	14	3	23
Brush Bronzewing		1		2	1	2		6
Brown Goshawk			1		1	1	1	4
Collared Sparrowhawk	1							1
Wedge-tailed Eagle			2				1	3
Little Eagle						1		1
Square-tailed Kite	1							1
Australian Hobby							1	1
Brown Falcon						1		1
Southern Boobook		1				2		3
Musk Lorikeet	4		6		5	6	11	32
Purple-crowned Lorikeet		3				1	4	8
Little Lorikeet					3		3	6
Red-tailed Black-Cockatoo					4	9		13
Yellow-tailed Black-Cockatoo		9	8	6	5	28		56
Gang-gang Cockatoo	2	3	4	6	2	4		21
Sulphur-crested Cockatoo	7	9	15	8	7	15	2	63
Long-billed Corella	5	2	6	1	16	15	2	47
Galah					5	3		8
Australian King-Parrot	1	6		1				8
Crimson Rosella	3	22	28	20	16	56	3	148
Eastern Rosella					5	6		11
Red-rumped Parrot					15	10	12	37
Blue-winged Parrot		5	3	5		24		37
Australian Owlet-nightjar		1	1			1		3
Laughing Kookaburra	2	9	16	4	16	14	1	62
Sacred Kingfisher	2	1	1	1	3	18		26
Rainbow Bee-eater			2		3	5	1	11
Pallid Cuckoo						1		1
Fan-tailed Cuckoo	2	6	7	5		8		28
Brush Cuckoo		1						1
Black-eared Cuckoo						2		2
Horsfield's Bronze-Cuckoo		1			2	1	1	5
Shining Bronze-Cuckoo	1	5	4	3		4		17
Welcome Swallow					5			5
Tree Martin					2	5	10	17
Grey Fantail	9	29	32	33	14	56	5	178
Rufous Fantail	2	17		3	2			24
Willie Wagtail					10	10	2	22
Leaden Flycatcher			3					3
Satin Flycatcher	3	6	1	1				11
Restless Flycatcher				3	4	7	2	16
Jacky Winter				1	6	23	4	34
Scarlet Robin		2	10	1	1	17	7	38
Red-capped Robin							1	1
Flame Robin		1	3					4
Pink Robin	1	2						3
Rose Robin		1						1
Hooded Robin					1	2		3
Eastern Yellow Robin	4	15	12	20	8	25	3	87
Golden Whistler	3	31	10	26	3	16	1	90
Rufous Whistler	5	9	43	15	6	58	12	148
Gilbert's Whistler					1		1	2
Olive Whistler		5		1				6
Grey Shrike-thrush	1	17	33	16	12	44	10	133
Crested Shrike-tit	1				2	1		4
Crested Bellbird					2		3	5
Black-faced Cuckoo-shrike		6	8	3	4	14	1	36

Species	Riparian Forest	Moist Foothill Forest	Dry Foothill Forest	Lowland Forest	Grassy Woodland	Heathy Woodland	Box Ironbark Forest	Totals
White-bellied Cuckoo-shrike					1			1
White-winged Triller			1		1	1	3	6
Spotted Quail-thrush			1					1
White-browed Babbler					7	6	7	20
Weebill					2		15	17
Southern Whiteface							2	2
Striated Thornbill	5	42	81	51	3	53	2	237
Brown Thornbill	7	28	39	39	11	69		193
Buff-rumped Thornbill	2		31	4	7	51	18	113
Yellow-rumped Thornbill					7	6	4	17
White-browed Scrubwren	3	39	27	33	5	24		131
Chestnut-rumped Heathwren						4		4
Rufous Songlark					2	1		3
Rufous Bristlebird		1		3				4
Southern Emu-wren				1		27		28
Mallee Emu-wren						1		1
Superb Fairy-wren	2	10	27	31	23	105	13	211
Variegated Fairy-wren						3		3
White-browed Woodswallow							8	8
Dusky Woodswallow			2		4	19	4	29
Varied Sittella		3	14	9		25	5	56
Brown Treecreeper	3				21	13	11	48
White-throated Treecreeper	5	27	47	28	6	60	8	181
Red-browed Treecreeper		3	2					5
Mistletoebird	1		1	2	6	15	5	30
Spotted Pardalote	7	23	56	25	12	29	15	167
Silvereye	4	18	2	3		6		33
White-naped Honeyeater	13	31	35	24	6	10	4	123
Black-chinned Honeyeater					1	3	4	8
Brown-headed Honeyeater		15	15	6	1	29	8	74
Eastern Spinebill	5	8	18	15	4	19		69
Tawny-crowned Honeyeater			1			5		6
Singing Honeyeater				1				1
Fuscous Honeyeater	5			1	11		12	29
Yellow-faced Honeyeater	11	24	37	30	22	37	3	164
White-eared Honeyeater	1	6	17	15	3	27		69
Yellow-tufted Honeyeater				1	2		6	9
White-plumed Honeyeater	6				27	7		40
Crescent Honeyeater	2	22	4	7		2		37
New Holland Honeyeater	8		21	4	3	62	6	104
Little Wattlebird				1		1		2
Red Wattlebird	2	15	8	14	15	12	2	68
Spiny-cheeked Honeyeater						1		1
Beautiful Firetail						2		2
Diamond Firetail					3		1	4
Red-browed Finch	7		2	5	10		2	26
Olive-backed Oriole		1		1	3	1		6
Satin Bowerbird		2						2
White-winged Chough			25		2	8	8	43
Pied Currawong	4	8	9	8		10		39
Grey Currawong	2	4	18	4	2	36	7	73
Australian Magpie		1	2	1	8	16	10	38
Bassian Thrush				2				2
Corvid	2	1		2	1	11		17
Forest Raven		8		5	2	2		17
Australian Raven			5	1	2	9	1	18
Little Raven			4		2	5	9	20
Striated Pardalote	3	24	26	18	36	19	10	136
Common Blackbird	2	2	2	1	2			9
European Goldfinch			1	2		3		6
Individuals	**172**	**592**	**841**	**586**	**483**	**1402**	**321**	**4397**
Surveys	**8**	**30**	**50**	**28**	**23**	**75**	**14**	
Total species	**46**	**56**	**60**	**61**	**76**	**89**	**59**	
Species/survey	**11.4**	**10.9**	**8.9**	**11.4**	**10.3**	**10.6**	**11.6**	

Data from spring surveys, and includes both 'off-site', 'far off-site' records,
and general observations either prior to or following formal counts.

Bird censuses were repeated at 90 of 122 fauna survey sites during a two week period June 1999. A total of 1950 individuals of 81 bird species were recorded from during these surveys. Only two new species were recorded from winter surveys, including Whistling Kite and Tawny Frogmouth.

Rare or Threatened Species

Brolga: A single pair of Brolgas was recorded nesting on 31 October 1998 at Nowackis Swamp, south-west of Dergholm. Another bird was seen at a swamp in Morea State Forest, north of Edenhope.

Square-tailed Kite: Approximately half of the Victorian sightings from the last decade of this vulnerable species come from the Midlands and Grampians Ranges. A single bird was observed hunting just above the tree canopy at a valley grassy forest site south of Teddington Reservoir (north-east of Avoca).

Red-tailed Black-Cockatoo: The area from Casterton to Edenhope and east to Balmoral forms the breeding range of this endangered species in Victoria. A total of nine birds were observed at or near six pre-selected sites.

Chestnut-rumped Heathwren: The Edenhope region is a key area for this elusive and rarely encountered species in Victoria. Birds in this study were only positively identified during passive observations after defined surveys at three sites in damp sands herb-rich woodland around Dergholm. A further individual was recorded from dry foothill forest in the Grampians during the winter surveys.

Rufous Bristlebird: This rare species is restricted to the Otways and coastal sections of the Portland region, with distinct sub-species in each district. Observations of single birds were recorded at three sites in the Otways (moist foothill forest; lowland forest, moist foothill forest – winter survey), in the Lower Glenelg region (lowland forest).

Reptiles and Frogs

Diurnal herpetofauna surveys were conducted between November 1998 and March 1999 at 121 sites. Multiple surveys were conducted at each site, a subset of the sites (21) were also visited a second time late in this survey period. Nocturnal frog surveys were conducted at 28 sites subjectively chosen at potential frog breeding habitats (eg. streams, dams, swamps, and forest water points). Data derived from both frog and reptile surveys were supplemented by incidental records, and were further supplemented from the 'by-catch' obtained from mammal hair-tubing and invertebrate pit-fall traps used at survey sites.

Survey Data

Diurnal reptile surveys yielded data from five families (skinks, geckos, dragon lizards, elapid snakes and myobatrachid frogs). The majority of these records were skinks, particularly Garden Skinks and Southern Water Skinks (Table 5.5). The only threatened species recorded during surveys was the Swamp Skink from the Enfield State Forest, south of Ballarat. The habitat at the site was also somewhat atypical for this species which has a more predominantly coastal distribution, with a *Eucalyptus* overstorey, but lacking *Melaleuca* species. Three frog species were also recorded during these surveys, two of which (Victorian Smooth Froglet and Southern Toadlet) were not recorded during nocturnal frog surveys. Three snake species; Little Whip Snake, Eastern Brown Snake and White-lipped Snake were recorded.

Twenty-eight nocturnal frog surveys yielded seven frog species from two families. These included the Southern Bullfrog, Striped Marsh Frog, Spotted Marsh Frog, Plains Froglet, Common Froglet, Southern Brown Tree Frog, and the Growling Grass Frog. The Growling Grass Frog was recorded in the northwest and southwest of the study area, and is the only threatened frog occurring in the study area (Table 5.6). Several frog species (Victorian Smooth Froglet, Southern Toadlet, Common Spadefoot Toad and Peron's Tree Frog) were not recorded during nocturnal frog surveys, but were detected by other means (diurnal herpetofauna surveys, incidental records and invertebrate pit-fall trap by-catch).

Table 5.5 Abundance of reptiles and amphibians from pre-selected survey sites grouped according to BVCs.

Species	Box Ironbark Forest	Dry Foothill Forest	Grassy Woodland	Heathy Woodland	Lowland Forest	Moist Foothill Forest	Riparian Forest	Total
Marbled Gecko	1	1	3	3				8
Tree Dragon	1			4				5
Large Striped Skink	1		1	4				6
Swamp Skink				3				3
White's Skink	2	8		2				12
Three-toed Skink		12	1					13
McCoy's Skink					2	1		3
Garden Skink	9	92	25	26	16	6	4	178
Coventry's Skink		1			5	4		10
Bougainville's Skink	2	10		8				20
Boulenger's Skink	1			1				2
Spencer's Skink				1				1
Blotched Blue-tongued Lizard					1			1
Stumpy-tailed Lizard		1		4				5

Species	Box Ironbark Forest	Dry Foothill Forest	Grassy Woodland	Heathy Woodland	Lowland Forest	Moist Foothill Forest	Riparian Forest	Total
White-lipped Snake					1			1
Eastern Brown Snake	1							1
Little Whip Snake	1	2						3
Southern Water Skink (CTF)		37		12	60	16	6	131
Lowland Copperhead				1				1
Unidentified scincid	1	41	8	43	21	8		122
Unidentified gekkonid		1	4	2				7
Unidentified agamid			1	3				4
Unidentified snake	1	1						2
Southern Grass Skink		1		3	2			6
Unidentified grass skink		1		11	4	1		17
# of surveys	**28**	**152**	**52**	**196**	**60**	**64**	**16**	
Individuals	**21**	**209**	**43**	**134**	**114**	**36**	**10**	

Data includes both 'off-site' and 'far off-site' records, and general observations either prior to or following formal counts

Table 5.6 Frog species detected with Western RFA region.

Species	Sites
Southern Bullfrog	11
Striped Marsh Frog	3
Spotted Marsh Frog	2
Plains Froglet	6
Common Froglet	19
Victorian Smooth Froglet	1
Southern Brown Tree Frog	7
Growling Grass Frog	10
Southern Toadlet	3
Common Spadefoot Toad	3
Peron's Tree Frog	1

Numbers indicate the number of number of sites with positive records from the 28 sites surveyed.

Incidental Records

Incidental records at survey sites yielded a further two reptile species (Carnaby's Wall Skink and Eastern Three-lined Skink) that were not recorded during surveys. The only on-site incidental record of a threatened reptile species was for the Swamp Skink, as detailed above. The Sand Goanna was recorded in the north of the Grampians National Park, and was the first record of this species in the park. The only record of the Black Rock Skink for this study also came from the Grampians. Tiger Snakes, Lowland Copperhead and the Red-bellied Black Snake, were also only recorded incidentally away from study sites.

Other incidental records obtained 'off-site' provided a considerable number of additional species not recorded during surveys, including three threatened species. These included the Growling Grass Frog, Striped Worm-lizard and Four-toed Skink. Prior to this study the Striped Worm-lizard had only been recorded 30 times in Victoria. An incidental search on private property in southwestern Victoria returned 15 of these lizards in the space of approximately one hour. The only other legless lizard recorded during the study, the Olive Legless Lizard, was also recorded twice incidentally, south of Mitre and north-east of Carisbrook. The Four-toed Skink had not been recorded in Victoria for 20 years prior to this study when a single individual was recorded at Discovery Bay Coastal Park. One species, Peron's Tree Frog, was also recorded incidentally at caravan park in Stawell.

Reptiles and frogs were occasionally caught as by-catch in mammal hair tubes and invertebrate pitfall traps, and provided additional survey site specific data. One threatened species, the Swamp Skink, was recorded from hair tubes in the Portland region, and in the northern Otway Ranges. The Metallic Skink was similarly recorded in the Otways Ranges, which was a considerable western range extension for this species. By-catch captured from invertebrate pit-fall traps included two threatened species, and the only records of the Obscure Skink in this study. Threatened species included a Striped Worm-lizard from south of Edenhope, and a Four-toed Skink from east of Dartmoor. This latter record was an inland range extension for the southwestern populations of this skink.

Terrestrial Mammals

Terrestrial mammals were sampled at sites using hair tubes. Fifteen hair tubes were set at each site for a 2 week period. Ten of the hair tubes were baited with a herbivore bait (rolled oats, peanut butter, pistachio essence), while five tubes used a bait more attractive to rare native carnivores such as quolls which included sardines. Hairtubes use a sticky surface to retain body hairs from animals as they try to access an enclosed bait. These hairs are mostly species-specific and can be identified following microscopic analysis. Only 'definite' records of species or genera are shown in the results, and 'likely' or 'possible' records were omitted. Records with a lower

level of reliability generally were for taxa such as brushtail possums, some small rodents (including Swamp and Bush Rats), and small dasyurids including Yellow-footed Antechinus.

Results from these analyses indicate that common species including Agile Antechinus, Echidna, Brushtail Possums, and Black Wallabies were readily detected across a wide range of habitat types (Table 5.7). Single detections were made of a Southern Brown Bandicoot from a site near Portland in western Victoria, and of a Long-nosed Potoroo also in the Portland-Casterton district. A Yellow-footed Antechinus was detected at a site north-east of Portland, which is a minor extension to the range of this species.

Pseudomys spp. are known to occur widely through the Grampians and the far south-west of the state, but were unfortunately not detected in these surveys. While several unidentified rodent species records were obtained in the Grampians region, no definite records of *Pseudomys* spp. or Bush Rats were made, the latter being in accordance with current known distributions (Emison, *et al*. 1978; Menkhorst 1997). Trapping surveys may need to be implemented at a selection of sites to confirm the continued presence of Heath Mouse, Smoky Mouse and Silky Mouse in the Grampians region.

Table 5.7 Detection of small and medium sized terrestrial mammals by hairtubing techniques at pre-selected sites.

Species	Box Ironbark Forest	Dry Foothill Forest	Grassy Woodland	Heathy Woodland	Lowland Forest	Moist Foothill Forest	Riparian Forest
Short-beaked Echidna	1	5	2	1	2	3	1
Yellow-footed Antechinus					1		
Agile Antechinus		20	1	1	2	1	
Unidentified *Antechinus* spp.		2			6		
Southern Brown Bandicoot					2		
Long-nosed Potoroo				1			
Black Wallaby	2	10	2	5		1	
Bush Rat		1		5			
Swamp Rat				1	3		
House Mouse		1		29	10		
Unid. Small rodent		1		1	2	7	
Red Fox				1		1	
Unid. Brushtail possum	3	3	9	16	2	1	2
Number of sites	**7**	**27**	**11**	**40**	**14**	**13**	**5**
Individuals	**6**	**43**	**14**	**61**	**30**	**14**	**3**
Total species	**3**	**8**	**4**	**10**	**9**	**7**	**2**

Numbers indicate the number of sites where positive identification of species were determined.

Predator Scats

An additional method that may allow for the detection of fauna is the analysis of hair and other remains from faecal pellets from predators. This on occasions can detect species that are difficult to detect by other methods. However, as the predators may have consumed their prey some distance from the collection site, some caution must therefore be used in assigning results to a particular BVC group. Other problems associated with this method are that some predators, notably cats, tend to bury their scats. Keeping these caveats in mind, results of analysis of both predator and non-predator scats are tabulated in Table 5.8. Common species recorded from both fox and dog scats include Brushtail Possums, Ringtail Possums, Black Wallabies, and Eastern Grey Kangaroos.

Interesting records from this analysis include the detection of a Southern Brown Bandicoot from a fox scat near Maldon in Central Victoria, and from a site in the Casterton district. The former record constitutes a significant range extension, and deserves further investigation. In addition to these bandicoot records, an unidentified *Perameles* species was recorded from a dog scat at a site near Jancourt. This record was most likely from a Long-nosed Bandicoot considering the habitat at the site, with a less likely possibility being a new record for the now threatened Eastern-barred Bandicoot (J. Seebeck, pers. comm.). Given their historic distributions, the site is one of the few areas where these species may have been sympatric. A further notable record was the detection of a Long-nosed Potoroo from a dog scat from a site within the Lower Glenelg National Park.

Table 5.8 Results of detection of prey species from predator scats retrieved during transects conducted at pre-selected sites.

Species	Box Ironbark Forest	Dry Foothill Forest	Grassy Woodland	Heathy Woodland	Lowland Forest	Moist Foothill Forest	Riparian Forest
Emu		*1*	*1*	*5*			
Short-beaked Echidna	(1)	(1)				(1)	
Agile Antechinus		1		4	1 (1)	1	
Southern Brown Bandicoot		1		1			
Common Ringtail Possum	1 (1)	6 (1)		2 (2)	4 (4) *1*	3 (1)	

Species	Box Ironbark Forest	Dry Foothill Forest	Grassy Woodland	Heathy Woodland	Lowland Forest	Moist Foothill Forest	Riparian Forest
Sugar Glider						1	
Eastern Pygmy-possum		1					
Koala	*1*	(1)					
Long-nosed Potoroo				(1)			
Black Wallaby	1 (2)	3 (11) *2*	1 *1*	1 (3)	1 (1)	2 (1) *1*	
Red-necked Wallaby						1	
Eastern Grey Kangaroo		1 (2)	1	1 (2) *2*	2 (3) *1*		1 *1*
Bush Rat		1				1	
Swamp Rat				1	1 (1)		
European Rabbit	1 (2)	4 (3)		1	(1)	(1)	
Cattle (feral)	1	(1)		1 (1)			
Sheep (feral)	2 (2)	4 (1)		(3)	(2)	1	
Dingo and Dog (feral)		(1)		(2)			
Red Fox	1 *3*	2 *1*	1	*2*	1 *1*	1	*1*
Unidentified *Perameles* spp.					(1)		
Unidentified brushtail possum		3 (2)	1	4	2 (3)	3 (2) *1*	2 *1*
Unidentified *Rattus* sp.		2		(1)		1	
Dog		*1*					

Numbers indicate the number of sites where positive identification of species were determined. Figures in normal type indicate identification from fox scat, figures in brackets indicate source was a dog or dingo scat, figures in italics indicate record from the original species. Doubtful records not included.

Bats

Microchiropteran bat surveys were conducted during 7 weeks between early January and mid March 1999. Two methods were employed within these surveys to record bats. Two harp traps (Austbat Equipment, Lower Plenty, Vic) were used to capture bats at each site, and an ultrasonic detector (Anabat System, Titley Electronics, NSW) connected to a laptop computer was used to record echolocation calls. A total of 110 sites were trapped for 222 trap-night; and 99 of these sites were surveyed with detectors for 826 hours. Apart from a single exception, all sites were surveyed for one night only.

Ultrasonic detectors were usually set at least 30 metres away from traps, with the microphone mounted on a stake approximately 0.5m above the ground. The rest of the unit was camouflaged with leaf litter or buried. Microphones were angled upward and pointing away from the traps, along the track or into a clearing. Bat species were identified from ultrasonic calls using an adaptation of the identification key developed during the North-East Victoria and Central Gippsland RFA fauna surveys. As echolocation calls of many bat species share similar characteristics, the key steps leading to any single species' identification were highly conservative. Yellow-bellied Sheath-tailed Bats were unable to be identifed with this method due to a lack of reference calls. Furthermore, there were a number of species whose calls were not sufficiently characteristic to enable single species identification. These included the Large-footed Myotis, Lesser Long-eared Bat, Gould's Long-eared bat and the Little Forest Bat, which could only be confidently identified as part of a species complex. As this technique does not identify the number of bats at a site, results were recorded as either presence or absence for a particular site.

A total of 2,216 captures (an average of 10 bats/trap-night) were recorded for 13 bat species (Table 5.9), which were mostly common and widespread species. Similarly, 20,815 individual echolocation calls identified the presence of 9 species at survey sites. A comparison of the frequency of detection of bat species between the two survey techniques showed that the two methods were complementary. Of the seven broad vegetation types, the greatest diversity was recorded in heathy woodland, with all of the 13 species recorded. However, heathy woodland was also the vegetation type that received the greatest survey effort (35% of surveys), as it was most widespread. Two of the species recorded usually associated with tall forests, Gould's Long-eared Bat and the Eastern False Pipistrelle, were recorded in these surveys from a broad range of vegetation types including heathy woodland and dry foothill forest. The study extended their previously known distribution of these species and filled in gaps within their known distributional range. The data from these surveys has significantly added information on the distribution of 11 of the 13 bat species. This has been particularly important for areas with previously low survey effort, including the Lower Glenelg National Park and surrounding State forest (eg. Cobboboonee and Annya), Dergholm and Roseneath State Forests, and Enfield State Forest.

Table 5.9 Abundance of bats recorded at pre-selected survey sites. Data grouped according to BVC groupings.

Species	Box Ironbark Forest	Dry Foothill Forest	Grassy Woodland	Heathy Woodland	Lowland Forest	Moist Foothill Forest	Riparian Forest	Totals

Species	Box Ironbark Forest	Dry Foothill Forest	Grassy Woodland	Heathy Woodland	Lowland Forest	Moist Foothill Forest	Riparian Forest	Totals
White-striped Freetail Bat				1				1
Gould's Long-eared Bat		11		5	40	46		102
Lesser Long-eared Bat	8	90	47	132	81	130	3	491
Common Bent-wing Bat				4				4
Gould's Wattled Bat		21	38	123	23	18		223
Chocolate Wattled Bat	6	98	51	105	94	65	6	425
Inland Broad-nosed Bat				3				3
Eastern False Pipistrelle		23		13	17	8	1	62
Southern Forest Bat		29	4	15	33	48	2	131
Little Forest Bat	12	38	57	172	69	10	2	360
Large Forest Bat	1	94	29	96	102	58	3	383
Southern Freetail Bat (long penis)			4	22				26
Southern Freetail Bat (eastern form)				4	1			5
Individuals	**27**	**404**	**230**	**695**	**460**	**383**	**17**	**2216**
Surveys	**7**	**22**	**12**	**39**	**15**	**14**	**3**	**112**
Total species	**4**	**9**	**7**	**14**	**9**	**8**	**6**	

Important records from surveys include the Common Bent-wing Bat, which is listed as vulnerable in Victoria. This species roosts in caves and disused mine shafts, and depends on only two known maternity sites in Victoria, for breeding. It was recorded at three sites which were all close to the limestone caves along the Glenelg River, although these are unlikely to be used as maternity sites. Also of interest was the capture of the Southern Freetail Bat (*Mormopterus sp.* - eastern form) at two sites; one in the Lower Glenelg National Park and another in Grampians National Park. Enzyme electrophoresis performed on tissue samples confirmed the identification of this species. These records extend the range of this species westwards by 200 km, as previously the species was known only as far west as Inglewood in central Victoria and the You Yangs, west of Melbourne. The Large-footed Myotis is the only microchiropteran species previously recorded in the region that was not recorded during these surveys. This was not surprising due to the absence of survey sites immediately adjacent to streams or rivers, which is where this species is usually trapped.

Owls and Arboreal Mammals

Large forest owls are top order predators that occupy large home ranges. It is known that they require hollow-bearing trees for nest-sites; and that their prey largely include hollow-dependent arboreal mammals such as possums. Several census methods were used to detect both owls and arboreal mammals at the pre-selected survey sites. The primary method was a playback technique used in earlier surveys in North-East Victoria, Central Highlands, Midlands and Gippsland. This relies on the response of owls and their arboreal prey to owl calls broadcast at ~120% of natural volume through a 10 watt megaphone. The standard tape consists of calls of four large owl species (Powerful, Barking, Sooty and Masked owls) and one smaller owl species (Southern Boobook). Following the broadcast and associated listening periods, a 10-minute, 200 metre spotlight transect was conducted at each site. A subset of sites additionally was surveyed with duskwatches. Incidental records (eg. feathers, dead owl carcasses) were also important in the detection of species.

Censuses were conducted at 117 pre-selected sites, and at 10 additional sites between November 1998 and April-May 1999. Two pre-selected sites were censused twice. Large forest owls were detected at 28 (23.5 %) of pre-selected sites and 6 (60 %) of extra sites. Large owls were most easily detectable through the use of playback and subsequent spotlighting, as compared to duskwatches. Results from all detection methods are combined in Table 5.10. Records of arboreal mammals detected during the same surveys are tabulated in Table 5.11.

Table 5.10 Number of individual forest owls recorded during censuses in Western Victoria RFA fauna surveys.

Species	Box Ironbark Forest	Dry Foothill Forest	Grassy Woodland	Heathy Woodland	Lowland Forest	Moist Foothill Forest	Riparian Forest	Totals
Southern Boobook	2	18	5	24	21	16	4	89
Powerful Owl	1	6	5	7	9	6	1	36
Masked Owl					1			1
Number of sites	**6**	**28**	**16**	**42**	**17**	**16**	**4**	**129**
Total	**3**	**24**	**10**	**31**	**31**	**22**	**5**	**126**

Data is amalgamated from several techniques including duskwatch, playback and spotlighting.

Table 5.11 Number of arboreal mammals recorded during censuses in Western Victoria RFA fauna surveys.

Species	Box Ironbark Forest	Dry Foothill Forest	Grassy Woodland	Heathy Woodland	Lowland Forest	Moist Foothill Forest	Riparian Forest	Valley Riparian/ Dry Foothill Forest	Totals
Common Brushtail Possum	4	8	16	11	7	2		1	49
Common Ringtail Possum		31	1	24	26	25	2	2	111
Yellow-bellied Glider		4	1		9	16	5		35
Sugar Glider	3	7	9	6	9	3		5	42
Koala			6	4	1	2	1		14
Number of sites	**6**	**28**	**16**	**42**	**17**	**16**	**4**	**1**	**130**
Totals	**7**	**50**	**33**	**45**	**52**	**48**	**8**	**8**	**251**

Data is amalgamated from several techniques including duskwatch, playback and spotlighting.

5.4 Terrestrial Invertebrates

Epigeal Invertebrates

Ground-dwelling invertebrates were sampled as part of the general fauna surveys using pitfall traps, which consisted of polyethylene jars dug into the soil with the upper edge continuous with soil surface. The traps contained a 1:1 mixture of ethylene glycol and 70% ethanol. Five traps were set at 117 pre-selected site and collected 2 weeks later. A total of 585 traps were set during the study for approximately 8,190 trap nights. Samples were sealed and sent for analysis by a specialist team of biologists at the Museum of Victoria.

A full analysis of these samples for all invertebrate taxa was beyond the constraints of this study. While all invertebrates were retained for later analysis, only ants were examined to species level. Ants have been identified as a potential 'indicator' taxa, following reported significant responses to altered environmental conditions. As many ants species still remain unclassified, 'morpho-species' were used as species surrogates. Voucher specimens for each 'morpho-species' have been retained at the Museum of Victoria.

Studies on the full complement of ant fauna over such a large geographic scale are very rare. More than 26,000 individual ants from 137 'morpho-species' were recorded in this survey (Appendix G). (Abundances of ants are approximate, as they were not counted where greater than 100 individuals of a particular morpho-species were present. In this case a substitute value of 125 was used to tally the total number of ants). An average of 14.7 ant morpho-species (range: 3 to 29) were recorded at survey sites. The more common morpho-species include *Anonychomyrma*, *Rhytidoponera* spp., *Iridomyrmex* spp., *Monomorium* spp., and *Pheidole* spp.

Collembola (Springtails)

Collembola are found in a variety of forest habitats in the region, including those associated with *Nothofagus*, where they occur in litter and in moss and feed mainly on fungi. Howard (1975) noted that Collembola comprised 11-18% of the *Nothofagus* litter fauna in Victoria and Tasmania, with a density of some 400-1000 per m^2. The Otways is a particularly rich source of Collembola with at least 10 species so far described, including local endemics such as *Phradmon trisetosus* (Aire's Creek Road), *P. maralali* (Beauchamp Falls, Torton's Track) and *Brachystomella disputa* (Aire's Creek Road, Mait's Rest), as well as more widespread species such *Adelphoderia regina*, which also occurs in the Central Highlands and Tasmania (Greenslade, 1982). *Australonura grossi* occurs in the Otways, Central Highlands and is also recorded from the summit of Mt William in the Grampians. *Australonura redita* is known only from the latter locality.

5.5 Threatened Species Studies

In addition to the fauna survey reported on in section 5.3, research projects wre commissioned to provide information on the distribution and status of threatened species in the West region. Assessments were produced for the following species:

- Powerful Owl
- Barking Owl
- Spot-tailed Quoll
- Squirrel Glider
- Brush-tailed Phascogale

The aim of these assessments was to provide information that would enhance the understanding of the species' requirements in the context of forest management, and to assist in their management in the West region.

It should be noted that study boundaries for these assessments extended beyond the West region in some cases. Results will need to be examined for their applicability to the west region.

5.5.1 Powerful Owl

The Powerful Owl is widespread but rare in Victoria. Its distribution is particularly sparse in the Box Ironbark forests of central Victoria. This project was designed to identify the home range and habitat requirements of Powerful Owls and provide information to inform management protocols in the selective-harvest forests of western Victoria. The study utilised call-response survey (playing of tape-recorded owl calls in order to elicit a territorial response) and nocturnal radiotracking to establish home range requirements of Powerful Owls in the Box Ironbark forests.

Preliminary results in these forests suggest that Powerful Owls occupy substantially large home ranges than previous estimates for other forest types. These large areas are apparently needed because prey is scarce in this fragmented and degraded forest ecosystem, with a high reliance on birds rather than on arboreal mammals as a food resource. Reproductive success is also apparently lower in this region than in the moister forests of Victoria. Preliminary analysis suggests that Powerful Owls are selecting habitat where large old trees and hollows are more abundant. This suggests that requirements for their conservation in this fragmented habitat consists of identifying 1000 ha core areas focussed on known records, and managing these areas to maintain habitat attributes required for Powerful Owl survival and reproduction.

5.5.2 Barking Owl

The aims of this project were to (1) locate, by a targeted sampling program, as many Barking Owl sites as possible in the West Region, and (2) to describe the main characteristics of sites supporting Barking Owls, compared with sites where the owls were absent. The study confirmed earlier perceptions that Barking Owls are extremely rare in the West Region, and in adjacent areas to the north-east of the Region (which were also surveyed). Barking Owls were recorded at only 4.3% of 257 sites surveyed even though the sites were carefully selected to maximise the chances of locating owls, based on existing knowledge of their habitat preferences. The owls were found at only 8% of 75 sites where they had previously been reported and listed in the Atlas of Victorian Wildlife. Thus, the accumulated Atlas records may not give an accurate impression of current distribution and abundance.

The study revealed three clusters of occupied sites: (1) adjacent to the base of the Grampians on all sides, and in the (2) Dunolly-Maldon and (3) Rutherglen-Beechworth areas — the second and third clusters are outside the West Region. A breeding site was found near Portland.

Despite the small number of sites where Barking Owls were recorded, differences in some aspects of habitat were found between these sites and sites where Barking Owls were not recorded. Sites with owls had significantly higher densities of large trees, and also had higher densities of tree hollows of a range of sizes including those suitable as nesting places for Barking Owls. Sites with owls were also closely associated with hydrological features such as rivers, swamps, and depressions.

5.5.3 Spot-tailed Quoll

This study suveyed systematically for Spot-tailed Quoll in the Otway Ranges (previously described as the stronghold of the species) between February and June 1999. Trap sites were selected based on the presence of suitable habitat (canopy, understorey and ground cover), recent reliable records, or historic records. A number of environmental variables were measured at each site.

Spot-tailed Quolls were recorded at three of 51 sites in two of the 28 blocks surveyed. They have previously been recorded from 27 blocks in the Otway Ranges. They were not recorded at six sites with recent (≤2 year old) records.

5.5.4 Squirrel Glider

Brief surveys were conducted within the West region to find Squirrel Gliders and habitat suitable for Squirrel Gliders, during December 1998 and March-April 1999.

Two major habitat types used by Squirrel Glider were sampled in two locatations in the West region using spotlighting, targetting abundantly flowering specimens of Yellow Gum or Grey Box. Following this, certain sites were selected for placement of "honey feeder" bottles and follow-up sampling was carried out, again using spotlighting. A combined total of 70 hours of spotlighting sampled 39 sites and revealed a total of five Squirrel Gliders from three new sites.

5.5.5 Brush-tailed Phascogale

Spatial organisation and home range of the Brush-tailed Phascogale in fragmented landscapes was investigated by radiotracking within a highly connected network of high quality remnant habitat habitats near Euroa. The study provided some evidence to suggest that if habitat quality (specifically the number of large trees) can be improved, then population densities may increase and home range sizes decrease. It also demonstrated that

Brush-tailed Phascogales are able to persist within highly fragmented landscapes if there are high levels of landscape connectivity and remnant habitat quality.

5.6 Fauna Species Reservation Analysis

5.6.1 Methods

A reservation analysis has been undertaken to assess the extent to which terrestrial vertebrate species in the West region are protected in the reserve system.

Using data from the Atlas of Victorian Wildlife, both formal survey and incidental records were intersected with existing land tenure to calculate the total proportion of records for each species in each of the major land tenure categories - see Table 5.12.

Table 5.12: Reservation analysis of priority fauna species records in West region

SPECIES	Total	Conservation Parks & Reserves		State Forest & Other Public Land		Private Land		Water Bodies	
		Number	%	Number	%	Number	%	Number	%
Mammals									
Broad-toothed Rat	35	10	29%	10	29%	15	43%		0%
Spot-tailed Quoll	102	10	10%	13	13%	79	77%		0%
Eastern Bent-wing Bat	87	41	47%	7	8%	39	45%		0%
Southern Myotis	34	6	18%	0	0%	14	41%	14	41%
Brush-tailed Phascogale	136	9	7%	16	12%	111	82%		0%
Squirrel Glider	37	13	35%	7	19%	17	46%		0%
Common Dunnart	46	17	37%	5	11%	24	52%		0%
Heath Mouse	404	171	42%	102	25%	130	32%	1	0%
Swamp Antechinus	232	76	33%	47	20%	109	47%		0%
Birds									
Regent Honeyeater	42	2	5%	13	31%	27	64%		0%
Painted Honeyeater	51	15	29%	10	20%	26	51%		0%
Swift Parrot	210	22	10%	65	31%	123	59%		0%
Red-tailed Black-Cockatoo	1272	102	8%	469	37%	693	54%	8	1%
Rufous Bristlebird	333	155	47%	25	8%	146	44%	7	2%
Bush Stone-curlew	183	22	12%	18	10%	143	78%		0%
Grey-crowned Babbler	67	15	22%	5	7%	47	70%		0%
Square-tailed Kite	32	7	22%	6	19%	19	59%		0%
Grey Goshawk	248	52	21%	25	10%	168	68%	3	1%
White-bellied Sea-Eagle	56	12	21%	4	7%	19	34%	21	38%
Barking Owl	85	16	19%	15	18%	53	62%	1	1%
Powerful Owl	470	122	26%	214	46%	131	28%	3	1%
Masked Owl	61	10	16%	20	33%	31	51%		0%
Chestnut-rumped Heathwren	132	54	41%	28	21%	49	37%	1	1%
Speckled Warbler	273	58	21%	41	15%	169	62%	5	2%
Reptiles									
Striped Worm-Lizard	21	2	10%	5	24%	14	67%		0%
Lace Monitor	50	9	18%	7	14%	33	66%	1	2%
Swamp Skink	45	27	60%	14	31%	4	9%		0%
Woodland Blind Snake	9	1	11%	0	0%	7	78%	1	11%
Amphibians									
Warty Bell Frog	318	37	12%	62	19%	200	63%	19	6%

5.6.2 Results and discussion

The results of the assessment are presented in Table 5.12. There are 12 species for which less than 20% of records are in Reserves, two of these species, the Red-tailed Black-Cockatoo and the Striped Worm Lizard, have their major occurrence in the West region.

The results should be considered in conjunction with the information on threatening processes. Many threatening processes operate across reserve and off-reserve areas and other measures are in place, in addition to reservation, to provide protection at the species level.

5.7 Significance of threats to fauna species

Table 5.13 summarises the significance of a range of threats for each species on a regional basis. The assessments were made recognising that practices on public land follow minimum prescriptions required under the Code of Forest Practices for Timber Production (NRE 1996a) and various State Acts and Regulations and that practices on private land are in accord with the *Planning and Environment Act* 1987 and the *Catchment and Land Protection Act* 1994. However assessments do not take account of additional protection afforded in various Action Statements, Park Management Plans, nor any additional measures that may be established in proposed or existing Forest Management Plans. Threats were rated as follows:

- Effect unknown

0 Processes not likely to be operating as a threat or there is no information to suggest that it is a threat

1 Process is a minor threat, which by itself is unlikely to lead to broad-scale decline of the species

2 Process is a moderate threat, which is likely to lead to some decline of the species, especially if it operates in combination with other threatening processes

3 Process is a major threat, which if not checked poses a significant risk to the viability of the species in the Region.

Further information in relation to these threat assessments is provided in Chapter 6 and Appendix G.

Table 5.13: Impacts of threatening processes on fauna species in West region

SPECIES	Clearing of Native Veg^{n}	Timber Harvesting	Fuel Reduction Burning	Firewood Collection	Unplanned Fire	Introduced Species	Grazing/ Trampling	Pest Control	Road Const^{n}/Maint	Mining/Quarrying	Tree Dieback	Recreation	Illegal Collect/Harvest	Vandalism	Dams/Impound	Interspecific Competition	Pasture Improvement	Loss of Genetic Diversity	Mineshaft Collapse	Rock Harvesting	Ozone Depletion
MAMMALS																					
Broad-toothed Rat	2	2	1	1	2	3	2	0	1	0	-	-	0	0	2						
Spot-tailed Quoll	2	3	3	2	3	3	1	3	1	1	1	0	0	0	1						
Eastern Bent-wing Bat	1	-	-	-	-	2	0	2	0	2	-	3	1	2	0				3		
Large-footed Myotis	1	2	-	-	-	1	1	2	2	-	-	1	0	1	0						
Brush-tailed Phascogale	3	2	1	2	2	2	1	1	1	1	1	0	0	0	0						
Squirrel Glider	3	1	2	2	3	1	2	1	2	1	2	1	0	0	0			2			
Common Dunnart	2	2	2	3	2	3	2	0	0	1	1	0	0	0	0						
Smoky Mouse	2	2	3	1	2	2	1	0	1	0	-	1	0	0	1						
Heath Mouse	3	2	1	1	2	2	2	0	1	1	1	0	0	0	0						
Swamp Antechinus	3	1	2	1	2	3	2	0	0	0	1	1	0	0	0						
Long-nosed Potoroo	2	2	1	1	1	3	2	1	1	0	0	1	0	0	0						
Yellow-footed Antechinus	2	2	1	2	1	2	2	1	1	1	2	0	0	0	0						
Yellow-bellied Glider	2	3	1	2	2	1	1	1	1	1	1	1	0	0	1						
White-footed Dunnart	2	2	2	0	2	2	2	0	0	0	0	0	0	0	0						
Inland Broad-nosed Bat	3	2	-	2	-	1	1	2	1	0	1	0	0	0	0						
Eastern False Pipistrelle	1	2	-	-	-	0	0	1	0	0	1	0	0	0	0						
BIRDS																					
Regent Honeyeater	2	2	1	2	1	1	2	0	2	1	2	1	0	-	0	2					
Painted Honeyeater	3	2	1	2	2	-	2	-	-	-	2	0	0	0	0	2					
Swift Parrot	2	2	-	2	-	1	2	-	1	1	2	-	-	-	0	-					
Red-tailed Black-Cockatoo	3	3	3	3	3	-	2	0	2	2	2	0	3	1	0	2					
Rufous Bristlebird	3	1	3	-	3	3	2	0	-	0	0	1	0	-	0						
Bush Stone-Curlew	3	1	1	3	-	3	2	2	2	-	1	0	1	1	0		3				
Grey-crowned Babbler	3	0	2	2	-	2	3	1	3	0	2	0	0	0	0	1	3				
Square-tailed Kite	2	2	2	1	2	0	1	-	1	-	1	-	2	2	0						
Grey Goshawk	2	2	2	1	2	0	1	2	1	-	1	-	-	2	0						
White-bellied Sea-Eagle	2	2	-	1	-	0	-	1	2	1	1	3	-	1	0	-					
Barking Owl	3	2	2	2	2	1	2	2	-	1	2	0	0	0	0						
Powerful Owl	2	3	1	1	2	1	1	1	1	1	1	0	0	0	0						
Masked Owl	3	2	2	2	2	1	2	3	1	-	2	0	0	0	0						
Chestnut-rumped Heathwren	2	-	2	2	2	-	1	-	0	-	-	0	0	0	0						
Azure Kingfisher	2	1	-	0	-	2	1	-	-	-	0	-	0	0	2						
Hooded Robin	2	-	2	2	2	3	2	-	-	-	2	0	0	0	0						
Speckled Warbler	2	2	1	2	1	2	2	0	0	-	1	0	0	-	0						
Gilbert's Whistler	3	2	2	2	1	-	2	-	-	2	1	-	0	0	0						
Black-eared Cuckoo	2	2	2	2	1	1	2	-	-	1	1	0	0	0	0						
REPTILES																					
Striped Worm-lizard	3	-	3	3	2	3	3	1	1	1	-	1	0	0	-						
Common Scaly-foot	3	1	3	2	2	2	2	1	1	2	-	0	0	0	0					1	
Lace Monitor	3	3	2	2	2	1	1	2	1	1	1	1	1	1	0						
Swamp Skink	3	2	1	0	1	2	2	-	1	1	1	1	0	0	2						
Anglesea Mountain Dragon	3	3	2	1	3	3	1	-	2	2	-	1	1	0	0						
Woodland Blind Snake	3	1	2	2	2	1	3	1	1	1	-	0	0	0	0						
AMPHIBIANS																					
Warty Bell Frog	3	1	1	1	1	3	2	3	-	-	-	0	1	-	-						2
TOTAL SCORE	**101**	**72**	**63**	**63**	**63**	**67**	**68**	**35**	**36**	**27**	**38**	**18**	**10**	**11**	**9**						
NO. OF SPECIES AFFECTED																					
Major threat	21	6	5	4	5	11	3	3	1	0	0	2	1	0	0						
Moderate threat	18	22	16	20	19	9	23	7	7	5	10	0	1	3	3						
Minor threat	3	8	13	10	8	12	12	12	18	17	18	11	5	6	2						

SPECIES	Clearing of Native Vegn	Timber Harvesting	Fuel Reduction Burning	Firewood Collection	Unplanned Fire	Introduced Species	Grazing/ Trampling	Pest Control	Road Constn/Maint	Mining/Quarrying	Tree Dieback	Recreation	Illegal Collect/Harvest	Vandalism	Dams/Impound	Interspecific Competition	Pasture Improvement	Loss of Genetic Diversity	Mineshaft Collapse	Rock Harvesting	Ozone Depletion
Not a threat	0	1	0	3	0	4	2	9	7	8	4	22	31	27	34						
Unknown threat	0	4	7	4	9	4	1	10	8	11	9	6	3	5	2						
TOTAL NO. AFFECTED	**42**	**37**	**35**	**35**	**33**	**33**	**39**	**22**	**27**	**21**	**28**	**14**	**7**	**8**	**6**						

6. REVIEW OF DISTURBANCES AND THEIR IMPLICATIONS FOR FLORA AND FAUNA

6.1 Introduction

The decline of species can be largely attributed to the impacts of disturbances, both direct—on species, and indirect—on essential components of their habitat. In this review, disturbances are defined as activities or events with associated environmental impacts. The environmental impacts may constitute potentially threatening processes (PTPs) for particular taxa. Such potentially threatening processes, as defined under the *Flora and Fauna Guarantee Act* (1988), could pose a significant threat to the survival, abundance and evolutionary development of native species or ecological communities of flora or fauna. There are currently 22 PTPs listed under the *Flora and Fauna Guarantee Act* (1988).

The responses of different plants, animals or communities to disturbances vary according to their ecological and life history characteristics. This review focuses on the relationship between disturbances (ie. activities or events), the environmental impacts of the disturbance and the life history attributes of taxa for which these impacts may constitute a threat (or PTP). For example, a disturbance such as road construction could lead to environmental impacts such as sediment input to streams, direct loss of plants or animals and changes in microclimate. These impacts could constitute PTPs (threats) for taxa or communities with a restricted range, a reproductive strategy sensitive to in-stream turbidity, or which have particular microclimatic requirements for growth or establishment.

Disturbances which impact on flora and fauna in the West were identified as part of an assessment of vulnerability, population parameters and life history attributes of 2900 vascular plants and 41 terrestrial vertebrates. These species were selected for analysis because they are either classified as rare or threatened in Victoria or considered to be indicators, representative of a suite of species which may be vulnerable to the continued action of threatening processes.

The majority of the species considered here are either forest dependent or require a component of their habitat to be within forest or woodland and may be affected by timber harvesting or related activities.

The disturbances reviewed fall into four categories: land management activities directly associated with forestry (such as timber harvesting), more general activities associated with management and use of public and private land (such as clearing native vegetation, grazing or fuel reduction burning), processes resulting from land disturbances such as environmental weed invasion or the impact of introduced fauna, and stochastic events such as wildfire. Each disturbance has been evaluated to determine the extent of its occurrence within the West, the potentially threatening processes which are associated with it, the overall significance of the threat to native flora and fauna in the West, the ecological, life-history and life-form attributes which might predispose a taxon to significant negative impacts, and examples of the plant and animal taxa that might therefore be susceptible to the disturbance. Management systems, including policies and processes, for the amelioration of the adverse biodiversity impacts of the disturbance are also summarised.

The disturbances reviewed here potentially have negative impacts on individual species of flora and fauna as well as on ecological communities. However, the responses of plants, animals and communities to the same disturbance are often complex and vary depending on the ecology of different taxa. For this reason, the PTPs associated with some disturbances are dealt with separately for flora and fauna. The significance of threats to flora and fauna was assessed through reference to the current literature and consultation with recognised experts in the biology of the species. The assessments were made recognising that practices on public land follow minimum prescriptions required under the Code of Forest Practices for Timber Production (NRE 1996a) and various State Acts and Regulations and that practices on private land are in accord with the *Planning and Environment Act* 1987 and the *Catchment and Land Protection Act* 1994. However, the assessments do not take account of additional protection afforded in various Action Statements, Park management plans, nor any additional measures that may be established in the Otways and Midlands Forest Management Plans**.** The following discussion applies only to the West Regional Forest Agreement (RFA) region.

6.2 Results and discussion

6.2.1 Clearing of native vegetation

Clearing of native vegetation occurs as part of agricultural, industrial, urban, tourist and utility development, and mining or extractive industry development (quarrying). Clearing of native vegetation associated with road construction and maintenance, and mining and quarrying, is a threatening process directly related to these disturbances and is discussed separately. Prior to European settlement in the middle of the 19th century, the region comprised tall open forests in higher rainfall areas, woodlands and open forests in the drier hills and

sedimentary plains, and extensive native grasslands and open woodlands on the basalt plains in the south. In the south-west, low stringybark forests and heaths were present on some areas of sandy soils. The land closer to the coast carried dense forests and large tracts of lowlands carried swamps and heath. The open forests, woodlands and grasslands of the inland plains of the region were particularly amenable to agriculture and were cleared or extensively modified and now persist largely as scattered remnants on or adjacent to private land, or as scattered linear strips along roadsides and water courses. Large areas of stringybark forests in the south-west corner of the region have been cleared for pine plantation (LCC 1972, CNR 1995a). The widespread disproportionate loss of habitat has been a significant factor in the decline of many species, causing regional and local population declines, and is largely responsible for the current threatened status of many species (Bennett 1993, Silveira *et al.* 1997).

Potentially Threatening Processes Affecting Flora and Fauna

Potentially threatening processes directly associated with clearing of native vegetation include damage or loss of individuals, disturbance to soil-stored seedbanks (dependent on the method of clearing) changes to structure and composition and loss or modification of habitat. This is particularly threatening to taxa that are rare, have specialised habitat requirements, low fecundity, and small or isolated populations where there is reduced opportunity for recolonisation.

Within the West, clearing of native vegetation associated with agricultural development is a particularly significant threat to species dependent on plains and woodland habitats. The widespread clearing of deep-rooted native vegetation and its replacement with shallow-rooted pastures and crops has resulted in rising watertables and salinity, which is a factor contributing to tree dieback in rural areas (Clunie in prep.). Few, if any, detailed studies of the impact of clearing on native flora have been undertaken. The greatest need for research is in the area of the impact of vegetation fragmentation on the reproductive biology of key taxa, and on the long term management of remnants. Few if any native plants can survive broadscale clearance of vegetation where the result is conversion of the land to intensive human use for urban, industrial, tourism or other purposes. However, clearing for agriculture does not always eliminate all native species. While the conversion of native vegetation to unimproved pasture usually involves the removal of trees and shrubs, many native herbs survive and in some cases prosper. However, as only vigorous reproducers (eg. many weed species) can tolerate such disturbance, its impacts are likely to be greatest on species with relatively low reproductive output. Once pastures are improved with the addition of exotic pasture species and fertiliser almost all native species are eliminated.

Many of the threatening processes indirectly associated with this disturbance result from fragmentation and isolation of habitat. Suitable habitat for the Grey-crowned Babbler, Bush Stone-curlew and Squirrel Glider now consists largely of small scattered blocks on private land, or linear strips along roadsides and watercourses (Bennett 1993, Menkhorst 1995d). Brush-tailed Phascogales have been recorded from dry forest and woodland habitats, including remnants on privately-owned land (Menkhorst 1995a, Atlas of Victorian Wildlife). Any further clearing of this habitat represents a threat to this species. Past clearing for agriculture is probably responsible for the drastic decline of the Woodland Blind Snake over the last 100 years. Some of the small number of records of this species for the region are from private land and loss of habitat through clearing is a major threat to populations in the West (P. Robertson pers. comm.).

Clearing native vegetation and drainage of wetlands and swamps for agricultural or urban development is a major threat to species such as the Swamp Antechinus, Swamp Skink and Warty Bell Frog which are dependent on these habitats. The Glenelg plains in the Portland FMA provide important habitat for the Swamp Antechinus. Loss of habitat as a result of drainage of wetlands is a major threat to populations of this species (Maxwell *et al.* 1996, A. Govanstone pers. comm.). The Warty Bell Frog is a largely aquatic species that inhabits woodlands, shrublands and open and disturbed areas with permanent still water (Cogger 1996). Loss of habitat from drainage of swamps and wetlands for agricultural and urban development is a major threat to this species (Ashworth 1998). The Swamp Skink also inhabits wetland habitats. Within the West, populations of this species are highly disjunct and loss of habitat from drainage of swamps and wetlands for agricultural and urban development

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are highly disjunct and loss of habitat from drainage of swamps and wetlands for agricultural and urban development is a threat to populations (Robertson 1980, Clemann 1997).

Populations that are small and fragmented or have limited distributions are particularly vulnerable to further loss of habitat as a result of clearing. Clearing affects these species indirectly through further fragmentation, with suitable patches of habitat becoming increasingly isolated by cleared land. Many local populations now consist of isolated groups persisting in habitat islands within the broader landscape. Large areas of cleared paddocks are barriers to movement of many animals that depend on forest vegetation. The Anglesea Mountain Dragon has an extremely restricted distribution in the West. Residential development is considered a major threat to populations (P. Robertson pers. comm.). The Rufous Bristlebird also has a restricted distribution in the West, and suitable habitat is limited. Loss of habitat as a result of clearing for development in coastal areas is a major threat to this species. Clearing has also resulted in fragmentation of the Rufous Bristlebird population; development at Anglesea now appears to have isolated a small population east of the town (Garnett 1992a, Smith and Baker-Gabb 1993, Chapman 1999). Small animals with low mobility (e.g. Woodland Blind Snake, pygopodid lizards, Heath Mouse, Swamp Antechinus) are particularly vulnerable to habitat isolation. Disjunct, isolated populations are vulnerable to extinction from catastrophic events such as wildfire and drought, and are more susceptible to threatening processes including predation and interspecific competition (Bennett 1990, 1993, Robinson 1993). The Common Scalyfoot has been recorded from a single location within the West. This population is highly susceptible to extinction due to clearing of habitat (G. Brown and P. Robertson pers. comm.).

Remnant woodland habitats on fertile soils are important food sources for mobile bird species that move between habitats on a seasonal basis, including the Regent Honeyeater, Painted Honeyeater and Swift Parrot. Although the presence of these species in an area is variable, there are sites from which they are regularly recorded (Webster and Menkhorst 1992, Tzaros and Davidson 1996, Menkhorst 1997, Tzaros 1997, D. Robinson pers. comm.). Selective loss of these habitats may deplete a food resource at a critical time of year, and contribute to local or regional population declines (Bennett 1993). For species which utilise woodland habitats as well as other forest types (e.g. Chestnut-rumped Heathwren, Speckled Warbler and Yellow-footed Antechinus), clearing for agriculture is considered a moderate threat.

Species which utilise forest/farmland edge are also significantly impacted by clearing of native vegetation within the West. The Masked Owl and Barking Owl both utilise forest edge and open woodland for hunting. The Masked Owl is also known to nest in isolated stands of trees in farmland (Hollands 1991). These species are hollow-dependent and require large areas for foraging. Loss and fragmentation of habitat as a result of clearing are significant threats to these species (E. McNabb pers. comm.).

Species that forage over large areas may be adversely affected by clearing of vegetation that removes and fragments their habitat as they need substantial areas of forest to support populations. Hollow-dependent species such as the Brush-tailed Phascogale, Yellow-bellied Glider and Inland Broad-nosed Bat are threatened by loss of shelter and nest sites as a result of clearing (Rhind 1996, Humphries and Seebeck 1997, A. Govanstone and L. Lumsden pers. comm.). The Spot-tailed Quoll utilises hollows, fallen logs and dense ground vegetation as den sites (Belcher 1997), the loss of which may impact on populations. Lace Monitors have large home ranges and appear to require connected systems of habitat with large trees in which to forage, bask and shelter (Brown and Bennett 1995). Fragmentation as a result of clearing potentially reduces the habitat quality of remnants for this species (G. Brown pers. comm.). The Red-tailed Black-Cockatoo utilises distinct habitats for feeding, nesting and roosting. Feeding habitat is concentrated on public land while known nesting and roosting habitat occurs mostly on private land. Loss of these critical habitat elements is a major threat to the population (Joseph 1982a, Joseph *et al.* 1991, Venn and Fisher 1993).

Clearing of native vegetation removes and alters habitat for the Warty Bell Frog (Gillespie *et al.* 1995), Woodland Blind Snake, Swamp Skink, Anglesea Mountain Dragon and is considered a major threat to these species in the region. Clearing of native vegetation threatens the Striped Worm-lizard and the Common Scaly-foot through loss of habitat and through loss of the source material for the ground debris layer, a vital habitat component for these lizards, and one that is often a source of prey (Ehmann 1992). The encroachment of softwood plantations into Striped Worm-lizard habitat also threatens this species (P. Robertson pers. comm.). The Common Scaly-foot is now largely restricted to remnant vegetation in the West because of clearing of native vegetation.

The depletion level of particular EVCs is influenced by many factors including arability, access and topography. See Table 3.2 for percentage remaining of each EVC within the West. EVCs most threatened by this process are those of the low foothills or plains. For a list of EVCs potentially threatened by clearing of native vegetation see Table 6.1.

Management

Clearing of native vegetation is significantly mitigated by the implementation of Native Vegetation Retention Controls under the *Planning and Environment Act* 1987. Under the Act, land holders and public authorities must apply for a permit to clear native vegetation from any parcel of land greater than 0.4 ha. For areas less than 10 ha, applications are assessed by Shire Councils, and for areas greater than 10 ha, by NRE. Minor clearing associated with normal farm and domestic activities is not prevented. Areas of significant vegetation and/or fauna habitat are protected by this process, and fragmentation of native vegetation is avoided. Permits to clear native vegetation are generally only granted for small areas with little significance, or slightly larger areas of degraded native vegetation. Despite these controls, however, clearing of native vegetation, particularly from private land, can still be significant (RAC 1992, Robinson 1994).

6.2.2 Timber Harvesting

Within the West region, the most commercially important species for sawlog production include Messmate *E. obliqua*, and Mountain Ash *E. regnans*. Sawlogs are also harvested from Manna Gum *E. viminalis*, Mountain Grey Gum *E. cypellocarpa*, Southern Blue Gum *E. globulus*, Candlebark *E. rubida,* Narrow-leaf Peppermint *E. radiata,* Broad-leaf Peppermint *E. dives,* Brown Stringybark *E. baxteri* and Swamp Gum *E.ovata*. Species harvested for minor produce such as sleepers, posts, and poles, include River Red Gum *E. camaldulensis*, Yellow Gum *E. leucoxylon*, Grey Box *E microcarpa,* Yellow Box *E. melliodora*, Red Box *E. polyanthemos*, Red Ironbark *E. tricarpa,* Broad-leaf Peppermint *E. dives* and White Cypress Pine *Callitris columellaris*. Blackwood *Acacia melanoxylon*, an important timber for the furniture and craft industry, is also harvested in the Otways (Brinkman and Farrell 1990, DCE 1992a, CNR 1995a, LCC 1972, 1979).

Within the region, timber is harvested under a range of silvicultural systems dependent on forest type and the eucalypt species requirements for regeneration.

The harvesting and regeneration of ash forests in the Otways are conducted using the clearfelling system. During clearfelling operations merchantable trees are removed from the coupe in one operation. Most of the understorey is also cleared. The seedbed is then prepared using high-intensity slash-burning or mechanical disturbance, usually in autumn. Seed is collected locally, then sown by hand or aerial means. In the mixed species foothill forests a range of silvicultural systems are applied, including clearfelling and selection systems, depending on forest type. Selection systems may involve the removal of scattered single trees or small groups at 15 to 20 year intervals. Stands regenerate by coppicing and natural seed fall. Selection systems result in uneven-aged stands contrasting with the even-aged regeneration on clearfelled stands (Brinkman and Farrell 1990).

In the Midlands FMA, the main timber harvesting methods employed are shelterwood, seed-tree and clearfell systems. The shelterwood system involves two commercial harvests. A proportion of the trees containing sawlogs remain after the first harvest, and these are harvested approximately 15 years later. Seedbeds for regeneration are prepared either by mechanical disturbance, or using ash bed techniques (NRE 1996b). The seed tree system involves the harvesting of merchantable trees while retaining seed trees and habitat trees and minimising damage to the remaining trees. Messmate is the most important commercial species in this FMA. Red Stringybark/Broad–leaf Peppermint forests produce limited amounts of minor products. Red Stringybark/box open forests produce farm timbers and firewood (CNR 1995a, ECC 1997).

In the Horsham area, River Red Gum *Eucalyptus camaldulensis* and to a lesser extent Yellow Gum *Eucalyptus leucoxylon*, are harvested using single tree selection. In the Portland FMA, Messmate and Brown Stringybark are the most commercially important species and are selectively harvested. Past management practices have resulted in stands containing an abundance of large, old, generally hollow-bearing non-commercial overwood trees. Cull treatment of stands aims to reduce the amount of overwood, reducing competition and allowing the regeneration of more productive stands.

Potentially Threatening Processes Affecting Individual Plant Species

The potentially threatening processes associated with timber harvesting may be grouped into three general categories:

1. the direct impacts of the harvesting operation, including falling, snigging and loading,
2. the indirect impacts on the site and surrounding vegetation subsequent to harvesting (including the compounding effects of subsequent disturbance such as regeneration burning)and
3. the impacts of a cycle of harvesting on forest structure, ecology and biodiversity.

Note: the impacts of regeneration burning, and road construction and maintenance which can be associated with timber harvesting are dealt with in later sections.

A key issue in evaluating the ecological impacts of timber harvesting has been the extent to which harvesting mimics the effects of natural disturbance, of which naturally occurring wildfire is the principal element. Other

natural disturbances include frost, snow, drought and violent windstorms [see Mueck and Ough (1997), Mueck and Peacock (1992) Murphy and Ough (1997), Ough and Murphy (1996), Ough and Ross (1992) and Commonwealth of Australia (1996) for comparison and identification of similarities and differences between the impacts of clearfelling (including regeneration burning) and wildfire on native forest flora and the recovery response of the vegetation to these disturbances. Briefly, disturbance that does not mimic a natural event (to which species and ecosystems have become adapted) will disadvantage some species and may advantage others resulting in change in structure and floristic composition of the forest ecosystem/EVC. For example, Silver Wattle *Acacia dealbata* regenerates entirely by soil-stored seed in certain EVCs (Ashton 1981). It requires fire to stimulate germination of this seed. Whereas regeneration burning after clearfell harvesting may mimic the natural system (given appropriate fire characteristics such as temperature), other harvesting methods where seedbed preparation occurs via mechanical disturbance are not successful in encouraging germination of the soil-stored seed of this species.

The potentially threatening processes directly associated with timber harvesting include damage or loss of individuals, particularly as a result of machinery use and falling trees, disturbance to the surface soil structure, disturbance of soil-stored seedbanks, and compaction of the soil surface on snig tracks and log landings. The species at greatest risk are those which rely wholly or partially on vegetative reproduction from organs/structures above, at or immediately below the soil surface (resprouters) after disturbance. See Mueck and Ough (1997) and Mueck and Peacock (1992) for effects in forest ecosystems dominated by Mountain Ash *Eucalyptus regnans*. Tree-ferns (Soft Tree-fern *Dicksonia antarctica* and Rough Tree-fern *Cyathea australis*) are particularly sensitive to mechanical disturbances associated with current clearfelling practices (Mueck and Ough 1997). Also potentially at risk are species which rely totally or partially on soil-stored seed for reproduction.

The potentially threatening processes indirectly associated with harvesting operations include habitat modification, specifically the removal of one or more forest strata and the loss of opportunity to develop habitat elements characteristic of mature and senescent forests (eg tall treefern trunks, decaying logs) on the coupe. This threatening process is considered to have a major impact in certain vegetation types such as those of wetter, protected, riparian or gully environments. The alteration of microclimatic conditions both on the coupe and in adjoining vegetation creates sharp boundaries and results in increased exposure and alteration to the humidity, light and temperature conditions in the adjoining vegetation at least until the regrowth canopy reaches the level of the surrounding vegetation. The distance of penetration of these "edge effects" and their significance in causing floristic changes has yet to be clearly demonstrated, but edge effects are likely to be of greatest threat to EVCs that are linear and small such as those confined to gully or stream habitats and to species which rely on stable, low light, high humidity, moderate temperature regimes. For a review of edge effects and microclimatic changes, see Burgman and Ferguson (1995). On the coupe itself, the microclimatic changes following harvesting are profound. In some cases these changes may mimic the impacts of wildfire. However, the impacts of wildfire may be less extreme than the impacts of clearfelling where some vegetation remains after the fire and species not killed by the fire rapidly resprout and recover. See Murphy and Ough (1997), Ough and Murphy (1996), Ough and Ross (1992) and Commonwealth of Australia (1996).

Operational trials of "understorey islands", areas within coupes in which machinery is excluded to minimise physical damage to long-lived understorey species, are being undertaken in the Central Highlands (Ough and Murphy, 1998).

The additional soil disturbance created by timber harvesting (compared to wildfire or other natural disturbances) has the potential to lead to erosion and sedimentation, both on the coupe and in adjoining vegetation, particularly on steeper sites, on granitic soils and in gullies. Some loss of soil-stored seed may also occur. The severity of this process may vary greatly from site to site. Its overall significance is considered to be low for most plants. Species potentially affected include small forest understorey plants and species of stream margins . The Code of Forest Practices (NRE, 1996a) specifies provisions to minimise erosion and sedimentation arising from harvesting operations. Facilitation of the spread of weed species may also occur as a result of soil disturbance (see later section).

The potentially threatening processes associated with the cycle of timber harvesting relate mainly to the frequency and regularity of harvesting (as opposed to that of the natural disturbance regime). A harvesting cycle of an average 80 years applied consistently across the harvested areas of State forest would progressively eliminate mature and old-growth growth stages from these areas, although this effect is mitigated by protection of significant areas in various forest reserve tenures and by the absence of harvesting in some forests of lower productivity. The impact of this on native flora would be greatest in situations where the environmental conditions, structure and floristics of forests continue to change with the age of the stand over hundreds of years. Species dependent on habitat elements or characteristics of mature and old-growth stands are likely to

experience a decline concomitant with the decline in the growth stages themselves. Species which require a long period to reach full reproductive maturity may also be at risk.

Potentially Threatening Processes Affecting Forest Ecosystems/Ecological Vegetation Classes (EVCs)

Individual species' response to disturbance will influence the structure and floristics of the vegetation as a whole (including vascular and non-vascular flora) and the inter- and intra-specific dynamics of the whole ecosystem (including vascular flora, non-vascular flora, vertebrate fauna, invertebrate fauna, soil micro-organisms *etc*.).

Different forest ecosystems/EVCs have varying requirements and will respond differently to the various silvicultural systems applied. The frequency and intensity of disturbance (here the silvicultural system being managed for wood production) during a harvesting rotation and the length of rotation appear to strongly influence species composition. The clearfell system of timber harvesting has greatest impact on the structural and age class attributes at a smaller scale (ie. the coupe level) by creating an essentially even-aged regrowth forest. However, this may vary at a large scale (eg. the forest block level) depending on the amount and type of vegetation retained and the frequency of logging. The result may be a simplification of the age class characteristics of the overstorey trees. On a broad scale the result will be a heterogeneous mosaic of unlogged and logged areas of various ages and utility as habitat for other species (Mueck and Ough 1997). Other harvesting methods impact similarly but to a lesser degree.

Species largely reliant on resprouting as a mode of recovery after disturbance are disadvantaged by mechanical disturbance associated with clearfell harvesting (see previous section). This can induce a significant long-term change in site floristics and may locally eliminate EVCs dominated by these species (Mueck and Ough 1997).

The effects of multiple harvesting cycles are unknown. Silvicultural systems that disturb the same site more than once during a rotation probably have a more significant impact on floristic composition and vegetation structure. In such cases the impacts are compounded and the vegetation has insufficient time between disturbances to recover and become reproductively viable (this includes treatment of a site where regeneration is considered inadequate which may re-disturb the site approximately one to three years after the original disturbance). This may alter the floristic composition by increasing the abundance of pioneer species and opportunistic colonisers or weed species at the expense of more shade tolerant species or species with specific substrate requirements for germination (eg. treefern trunks and decaying logs) (Mueck and Ough 1997, Mueck and Peacock 1992). See also section on environmental weeds.

Regrowth forests are considered to be more flammable than surrounding mature forest (Jackson 1968). This poses an increased fire risk to adjacent fire-sensitive vegetation (Mueck and Ough 1997).

In all but the rarest cases local provenance is always used in regeneration by seed or seedling methods, in accordance with the Code. However, problems arise if the species mix present at the time of harvesting is not represented equally in the seed trees selected, or the species present differ in their ability to re-establish from seed under the prevailing conditions. Consequently there is a possibility for a significant change in the proportion of overstorey species and the overall floristic composition of a coupe following regeneration by seed (Mueck and Ough 1997); the same possibility could apply to regeneration after some natural disturbances. The Code of Forest Practices requires that regeneration techniques aim to approximate the composition and spatial distribution of species present prior to harvesting.

For a list of EVCs potentially threatened by timber harvesting see Table 6.1.

Potentially Threatening Processes Affecting Fauna

Timber harvesting threatens a range of fauna species through the immediate and short-term effect of habitat removal and, more importantly, through the medium and longer-term effect of producing even-aged regrowth forests that are less suitable for some species than older forest. Ecologically mature, or old-growth, forests are generally more structurally and floristically diverse than regrowth forests, and provide a greater range of foraging substrates. Mature forests may support higher populations and diversity of bird species (Gilmore 1985, Scotts 1991, Traill 1991). Large old eucalypts provide important resources such as hollows, and have heavier flowering and nectar flows, a more plentiful supply of insects, a higher foliage density and specialised sources of food including peeling bark, mistletoe infestations and rotten wood (Bennett 1993, Traill 1993, Robinson and Traill 1996). Fauna species dependent on these resources are likely to be adversely affected by timber harvesting operations. Disturbance and loss of litter and ground layers during timber harvesting operations will adversely affect ground foraging species. Seedbed preparation by mechanical disturbance creates additional disturbance to the soil and is particularly detrimental to understorey species that resprout vegetatively (K. Ough pers. comm.). Soil disturbance has the potential to lead to soil erosion and sedimentation of streams. Subterranean species and those dependent on instream habitats are particularly vulnerable to these

threatening processes. Timber harvesting operations also cause habitat fragmentation resulting in some areas of forest becoming sub-optimal for many species. Species may need to expend more energy to forage in fragmented habitat. For many fauna the ability to reproduce and disperse may be curtailed, and the likelihood of predation and the probability of mortality resulting from changes in fire regimes and other environmental factors may increase (Norton and Dovers 1994). Species with large home range requirements are particularly vulnerable to habitat fragmentation. Few studies have been conducted to determine the effects of harvesting operations on reptiles and amphibians.

Timber harvesting is considered a major threat to the Spot-tailed Quoll, Yellow-bellied Glider, Powerful Owl, Red-tailed Black-Cockatoo, Anglesea Mountain Dragon, and Lace Monitor. Many of these species forage over large areas and utilise hollow-bearing trees as nest, shelter or foraging sites, and a significant proportion of suitable habitat is found in state forest. As a result, threatening processes related to timber harvesting include the loss of hollow-bearing trees, the conversion of mature stands to young regrowth stands, and fragmentation of habitat. The Brush-tailed Phascogale, Yellow-footed Antechinus, Inland Broad-nosed Bat, Eastern False Pipistrelle, Masked Owl, and Barking Owl also utilise tree hollows for nesting; timber harvesting is considered a moderate threat to these species.

The Regent Honeyeater is known to select larger trees for foraging (Webster and Menkhorst 1992). Large old trees which produce high nectar yields in winter are a significant food resource of the Swift Parrot (Brereton 1996). The Grey Goshawk predominantly utilizes older age-classes of forest for nesting and foraging. Conversion of older age-classes of forest to young regrowth stands as a result of timber harvesting operations results in the loss of both nesting and foraging habitat for the Grey Goshawk (Mooney 1987, Mooney 1988, Mooney and Holdsworth 1988), and a reduction in the quality of foraging habitat for the Regent Honeyeater and Swift Parrot (Traill 1993) and the Painted Honeyeater. The Square-tailed Kite uses traditional nest sites located on branches, not in hollows, and is therefore not hollow-dependent, but has a specialized diet consisting mainly of passerine nestlings and eggs taken from nests in the outer foliage of the canopies of eucalypts (Debus and Czechura 1989). Timber harvesting may result in a loss of nest sites and a reduction in prey availability for this species.

For species reliant on instream habitat, timber harvesting may cause siltation downstream of harvesting operations, and also increase nutrient levels in streams. The regeneration of large areas of forest following timber harvesting operations may alter stream flow and perenniality within catchments. The Large-footed Myotis and Azure Kingfisher feed on aquatic insects and fish. Loss of forest cover as a result of timber harvesting operations may increase light reaching streams, thereby increasing stream temperatures (Campbell and Doeg 1989). Altered stream conditions may indirectly impact on these species by affecting prey (L. Lumsden pers. comm., Shields 1994).

Soil disturbance during timber harvesting operations is a potential threat to subterranean species such as the Striped Worm-lizard and Woodland Blind Snake. The Common Scaly-foot often pursues prey in burrows (Ehmann 1992), and may also be threatened by timber harvesting operations. Loss of soil structure, removal of surface sheltering sites, and changes to soil microclimate is likely to reduce habitat quality for these species (Sadlier and Pressy 1994, Brown and Bennett 1995). Litter is important foraging habitat of the Speckled Warbler and Gilbert's Whistler. Disturbance and loss of litter during timber harvesting operations will adversely affect these species (Tzaros 1996, SAC 1994). Soil disturbance and a reduction of litter may affect the availability of hypogeal fungi, an important food of the Long-nosed Potoroo and Heath Mouse. Timber harvesting operations can result in complete or partial removal of the ground layer and understorey vegetation. These layers provide foraging and nest sites and shelter to many species including the Broad-toothed Rat, Common Dunnart, White-footed Dunnart, Smoky Mouse, Heath Mouse, Gilbert's Whistler, Chestnut-rumped Heathwren and Black-eared Cuckoo.

Management

Timber harvesting and associated roading and burning activities are managed under the forest management planning process which includes the Code of Forest Practices for Timber Production (NRE 1996a), the Code of Practice for Fire Management on Public Land (CNR, 1995), the Otways Forest Management Plan, the Midlands Forest Management Plan, Regional prescriptions and the annual Wood Utilisation Plans. The Code of Forest Practices for Timber Production and Forest Management Plans are subject to periodic review with formal public consultation, while regional prescriptions and Wood Utilisation Plans are prepared in consultation with regional flora and fauna staff and community input.

The Code of Forest Practice for Timber Production (NRE 1996a) sets minimum standards for forest operations. It provides principles and guidelines for regional prescriptions controlling timber production activities in state forest. The Code aims to ensure that environmental values and water catchments are protected by careful operation planning, reservation of appropriate areas and vegetation corridors. Vegetation must be retained

within at least 20m of permanent streams, and at least 5m either side of temporary streams and drainage lines. Trees must not be felled within such areas, and timber extraction roading should be planned to minimise impacts on catchments**.** Such prescriptions will benefit species associated with riparian habitat, including the Southern Myotis, Azure Kingfisher and Broad-toothed Rat.

Potentially threatening processes listed under the *Flora and Fauna Guarantee Act* 1988 which may be relevant to timber harvesting are: *Degradation of native riparian vegetation, Increase in sediment input into Victorian rivers and streams due to human activities, Loss of hollow-bearing trees in Victorian native forests, and The invasion of native vegetation by 'environmental weeds'.*

Prescriptions for the protection of wildlife habitat are specified in Forest Management Plans (FMPs). The West region encompasses all of the Midlands, Otway and Portland FMAs, and part of the Horsham, Central and Dandenong FMAs. FMPs exist for the Midlands and Otway FMAs, but not for the Portland or Horsham FMAs Dandenong and Central FMAs are included in the Central Highlands Forest Management Plan. Management strategies for species and threatening processes listed under the *Flora and Fauna Guarantee Act* 1988 are incorporated into FMPs. Priorities and permitted uses in different parts of State forest are set by forest management zones. The Special Protection Zone (SPZ) is managed for conservation, and timber harvesting is excluded from this zone. The Special Management Zone (SMZ) is managed for specific features, timber harvesting is permitted, but is conducted under certain conditions. In the General Management Zone (GMZ) forests are managed for the sustainable production of timber and other forest products. . However, the effectiveness of current practices in maintaining viable populations of forest dependent species is unknown. Habitat retention for the purpose of the conservation of wildlife habitat within the GMZ is an issue currently under review. Currently there is a range of prescriptions for retention of habitat trees in the various forest types of the West region. Research on the requirements of hollow-dependent fauna in timber production forests is reviewed in Gibbons and Lindenmayer (1997).

6.2.3 Grazing

Cattle and sheep, as well as feral animals including rabbits, hares, pigs, deer, wild horses and goats are the main agents of grazing or browsing and trampling of native vegetation within the West. Rabbits are widespread within the study area. Hares mainly inhabit agricultural and pastoral land, but will extend into natural vegetation where grasses are a major component of the understorey, such as River Red Gum forests and some mallee associations (Menkhorst 1995i). In the Otway FMA hares usually inhabit undulating plains country (Brinkman and Farrell 1990). Most feral goats occur in small isolated herds throughout the state (Menkhorst 1995j), and are present in public land in the region (NRE 1996b). Deer, while not currently considered a major problem, have the potential to cause significant damage if their numbers increase dramatically (DCE 1992a, NRE 1996b). Pigs occur in several FMAs in the region, and are known to be destructive omnivores. Recreational hunting assists NRE trapping programs in the control of pigs (Cuddy *et al.* 1993, NRE 1996b). In the north of the region overgrazing by wild horses is a potential problem (Cuddy *et al.* 1993). Grazing by native herbivores is not considered as a disturbance in this review.

On public land, licensed grazing of domestic stock, is practised in the West and includes State forest, roadside reserves, water frontages and reserves. Areas of public land are also made available for graziers to provide short-term feed at times of drought, fire and flooding (B. Lyons pers. comm.). Many areas traditionally used for grazing are unavailable under current management practices in order to encourage the regeneration of Red Gum forests.

Potentially Threatening Processes Affecting Flora

The impact of grazing stock will depend on the habitat, grazing intensity, timing, duration, stocking rate, type of stock and climatic conditions (Clunie in prep.). Threatening processes associated with grazing of native vegetation include lack of regeneration, trampling and loss of existing vegetation and litter, soil compaction and erosion, spread of weeds, ringbarking and subsequent death of trees, simplification of understorey and ground layers, and reduced structural heterogeneity (Lunt 1991, Brown and Bennett 1995, Robinson and Traill 1996). Grazing may also affect the health and longevity of existing trees by increasing nutrient levels, root damage and soil compaction, which may lead to dieback (Landsberg *et al.* 1990). Species particularly susceptible to threatening processes associated with grazing include those whose habitat is largely restricted to remnant patches of habitat within an agricultural landscape, species which live underground, species which require structural complexity near ground-level, and species restricted to sensitive vegetation types.

The ecological attributes which predispose plants to threat from grazing include palatability (mainly herbaceous species, but may include woody species when young, such as some *Eucalyptus* spp, some *Acacia* spp, *Coprosma* spp) and occurrence in habitats which tend to be grazed more frequently or heavily, such as the grassy and forb-rich EVCs. The historical combination of alienation, grazing and clearing has resulted in most

of these ecological vegetation classes being scarce on public land and are often present as degraded remnants on private land.

For a list of EVCs potentially threatened by grazing see Table 6.1.

Potentially Threatening Processes Affecting Fauna

Lack of regeneration as a result of grazing of remnant patches of native vegetation is a significant threat to the long-term persistence of species such as the Painted Honeyeater, Regent Honeyeater, Swift Parrot, Bush Stone-curlew, Red-tailed Black-Cockatoo, Grey-crowned Babbler, and Squirrel Glider. A large proportion of the preferred habitat of these species is found in remnant patches of woodland habitat on private land, roadside reserves and water frontages. Trees in paddocks are particularly vulnerable to dieback processes associated with grazing, including soil compaction, increased nutrients causing changes to soil chemistry and girding of trees (Heatwole and Lowman 1986). Most known nest sites of the Red-tailed Black-Cockatoo are found in remnant trees amidst pasture. Lack of nesting habitat in the long-term may limit populations in the future (R. Hill pers. comm.). Lack of regeneration resulting in long-term loss of habitat may also have a significant impact on species which utilise forest farmland edges, such as the Masked Owl and Barking Owl.

Soil disturbance resulting from grazing is likely to adversely affect species such as the Striped Worm-lizard and Woodland Blind Snake. These reptiles are fossorial, and their presence is influenced by soil characteristics including penetrability, moisture content and particle size (Ehmann and Bamford 1993). Soil compaction and erosion resulting from grazing is likely to reduce habitat quality for these species. Other deleterious impacts for fossorial reptile species include loss of soil structure, removal of surface sheltering sites and changes to soil microclimate (Sadlier and Pressy 1994, Brown and Bennett 1995). The Azure Kingfisher nests in tunnels which it excavates in stream banks near the water. Erosion and collapse of river banks as a result of grazing of streamside frontages may result in lost nesting habitat (Shields 1994).

Elimination and simplification of understorey vegetation and trampling of litter as a result of grazing are threatening processes for several reptile species and ground-foraging mammals and birds. The Swamp Skink is reliant on tussock life-form vegetation for basking, shelter and foraging sites (Clemann 1997), and this vegetation is sensitive to trampling by domestic stock (P. Robertson pers. comm.). The presence of the Woodland Blind Snake may be influenced by substrate complexity on, or near, ground level (Brown and Bennett 1995); simplification of this layer as a result of grazing may lead to a decline in populations. Grazing and trampling may remove or disturb ground-level vegetation and debris, destroying the habitat of the Striped Worm-lizard and Common Scaly-foot. Trampling of Warty Bell Frog habitat is identified as a threat to this species in the region. Similarly, other agricultural practises, such as the application of fertilizer, is likely to affect water quality, further affecting the viability of this frog in the West (Ashworth 1998). Litter is an important habitat component of the Grey-crowned Babbler, Speckled Warbler and Chestnut-rumped Heathwren. Understorey shrubs provide foraging substrates and nest sites for species such as the Common Dunnart, Heath Mouse, Yellow-footed Antechinus, Gilbert's Whistler, Black-eared Cuckoo and Chestnut-rumped Heathwren (Blakers *et al.* 1984, Emison *et al.* 1987). Loss or disturbance of these habitat components may adversely impact on these species. Ground nesting birds (e.g. Bush Stone-curlew and Speckled Warbler) are also vulnerable to loss of eggs and young resulting from trampling by cattle.

Management

Rabbits are the most widespread pest species in the study area and have a significant impact on vegetation communities, leading to altered structure, floristics and soil erosion. Rabbits and hares are usually controlled using 1080 poison, poisoned carrot baiting, fumigation of warrens and through the release of new strains of the myxomatosis virus. The recent release of Rabbit Calicivirus Disease is a major initiative in rabbit control. Goats and pigs are heavy browsers and have the potential to significantly alter vegetation communities. Populations are generally small and transient within the West, and control programs usually involve trapping and shooting (Brinkman and Farrell 1990, Cuddy *et al.* 1993, NRE 1996b).

Appropriate management of stream frontages and roadsides that are grazed by domestic stock is important for many species within the West including grassy woodland plants which are only found on roadsides. If adequate regeneration of trees and shrubs is maintained, roadside grazing may be compatible with habitat management for species such as Grey-crowned Babbler and Bush Stone-curlew. Light or occasional grazing may reduce the growth of exotic pasture species and help maintain a ground layer of sparse native grasses. This ensures Babblers have access to the ground layer for food, and that the ground-level vision of Bush Stone-curlews is unobstructed by dense, taller grasses (Davidson and Robinson 1992, Johnson and Baker-Gabb 1994, Robinson *et al.* in prep.). Research is required to investigate the role of grazing in arresting the spread of introduced pasture species (eg. *Phalaris, Avena, Bromus, Lolium* spp.). Development of roadside management plans, which address issues such as grazing, are critical to ensure habitat conservation for many species.

Many stream frontages are grazed under licence within the West. Annual licences were recently (1995) converted to 35 year licences. Many areas have suffered habitat modification, including shrub loss and inadequate regeneration (Weber in prep.). The Grampians National Park, for example, today has a different vegetation structure in some areas due to grazing being carried out in the past. Current levels of grazing in some areas may not be compatible with habitat management for species such as the Squirrel Glider. Few studies exist which examine the effects of different grazing regimes on many terrestrial species. There is a need for further research to define these impacts, and for active management to prevent further degradation, especially on public land (Bennett 1993).

6.2.4 Fuel Reduction

Fire is a fundamental element of the Australian environment. Most native terrestrial plants have evolved reproductive mechanisms in response to fire. Fauna also respond to fire and factors such as shelter and food requirements and behavioural patterns will affect these responses (Wilson 1996). This disturbance category includes the effects of fuel reduction (fire prevention) techniques such as burning within forested areas, and ploughing, slashing and burning along roadsides. Prescribed fire is also used as a management tool to regenerate harvested forest and manipulate habitat. Potentially threatening processes associated with regeneration burning are included within the Timber Harvesting category. Within the West, fuel reduction burning is carried out in a wide range of forest types. It generally occurs in the vicinity of 3-7 years frequency for areas that require asset protection, and less frequently for other areas.

The effects of fire on fauna vary depending on the fire regime. Regime variables include the scale, frequency, intensity and season of burns (Wilson 1996). Most fuel reduction burns are low intensity and aim to reduce the ground, understorey and bark fuel loadings (NRE 1999). The upper tree layers are not usually burnt. Frequencies of burns vary depending on a zoning system; the most frequent burns are usually 6-7 years apart, and are conducted in spring or autumn. The immediate and short-term impacts of fire on fauna populations include mortality during the fire, loss of shelter and nesting habitat, increased predation and decreased prey availability. Longer term effects involve changes to vegetation characteristics. Inappropriate burning regimes, such as too frequent or too infrequent burning, can alter vegetation floristics and structure, and may affect habitat suitability for some fauna. Fires may reduce the regenerative abilities of plants. Repeated burns may not allow plants sufficient time for full recovery, which could eventually result in the loss of flora species (Tolhurst and Oswin 1992). Recolonisation of burnt areas by fauna is influenced by the presence of adequate foraging, shelter and breeding sites (Humphries and Tolhurst 1992).

Potentially Threatening Processes Affecting Flora

The impacts of fuel reduction burning include the direct impact of the fire itself and the indirect impacts of an imposed fire regime which may differ from the "natural" (pre-European) regime (eg. fire interval, intensity and season of burn) that can result in changes to vegetation floristics and structure.

The direct impact of a fuel reduction burning event is the damage or loss of fire sensitive species as a result of the fire itself. This impact is of low significance in naturally frequently burnt vegetation types (eg. grassy woodlands) comprised of fire resistant or fire tolerant species which are adapted to regenerate following fire but of high significance in fire-sensitive vegetation and can result in total loss. Such vegetation is often associated with gullies which provide enhanced protection from fire for fire-sensitive vegetation and are rarely burnt.

Another potentially threatening process associated with fuel reduction burning is inappropriate fire conditions. That is, many species (and EVCs) require or are adapted to a natural burning regime where the frequency, season and intensity of burning fall within a certain range of parameters. When burning frequency is too high species may fail to reproduce adequately before the next burn so that there are no propagules available for regeneration after subsequent burning events. This is a problem to obligate seed reproducers such as members of the Proteaceae, Fabaceae and Epacridaceae families. In addition, fires must be in the appropriate season and at a suitable intensity in order to stimulate germination and to provide suitable conditions for establishment and to avoid competition from native or introduced species better suited to the fire regime.

For a list of EVCs potentially threatened by fuel reduction burning see Table 6.1.

Potentially Threatening Processes Affecting Fauna

Fuel reduction burning in the West is regarded as a major threat to the Spot-tailed Quoll, Red-tailed Black-Cockatoo, Rufous Bristlebird, Striped Worm-lizard and Common Scaly-foot.

Some fauna may be specially adapted to certain successional stages of vegetation. The availability of optimum habitat of the Heath Mouse appears to be strongly related to frequent fires and inappropriate fire regimes may retard the development of suitable habitat. Development and implementation of suitable fire regimes may be essential for the survival of this species (Menkhorst 1995c). Similarly, the Swamp Skink may be dependent on

late successional stages of riparian scrub and coastal heathland, and inappropriate fire regimes may threaten this lizard (Gillespie *et al.* 1992). The Swamp Skink is also reliant on dense ground-level vegetation (Clemann 1997), which may be destroyed or altered during prescription burning. There appears to be a link between the post-fire vegetation successional stage and Common Dunnart abundance (Fox and McKay 1981, Fox 1982) and inappropriate fire regimes may be detrimental to local survival of this species. This may also apply to the White-footed Dunnart although requires further investigation (Menkhorst 1995g). A potentially critical food source for young Red-tailed Black-Cockatoos, now found only on roadsides, is particularly vulnerable to fire prevention activities in these areas.

Frequent low-intensity burns can simplify and eventually eliminate dense understorey (Catling 1991). This can reduce shelter and foraging sites for species such as the Spot-tailed Quoll, Rufous Bristlebird, Yellow-footed Antechinus and Swamp Antechinus. The shrub and ground layers are important habitat components of the Black-eared Cuckoo, Gilbert's Whistler, and White-footed Dunnart. Frequent fuel reduction burning is likely to be detrimental to these species. Species that nest on or near the ground, such as the Common Dunnart, Chestnut-rumped Heathwren and Rufous Bristlebird, could be impacted by the loss of these sites. The Spot-tailed Quoll may lose habitat components such as logs and windrows that are important for den sites. The death of young trees and shrubs as a result of frequent burns can result in the loss of roosting habitat for the Masked Owl and Barking Owl (E. McNabb pers. comm.). Too frequent burning can limit the regeneration of tree species and thereby limit long-term habitat suitability for species such as the Yellow-bellied Glider and Squirrel Glider, both of which require tree hollows for nesting and roosting.

The Square-tailed Kite may face prey shortages if forest and woodland bird communities are adversely affected by current fire regimes (Debus and Czechura 1992). The effect of fire on hypogeal (underground fruiting) fungi, an important food resource for the Long-nosed Potoroo (Seebeck 1995) and Heath Mouse (Watts and Braithwaite 1978), is unclear. However, if the effects on fungi availability are detrimental, the impact on these species may be severe.

Fire prevention techniques used in remnants of native vegetation along roadsides include bulldozing, grading, slashing, ploughing, grazing and burning. These activities may result in the degradation and loss of habitat of species reliant on roadside remnants, such as Squirrel Gliders, Bush Stone-curlews and Grey-crowned Babblers (Menkhorst *et al.* 1988, Davidson and Robinson 1992, Adam and Robinson 1996). Seeds of Buloke *Allocasuarina luehmannii* are thought to be a particularly important food for newly flying Red-tailed Black-Cockatoos. In the West, Buloke are now found mainly on roadsides and fire prevention activities may have a negative impact on this potentially critical food supply.

The removal of litter and the death of young trees and shrubs caused by fuel reduction burning may result in an increase in introduced vigorous pasture grasses and other weeds such as Canary Grass (*Phalaris* spp.). These weeds prevent ready access to the litter layer, and therefore reduce the amount of foraging habitat available for species such as the Grey-crowned Babbler (Davidson and Robinson 1992). Litter provides foraging habitat for Gilbert's Whistlers. Loss of litter and logs threatens species that are dependent upon these habitats, such as the Striped Worm-lizard, Common Scaly-foot, Anglesea Mountain Dragon, and Woodland Blind Snake (P. Robertson pers. comm.). The loss of such shelter and foraging sites may leave these species vulnerable to predation. Fuel reduction burning may remove shelter sites for the Warty Bell Frog (Gillespie *et al.* 1995).

Management

Fire management in the West is guided by the Code of Practice for Fire Management on Public Land (CNR 1995c), which outlines general principles and guidelines for fuel reduction burning, and Regional Fire Protection Plans. Each Fire Protection Plan includes a fuel management strategy, based on five zones. To maintain fuel at defined levels fuel-reduction burns are undertaken in three of the strategically located zones. Areas containing significant biological, cultural or economic values which can be damaged by fire are generally located in Zone 5, in which prescribed burning is excluded, or Zone 4 where the ecological requirements of an area are given priority. Before fuel reduction burning is undertaken on Public land, each burn must be the subject of an approved burn plan in accordance with the Code of Practice for Fire Management on Public Land and regional Fire Protection Plans. These plans detail ecological issues, including the known or likely presence of rare or threatened fauna in or near the area to be burnt, and particular habitats needing protection. Such plans must take into account prescriptions developed for the protection of threatened species (CNR 1995c). Action statements include fire management prescriptions for species which are threatened by this process. However, for many species, the effect of fuel reduction burning is unknown, particularly the effect of burning frequencies. It is therefore difficult to interpret the impact of fuel reduction burning retrospectively. Monitoring of flora and fauna populations is required to determine the effectiveness of prescriptions and NRE is presently undertaking long-term research on fuel reduction burns in the Wombat State Forest.

6.2.5 Regeneration Burning

Regeneration burning is a standard component of forest management in most harvesting operations in the West. It involves the burning of the windrowed or heaped debris from harvesting (including heads, butts, and other material such as unusable logs and non-commercial species). The primary purpose of regeneration burning is to create optimal conditions for the natural germination of eucalypt seed shed from retained seed trees, or for sown seed where this is required. Regeneration burns must be of high intensity to be effective. They usually take place in late summer or early autumn. Unsuitable weather conditions and/or late season harvesting sometimes result in harvested coupes not being burnt until the following season. Regeneration burns occur in areas where clearfell harvesting systems are employed. The impacts of regeneration burning are discussed here with reference to flora. For a discussion of the impacts of planned fire on fauna see the section on fuel reduction burning.

Potentially Threatening Processes Affecting Flora

The direct impact of regeneration burning is the damage or loss of fire sensitive species as a result of the fire itself. This impact is strongly associated with regeneration burning, particularly where it may reinforce direct damage or loss as a result of timber harvesting. At greatest risk are fire sensitive species on the coupe and in the surrounding vegetation. Species also at threat are obligate root resprouters which may be stimulated to resprout by mechanical disturbance of the harvesting operation or by the regeneration burn but unable to withstand these disturbances in combination. Where the coupe is bounded by gullies, regeneration burns can impact upon the gully vegetation which tends to comprise a greater proportion of fire sensitive species than other vegetation types. Given also the typically linear configuration of these sensitive EVCs any intrusion of fire has the potential to modify microclimatic conditions (reinforcing changes associated with timber harvesting) to allow the establishment of weeds or species from the adjacent EVCs.

The longer-term, indirect impacts of a regime of regeneration burning include failure to reproduce adequately (where the intensity or season are unsuitable), absence of suitable conditions for establishment as a result of fire and competition from native or introduced species better suited to the fire regime. Assuming a harvesting cycle of 80 years, these impacts are likely to affect only those species which are adapted to fire frequencies greater than 80 years. However, it is important to assess these longer-term impacts of regeneration burning within the broader context of disturbance, which includes harvesting, roading, wildfire and disease in some cases.

For a list of EVCs potentially threatened by regeneration burning see Table 6.1.

Management

The Code of Forest Practices contains specific guidelines to prevent damage to surrounding vegetation from regeneration burns, particularly in relation to riparian EVCs which are fire-sensitive. The Code specifies that where fire is needed to produce a seedbed, measures must be taken to protect, as far as practicable, retained vegetation including streamside buffers, habitat trees, and areas of existing regrowth that could be damaged by fire.

6.2.6 Planned Absence of Fire

The deliberate exclusion of fire is a result of successful fire prevention and fire suppression activities directed towards the protection of life, property and other assets. It also may reflect management decisions, to exclude fire as much as possible (eg. in fire-sensitive vegetation such as rainforests and sub-alpine communities). The deliberate exclusion of fire is particularly associated with remnant vegetation in areas where fuel reduction burning may not be regularly undertaken, and where wildfires have been successfully prevented or suppressed.

Potentially Threatening Processes Affecting Flora

The threatening processes associated with the long-term absence of fire are similar to those indirect impacts of the types of planned fire discussed above. For example, the frequency, intensity or season of fire may increase competition from other native or introduced species better suited to the fire regime. When burning frequency is too high, species may fail to reproduce adequately before the next burn so that there are no propagules available for regeneration after subsequent burning event. This is a problem for obligate seed reproducers such as members of the Proteaceae, Fabaceae and Epacridaceae families.

The EVCs most prone to structural and floristic changes in the absence of fire include heathy EVCs that carry a high proportion of species that are dependent on fire for reproduction via resprouting and/or seedling establishment such as members of the Proteaceae, Fabaceae and Epacridaceae families and those such as grasslands and grassy woodlands that require fire to reduce biomass of dominant ground species so as to allow establishment of other species and thereby increase biodiversity.

For a list of EVCs potentially threatened by planned absence of fire see Table 6.1.

Management

Ecological burns are undertaken in accordance with management plans or Action Statements for specific species, communities or sites.

6.2.7 Unplanned Fire (Wildfire)

Fire is a fundamental element of the Australian environment and most native terrestrial plants have evolved reproductive mechanisms in response to fire. See Gill *et al*. 1981 for a general introduction.

Fire is the major natural disturbance maintaining the mosaic of floristic and structural diversity within native vegetation (others include flood, high winds etc). This mosaic is important in maintaining a natural system which provides floristic and habitat diversity, a propagule source and results in vigorous individuals able to withstand pests and disease. For example, native grasslands dominated by Kangaroo Grass *Themeda triandra* require periodic burning. Without regular fires this species increases and dominates to the exclusion of other species, resulting in a net loss in diversity and abundance. Periodic burning reduces the biomass of the Kangaroo Grass without killing it and opens up inter-tussock spaces allowing other species to flourish.

Similarly, fire can be a positive disturbance for fauna populations. Even intense wildfires can be patchy, resulting in a mosaic of structure and floristics within an area. Consequently, a natural fire regime may result in a range of habitats providing for a range of fauna with different requirements.

Wildfire may have both positive and negative outcomes for flora and fauna populations. Negative impacts of wildfire are generally associated with other human-induced disturbances and it is in this context that wildfire will be discussed here.

Potentially Threatening Processes Affecting Flora and Fauna

The intensity, frequency and season of occurrence of fires strongly influences the overall impact, and subsequent response, of both plants and animals. Fire can cause direct mortalities of animals and may eliminate critical habitat components. Species occurring in small disjunct populations, or species with narrow habitat requirements, are particularly vulnerable to wildfire. Wildfire is regarded as a major threat to the Spot-tailed Quoll, Smoky Mouse, Squirrel Glider, Red-tailed Black-Cockatoo, Rufous Bristlebird and Anglesea Mountain Dragon. Of the species covered by this review, all were considered to be under some degree of threat from wildfire. However, there are 9 species for which the effects of this potentially threatening process are unknown.

The effects of fire on vegetation include changes in species composition and abundance, physical structure and age structure. The intensity of a fire will determine the degree to which vegetation is altered. High intensity fires can damage and/or remove all strata levels (tree canopy, understorey and shrub layer, as well as litter and fallen tree debris and logs), while low intensity fires may only damage the lower layers (Meredith 1988). Low intensity fires leave more areas of unburnt vegetation and may allow animals to shelter in burrows, under rocks or in hollows during the fire. After a fire the vegetation often recovers in a series of successional stages. Recolonisation of fauna can be related to these stages, with species returning once particular habitat components are re-established (Friend 1993). A burnt area of forest may take years to return to its initial form. Large intense fires occasionally result in uniform even-aged stands, and tall open forest may be changed to a dense low shrubland of regenerating trees (Meredith 1988). The time of year that a fire occurs can be important, as the breeding seasons of many fauna species may be interrupted, and fires during autumn are generally hotter than spring burns (Wilson 1996). The frequency of wildfire can influence the regeneration of vegetation and, therefore, the recolonisation of an area by animal species. The recolonisation of a species into a particular area is influenced by the dispersal abilities of the species, the existence of any meta-populations within dispersal distance of the burnt area, and the number of individuals available for dispersal from a meta-population into the burnt area (Bennett 1990).

Adverse affects of wildfire on animal species include mortality during the fire, subsequent loss of shelter and nest sites, reduction in prey availability and foraging substrate, and increased risk of predation by introduced species (Catling 1991, Wilson 1996). Species with low mobility, such as small ground mammals and reptiles, may not be able to escape during a fire, and perish. Shelter, food requirements and behavioural patterns of species will affect their responses to a fire (Friend 1993, Wilson 1996). Small isolated populations are particularly vulnerable to stochastic catastrophic events such as wildfire. Because of the size of these populations they are easily destroyed, and little chance of recolonisation exists because of their isolation.

Fires that damage tree canopies may impact arboreal and hollow-dependent animals that are prey for species such as the large forest owls, thereby reducing prey availability for these species (E. McNabb pers. comm.). A loss in tree hollows reduces nesting and shelter sites for a number of species, including the owl species, the bat species, Southern Myotis, Brush-tailed Phascogale, Squirrel Glider, Spot-tailed Quoll, Yellow-bellied Glider, Yellow-footed Antechinus, White-footed Dunnart, Red-tailed Black-Cockatoo, and Lace Monitor.

Fires can destroy understorey vegetation, an important foraging resource for the Squirrel Glider and Yellow-bellied Glider. Damage to the outer canopy of eucalypts may impact on the Square-tailed Kite which feeds on passerine nestlings and eggs taken from nests situated within this section of the tree (Debus and Czechura 1989). Extensive hot fires which burn the forest canopy may reduce the availability of Brown Stringybark fruit, a major component of the diet of the Red-tailed Black-Cockatoo, for up to five years limiting the cockatoos food supply (R. Hill pers. comm.). Species that nest on or near the ground, such as the Bush Stone-curlew, Speckled Warbler, Heath Mouse and Broad-toothed Rat, may lose these nest sites during a wildfire. Disturbance of the litter and ground debris by wildfire eliminates important foraging and shelter habitat for many species such as the White-footed Dunnart, Swamp Antechinus, Striped Worm-lizard, Woodland Blind Snake, Swamp Skink, Gilbert's Whistler, Chestnut-rumped Heathwren and Bush Stone-curlew. The loss of this habitat component may leave these species susceptible to increased rates of predation. The small size and isolated nature of Common Scaly-foot, Anglesea Mountain Dragon, and Rufous Bristlebird populations renders them particularly susceptible to catastrophic events such as wildfire which can destroy these populations and their habitat, and leave little chance of recolonisation (SAC 1994, SAC 1995, P. Robertson pers. comm.). The effect of fire on hypogeal (underground-fruiting) fungi, an important food resource for the Long-nosed Potoroo and Heathmouse, is not clear.

Most research on the impacts of fire on forest fauna has concentrated on certain mammal groups and birds. However there is a lack of knowledge for some groups, such as arboreal marsupials and bats. Some habitat types have been the focus of more research than others. Information on the responses of reptiles and amphibians to fire is extremely limited (Wilson 1996), and the effect of fire frequency on populations of these taxa requires more research. The large number of species in the West for which the effects of unplanned fire are unknown highlights a need for fire-related research.

For a list of EVCs potentially threatened by unplanned fire (wildfire) see Table 6.1.

Management

The Department of Natural Resources and Environment has the responsibility for prevention and suppression of fire in state forest, national parks and all protected public land. The Code of Practice for Fire Management on Public Land (CNR 1995b) and regional fire protection plans include strategies for fire prevention, preparedness, fire suppression and recovery following wildfire. Significant and sensitive natural values are taken into account by these plans, which can be revised regularly to take account of new information and requirements.

As described above, regional fire protection plans include a fuel management strategy incorporating a zoning system for fuel management. The fuel management strategy aims to reduce the rate of wildfire spread and improve the prospects for controlling wildfire close to assets and in strategically located regional corridors. The fuel management strategy zoning gives consideration to the natural values (including fauna values) and principles of environmental care. Similarly, fire suppression follows consideration of factors including values at risk from the wildfire or suppression activities.

There has been much research on the effects of fire on mammals and birds in general. However, there is a lack of knowledge for some groups such as arboreal marsupials and bats. Some habitat types have been covered by research more than others. Information on the responses to fire of reptiles and amphibians is extremely limited (Wilson 1996). The effect of fire frequency on populations also requires more research. The large number of species for which the effects of this disturbance are unknown highlights a need for fire-related research.

6.2.8 Road construction and maintenance

Road construction and maintenance activities, including upgrading and widening of roads, and fire prevention activities such as ploughing, can directly destroy habitat, create barriers to movement, increase the potential of erosion and weed invasion, alter hydrological regimes and increase water turbidity and siltation when associated with creek crossings (Lumsden *et al*. 1991). The establishment of roads through undisturbed forest may allow introduced predators such as foxes to colonise new areas (May and Norton 1996). All new roads and tracks must be built to standards outlined in the Code of Forest Practices (NRE 1996a). However, many roads and tracks were built prior to the introduction of the Code, and do not meet current standards. Species particularly vulnerable to threatening processes associated with road construction and maintenance include those dependent upon roadside vegetation as habitat, those associated with riparian environments, and those dependent on sensitive habitat types.

Potentially Threatening Processes Affecting Flora

The potentially threatening processes associated with this disturbance include direct damage or loss of plants by machinery, habitat loss and/or fragmentation, altered micro-climatic and light conditions, erosion, sedimentation, introduction of soil or gravel contaminated with weed seed or fungal spores and the facilitation of weed spread (due to continual disturbance of road margins, introduction in soil on vehicles and machinery

and contamination via the stream system). The impact of road construction and maintenance is greatest in the construction phase, especially where the road is major and the terrain is steep, requiring large batters. Stream crossings sometimes present major engineering challenges, and have been shown to be the main sources of sediment input to streams. The erosion hazard will also be greatest in steep terrain, particularly in high rainfall areas. Gully vegetation is therefore most at risk from the major impacts of road construction and maintenance. *Degradation of native riparian vegetation along Victorian rivers and streams*, *Increase in sediment input into Victorian rivers and streams due to human activities*, and *The invasion of native vegetation by environmental weeds* are listed as Potentially Threatening Processes under the *Flora and Fauna Guarantee Act* 1988.

Indirect impacts of road construction and maintenance include potentially threatening processes that lead to habitat modification (soil erosion, sedimentation, microclimatic changes, increase of water turbidity and alteration of hydrological regimes). These processes are most significant in the vicinity of gullies in the steeper, higher-rainfall areas such as the Otways. In addition, gullies and streams act as conduits for the spread of weed propagules downstream. Consequently, species associated with gully and riparian environments are most likely to be affected**.**

For a list of EVCs potentially threatened by road construction and maintenance see Table 6.1.

Potentially Threatening Processes Affecting Fauna

Fauna particularly vulnerable to threatening processes associated with road construction and maintenance include those dependent upon roadside vegetation as habitat, species associated with riparian environments or species dependent on sensitive habitat types.

Roadside vegetation provides an important proportion of the habitat of the Grey-crowned Babbler, Bush Stone-curlew, Swift Parrot, Regent Honeyeater, Swift Parrot, Red-tailed Black-Cockatoo and Squirrel Glider. Roadworks such as road-widening, upgrading and installation of utilities degrade and reduce habitat by removing and damaging mature trees, saplings and shrubs, and result in weed invasion causing a deterioration of ground-layer habitat. Roadworks also contribute to eucalypt dieback as a result of altered drainage patterns, nutrient run-off or introduced plant pathogens (Heatwole and Lowman 1986, Landsberg *et al.* 1990, Robinson *et al.* in prep). The majority of Grey-crowned Babbler populations depend upon roadside vegetation for habitat, and this disturbance is considered a major threat to this species. In addition to loss of habitat, upgraded sealed roads carry faster traffic and may result in increased roadkills (Robinson *et al.* in prep.). Brush-tailed Phascogales and Lace Monitors are also known to use roadside vegetation, and roadkills of these species are not uncommon (Atlas of Victorian Wildlife, P. Robertson pers. comm.). Masked Owls are known to hunt along roads and road widening and maintenance activities may result in a loss of habitat. Road-kill Masked Owls have been recorded in the past and upgraded roads carrying faster traffic increase the likelihood of road-kill deaths (Atlas of Victorian Wildlife, E. McNabb pers. comm.).

Roads fragment habitat and create barriers to movement. Species with limited mobility, such as small mammals and reptiles, are particularly vulnerable. The Squirrel Glider requires continuous tree cover for movement. Road maintenance and widening can result in loss of canopy connectance (Alexander 1989, J. Alexander pers. comm.). Gaps can prevent access to adjoining habitat, and Gliders attempting to cross open space on the ground are highly vulnerable to predation. White-bellied Sea-eagles are particularly vulnerable to disturbance while nesting. Road construction and maintenance activities in the vicinity of nest sites may cause breeding pairs to abandon nests, leading to reduced breeding success (Williams 1997, P. Clunie pers. comm.). The removal and fragmentation of habitat due to road construction and maintenance is also considered a threat to the Broad-toothed Rat and Lace Monitor in the West.

Construction of roads and tracks results in the exposure of soil, which is then susceptible to erosion and weed invasion. Road construction can cause increased sedimentation of streams and alteration of riparian habitats. The principal sources of sedimentation associated with roads are usually unsealed roads and tracks, including fire trails and accessible roads used for timber harvesting, recreation and management access (O' Shaughnessy *et al.* 1997). Roads along riparian terraces, and road crossings of drainage lines and streams throughout a catchment, may cause an increase in water turbidity and an increase in sediment loads reaching streams (Lumsden *et al*. 1991, Gillespie and Hollis 1996). The Southern Myotis is largely dependent on aquatic prey; increased sedimentation and turbidity of streams may indirectly affect this species through reduced prey availability (L. Lumsden pers. comm.).

Management

In state forest all new roads and tracks must comply with the Code of Forest Practices for Timber Production (NRE 1996a). This Code includes proposed goals and guidelines covering the planning, location, design, construction, maintenance and use of timber extraction roads and stream crossings. In all cases, efforts are made to reduce the environmental impacts consistent with safety considerations, traffic levels and engineering

requirments. Such factors will affect the extent to which desired environmental outcomes can be accommodated.

The likelihood of new road construction on public land in the West is low. However there are a range of processes (eg. Code of Forest Practices) in which flora and fauna values are addressed prior to the approval of the construction of new roads on public land.

VicRoads (a Victorian Government Agency) is responsible for main roads and highways throughout Victoria. VicRoads has published an environmental strategy (VicRoads 1995) which includes objectives and committmentes relating to the conservation of native flora and fauna. Local municipalities are responsible for all other public roads (and roadsides) excluding those managed by NRE.

Local Government Roadside Management Plans, which incorporate recommendations for habitat management, will assist species dependent upon roadside vegetation. Development of roadside management plans requires liaison with major land managers whose areas of responsibility include roadside vegetation. These managers include local government authorities, Country Fire Authorities and local landholders (Davidson and Robinson 1992).

6.2.9 Recreation

A range of recreational activities can disturb flora and fauna and damage or destroy habitat. These activities include four wheel driving, hiking, camping, caving, fishing, canoeing, boating, trail bike riding and horse riding. Such activities can directly remove or trample vegetation, compact soil, cause pollution and sedimentation of streams, contribute to erosion and facilitate the spread of weeds. Within the West, species most vulnerable to threatening processes associated with recreational activities are those dependent on sensitive habitat types, and whose distributions are restricted to areas where recreational activities are concentrated. However, the majority of species were not considered threatened by this disturbance.

Potentially Threatening Processes Affecting Flora

The potentially threatening processes associated with recreation activities that directly impact on native vegetation are the direct damage or loss of individuals and habitat loss or modification via weed invasion, soil disturbance etc.

Indirect impacts on vegetation result in overall habitat degradation. This may involve the disturbance to soil structure by compaction and erosion, the facilitation of spread of disease, pathogens or environmental weeds, altered soil or surface hydrology and the increase in sediment input into streams.

The EVCs likely to be at greatest risk from recreational activities are those associated with riparian environments where recreation activities are concentrated.

For a list of EVCs potentially threatened by recreation see Table 6.1.

Potentially Threatening Processes Affecting Fauna

Recreational cave exploring has the potential to rouse inhabitant Eastern Bent-wing Bats from energy-saving torpor; this may cause fatalities or roost abandonment and is considered a major threat to this species (L. Lumsden pers. comm.). Records of the White-bellied Sea-Eagle are concentrated near several large permanent water bodies and include a number of nest sites. Disturbance at the nest site can lead to abandonment of the nest, resulting in reduced breeding success (Dennis and Lashmar 1996, Williams 1997). Recreational activities near nest sites may cause population declines (P. Clunie pers. comm.). Protection of White-bellied Sea-Eagle nest sites from disturbance is recognized as a significant factor in the conservation of this species (Clunie 1994).

Recreational activities, such as camping and hiking along rivers and bush tracks, have the potential to disturb fauna or their microhabitat (e.g. nesting sites). Trampling of vegetation and collection of firewood associated with camp fires may degrade foraging, shelter and nest sites. Species potentially impacted include Lace Monitor, Striped Worm-lizard, Swamp Antechinus, and Long-nosed Potoroo. Recreational fishing may potentially impact on populations of the Southern Myotis due to general disturbance of creek areas, such as trampling of vegetation (L. Lumsden pers. comm.).

Management

Vehicle-based activities on public land are managed through the relevant management planning process (Forest Management Area Plan or Park Management Plan). Effort is generally made to encourage activities in appropriate zones where these activities are compatible with overall management objectives, or where impacts can be minimised.

6.2.10 Environmental weed invasion

Environmental weeds are widespread throughout the West, occurring in all habitats and areas. Invasion of environmental weeds involves the naturalisation and spread of exotic taxa and the extension beyond "normal" range or habitat of native species.

The impact of environmental weeds varies. Some are relatively benign, occurring at low cover/abundance levels and/or spreading slowly. Others spread rapidly due to high reproductive output, large dispersal ranges and/or broad habitat tolerances. The most destructive environmental weeds are those which out-compete native species to the extent that their habitat can become grossly modified, with particular niches being lost altogether.

Among the most destructive or aggressive exotic weeds in the Otway FMA and Midlands FMA are Blackberry *Rubus fruticosus* spp. agg., Furze *Ulex europaeus*, English Broom *Cytisus scoparius*, Tutsan *Hypericum androsaemum*, Ragwort *Senecio jacobaea,* Spear Thistle *Cirsium vulgare*, Spanish Heath *Erica lusitanica*, Blue Periwinkle *Vinca major*,, English Ivy *Hedera helix*, Smilax *Myrsiphyllum asparagoides*, Radiata Pine *Pinus radiata*, Tree Lucerne *Cytisus palmensis,* Quaking Grass *Briza maxima*, Variegated Thistle *Silybum marianum*, St Johns Wort *Hypericum perforatum* and Boneseed *Chrysanthemoides monilifera*. The native species of greatest concern are Sweet Pittosporum *Pittosporum undulatum*, Cootamundra Wattle *Acacia baileyana* and Black Wattle *A. decurrens.*

Potentially Threatening Processes Affecting Flora

Environmental weed invasion is a potentially threatening process leading to competition and habitat modification. Environmental weed invasion can occur in any EVC but those EVCs and species growing in environments with adequate moisture and soil fertility are more susceptible. These include riparian zones, relatively fertile soil types and fragmented habitats in close proximity to weed sources, such as waste disposal areas and agricultural lands. Various suites of weeds are often found in particular environments where disturbance regimes and environmental characteristics are suitable. Blackberry *Rubus fruticosus* spp. agg, for example, in riparian and gully environments.

For a list of EVCs potentially threatened by environmental weed invasion see Table 6.1.

Potentially Threatening Processes Affecting Fauna

Invasion of habitats by introduced weeds contributes to habitat degradation, particularly for ground-foraging species. Ground-foraging birds whose habitat is largely restricted to roadside vegetation, such as the Apostlebird and Grey-crowned Babbler, are threatened by weed invasion as it reduces foraging habitat by limiting access to ground litter. Invasion of roadside habitats by introduced pasture species, eg. *Phalaris* spp, is an important cause of habitat loss for these species (Robinson *et al.* in prep.)

Management

The invasion of native vegetation by environmental weeds is listed as a Potentially Threatening Process under Schedule 3 of the *Flora and Fauna Guarantee Act* (1988). The management of environmental weed invasions is the responsibility of the land manager. On public land, environmental weeds are considered along with agricultural weeds under the Victorian *Catchment and Land Protection Act* 1992. Under this Act, weed species may be listed as State Prohibited, Regionally Prohibited or Regionally Controlled weeds. Within this framework, regional environmental weed management priorities are established through the relevant management plans.

The Victorian Parliament, through the Environment and Natural Resources Committee, has investigated the significance of the weed problem in general, including specific reference to environmental weeds (Parliament of Victoria 1998).

The Commonwealth, in consultation with State and Territory agencies, has recently completed the National Weeds Strategy (ARMCANZ and ANZECC 1997) which outlines strategies to address major issues. A Victorian Weeds Strategy has been developed within the context of the National Weeds Strategy to reduce the impact of weeds (NRE 1998 unpub.). Limited resources and a general lack of strategic planning, tactical planning, follow-up, monitoring and experimental management were the major issues identified.

The distribution of environmental weeds is generally well understood as a result of their inclusion in floristic surveys conducted in the West. A considerable amount of research on the ecology and management of particular environmental weeds, especially those that impact on agriculture, has been undertaken.

The most significant gaps in knowledge are:

- the ecology of a suite of environmental weeds which do not impact significantly on agriculture,
- the long-term management of multi-species invasions,
- the relationship between weed invasion and other disturbances.

6.2.11 Introduced Fauna Species

This category covers predation by introduced species (e.g. cat, fox, trout), as well as competition by introduced species for resources such as food and shelter. It does not include predation or competition by native species. Introduced species can also contribute to the spread of weeds (e.g. Blackberries) and disease (Mansergh and Marks 1993). Invasion of habitats by introduced weeds contributes to habitat degradation, particularly for ground foraging species. Species particularly at risk from predation by introduced animals are those that have a very localised and/or fragmented distribution, or occur in specific habitats which have been largely destroyed or modified by humans (Seebeck and Clunie 1997). Introduced carnivores are likely to have their greatest impact on ground-dwelling or ground-nesting animals (Bennett 1993).

Potentially Threatening Processes Affecting Fauna

Foxes and cats are widespread throughout Victoria, occurring in most habitat types. Predation by both foxes and cats is listed as a potentially threatening process under the *Flora and Fauna Guarantee Act* 1988, with published Action Statements for both species (Mansergh and Marks 1993, Seebeck and Clunie 1997). Predation by cats is also listed as a threatening process under the *Endangered Species Protection Act* 1992, and a threat abatement plan has been prepared (Dickman 1996). The extent of cat and fox predation on native animals is largely determined by prey availability (May and Norton 1996). Rabbits are a major prey item for both species, with alternative prey (including native fauna) sought when rabbit numbers decline (Catling 1988). However, cats tend to prey on native fauna even when rabbits are readily available (May and Norton 1996). In areas where rabbits are scarce (such as alpine areas and dense forest), native fauna, including mammals, birds, reptiles, invertebrates and amphibians, are more heavily relied upon by predators (May and Norton 1996, Seebeck and Clunie 1997). With the recent introduction of the Rabbit Calicivirus Disease, predation upon native animals may increase as rabbit numbers decline (Seebeck and Clunie 1997).

Predation by introduced species is a threat to many species covered by the review. Species that have a limited distribution in the West are particularly under threat of decline as a result of predation. Such species include the Broad-toothed Rat, Long-nosed Potoroo, Swamp Antechinus, Rufous Bristlebird, Striped Worm-lizard and Anglesea Mountain Dragon. The proximity of Anglesea Mountain Dragon populations to townships increases the risk to this species of predation by domestic animals. Bird species that nest on or near the ground, such as the Bush Stone-curlew, Rufous Bristlebird, and Speckled Warbler, are vulnerable to predation by foxes, cats and dogs, with both adults, nestlings and eggs taken. The Hooded Robin is a ground foraging species that often nests close to the ground, and is particularly vulnerable to predation by introduced species (Fitri and Ford 1997). Eastern Bent-wing Bats can be preyed upon by cats as they leave their cave/mineshaft roosts; this is considered a moderate threat to this species (Menkhorst and Lumsden 1995a, L. Lumsden pers. comm.). The Common Dunnart exists in small isolated populations in the West and predation by introduced species is considered a major threat. For species such as the Brush-tailed Phascogale, which occurs at low densities, continuous predation is considered a moderate threat, particularly at the local level.

Competition with introduced species for food and or nest hollows is recognised as a major threat to the Spot-tailed Quoll, and a minor threat to the Lace Monitor**,** Barking Owl, Masked Owl, Regent Honeyeater and Swift Parrot. There appears to be some dietary overlap between cats and foxes and the Spot-tailed Quoll and Lace Monitor; competition for prey items may potentially threaten the viability of these species in the West (Mansergh 1984, Mansergh and Belcher 1992, G. Brown and P. Robertson pers. comm.). The fox also competes for prey with the Barking Owl and Masked Owl (R. Loyn pers. comm.). Introduced prey such as rabbits may be important dietary components for such species, particularly in agricultural areas. However, the extent of competition between these species and foxes is unknown. Feral European Honey Bees are known to occupy hollow trees, and may compete for this resource with several native species which use hollows (Lawler *et al.* 1995, Wood and Wallis 1998). Preferred sites for Honeybees are usually within drier mixed-species eucalypt forests, and the presence of bees may impact on species such as the Brush-tailed Phascogale (T. Soderquist pers. comm.). Honey production is widespread throughout the region. Hives are moved from district to district to coincide with the peak nectar flows of various eucalyptus species (Briggs 1993, NRE 1996b). The Regent Honeyeater and Swift Parrot are partially dependent on eucalypt nectar and exploit sites with high nectar yield. Honey Bees may compete for nectar with these species.

Weed invasion is facilitated by other disturbances and has the potential to severely degrade many areas. Ground-foraging birds whose habitat is largely restricted to roadside vegetation, such as the Grey-crowned Babbler, are threatened by weed invasion, as this process deteriorates ground-layer habitat and reduces access to litter. Invasion of roadside habitats by introduced pasture species, eg. *Phalaris* spp, is an important cause of habitat loss for these species (Robinson *et al.* in prep.). Native grassland habitats on roadsides in the West are particularly susceptible to invasion and degradation by *Phalaris* spp. (A. Govanstone pers. comm.). Other grassy weeds such as Rye Grass, Sweet Vernal Grass, *Vulpia* spp., Yorkshire Fog, Chilean Needle Grass and Serrated Tussock are the cause of considerable environmental degradation in the region, and in the wetter

forests several species of Broom degrade habitat, and infestations of Blackberry and Gorse along watercourses are problematic (L. Morcom and R. Price pers. comm.).

European Carp stir up water debris, increasing turbidity to such an extent that the Azure Kingfisher, which requires clear water to locate prey, has trouble feeding and is significantly threatened by the activities of these fish (R. Loyn pers. comm.). The larval stage of the Warty Bell Frog may be susceptible to predation from introduced Mosquito Fish (*Gambusia affinis* and *G. holbrooki*), and this threat is considered a major threat to this frog in the region (Gillespie *et al.* 1995, White and Pyke 1996, Tyler 1997).

Management

Predator control in the West involves snaring and baiting for foxes and dogs, mainly along the private land/public land interface (DCE 1992a, Cuddy *et al.* 1993, NRE 1996b). Pest animal control measures in the West include programs coordinated with adjacent landowners (Good Neighbour Program) and, where feasible, targeted programs through the region. Management plans include strategies relating to pest animal control.

The significance for many populations of predation by introduced species, competition for resources such as tree hollows and food items, and invasion of habitat by weeds is unknown. Research is needed to identify the extent of these potential threats. Control programs for introduced species need to be closely monitored to assess their effectiveness at protecting populations of native fauna.

6.2.12 Pest Control

Potentially Threatening Processes Affecting Fauna

Threatening processes associated with pest control include mortality of native species as a result of the consumption of poison baits (non-target poisoning), and secondary poisoning as a result of the ingestion of poisoned prey and food chain contamination by heavy metals. Other threatening processes include the potential impact of loss of significant food sources following control programs for introduced species such as rabbits, spraying of herbicides and pesticides for weed and insect control. Species particularly vulnerable to pest control measures include carnivores such as the Spot-tailed Quoll and Lace Monitor, and birds of prey such as the White-bellied Sea Eagle, as well as predators which rely at least partially on targeted pest species. The impact of weed and insect control is largely unknown, although for many species, particularly those whose habitat is surrounded by a largely agricultural landscape (eg. many woodland birds), the impacts of such control measures may be considerable.

Foxes and wild dogs are controlled in the West by snaring, baiting and occasionally by shooting, mainly along the private land/public land interface (DCE 1992a, Cuddy *et al.* 1993, NRE 1996b), which may impact on native species. The Spot-tailed Quoll is especially at risk from non-target poisoning by ingesting 1080-poisoned baits intended for foxes and dogs (Mansergh and Belcher 1992, Belcher 1995c, Murray 1998). Although baits are buried to minimise the risk of non-target poisoning, Spot-tailed Quolls are known to dig up and ingest buried baits (Belcher 1995c). Non-target poisoning is a minor threat to the Brush-tailed Phascogale, as baits are sometimes not buried as required (T. Soderquist pers. comm.). Other species that may ingest poisoned baits laid for pest animals include the White-bellied Sea Eagle (A. Williams pers. comm.) and Lace Monitor (G. Brown pers. comm.).

Rabbits are an important prey item for the Masked Owl, and are also taken by Barking Owls. A reduction in rabbit numbers due to control programs, such as poisoned-baiting and Calicivirus, is considered a threat to these species. Similarly, the Lace Monitor preys on rabbits and may suffer from a large reduction in prey numbers following rabbit control programs. There is also the risk to these species of secondary poisoning after consuming poisoned rabbits or rats (Peake *et al.* 1993, R. Loyn and P. Robertson pers. comm.). Secondary poisoning via the ingestion of poisoned prey is also a threat to the Spot-tailed Quoll (Mansergh and Belcher 1992, Belcher 1995c) and the Grey Goshawk (Mooney 1988). Rabbit control may also involve the destruction of burrows and piles of logs and debris that might provide refuge for native fauna. These control activities are a potential threat for species that use these sites for shelter and foraging, such as the Lace Monitor (P. Robertson pers. comm.).

Insectivorous bats, such as the Eastern Bent-wing Bat, Eastern False Pipistrelle and Inland Broad-nosed Bat, may be susceptible to poisoning through the bio-accumulation of pesticides ingested via prey (Dunsmore *et al.* 1994, L. Lumsden pers. comm.), although the full extent of this threatening process is unknown. Top order predators such as the Grey Goshawk and White-bellied Sea Eagle may also be susceptible to food chain contamination by pesticides (Bilney and Emison 1983, Clunie 1994, Mooney and Holdsworth 1988). Pesticide use may result in decreased prey availability for the Woodland Blind Snake, reducing this species' numbers (Ehmann 1992). Pesticides and herbicides may drain into streams, reducing water quality, which could impact on the Southern Myotis by affecting its aquatic prey of invertebrates and fish (L. Lumsden pers. comm.). The Warty Bell Frog may also be affected by such chemicals, either by direct poisoning or loss of prey (G. Gillespie

pers. comm.), and both herbicides and pesticides have been implicated in the decline of this frog (Gillespie *et al.* 1995, Tyler 1997). Pesticide use may reduce the amount of prey available to species such as the Striped Worm-lizard and Common Scaly-foot.

The effect of pest control methods on most species is not well documented. It is important that pest control programs are closely monitored for adverse impacts on native fauna, and the programs effectiveness in controlling target species is determined. Overall, the ecological implications for native fauna of pesticide use is poorly known, but potentially significant given the importance of insects and other invertebrates as prey for many species. This issue requires further investigation.

6.2.13 Firewood and Other Minor Forest Produce

Apart from firewood collection, minor forest produce includes posts, poles, round timbers and other hewn timbers as well as speciality timbers and craftwood.

In Victoria firewood represents one of the highest volume forest products, with a total annual consumption in the range of 1.2 - 2.5 million cubic meters (RAC 1992, Read Sturgess and Associates 1995). Within the West the majority of firewood collected by commercial cutters is the by-product of other forest operations in State forest. In harvested coupes firewood is collected after the area has been harvested, and all merchantable timber has been removed (NRE 1996b). Collection for non-commercial (domestic) use is permitted in most State forests, although collectors must have a permit. Firewood collection is prohibited in areas of State forest designated Special Protection Zones. In specific areas of some state forests thinning for 'green' firewood occurs. Permits for this type of collection cost more than standard collection permits. In the West most firewood is collected near major population centres.

In the Otway forest management area (FMA) most firewood is collected from foothill forests where denser, more durable timber species are found. The stringybark foothill forests south of Colac are targeted intensively for firewood, particularly Messmate *E. obliqua* and Narrow-leaved Peppermint *E. radiata.* In the Horsham/Wimmera area the majority of firewood collected is River Red Gum *E. camaldulensis*. In this area no cutting of firewood is permitted on public land; only fallen timber may be collected. Firewood collection on roadside reserves is common, as is collection in State forests in the area (J. McGuire pers. comm.). In the Portland district firewood is primarily collected from mixed species State forest, where the most commonly collected species is Messmate. In the Portland district a large proportion of the firewood collected on private land is River Red Gum, and private collectors harvest more firewood on public land than do commercial operators.

Substantial quantities of firewood are harvested from the Midlands FMA, where most State forests produce some firewood. Most of this produce originates from thinning activities, areas that yield low volumes of sawlogs, and sawlog harvesting operations, and is harvested by commercial operators. Limits have been set on the amount of firewood that can be harvested from the Pyrenees State Forest. Considerable illegal collection is believed to occur in the Midlands FMA (NRE 1996b).

The main timbers used for post and pole material in the West are River Red Gum, box and other durable species and Messmate from low forest foothills and woodlands. Whilst a number of commercial cutters supply posts, poles and other hewn timbers to the local market, some landowners have traditionally met their own requirements under licences issued over nearby forest (VicRFASC 1999). In the Midlands FMA, it is estimated that more than 25 000 cubic metres of firewood and almost 50 000 pieces of farm timber (posts and poles) are harvested each year (CNR 1995a).

Speciality timbers and craftwood are much sought after for use in furniture manufacturing and wood turning. These timbers include River Red Gum *Eucalyptus camaldulensis*, Blackwood *Acacia melanoxylon*, Satinwood *Phebalium squameum* and Cherry Ballart *Exocarpos cupressiformis*. In the West, the market for speciality timbers is small, and is variable depending on the availability of suitable species. Speciality timbers and craftwood, with the exception of Blackwood in the Otway Ranges, are generally obtained by sawmillers, local producers and individuals.

Blackwood sawlogs are an important speciality timber resource of mountain forests in the south of the region. In the Otway FMA these sawlogs are generally a product of normal harvesting operations or are produced from a program of Mountain Ash reforestation of former farmland in the Otway Ranges.

Potentially Threatening Processes Affecting Flora

The direct impacts of firewood collection are similar to those for timber harvesting. These include damage or loss of individuals as a result of accessing the site and the removal of timber, alteration of microclimatic conditions and the loss or modification of habitat (eg. logs, litter and debris provide important microhabitats and substrates for smaller plants and fungi, removal and disturbance of these elements may result in loss of symbiotic fungi and changes in nutrient and moisture levels).

Indirect impacts of firewood collection may result in weed invasion and the spread of pathogens, increased erosion and sedimentation and disturbance to understorey by vehicles.

For a list of EVCs potentially threatened by firewood and other minor forest produce see Table 6.1.

Potentially Threatening Processes Affecting Fauna

Fallen logs, branches, timber debris and standing live and dead trees are removed and the litter layer disturbed during firewood collection. Fallen timber provides shelter, refuge, foraging and breeding sites for many fauna (Brown and Bennett 1995, Silveira *et al*. 1997). Firewood collection is likely to be a significant threat to species that utilise fallen branches or logs, or hollows in dead standing trees (Robinson 1994). Logs, litter and debris are important microhabitats for many reptile species, providing foraging areas, breeding and basking sites, and shelter from predators (Webb 1985, Greer 1989). Fallen logs provide shelter for the Woodland Blind Snake, Striped Worm-lizard, and Common Scaly-foot, and foraging and basking sites for the Anglesea Mountain Dragon (Ehmann 1992, Brown and Bennett 1995, Cogger 1996). Fallen timber also provides foraging substrates for mammals such as the Common Dunnart, Brush-tailed Phascogale, Spot-tailed Quoll and Yellow-footed Antechinus. In the West, firewood collection is considered a major threat to the Common Dunnart, Red-tailed Black-Cockatoo, Bush Stone-curlew and Striped Worm-lizard.

Accumulations of woody debris are important microhabitats for ground foraging birds. The disturbance and loss of litter, invertebrates and shelter that accompanies firewood collection are threatening processes for species such as Chestnut-rumped Heathwren and Speckled Warbler (Robinson 1994). Removal of fallen timber decreases the amount of foraging habitat available for the Grey-crowned Babbler (Davidson and Robinson 1992). Fallen debris is used as camouflage by the Bush Stone-curlew at day roosts (Johnson and Baker-Gabb 1994), and loss of this habitat component is a major threat to this species (D. Robinson pers. comm.). Logs, litter and debris provide critical habitat for many invertebrate groups, often providing an important refuge during dry periods.

On private land harvesting of firewood for domestic use and the cutting of standing dead trees is permitted under the Native Vegetation Retention Controls (Robinson 1994, Read Sturgess and Associates 1995). The loss of old trees from woodland remnants on private land is a particularly significant threat to species that utilise these habitats. Red-tailed Black-Cockatoo nesting habitat is now mostly confined to remnant trees on private land. Dead trees make up the majority of known nest sites. Loss of this critical habitat element as a result of felling for firewood is a major threat to the population. (Joseph *et al.* 1991, Garnett 1992b, Venn and Fisher 1993). nesting habitat (J. McGuire pers. comm.). Wooded farmland provides foraging habitat for the Barking Owl (Emison *et al*. 1987), and foraging and nesting habitat for the Masked Owl (Hollands 1991). Standing dead trees provide foraging and sheltering sites for many species as well as nest sites for species such as the Brush-tailed Phascogale and basking sites for the Lace Monitor (Alexander 1997). Loss of these habitat components as a result of firewood collection is likely to contribute to population declines of these species. Within the West, the Regent Honeyeater, Swift Parrot, Painted Honeyeater, Bush Stone-curlew, Grey Crowned Babbler and Squirrel Glider are at least partially dependent on remnant woodland habitats on either private land, streamside reserves or roadside reserves. Firewood collection may contribute to overall loss and degradation of their woodland habitats, and is an important threat to these species. Large old trees, especially dead ones, are often the target of firewood collectors and are important habitat components of the Yellow-bellied Glider; removal of these trees is a significant threat to this species (S. McDougall pers. comm.).

Management

Firewood collection for domestic use on public land is controlled by the issue of licences which stipulate the amount of timber permitted to be collected and the duration of the licence. Licences are generally for the collection of fallen or felled timber only. Green firewood harvesting may be allowed as part of silvicultural thinning programs in the Midlands FMA. Maps of collection areas are included with licences. These areas may be specifically designated collection areas, or specified areas of some State forests. Local government permission and a licence is required for firewood collection along roadsides. Some shires have roadside management plans which may ban firewood collection from certain sites. The number of licences issued for commercial firewood operations on public land depends upon an assessment of the amount of wood available in accordance with the Wood Utilisation Plan in each FMA. Commercial cutters must also hold a forest

operators licence and operate in accordance with the Code of Forest Practices for Timber Production (NRE 1996a), and local NRE prescriptions (Read Sturgess and Associates 1995).

A large proportion of the firewood collected from the West is from woodland remnants on private land. The *Flora and Fauna Guarantee Act* 1988, the *Conservation, Forests and Lands Act* 1987 and the *Planning and Environment Act* 1987 provide some controls for firewood collection on private land. Domestic collection on private land is exempt under Native Vegetation Retention Controls (Robinson 1994, Read Sturgess and Associates 1995). One of the major impacts of firewood collection, *The loss of hollow-bearing trees in Victorian native forests*, is listed as a Potentially Threatening Process under the FFG Act.

Firewood collection is recognised as an issue to be addressed by management actions in the Grey-crowned Babbler Action Statement (Davidson and Robinson 1992). Habitat management on public land for this species must include the retention of large logs within the home ranges of families of these birds, and minimal disturbance to ground layers. Restriction of firewood collection on public land, particularly roadsides, would help in achieving these management objectives (Davidson and Robinson 1992). The Regent Honeyeater Action Statement recognises firewood collection as an issue, particularly for woodland remnants on private land. Firewood collection may be compatible with Regent Honeyeater conservation, providing mature trees are retained and sufficient areas allowed to regenerate (Menkhorst 1993). However, for the majority of listed species covered by this review, Action Statements are yet to be published. Research is required to address the long-term ecological effects of firewood harvesting on vertebrate fauna, which to date are largely unknown (Robinson 1994).

6.2.14 Illegal collecting/harvesting

This disturbance includes direct interference to plants and animals by humans in the form of illegal hunting, poisoning, trapping, collecting or harvesting of species.

Potentially Threatening Processes Affecting Flora

Deliberate collection is a significant disturbance or threat to a small number of taxa which are considered to be desirable by collectors. These taxa are naturally rare, exist in small populations and often have low fecundity. Most collectors are believed to be amateurs acting alone rather than commercially motivated. Most at risk are the native orchids, particularly terrestrial orchids.

For a list of EVCs potentially threatened by illegal collecting/harvesting see Table 6.1.

Potentially Threatening Processes Affecting Fauna

The Square-tailed Kite is under threat from egg collectors (Garnett 1992a, Marchant and Higgens 1993), and although the extent of this activity within the West is unknown, it is potentially significant given the small population size of this species in the region. Egg collection of the Bush Stone-curlew is known to have occurred in the past, although it is considered a minor threat at present (Johnson and Baker-Gabb 1994). Similarly, the Lace Monitor is known to have been the target of illegal collection in the past. The Anglesea Mountain Dragon may also be threatened by illegal collecting in the West (P. Robertson pers. comm.).

Cockatoos and parrots are prized for the live pet trade, although the extent of illegal collection within the West is unknown. The impact of this disturbance on the Swift Parrot is unknown. However, the impact on the Red-tailed Black-Cockatoo is potentially significant and is considered a major threat to the species.

Management

Collection of native orchids is listed as a Potentially Threatening Process under the *Flora and Fauna Guarantee Act* 1988. Removal of wildlife from the wild is prohibited under the *Wildlife Act* 1975, and the FFG Act requires a permit to take from the wild all listed species.

6.2.15 Dieback

Tree dieback is a process involving the protracted decline of health and vigour of trees. It is characterised by progressive general deterioration, beginning with a decline and thinning of the crown, and often ending in the death of the tree (Heatwole and Lowman 1986). Isolated trees or whole forests may be affected, although dieback is generally more severe for isolated trees or small remnants of vegetation amongst pasture than for larger protected blocks (Bennett 1993). Causes of tree dieback are not fully understood, although it is likely many factors interact to contribute to tree stress, which may lead to dieback (Landsberg and Wylie 1988). Possible contributing factors include insect defoliation, fungal diseases, drought, fire, altered water tables and increased salinity, nutrient imbalances as a result of applications of fertilizers, soil erosion and reduced soil aeration, land clearing, lack of regeneration and overgrazing (Heatwole and Lowman 1986). Nutrient redistribution and enrichment by livestock may be a key factor contributing to the abundance of defoliating insects and, hence, dieback in woodland remnants used by grazing stock (Landsberg *et al*. 1990). Grazing also contributes to dieback through soil compaction, root damage, tree girding and prevention of regeneration.

Potentially Threatening Processes Affecting Flora

In forest blocks, dieback is generally associated with fungal pathogens such as *Phytophthora cinnamomi* (Cinnamon Fungus), or *Armillaria* spp. (Honey Fungus), or defoliation by phasmatid insects. Forests growing on poor soils with low organic content and few soil microbes are more susceptible to Cinnamon Fungus outbreaks than forests growing on organically rich, well-drained soils. This disease is favoured by soil temperatures of at least 10^0C and wet weather during spring, summer and autumn (NRE 1996b). Some plant communities may be altered following outbreaks of Cinnamon Fungus. Plants susceptible to the fungus may be replaced by resistant species, changing the species composition of the community (Kennedy and Weste 1986, Weste 1986). Cinnamon Fungus is known to cause the extensive loss of grass trees (*Xanthorrhoea* spp.) in some areas in the West (Weste 1993, L. Morcom pers. comm.). The spread of Cinnamon Fungus is facilitated by the use of infected gravel during road construction and through the run-off of drainage water from infected sites. Infected soil may be introduced to uninfected areas of forest by vehicles and machinery (NRE 1996b). *Armillaria* spp. can be spread through adjacent tree roots, stumps or pieces of infected timber (NRE 1996b). Stringybarks and peppermints are more susceptible than gums, boxes and ironbarks (Neumann *et al.* 1981, Weste 1993). Understorey species in these forests may also be affected (Weste 1993), and plants on dry steep slopes that succumb to Cinnamon Fungus are often not replaced, leading to increased erosion of the soil surface (Kennedy and Weste 1986).

Within the West there have been numerous incidences of dieback in forest stands. Cinnamon Fungus is known to be problematic in the Angahook Forest Park in the Otway FMA (DCE 1992a, Weste 1993), several areas in the Midlands FMA, including severe outbreaks in the Brisbane Ranges (Weste 1986, Weste 1993, NRE 1996b), in the Horsham FMA, particularly in the Grampians National Park (Weste 1993), and in the south-west of the region (LCC 1979). Dieback attributable to *Armillaria* spp. has been recorded in two State forests in the Midlands FMA (NRE 1996b). Dieback (general tree decline) has been recorded on the Dundas Tablelands in the Portland FMA (A. Govanstone pers. comm.).

For a list of EVCs potentially threatened by dieback see Table 6.1.

Potentially Threatening Processes Affecting Fauna

For fauna species which utilise resources produced by eucalypts, and whose habitat mostly exists as small patches or linear corridors embedded in farmland, eucalypt dieback is a significant threat. Remnants of habitat amongst farmland provide important foraging resources and shelter sites for a number of species. They often contain large old trees on fertile soils that provide copious and relatively predictable sources of nectar which is critical for the survival of species such as the Regent Honeyeater (Menkhorst 1997) and Swift Parrot (Tzaros and Davidson 1996, Tzaros 1997). Trees suffering from dieback may produce fewer flowers and lower quantities of nectar. The defoliation of eucalypts, particularly *E .tricarpa*, causes the death of parasitic mistletoes, the exclusive food source of the Painted Honeyeater (Eddy 1961). The majority of Squirrel Glider records in the West are from roadside reserves and remnants on private land. Eucalypts supply nest and den sites, and are also a source of pollen, nectar and sap for this species. The Grey-crowned Babbler is also largely dependent on remnants, and habitat degradation as a result of dieback is a considerable threat to both species (Davidson and Robinson 1992, Weber in prep.).

Loss of canopy cover reduces protection from predators and environmental effects, such as strong wind and extreme heat and cold, which may lead to a decrease in subcanopy bird species (Er 1997). This could lead to a reduction of prey for species such as the Square-tailed Kite, which feeds mainly on passerine nestlings and eggs taken from nests in the outer foliage (Debus and Czechura 1989). Loss of nest sites is a threatening process associated with eucalypt dieback for species such as the Red-tailed Black-Cockatoo, Masked Owl and Hooded Robin (Hollands 1991, Fitri and Ford 1997). Arboreal mammals, such as the Brush-tailed Phascogale and Yellow-bellied Glider, may suffer from a reduction in quality foraging habitat. These two species would need to increase an already large foraging area to satisfy requirements. Habitat degradation as a result of dieback is considered a moderate threat to the Lace Monitor in the West.

Management

The implications of dieback for a number of the fauna and flora species covered by this review are unknown. Development of appropriate long-term management strategies are essential and requires a major research effort (RAC 1992).

Management of dieback is aimed at minimising the risk of introduction or movement of the fungus. The Code of Forest Practices, management plans and conditions of exploration licences address the threatening process, *Use of Phytopthera cinnamomi-infected gravel in construction of roads, bridges and reservoirs*, which is listed as a Potentially Threatening Process under the FFG Act. Measures to contain and control the spread of Cinnamon Fungus include hygiene procedures such as the cleaning and disinfecting of vehicles, machinery, tools and equipment used in infected areas, and the restriction and control of activities that have the potential to move or

relocate infected sand, gravel and water into uninfected areas (NRE 1996b). Minimising the spread of *Armillaria* spp. (Honey Fungus) relies on the appropriate choice of silvicultural system (NRE 1996b).

The implications of dieback for a number of the fauna covered by this review are unknown. There is some concern that the recent drought conditions may act as a precursor to other incidences of dieback within the region (Weste 1993). Development of appropriate long-term management strategies are essential, and require a major research effort (RAC 1992).

6.2.16 Mining/Quarrying

The main deposits for extractive industries in the West are gold, sand, gravel and limestone. Historically, parts of the region have long been associated with the search for, and extraction of, gold. This is particularly the case in parts of the Midlands, Horsham and Portland FMAs. Gold is still extracted from within the Midlands and Horsham FMAs. A range of activities conducted on private land and public land are associated with this industry, from minor prospecting and alluvial screening, to 'doze and detect' operations and open-cut mines (P. Johnson pers. comm.). In the Horsham FMA the country around Stawell and the Grampians has been extensively prospected and mined for gold since last century (CFL 1985). Mining and quarrying is not widespread in the Portland FMA; there are few limestone and gravel extraction sites and smale-scale basalt and scoria quarries. Other minerals extracted in the West include antimony, coal, kaolin and manganese. Rock, gravel, clay, sand, gypsum, tuff and soil are extracted from a number of quarries within the region. To minimise haulage costs, sources of crushed rock and gravel are often sought close to where they will be used (DCE 1992a, Cuddy *et al.* 1993, NRE 1996b).

Potentially Threatening Processes Affecting Flora and Fauna

Potentially threatening processes associated with mining/quarrying include tailings disposal and treatment, disposal of effluents or treatment wastes, and new surface works or developments. These activities may result in the loss of habitat elements that are not easily replaced during rehabilitation (NRE 1996b). Quarrying (gravel and stone extraction) involves direct habitat destruction, contributes to erosion and can alter the drainage characteristics of the soil. In the Stawell area, gold prospecting and gravel extraction can have an adverse effect on many orchid species as well as disturbing the habitat of Heathy Woodland. Weed control and ineffective or inappropriate revegetation measures are areas of concern during minesite rehabilitation works. Poorly planned and located quarries and borrow pits can have an adverse effect on water quality. Although mining/quarrying has the potential to affect many of the species covered in this review, activities are now limited in the region and as a result for the majority of species the affects of this disturbance are either likely to be minor or were unknown. This disturbance was identified as a moderate threat to the Eastern Bent-wing Bat, Red-tailed Black-Cockatoo, Gilbert's Whistler, Common Scaly-foot and Anglesea Mountain Dragon.

Disused mine shafts are important roosting sites for the Eastern Bent-wing Bat. The reworking of old mines can cause bats to abandon their roosts and is considered a moderate threat to this species (L. Lumsden pers. comm.). The Anglesea Mountain Dragon and Common Scaly-foot have highly localised distribution in the West and any habitat destruction or alteration as a result of mining or quarrying activities may have a large impact on populations of these species (P. Robertson pers. comm.). A large number of records of the Red-tailed Black-Cockatoo are from forests south of Minimay and Goroke in the Horsham FMA where gold extraction is continuing. This disturbance has the potential to remove and degrade habitat of this species (Venn and Fisher 1993). A substantial proportion of the Gilbert's Whistler records for the West region are also from areas where gold mining is continuing. Mining results in the removal of shrub layers and litter that provide foraging and nesting substrates and cover for this species (D. Robinson pers. comm.).

Other species identified as being impacted by mining/quarrying include those associated with riparian habitats (Southern Myotis and Swamp Skink). Mining and extraction activities in and around streams may adversely affect the Southern Myotis through a reduction in aquatic prey resulting from reduced water quality, although the severity of this impact is unknown (L. Lumsden pers. comm.). Degradation of swampland from an increase in sedimentation as a result of mining/quarrying run-off may affect Swamp Skink populations and is considered a moderate threat to this species. The Brush-tailed Phascogale and Yellow-footed Antechinus are considered to be vulnerable to habitat alteration as much their range has been reduced, fragmented and degraded due to a multitude of disturbances such as clearing of native vegetation and timber harvesting. Further reduction in the quality of habitat as a result of mining activities is seen as a threat to these species (P. Menkhorst and T. Soderquist pers. comm.). Habitat degradation and fragmentation may affect other species that forage on the ground (Common Scaly-foot, Common Dunnart and Heath Mouse), largely rely on remnant vegetation (Squirrel Glider) or require large home ranges (Spot-tailed Quoll, Yellow-bellied Glider and Lace Monitor). The fossorial nature of the Striped Worm-lizard and Woodland Blind Snake makes these species vulnerable to activities that disturb the soil, such as mining and quarrying (P. Robertson and G. Brown pers. comm.).

For a list of EVCs potentially threatened by mining and quarrying see Table 6.1.

Management

Mineral exploration, mining and extractive industries are not permitted in reference areas, nor in national, state and wilderness parks, except where a tenement or application pre-dates the park, and the Minister responsible for national parks consents to these activities. Within the Grampians National Park, there are many gravel pits which need to be rationalised in order to minimise impact on Park values. For restricted Crown land, including most conservation reserves, the consent of the responsible Minister is required, which may be conditional. Mining and exploration operations require a licence and work plan approved by Minerals and Petroleum Victoria (a division of NRE) before exploration or mining works can be undertaken. For mining and exploration on unrestricted Crown land, relevant land management divisions of NRE can comment on licence applications, conditions and work plans, which address environmental considerations such as biodiversity conservation. Similarly, extractive industries require a work plan and the consent of the relevant Minister for extractive operations.

6.2.17 Other Disturbances

This category includes a number of threats that were identified by experts as being relevant to particular species, but were not covered by any of the above categories.

Dams/Impoundments

Within the West many minor dams/impoundments and weirs exist, modifying the natural flow regimes of rivers and streams. Major dams/impoundments in the region include Rocklands Reservoir, Pykes Creek Reservoir and Lal Lal Reservoir.

Potentially Threatening Processes Affecting Flora and Fauna

Threatening processes associated with dam/impoundment construction and subsequent operation include loss and fragmentation of habitat, large increases in sediment input into rivers and streams, and modifications to natural temperature fluctuations and flow rates (Koehn *et al.* 1996). Alterations to temperatures and flow regimes, and increases in sedimentation into rivers and streams which result in the degradation of adjacent native riparian vegetation are listed as potentially threatening processes under the *Flora and Fauna Guarantee Act* 1988 (SAC 1991, 1992, 1996). Salinity is an associated threatening process often resulting from large-scale irrigation, together with extensive clearing of native vegetation, and is recognised as a considerable problem in parts of the region (L. Morcom, J. McGuire and R. Price pers. comm.). Many parts of the region are affected by dryland salinity, which is unrelated to irrigation activities (D. Heislers pers. comm.). Salinity as a threatening process, its effect on flora and fauna, and recommendations for amelioration, are outlined in Clunie (in prep).

The Azure Kingfisher is sensitive to disturbances that result in the fouling of streams and alterations to stream flow, as well as the removal of adjacent riparian vegetation. This species nests in tunnels that it excavates in stream banks, which are liable to flood as a result of water releases from impoundments (Shields 1994). Cold water releases from impoundments can change the water temperature in rivers downstream, which is known to have a significant effect on the species composition and abundance of fish and macroinvertebrate fauna (Koehn *et al.* 1996). This may result in reductions in food availability for the Azure Kingfisher, and is considered a moderate threat (R. Loyn pers. comm.). Dam or impoundment construction and operation in the riparian habitat of the Broad-toothed Rat and Swamp Skink has the potential to fragment and degrade this vegetation and is considered a moderate threat to populations of these species. Fragmentation and loss of habitat due to dam construction can have an impact on those species that need large areas of forest to meet foraging requirements, such as the Yellow-bellied Glider and Spot-tailed Quoll.

For a list of EVCs potentially threatened by dams and impoundments see Table 6.1.

Management

The environmental impacts of dams/impoundments have been the subject of numerous studies and it is recognised that construction and operation of these structures have many adverse effects on downstream fauna. However, there is little active management to alleviate related disturbances (Koehn *et al.* 1996). Some processes in place to minimise impacts include environmental flow allocations, construction of fish ladders and regulating the temperature flowing out of storages.

Interspecific Competition

This category refers to competition for resources such as food and shelter with other native species. Although this occurs to some extent for most native species, this category has been included for species that are particularly impacted by this process. Competition from introduced species is discussed under the category of Introduced Species.

Interspecific competition has been identified as a threat in the West to the Grey-crowned Babbler, Regent Honeyeater, Painted Honeyeater, and Red-tailed Black-Cockatoo (Tzaros 1995, Robinson *et al*. in prep., Menkhorst 1997). Loss and fragmentation of high quality sites can lead to increased competition for limited resources between Regent Honeyeaters, Painted Honeyeaters, Swift Parrots, and other nectivores. The expenditure of energy in aggressive encounters could potentially reduce the available time and energy for feeding (Franklin and Robinson 1989, Ford *et al.* 1993, Menkhorst 1993, Robinson 1993, Grey *et al*. 1997). The affect of interspecific aggression on accessibility of nectar, breeding success, use of optimum habitat and the survival of the Regent Honeyeater requires monitoring and research (Menkhorst 1993, Menkhorst 1997). Competition for nest sites between the Red-tailed Black-Cockatoo, Yellow-tailed Black-Cockatoo, Slender-billed Corellas, and Galahs may have a significant impact on breeding, particularly as nest sites are limiting (Joseph *et al.* 1991, Venn and Fisher 1993). Competition between White-bellied Sea-Eagles and Wedge-tailed Eagles for nest sites and food has been recorded, although its significance is not known (Clunie 1994, Wiersma 1996). Mobs of Noisy Miners are known to destroy Grey-crowned Babbler nests, especially when the nests are in small groups and contain young (Tzaros 1995, Robinson *et al.* in prep.).

Pasture Improvement

Pasture improvement involves the replacement of native grasses with exotic pasture species. Activities associated with pasture improvement, such as higher rates of clearing, higher stocking rates and increased use of fertilisers, are likely to impact on many species. However, these activities are included in other disturbance categories in this review. Pasture improvement activities are restricted to private land, and are not generally addressed by active management. Potentially threatening processes to flora include the loss of native grasses and forbs and weed competition. Fauna identified as being adversely impacted by pasture improvement are ground foraging or ground nesting species with a substantial proportion of habitat occurring on private land.

Remnant patches of native vegetation on private land provide important habitat for the Bush Stone-curlew and Grey-crowned Babbler. A relatively sparse ground layer with abundant ground litter is an important component of foraging habitat for Grey-crowned Babblers. Replacement of native grasses with exotic pasture species reduces foraging habitat and depletes the invertebrate prey of this species (Robinson *et al.* in prep.). Bush Stone-curlews are rarely recorded from sites with sown pasture. Pasture improvement is considered to be the principal cause of population declines of this species between 1985 and 1991 (Webster and Baker-Gabb 1994).

Education programs which inform land managers of the ecological effects of intensified land use practices, such as pasture improvement, is a management issue identified by the Bush Stone-curlew Action Statement. A range of other actions undertaken through programs such as *Land for Wildlife* and Landcare in conjunction with land owners can also assist in mitigating impacts on native species (VicRFASC 1999).

Mineshaft Collapse

Mineshaft collapse and mineshaft entrances becoming overgrown are recognized as major threats to the Eastern Bent-wing Bat. This species is dependent on caves and mineshafts for roosting and breeding. Restricted access to roost sites, and loss of breeding habitat due to these processes is likely to lead to a decline of this species in the West (L. Lumsden pers. comm.).

Vandalism

This category covers the direct interference to animals by humans through activities such as shooting and disturbance at nest and roost sites. This category does not include interference for the sake of animal collection. Vandalism is a moderate threat to the Eastern Bent-wing Bat, Square-tailed Kite and Grey Goshawk, and a minor threat to the Southern Myotis, Bush Stone-curlew, White-bellied Sea-Eagle, Red-tailed Black-Cockatoo and Lace Monitor.

Deliberate disturbance of Eastern Bent-wing Bats and the Southern Myotis by humans may cause the bats to abandon their roost sites. Disturbance of bats in torpor causes them to use valuable energy reserves to raise body temperatures to become active. During winter when food supplies are low, energy supplies may not be replenished and mortalities may occur (Lumsden *et al.* 1991). The White-bellied Sea-Eagle is vulnerable to human disturbance, particularly at the nest. Birds may desert nests if disturbed by humans (Hunt and Mooney 1983). The action statement for this species states visitors to nest sites will be discouraged, and the sites kept confidential (Clunie 1994). Red-tailed Black-Cockatoos are also sensitive to human disturbance at the nest.

The Square-tailed Kite and Bush Stone-curlew are known to have been the target of illegal shooting (Jolly 1989, Johnson and Baker-Gabb 1994). Similarly, shooting of the Grey Goshawk is known to occur in Tasmania (Brereton and Mooney 1994), and although there are no known incidences of illegal shooting in the West, small populations would be significantly impacted by loss of individuals. Lace Monitors may also be the target of random acts of vandalism (P. Robertson pers. comm.).

All wildlife is protected under the *Wildlife Act 1975.*

Rock Harvesting

Rock harvesting involves the removal of rocks and boulders from species' habitat to be used in the garden trade. This practise has been shown to deleteriously impact populations of threatened reptiles that rely on rocks for shelter and foraging habitat (eg. Shine *et al.* 1998). The Common Scaly-foot is usually encountered beneath rocks and stones, and the removal of these habitat components is likely to be detrimental to the survival of this species in the region (P. Robertson pers. comm.).

Ozone Depletion

Ozone depletion is the process whereby the natural equilibrium between chemical reactions forming and destroying stratospheric ozone is disturbed by the release of human-manufactured chemicals (commonly referred to as 'Greenhouse gases'). This results in a lessening of the ozone layer's ability to intercept ultra-violet (UV) radiation in the stratosphere (National Greenhouse Advisory Committee 1992).

As a basking species, the Warty Bell Frog is exposed to UV rays, and it is considered likely that increased UV radiation, resulting from a depletion of the ozone layer, may be harmful to this species (Gillespie *et al.* 1995, Tyler 1997).

Climate Change

Greenhouse-related climate change may well be a long term issue for many threatened species. An examination of potential effects of this process on a number of representative fauna using BIOCLIM (Bennett *et al.* 1991, Brereton *et al.* 1995) indicated that most would undergo reductions in bioclimate range following climate change. Human development has created a large number of barriers which will prevent less mobile species from shifting their ranges in response to climate change. In order to accommodate changes in the distribution of fauna, Brereton *et al.* (1995) proposes the need for long-term biotic conservation strategies.

Loss of Genetic Diversity

Genetic pollution of natural populations of native flora is most likely to occur from garden escapees or as a result of the establishment of plantations of silvicultural or horticultural species closely related to native species within reproductive range. The advent of genetically-modified types may increase the impact. The other major source of genetic pollution is as a result of the use of non-local provenance seed or seedlings in re-afforestation or forest regeneration following harvesting. This is not currently practised, although it tended to occur more frequently in the past. Although potentially significant, major impacts have not been revealed by research to date.

A lack of genetic diversity is a problem for very small, fragmented populations of native flora, resulting in reproductive difficulties and a risk of extinction. For fauna, loss of genetic diversity is considered to be a potential threat to the Squirrel Glider. This species exists in largely fragmented populations which are in danger of becoming isolated resulting in loss of genetic diversity within populations (R. van der Ree pers. comm.). This can lead to a reduced capacity to resist recessive lethal alleles or to respond to changes in environmental conditions (Bennett 1990). Although not identified as a threat to other species, any populations that are small and isolated are at risk from loss of genetic diversity. The full implications of this are unknown, and research is required to address this potentially major issue.

Apiculture

Apiculture is an important, though fluctuating activity in the West and contributes significantly to Victoria's honey production. The forests provide a source of nectar and pollen for the production of honey, beeswax and other by-products. Usage of the forests varies from year to year due to the flowering patterns of the eucalypts which form the major nectar source (NRE 1996b). Some studies suggest that introduced bees may adversely affect native ecosystems (Paton 1993). Potential threats to flora and fauna include competition with native fauna for nectar and pollen, a long-term decline in native pollinator populations as a result of competition for resources, inefficient pollination of native plant species, hybridisation of native plant species and occupation of tree hollows by feral bees (NRE 1996b).

Access to public lands for bee-keeping is controlled through the issue of annual licences and temporary permits (3 or 6 month), usually under the *Forests Act* 1958 or *National Parks Act* 1975. Licences allow access to a site for locating hives and, usually, exclusive use of forest nectar and pollen resources within a radius of 1.6 km or 0.8 km (NRE 1996b). Beekeeping in areas managed under the provisions of the *National Parks Act* 1975 must be authorised by the Minister for Natural Resources and Environment.

Table 6.1 Potentially Threatening Processes affecting EVCs in the West RFA

EVC No	EVC Name	Potential Threatening Processes
1	Coastal Dune Scrub Mosaic	clearing, inappropriate fire regimes, recreation, car park and road construction and maintenance, residential development, weed invasion
3	Damp Sands Herb-rich Woodland	grazing, weed invasion, inappropriate fire regimes, clearing, agriculture, softwood plantation
6	Sand Heathland	inappropriate fire regimes, fire, clearing for pine plantations, recreation
8	Wet Heathland	clearing, grazing, weed invasion, hydrological alteration, inappropriate fire regimes, fragmentation
9	Coastal Saltmarsh	alteration of drainage patterns and flooding regimes, recreation, clearing, residential and commercial development, marine pollution
10	Estuarine Wetland	clearing for agriculture, grazing, alteration of drainage patterns and flooding regimes, residential and commercial development
13	Brackish Sedgeland	agriculture, weed invasion, alteration of drainage patterns and flooding regimes
16	Lowland Forest	timber harvesting, clearing, weed invasion, inappropriate fire regimes, minor forest produce,, dieback
17	Riparian Scrub Complex	hydrological alteration, indirect impacts of road construction and maintenance, weed invasion, indirect impacts of timber harvesting, inappropriate fire regimes
18	Riparian Forest	weed invasion, grazing, recreation, clearing, fire, indirect impacts of road construction and maintenance and timber harvesting, alteration of drainage patterns and flooding regimes
19	Riparian Shrubland	weed invasion, grazing, hydrological alteration
20	Heathy Dry Forest	inappropriate fire regimes, mining/quarrying, minor forest produce, recreation, weed invasion
21	Shrubby Dry Forest	inappropriate fire regimes, minor forest produce, weed invasion, pest animals
22	Grassy Dry Forest	clearing, weed invasion, grazing, minor forest produce, recreation, inappropriate fire regimes, pest animals
23	Herb-rich Foothill Forest	timber harvesting, clearing for agriculture, grazing, weed invasion, minor forest produce
28	Rocky Outcrop Shrubland	recreation, weed invasion, inappropriate fire regimes, pest animals
29	Damp Forest	timber harvesting, inappropriate fire regimes, indirect impacts of road construction and maintenance, weed invasion
30	Wet Forest	timber harvesting, inappropriate fire regimes, indirect impacts of road construction and maintenance, weed invasion, illegal collecting/harvesting
31	Cool Temperate Rainforest	fire, clearing, indirect effects of timber harvesting and of road construction and maintenance, illegal collecting/harvesting, dieback
37	Montane Grassy Woodland	timber harvesting, clearing, weed invasion, recreation
45	Shrubby Foothill Forest	minor forest produce, timber harvesting, inappropriate fire regimes, weed invasion
47	Valley Grassy Forest	weed invasion, grazing, clearing, minor forest produce, agriculture, fire
48	Heathy Woodland	inappropriate fire regimes, clearing for agriculture and pine plantations
50	Coastal Heathland	indirect impact of commercial development
52	Coastal Saltmarsh Complex	alteration of drainage patterns and flooding regimes, recreation, residential and commercial development, marine pollution
53	Swamp Scrub	clearing for agriculture, grazing, weed invasion, fragmentation, inappropriate fire regimes, hydrological alteration
55	Plains Grassy Woodland	clearing for agriculture, fragmentation, grazing, weed invasion, road construction and maintenance, minor forest produce, timber harvesting, inappropriate fire regimes, dieback
56	Floodplain Riparian Woodland	clearing for agriculture, fragmentation, minor forest produce, alteration of drainage patterns and flooding regimes, grazing, weed invasion, dieback
61	Box Ironbark Forest	timber harvesting, minor forest produce, mining, fragmentation, weed invasion, clearing, inappropriate fire regimes, recreation
64	Rocky Chenopod Woodland	inappropriate fire regimes, weed invasion, residential development, pest animals
65	Sedge-rich Woodland	clearing for agriculture, grazing, weed invasion, minor forest produce
67	Alluvial Terraces Herb-rich Woodland	grazing, weed invasion, clearing for agriculture, minor forest produce
68	Creekline Grassy Woodland	grazing, weed invasion, clearing for agriculture, hydrological alteration
69	Metamorphic Slopes Shrubby Woodland	inappropriate fire regimes
70	Hillcrest Herb-rich Woodland	weed invasion, overgrazing
71	Hills Herb-rich Woodland	clearing for agriculture, weed invasion, pest animals, minor forest produce
73	Rocky Outcrop Shrubland/Herbland Mosaic	weed invasion, recreation, pest animals, inappropriate fire regimes
74	Wetland Formation	drainage and other hydrological alterations, salinity, grazing, weed invasion, clearing, cropping, agricultural runoff, indirect impacts of road construction and maintenance
83	Swampy Riparian Woodland	clearing for agriculture, grazing, weed invasion, alteration of drainage patterns and flooding regimes, indirect impacts of road construction and maintenance, habitat loss, fragmentation
93	Broombush Mallee	minor forest produce, pest animals, inappropriate fire regimes
103	Riverine Grassy Chenopod Woodland	clearing for agriculture, salinity, minor forest produce, grazing, pest animals
104	Lignum Wetland	hydrological alteration, grazing, clearing for agriculture, agricultural runoff
124	Grey Clay Drainage-line Herbland/Sedgeland	grazing, agriculture, hydrological alteration, agricultural runoff
125	Plains Grassy Wetland	agriculture, drainage and other hydrological alteration, grazing, weed invasion, fire breaks
127	Valley Heathy Forest	weed invasion, grazing, clearing, minor forest produce, agriculture, fire
128	Grassy Forest	weed invasion, grazing, clearing, minor forest produce, agriculture, fire
132	Plains Grassland	inappropriate grazing regime, ploughing and cropping, fragmentation, weed invasion, inadequate burning, road construction and maintenance, utility services,
133	Limestone Pomaderris Shrubland	weed invasion
134	Sand Forest	inappropriate fire regimes, dieback
136	Sedge Wetland	drainage and other hydrological alteration , weed invasion
140	Mangrove Shrubland	recreation, earthworks and construction associated with development, marine pollution

EVC No	EVC Name	Potential Threatening Processes
154	Bird Colony Shrubland	soil erosion
155	Bird Colony Succulent Herbland	recreation
160	Coastal Dune Scrub	clearing, weed invasion, inappropriate fire regimes, recreation, car park and road construction and maintenance, residential development
161	Coastal Headland Scrub	recreation, weed invasion, residential and commercial development, clearing, inappropriate fire regimes
163	Coastal Tussock Grassland	grazing, recreation, weed invasion
164	Creekline Herb-rich Woodland	clearing for agriculture, grazing, weed invasion, recreation
165	Damp Heath Scrub	hydrological alteration, indirect impacts of road construction and maintenance, weed invasion, indirect impacts of timber harvesting, inappropriate fire regimes
167	Depauperate Heathy Dry Forest	inappropriate fire regimes, mining/quarrying, minor forest produce, recreation, weed invasion
175	Grassy Woodland	grazing, weed invasion, habitat loss, fragmentation, clearing for agriculture, minor forest produce, mining
177	Valley Slopes Dry Forest	Inappropriate fire regimes, weed invasion, dieback
179	Heathy Herb-rich Woodland	clearing for agriculture and pine plantations, minor forest produce
181	Coast Gully Thicket	
184	Montane Wet Heathland	
191	Riparian Scrub	hydrological alteration, indirect impacts of road construction and maintenance, weed invasion, indirect impacts of timber harvesting, inappropriate fire regimes
192	Montane Rocky Shrubland	inappropriate fire regimes, weed invasion
193	Rocky Outcrop Herbland	weed invasion, pest animals
195	Seasonally Inundated Shrubby Woodland	weed invasion, alteration of drainage patterns and flooding regimes, grazing, clearing, minor forest produce
196	Seasonally Inundated Sub-saline Herbland	Weed invasion, hydrological alteration, agricultural run-off, grazing
198	Sedgy Riparian Woodland	clearing for agriculture, drainage and other hydrological alteration, grazing, weed invasion, altered fire regimes
200	Shallow Freshwater Marsh	grazing, hydrological alteration, weed invasion
201	Shrubby Wet Forest	timber harvesting, indirect impacts of road construction and maintenance
203	Stony Rises Woodland	grazing, weed invasion, inappropriate fire regimes, pest animals,
233	Wet Sands Thicket	fire, hydrological alteration, indirect impacts of road construction and maintenance
264	Sand Ridge Woodland	minor forest produce, inappropriate fire regimes, clearing, weed invasion, pest animals
278	Herb-rich Heathy Forest	inappropriate fire regimes, dieback
279	Heathland Thicket	inappropriate fire regimes, dieback
280	Floodplain Thicket	clearing, agriculture, grazing, weeds, hydrological alteration, pest animals
281	Sedge-rich Wetland	clearing for agriculture, grazing, weed invasion,
282	Shrubby Woodland	weed invasion, inappropriate fire regimes
283	Plains Sedgy Woodland	minor forest produce, drainage for agriculture, grazing, weed invasion
284	Claypan Ephemeral Wetland	weed invasion
285	Dry Creekline Woodland	grazing, minor forest produce, weed invasion
291	Cane Grass Wetland	clearing for agriculture, hydrological alteration, grazing, peripheral weed invasion
292	Red Gum Wetland	clearing and draining for agriculture, weed invasion, grazing
295	Riverine Grassy Woodland	clearing for agriculture, grazing, weed invasion, minor forest produce
298	Riverine Sedgy Forest	clearing for agriculture, grazing, alteration of drainage patterns and flooding regimes, timber harvesting, weed invasion, recreation
300	Reed Swamp	hydrological alteration and associated weed invasion
311	Berm Grassy Shrubland	
332	Depauperate Herb-rich Foothill Forest	timber harvesting, clearing for agriculture, grazing, weed invasion, minor forest produce
636	Brackish Lake Mosaic	clearing for agriculture, grazing, hydrological alteration, salinity, weed invasion
640	Creekline Sedgy Woodland	clearing for agriculture, grazing, weed invasion, minor forest produce
641	Riparian Woodland	clearing for agriculture, grazing, weed invasion, recreation, hydrological alteration, minor forest produce
642	Basalt Shrubby Woodland	grazing, weed invasion, inappropriate fire regimes, agricultural utilisation, utility services
643	Brackish Drainage Line Herbland/Sedgeland	clearing for agriculture, weed invasion, grazing, hydrological alteration
644	Cinder Cone Woodland	weed invasion, agricultural utilisation
647	Plains Sedgy Wetland	agriculture, drainage and other hydrological alteration, grazing, weed invasion, fire breaks
648	Saline Lake Verge Herbland/Sedgeland	clearing for agriculture, hydrological alteration, salinity, weed invasion
649	Stony Knoll Shrubland	clearing for agriculture, weed invasion, rock removal, inappropriate grazing regimes or inappropriate fire regimes
651	Plains Swampy Woodland	agriculture, weed invasion, hydrological alteration
652	Lunette Woodland	agriculture, grazing, weed invasion, minor forest produce
653	Aquatic Herbland	draining for agriculture
654	Creekline Tussock Grassland	clearing, grazing, cropping, fertilisers, weed invasion, hydrological alteration
655	Lignum Cane Grass Swamp	weed invasion hydrological alteration, grazing, clearing for agriculture, agricultural runoff
656	Brackish Wetland	clearing for agriculture, grazing, hydrological alteration, salinity, weed invasion
657	Freshwater Lignum Shrubland	weed invasion hydrological alteration, grazing, clearing for agriculture, agricultural runoff
659	Plains Riparian Shrubby Woodland	weed invasion, uncontrolled access, minor forest produce
663	Black Box Lignum Woodland	clearing for agriculture, weed invasion, salinity, hydrological change, grazing
664	Limestone Ridge Woodland	inappropriate fire regimes, weed invasion
665	Coastal Mallee Scrub	clearing, grazing, inappropriate fire regimes, weed invasion
670	Limestone Woodland	clearing for agriculture
671	Limestone Rise Grassland	grazing, weed invasion

EVC No	EVC Name	Potential Threatening Processes
673	Dune Soak Woodland	clearing for agriculture, grazing, minor forest produce
674	Sandy Stream Woodland	clearing, grazing, weed invasion, hydrological alteration
676	Salt Paperbark Woodland	clearing for agriculture, grazing, weed invasion, hydrological alteration
677	Inland Saltmarsh	agriculture, grazing, weed invasion, hydrological alteration
679	Drainage-line Woodland	clearing for agriculture, weed invasion, hydrological alteration
680	Freshwater Meadow	agriculture, drainage and other hydrological alteration, grazing, weed invasion
681	Deep Freshwater Marsh	draining for agriculture
682	Permanent Open Freshwater	hydrological alteration, agricultural runoff, water-borne pollutants
683	Semi-permanent Saline	hydrological alteration, agricultural runoff, water-borne pollutants
684	Permanent Saline	hydrological alteration, agricultural runoff, water-borne pollutants
690	Floodplain Riparian Woodland/Billabong Wetland Mosaic	clearing for agriculture, fragmentation, minor forest produce, alteration of drainage patterns and flooding regimes, grazing, weed invasion, dieback
704	Lateritic Woodland	gravel extraction, clearing for agriculture, weed invasion, grazing, minor forest produce
705	Basalt Creekline Shrubby Woodland	clearing for agriculture, weed invasion, hydrological alteration
706	Limestone Rise Woodland	clearing for agriculture, grazing, weed invasion, inappropriate fire regimes
707	Sedgy Swamp Woodland	clearing for agriculture, clearing for pine plantations, weed invasion, inappropriate fire regimes
708	Hypersaline Inland Saltmarsh	grazing, weed invasion, hydrological alteration
709	Scree-slope Grassland/Woodland	recreation, altered fire regimes, weed invasion
710	Damp Heathland	clearing for agriculture, altered fire regimes, clearing for softwood plantations, hydrological alteration, weed invasion
717	Saline Lake Mosaic	clearing for agriculture, weed invasion, grazing, hydrological alteration, salinity
718	Freshwater Lake Mosaic	clearing for agriculture, weed invasion, grazing, hydrological alteration
793	Damp Heathy Woodland	clearing for agriculture, altered fire regimes, clearing for softwood plantations, hydrological alteration, weed invasion
803	Plains Woodland	clearing, grazing, weed invasion, salinity, utility services, roadside management practices
851	Stream-bank Shrubland	weed invasion, grazing
857	Stoney Rises Pond	Otways?
858	Calcarenite Dune Woodland	clearing for agriculture, recreation, grazing
863	Floodplain Reedbed	hydrological alteration and associated weed invasion
876	Spray-zone Coastal Shrubland	
882	Shallow Sands Woodland	clearing for agriculture, grazing, minor forest produce, weed invasion
891	Plains Brackish Sedge Wetland	weed invasion, water pollution, grazing
894	Scoria Cone Woodland	clearing for agriculture, weed invasion, mining
895	Escarpment Shrubland	clearing for agriculture, grazing, pest animals, weed invasion
898	Cane Grass-Lignum Halophytic Herbland	weed invasion hydrological alteration, grazing, clearing for agriculture, agricultural runoff
899	Plains Freshwater Sedge Wetland	weed invasion, water pollution, grazing

7. AQUATIC FAUNA SPECIES ASSESSMENT

7.1 Introduction

The quality of aquatic habitats and diversity of the associated fauna are primarily influenced by activities that occur in the catchment outside the rivers, streams or wetlands themselves. The impacts of activities such as timber harvesting, water regulation, roading, grazing, recreation and mining are expressed indirectly in the aquatic habitat through environmental changes such as degraded water quality (e.g. increased sedimentation, nutrients, toxic chemicals). Hence, off-site management is essential to ensure the viability of the biodiversity. In this way, aquatic systems are significantly different from terrestrial systems, and need specific management actions to protect them.

Because rivers and streams are linear ecosystems, all points in the system are connected. Water and energy (food) flow downstream, but so do the influences of disturbance. A significant disturbance at a single site (a source of sediment for example), can have impacts many kilometres downstream, even in areas which may have adequate local protection in place.

Additionally, some species may use large parts of the river system at some stage in their life cycle. Migratory fish species south of the Great Dividing Range in particular can move through an entire river system from the headwaters to the sea, hence, appropriate environmental conditions are required in the entire river system. North of the Great Dividing Range, in the Murray-Darling basin, fish species can move significant distances within the river system. Even a small section of a stream in significantly degraded condition may block fish passage and exclude species from key habitats, which may affect breeding success.

A good example of this is found in the Yarra River, where a relatively small barrier at Dight's Falls in the lower reaches has effectively prevented a number of migratory fish species from utilising the entire Yarra River, even though suitable habitat exists in many parts of the system. A fish ladder constructed in 1996/7 has been successful in reintroducing many species of migratory fish into the Yarra catchment.

The strategy for conserving aquatic biodiversity relies not just on a CAR reserve system, but also on the application of ecologically sustainable forest management practices in off-reserve areas. While rivers and streams within a CAR system are accorded protection due to the lack of disturbing activities in the surrounding catchment, the adoption and implementation of adequate catchment management actions outside the reserve system are equally important if the aquatic fauna is to retain its integrity and viability. This is achieved in timber harvesting areas largely by the provision of undisturbed areas (buffers) along streams.

Protection of the stream length is recognised in the Victorian Biodiversity Strategy, where a key vision is to restore native vegetation along almost 90% of the rivers and streams by the year 2020 (State of Victoria 1997: *Victoria's Biodiversity: Directions in Management*, p. i)

This aquatic species assessment for the West RFA Region provides an overview of information on fish and aquatic macroinvertebrates, to assist in the development of management arrangements which address the issue of viability of populations of aquatic native species throughout their natural ranges.

To meet this objective, the following assessments have been conducted:

- identification of the distribution, habitat and life history attributes of aquatic biota (primarily fish and aquatic macroinvertebrate species);
- identification of factors affecting the conservation status (risk of extinction) of aquatic species;
- identification of the threatening processes (disturbances) affecting aquatic species and their habitat;
- a description of the current management prescriptions for aquatic species and their habitat, with priority given to those species which are rare or threatened; and
- identification of the gaps in survey and research on aquatic species, habitats and threatening processes.

7.1.1 Fish and Aquatic Macroinvertebrates of the West RFA Region

Fish

The West RFA Region mainly encompasses the catchments south of the Great Dividing Range (GDR) in the west half of Victoria. Because of the position of the boundary, a number of small parts of north flowing streams are incorporated into the region: the Wimmera River upstream of Horsham, Richardson River upstream of the Wimmera Highway, Avoca River upstream of Avoca, Loddon River upstream of Cairn Curran Reservoir, Coliban River upstream of Upper Coliban Reservoir and the Goulburn River between Seymour and Lake Nagambie (including the Sunday Creek and Sugarloaf Creek tributaries).

A total of 21 native freshwater fish have been recorded from the West RFA Region to date (Victorian Fish Database, NRE). Of these, nine are listed as threatened fauna in Victoria (NRE 1999) of which six are listed on the Victorian *Flora and Fauna Guarantee Act 1988* (Table 7.1).

Eight species of fish have been recorded north of the GDR and 18 species south of the GDR. Five wide-ranging species occur in both north and south flowing river systems (*Galaxias olidus* Mountain galaxias, *Gadopsis marmoratus* River Blackfish, *Retropinna semoni* Australian Smelt, *Nannoperca australis* Southern Pygmy Perch and *Hypseleotris klunzingeri* Western Carp Gudgeon). Only three species are restricted to the north flowing rivers (*Tandanus tandanus* Freshwater Catfish, *Galaxias rostratus* Flat-headed Galaxias and *Macquaria ambigua* Golden Perch), with the remaining thirteen species restricted to the south.

There is a possibility that the identification of Flat-headed Galaxias from the upper Loddon River is incorrect (T. Raadik, NRE, pers. comm.), and the record should refer to Mountain Galaxias. If this is the case, this species does not occur in the West RFA region, and so it is not considered among the priority species. Similarly, some records of Common Galaxias north of the divide are also probably incorrect, so they are included only in the southern species.

Ten of the native species are known to be migratory (one inland species, 9 coastal species), and 10 are thought to be non-migratory (2 inland species, 4 coastal species, and four of the five wide-spread species). In the final species (Australian Smelt), migration is suspected, but has not been shown. The greater number of migratory species in coastal catchments indicates that migration, and unimpeded instream passage, is more important to the southern fauna within the West RFA Region.

Of the migratory taxa, adults of the inland species, Golden Perch, undertake upstream spawning migrations, with larvae subsequently drifting downstream, probably triggered by the onset of high flows. Of the southern migratory species, 4 species spawn either at sea or in estuaries (Short-finned Eel, Australian Mudfish, Common Galaxias and Tupong) with an upstream migration of juveniles. Five species spawn in upstream reaches (Australian Grayling, Spotted Galaxias, Pouched Lamprey, Short-headed Lamprey, Broad-finned Galaxias) with larvae washed downstream during high flows in winter/spring, to re-migrate upstream at a later life stage.

Table 7.1. Scientific and common names, conservation status (NRE 1999)

Scientific name	Common Name	Conservation Status	FFG/ESP Act status	Migratory
Anguilla australis	Short-finned Eel			+
Edelia obscura	Yarra Pygmy Perch	Near threatened	FFG/ESP	
Gadopsis marmoratus	River Blackfish	Data Deficient		
Galaxias brevipinnis	Broad-finned Galaxias			+
Galaxias maculatus	Common Galaxias			+
Galaxias olidus	Mountain Galaxias	Data Deficient		
Galaxias rostratus	Flat-headed Galaxias	Data Deficient		
Galaxias truttaceus	Spotted Galaxias			+
Galaxiella pusilla	Dwarf Galaxias	Near threatened	FFG	
Geotria australis	Pouched Lamprey			+
Hypseleotris klunzingeri	Western carp Gudgeon			
Macquaria ambigua	Golden Perch	Vulnerable		+
Mordacia mordax	Short-headed Lamprey			+
Nannoperca australis	Southern Pygmy Perch			
Nannoperca variegata	Variegated Pygmy Perch	Vulnerable	FFG/ESP**	
Neochanna cleaveri	Australian Mudfish		FFG	+
Philypnodon grandiceps	Flat-headed gudgeon			
Prototroctes maraena	Australian Grayling	Vulnerable	FFG/ESP	+
Pseudaphritis urvillii	Tupong			+
Retropinna semoni	Australian Smelt			+?
Tandanus tandanus	Freshwater Catfish	Vulnerable	FFG	

FFG and/or ESP listing, and presence of migration of the native freshwater fish species found in the West RFA Region. **?** - migratory status suspected but not shown.Note: **FFG** - *Flora and Fauna Guarantee Act* 1988 ; **ESP** - Endangered Species Protection Act 1992.

* - FFG Action Statement draft, ** - Action Statement completed.

Aquatic Macroinvertebrates

While our knowledge of the macroinvertebrate fauna of the region is increasing, there is insufficient data to estimate the total number of aquatic macroinvertebrate species in the West RFA Region. Only seven known non-decapod macroinvertebrate taxa in the region are listed as threatened fauna in Victoria (NRE 1999), and only one of these is listed under the *Flora and Fauna Guarantee Act* 1988 (Table 7.2).

Doeg (1997) surveyed aquatic macroinvertebrates at 32 sites in the Grampians National Park, identifying 236 taxa. Of these, 10% had not been recorded in Victoria and were probably endemic and restricted to the Park and maybe surrounding areas. In the fragmented landscape of the West RFA Region, it is certain that many other taxa display restricted distributions that would make them eligible for inclusion in a threatened fauna list or listing under the *Flora and Fauna Guarantee Act* 1988.

Table 7.2. Aquatic macroinvertebrates known from the West RFA Region listed (or nominated) under the *Flora and Fauna Guarantee Act* 1988 or included in the CNR list of threatened Victorian fauna

Scientific Name	Class, Order	Conservation Status	FFG/ESP Act Status
Hyridella glenelgensis	Mollusca, Bivalvia	Rare	
Plectrotarsus gravenhorstii	Insecta, Trichoptera	Ins. known	
Archeophylax canarus	Insecta, Trichoptera	Rare	FFG
Orphinotrichia justini	Insecta, Trichoptera	Ins. known	
Taskiria otwayensis	Insecta, Trichoptera	Endangered	
Boekella nyoraensis	Crustacea, Copepoda	Rare	
Fibulacamptus gracilor	Crustacea, Copepoda	Ins. known	

Note: **FFG** - *Flora and Fauna Guarantee Act* 1988 ; **ESP** - Endangered Species Protection Act 1992.

The decapod crustacea (freshwater crayfish, shrimp and crabs) fauna of the area are better known, having been the target of taxonomic and other studies (Avery and Austin 1997, Austin 1996, Bishop, 1963, Horwitz 1990a,b,, Lucas 1980, Morgan 1986; Riek 1953, 1969, 1972, Smith and Williams 1982, Sokol 1988, Walker 1969, Walsh and Mitchell 1995, Williams 1977, Williams and Smith 1979, Zeideler and Adams 1990,) and have been included as part of fish surveys conducted since 1990 (see below). Numerous incidental records also exist.

Potentially 14 species of cray are present (Table 7.3), including a single species of shrimp and freshwater crab. All decapod crustacea are native species. Of the crays, there is one species of Common Yabby (*Cherax*), potentially two species of freshwater cray (*Geocherax*) (however, the taxonomy of this genus is confused), one species of Swamp Cray (*Gramastacus*), seven species of burrowing cray (*Engaeus*), and three widely separated species of spiny cray (*Euastacus*). Only two species in the region are listed as threatened fauna in Victoria (NRE 1999), and none are listed under the *Flora and Fauna Guarantee Act* 1988 (Table 7.2).

Table 7.3. Scientific and common names, conservation status (NRE 1999) and FFG listing of the native freshwater decapod crustacea found in the West RFA Region.

Scientific name	Common name	Conservation Status	FFG/ESP Act status
Parastacidae			
Cherax destructor	Common Yabby		
Geocherax falcata	Western Cray		
Geocherax gracilis	Otway Cray		
Grammastacus insolitus	Western Swamp Cray		
Engaeus cunicularis	Granular Burrowing Cray		
Engaeus quadrimanus	Lowland Burrowing Cray		
Engaeus lyelli	Upland Burrowing Cray		
Engaeus strictifrons	Portland Burrowing Cray		
Engaeus merosetosus	Western Burrowing Cray		
Engaeus sericatus	Hairy Burrowing Cray		
Engaeus fultoni	Otway Burrowing Cray		
Euastacus yarraensis	Southern Victorian Spiny Cray		
Euastacus bispinosus	Glenelg Spiny Cray	Ins. known	
Euastacus armatus	Murray Spiny Cray	Ins. known	
Atyidae	**Shrimps**		
Paratya australiensis	Common Freshwater Shrimp		
Hymenosomatidae			
Amarinus lacustris	Freshwater Crab		

Note: **FFG** - *Flora and Fauna Guarantee Act* 1988 ; **ESP** - Endangered Species Protection Act 1992.

7.2 Review of Existing Site-Based Data

The data review process involved systematically working through the Victorian Freshwater Database to determine the adequacy of existing site-based biological data. The outputs of the review were used to identify priority areas and data gaps to be filled through additional survey work. As there are no fixed standards on the density of survey effort to adequately construct an inventory of species present, the data review relied on expert knowledge and professional judgment.

The distribution of survey sites where adequate data on fish and aquatic macroinvertebrates is shown in Map XX.

7.2.1 Fish

Intensive inventory surveys of fish assemblages in the West RFA Region have primarily been conducted by the Department of Natural Resources and Environment (NRE). Some investigations which incidentally recorded fish species, were conducted by other government agencies, universities or private individuals.

Pre - 1990 fish surveys

Very few historical records (pre-1970) exist for the West region, and prior to 1965, records were spasmodic, consisting of observations of individual species from only a few locations. The first survey of fish assemblages was undertaken in 1967 at fourteen sites on the Otway Coast (Renowden 1968), closely followed by six sites in the Otway Coast, Werribee and Glenelg Basins (Frankenberg 1969). Between 1970 and 1990, a total of 16 recognised major surveys occurred in the area contributing 164 new sites (Table7 4), exclusive of resampled sites. The survey by Koehn and O'Connor (1990) surveyed the most sites in State Forest, but mainly in the Otway Coast Basin. The Museum of Victoria has records from 52 sites, dating from 1963-89 with the majority dating 1974. These sites come from random areas, with usually only one species recorded from various collectors.

Four of the major surveys during this period were fisheries orientated, only targeting larger, recreational species using techniques designed to capture larger fish species (eg. netting with large mesh sizes). These types of surveys are referred to in this report as "partial surveys". Consequently smaller fish species were not sampled by these surveys, and the surveys were generally conducted in the larger reaches of the main rivers in lowland to foothill areas only. Other sites surveyed regarded as "partial surveys" occurred when a certain fish species was targeted, and subsequently not all fish were captured or recorded from that particular site.

Table 7.4. Major surveys (5 or more sites) conducted for freshwater fish including areas in the West RFA Region prior to 1990

Date	Area surveyed	Sites surveyed	Source
1963-89	Werribee, Glenelg, Wimmera-Avon and Barwon Catchments and Otway Coast.	52	Museum of Victoria
1967	Otway Coast	14	Renowden 1968
1969	Werribee and Glenelg Catchments and Otway Coast	6	Frankenberg 1969
1974	Otway Coast	8	Jackson and Williams 1980
1974-5	Barwon Catchment and Otway Coast	8	Emison *et al*. 1975
1976-80	Werribee Catchment	6	Beumer and Harrington 1982
1977	Loddon Catchment	24	Hume 1979
1979	Glenelg and Wimmera-Avon Catchments	9	Jackson and Davies 1983
1979-82	Barwon and Loddon Catchments and Otway Coast	18	Baxter 1985*
1982	Otway Coast	6	Tunbridge and Glenane 1988*
1982-8	Barwon Catchment and Otway Coast	50	Koehn and O'Connor 1990
1984-5	Maribyrnong and Moorabool Catchments	5	Raadik 1986
1985	Barwon Catchment	6	Tunbridge (unpub data) *
1986-7	Otway Coast	5	Jackson *et al*. 1988
1986-8	Barwon, Glenelg and Moorabool Catchments and Otway Coast	25	Tunbridge 1988 *
1987-8	Otway Coast	8	O'Connor (unpub data)
1988	Avoca, Goulburn, Glenelg, Loddon and Wimmera-Avon Catchments and Otway Coast.	21	Koehn *et al*. 1991

(note: the number of sites listed exceed the total of 164 sites, as some sites were replicated between surveys, and some smaller surveys have been omitted). * indicated fisheries surveys.

All sampling of fish in the region was spasmodic pre 1990 (and also post 1990 - see below), and the overall direction of surveys has been uncoordinated. Information obtained from successive surveys has not necessarily been complementary, resulting in significant gaps in the knowledge of species distributions in the region, and within particular river systems.

Post - 1990 fish surveys

Since 1990, survey intensity and coordination has improved for the region, though mainly due to intensive sampling of specific areas, with 157 new sites (exclusive of resampled sites) being assessed in major surveys. Further, the majority of surveys used techniques which potentially sampled the entire community rather than just selected species (e.g. electrofishing - termed "full" surveys), and were also conducted in foothill to upland areas in many of the smaller streams.

Both Raadik (1996 and unpublished data) and Saddlier (unpublished data) have intensively surveyed a total of 152 sites across the region (Table 7.5), concentrating on the smaller fish species and sampling in foothill and upland areas for specific projects, some of which is reported in Koehn *et al* (1991). Koehn *et al*. (1991) details various miscellaneous surveys conducted in the region, while Koehn and O'Connor (1990) specifically targeted the Otway region.

As part of the RFA research program "An Integrated Program for Aquatic Fauna Survey and Research for Comprehensive Regional Assessments (RFA) and Regional Forest Agreements (RFA)", streams and tributaries within known data-gap areas are being targeted. To date, 61 new sites have been surveyed across the West RFA Region (O'Connor unpublished data). At the time of writing, surveys in the Glenelg and Portland catchments are still underway and additional sites will be sampled.

Table 7.5. Major surveys conducted for freshwater fish, which included sites in the West RFA Region since 1990

Date	Area surveyed	Sites surveyed	Source
1990	Avoca River and Otway Coast	17	Koehn *et al* 1991
1990	Otway Coast	7	O'Connor (unpub data)
1990	Goulburn Catchment	7	Unmack (unpub data)
1990	Glenelg and Hopkins Catchments and Portland Coast	14	Saddlier (unpub data)
1990-2	Otway Coast	32	Raadik (unpub data)
1991-2	Otway Coast	16	O'Connor (unpub data)
1992-3	Barwon Catchment and Otway Coast	35	Saddlier (unpub data)
1993	Wimmera-Avon Catchment	7	Kemp (unpub data)
1994	Grampians National Park	6	Doeg (unpub data)
1995	Otway Coast	16	Victorian Fish Database
1995-6	Avoca, Glenelg. Goulburn, Hopkins, Wimmera-Avon and Maribyrnong Catchments	36	Raadik (unpub data)
1996	Glenelg Catchment	35	Raadik (unpub data)

(note: the number of sites listed exceed the total of 157 sites, as some sites were replicated between surveys, and some smaller surveys have been omitted). * indicates fisheries surveys.

The total number of freshwater survey sites in the West RFA Region appears to be fairly extensive at 471, with 95 in the catchments located north of the divide and 376 in the catchments to the south (Table 7.6). However, only 219 sites are considered to be full surveys (full coverage of species diversity) which provide adequate data quality, 22 north of the divide and 197 in the south.

Because of the nature of individual survey objectives, 130 sites (27.6%) have been located in areas set aside for conservation purposes, with a high portion of these coming from the Grampians and Otway regions. Two hundred and forty-five (52.0%) were located in private land and other areas of public land (eg. licensed stream frontages, which do not provide protection for significant portions of the catchments as parks systems do). Ninety-six sites (20.4%) have been located in State forest, with many of these surveyed since 1990, or between 15 and 25 years ago.

Table 7.6. Summary of information on fish survey sites in the West RFA Region from 1973-1994. Full - all fish species recorded; Partial - only larger, recreational species collected.

Land tenure	State forest		Private land and other Public land		Conservation reserves		
Survey Type Catchment	Full	Partial	Full	Partial	Full	Partial	Total
Maribyrnong	1	1	3	-	-	-	5
Werribee	-	2	6	1	3	2	14
Moorabool	-	2	9	2	-	-	13
Barwon	3	1	25	4	4	4	41
Corangamite	3	-	4	-	-	-	7
Otway Coast	26	41	44	45	12	13	181
Hopkins	-	3	14	4	-	1	22
Portland	1	1	-	-	-	-	2
Glenelg	3	2	13	10	23	40	91
Goulburn	-	1	1	8	-	-	10
Campaspe	-	1	2	6	-	-	9
Loddon	1	-	8	20	-	-	29
Wimmera-Avon	3	-	2	14	5	23	47
Sub total	41	55	131	114	47	83	
Total sites	96		245		130		471
% of total	20.4		52.0		27.6		

7.2.2 Aquatic macroinvertebrate fauna

Pre-1990 macroinvertebrate surveys

The Department of Water Resources (DWR, 1989) recorded 66 sites where aquatic macroinvertebrate surveys have been conducted in the West region prior to 1990 (Table7 7). These were sampled as part of several studies, primarily biological monitoring studies by the Rural Water Commission (Metzeling and Newall 1987) and a number of small surveys by the State Rivers and Water Supply Commission (e.g. Bennison 1980). Also included are post-graduate projects at Monash University (e.g. Yule 1978, Rankin 1978) and impact assessments by private companies.

Unfortunately, a variety of different survey techniques were employed in each of these studies. As these have often used different sampling methods and regimes, any data comparisons between these surveys should be treated with extreme caution.

Table 7.7. Major surveys conducted for aquatic macroinvertebrates in the West RFA Region prior to 1990 (DWR 1989).

Date	Catchment	Sites surveyed	Institutions responsible
1986-1987	Wimmera	3	Rural Water Commission
1977	Werribee	11	Melton Sewerage Authority
1977	Werribee	3	SRWSC
1986-1987	Werribee	3	Rural Water Commission
1980	Moorabool	4	SRWSC
1975	Barwon	6	Monash University
1987	Barwon	7	Warnambool Institute
1978	Corangamite	10	Monash University
1978	Otway Coast	5	Monash University
1979	Hopkins	1	SRWSC
1980	Portland	9	Alcoa Pty Ltd
1986-1987	Maribyrnong	4	Rural Water Commission

Post-1990 macroinvertebrate surveys

Since 1990, surveys have continued in some catchments. A number of projects at Deakin University have continued, primarily in the Wimmera, Glenelg and Barwon River catchments (B. Mitchell, Deakin University, unpublished data). The only recent intensive survey conducted was in the Grampian National Park, where 60 riverine sites were sampled in 1993 (Doeg 1997). Sampling in the Barwon River by Kefford (1997) were targeted at evaluating the impact of saline discharges from the Loch Calvert scheme. In the Otway Ranges, a number of sites were sampled in the East Barham River area, as part of the Silvicultural Systems Project (T. Doeg, NRE, unpublished data). As for the pre-1990 surveys, all these have been un-coordinated, using a variety of sampling techniques, and the data gathered is of limited use for the RFA process.

However, as part of the Monitoring River Health Initiative (MRHI), a program of sampling was conducted to enable the prediction of aquatic macroinvertebrate community composition in streams throughout Australia. Although not intended as a biodiversity measurement (it is designed as a monitoring tool) this program produces good quality data on the distribution of many species and communities. Eighty-three sites in the West RFA Region have been monitored by the Victorian EPA (Table 7.8, Map X). Additional sampling at 22 sites using the same methodology as the MRHI, has been conducted over 1998-9 by NRE as part of the RFA research program "An Integrated Program for Aquatic Fauna Survey and Research for Comprehensive Regional Assessments (RFA) and Regional Forest Agreements (RFA)" (P. Papas, NRE, unpublished data, Table 7.8, Map X).

The sites surveyed under the MRHI and RFA research program will provide valuable baseline data for the region, particularly for some of the more common taxa. However, more significantly, the data from these 105 sites can be used to construct a regional predictive model, allowing the invertebrate fauna at an unknown site to be predicted on the basis of the river characteristics (e.g. water quality, altitude, bed structure). This has important implications for the design of a monitoring program for the region.

Table 7.8. Number of sites sampled as part of the MRHI and NRE in each catchment in the West RFA Region.

Catchment	Number of sites - MRHI	Number of sites - NRE
Goulburn	2	-
Loddon	-	-
Maribyrnong	9	-
Wimmera	10	2
Werribee	6	2
Moorabool	3	3
Barwon	7	1
Corangamite	4	-
Otway Coast	16	9
Hopkins	8	-
Portland	5	-
Campaspe	-	1
Glenelg	13	4

7.3 Life History and Population Parameters for Aquatic Species

A priority list of 20 aquatic species (Table 7 9) was compiled for inclusion in the more detailed assessment of species' response to disturbance and life history dynamics. The list consists of species in the West RFA Region which are listed under the *Flora and Fauna Guarantee Act* 1988, the Commonwealth *Endangered Species Protection Act* 1992 (ESP Act) and the Threatened Fauna of Victoria list (NRE 1999).

Table 7.9. Priority aquatic species included in the disturbance and life history assessment.

Species Name	Common Name
Fish	
Edelia obscura	Yarra Pygmy Perch
Gadopsis marmoratus	River Blackfish
Galaxias olidus	Mountain Galaxias
Galaxias truttaceus	Spotted Galaxias
Galaxiella pusilla	Dwarf Galaxias
Geotria australis	Pouched Lamprey
Macquaria ambigua	Golden Perch
Nannoperca variegata	Variegated Pygmy Perch
Neochanna cleaveri	Australian Mudfish
Prototroctes maraena	Australian Grayling
Tandanus tandanus	Freshwater Catfish

Species Name	Common Name
Decapod Crustacea	
Euastacus armatus	Murray Spiny Cray
Euastacus bispinosus	Glenelg Spiny Cray
Non-decapod invertebrates	
Hyridella glenelgensis	
Plectrotarsus gravenhorstii	
Archeophylax canarus	
Orphinotrichia justini	
Taskiria otwayensis	
Boekella nyoraensis	
Fibulacamptus gracilor	

7.3.1 Fish

Basic life history and population characteristics for fish species were obtained primarily from Cadwallader and Backhouse (1983) and Koehn and O'Connor (1990).

Nannoperca variegata *(Variegated Pygmy Perch)*
A small (adults to 6 cm) species found in the south-western corner of Victoria (tributaries of the Glenelg River system). Adults inhabit heavily vegetated areas with a relatively high flow, unlike the Southern Pygmy Perch which prefers slow flowing areas. Little is known of the spawning biology and specific habitat requirements of this species. Spawning occurs between mid-July and mid-November and females carry up to 5000 eggs which are deposited on aquatic vegetation.

Neochanna cleaveri *(Australian Mudfish)*
A small (adults to 14 cm) migratory species located south of the divide. Adults live in still waters in heavily vegetated mud-bottomed swamps and are known to aestivate in water bodies that periodically dry up. Little is known of the life history of this species. Spawning occurs in winter and newly hatched larvae are washed or move to the sea until spring, when juveniles migrate back to freshwater habitats.

Galaxiella pusilla *(Dwarf Galaxias)*
A small (adults to 4 cm) non-migratory species, located south of the divide. Adults live in still, slow flowing vegetated waters. Spawning occurs in freshwater during winter/spring, after which the adults die. Spawning trigger is unknown. Adult females lay few (<200) eggs which are attached to the substrate. Eggs hatch after 2-3 weeks. Movements patterns are unknown.

Prototroctes maraena *(Australian Grayling)*
A small (adults to 20 cm and 500 gm) migratory species located south of the divide. Adults live in predominantly stony fast-flowing streams. Spawning occurs in freshwater but the timing is uncertain. Spawning trigger is unknown.. Adult females (maturity probably occurs at 2 years old) lay up to 80,000 eggs into the water column which settle on the substrate (although this is uncertain). Eggs hatch after a few weeks. Larvae are washed to sea to grow and juveniles migrate upstream in spring/summer.

Edelia obscura *(Yarra Pygmy Perch)*
A small (adults to 7.5 cm) non-migratory species found south of the divide. Adults inhabit well vegetated streams and are often found in small groups, mixed with Southern Pygmy Perch. Little is known of the spawning biology of this species though it is likely to be similar to Southern Pygmy Perch. Spawning occurs during September and October (slightly later than southern piggy perch) and is most likely initiated by a rise in water temperature. Females (approximately 2 years old) lay 500 - 4000 slightly adhesive demersal eggs, that adhere to rocks and vegetation, the eggs hatch in 2-4 days and the newly emerged larvae being about 3-4 mm long

Tandanus tandanus *(Freshwater Catfish)*
A large (adults to 90 cm) non-migratory species found north of the divide. Adults live in slow flowing water usually fringed with vegetation. Spawning occurs in freshwater from October to March in shallow or flooded waters. About 20,000 eggs are laid in a nest, gravel substrate is preferred to mud as eggs pass down between the gravel, with adults protecting eggs until they hatch (approx. 7 days). Larvae are free swimming after 12 days.

Macquaria ambigua *(Golden Perch)*
A large (Adults to 76cm) migratory species, located north of the divide. Adults live in slow flowing water. Spawning occurs in freshwater during spring to summer after an upstream adult migration, triggered by rising temperature and flow. Adult females (maturity occurs at 2-4 years old) lay up to 500,000 eggs into the water

column. Eggs hatch after 1-2 days. Larvae are washed downstream and adults migrate downstream after spawning.

Galaxias truttaceus *(Spotted Galaxias)*
A small (adults to 20 cm) migratory species, located south of the divide. Adults live in lower, slow flowing reaches of streams. Spawning occurs in freshwater during winter, possibly triggered by rising waters. Adult females (maturity occurs at 2 years) lay 5000-6000 adhesive eggs which hatch after 4-6 weeks. Larvae are washed to sea. Juveniles move back upstream in spring/summer.

Geotria australis *(Pouched Lamprey)*
An anadromous species to 67 cm. Spawning occurs in late spring/early summer in a nest of stones. Pouched Lampreys contain a large number of eggs (58 000). Ammocoetes burrow into mud/soft sediment during the day. At 90-115 mm ammocoetes migrate to the sea usually in July/August. Adults mature at sea, then migrate upstream from July-December and can climb wet vertical surfaces.

Galaxias olidus *(Mountain Galaxias)*
A small (adults to 15 cm) non-migratory species, located both sides of the divide. Adults live in stony fast-flowing streams. Spawning occurs in freshwater during winter/spring. Spawning trigger is unknown. Adult females (maturity occurs at 3 years old) lay few (<500) eggs into the water column which settle. Incubation time is unknown.

Gadopsis marmoratus *(River Blackfish)*
A moderate sized (adults to 60 cm) non-migratory species, located both sides of the divide. Adults live in relatively quiet upland and lowland streams. Spawning occurs in freshwater during spring, triggered by rising water temperatures. Adult females (maturity occurs at 3-4 years old) lay few (<500) eggs attached to the substrate in hollow logs. The parental male guard the eggs. Eggs hatch after about 2 weeks. Larvae are believed to live among leaf litter for at least 12 months.

7.3.2 Aquatic macroinvertebrates

Little is known about the life history of most of the priority aquatic macroinvertebrates species listed in Table7 9. Some specific information is known for some of the crustacea (Horwitz 1990a,b), but most of this data come from casual observations, rather than well-conducted scientific surveys and research.

Euastacus armatus *(Murray Spiny Cray)*
Euastacus armatus is the best known of the decapod crayfish in Table 7.9. A large animal (specimens 45-50 cm long and 2.5-2.7 kg have been recorded), it has been found in a number of stream habitats (dry and wet sclerophyll forest at a variety of altitudes). Reproduction (adults reach maturity at 6-9 years) occurs annually in autumn. The number of eggs produced depends on the size of the adult, with one 450gm carrying about 800 eggs. Eggs develop over 4 months and juveniles remain attached to the adult for a further month.

Euastacus bispinosus *(Glenelg Spiny Cray)*
Euastacus bispinosus is a large (maximum OCL: 130 mm) spiny crayfish found in the south-west of Victoria and south-eastern South Australia (Glenelg River Catchment, Victoria, to Port MacDonnell, South Australia). The range extends from sea level to altitudes of 320 m, and slightly higher in the Grampians. In lowland areas this species has been collected at sites where vegetation is comprised of wet sclerophyll forest, bracken, *Eucalyptus* and *Leptospermum.* In the Grampians, this cray has been collected from areas that are bordered by heath, and vines and ferns in sheltered valleys. Little is known about the biology, however, females carrying eggs have been collected from early to late spring.

Archeophylax canarus *(Caddisfly)*
Small caddisfly primarily known from higher altitude areas, but with some records from the Werribee and Otway catchments . Nothing is known specifically of its life history or habitat requirements.

Plectrotarsus gravenhorstii *(Caddisfly)*
Caddis fly from the primarily known from the Yarra and Goulburn Rivers, but with 2 records from the West RFA Region. Nothing is known specifically of its life history or habitat requirements.

Hyridella glenelgensis *(Glenelg Mussel)*
A relatively small (30-40mm) mussel found in silty mud in rivers and associated wetlands (Smith and Kershaw 1979).

Orphinotrichia justini *(Caddisfly)*
A small caddisfly only known from a single site in the Otway Ranges. Nothing is known specifically of its life history or habitat requirements.

Taskiria otwayensis *(Caddisfly)*
A small caddisfly only known from a single site in the Otway Ranges. Nothing is known specifically of its life history or habitat requirements.

Boekella nyoraensis *(Copepod)*
Only known from 2 coastal lake localities in Victoria at Portland and near Westernport Bay (Horwitz 1990b). Nothing is known specifically of its life history or habitat requirements.

Fibulacamptus gracilor *(Copepod)*
Only known from the Werribee River, in "slow moving brooks, among dirt and living or dead material" (Horwitz 1990b). Nothing is known specifically of its life history or detailed habitat requirements.

7.4 Review of Disturbances and their Implications for Aquatic Fauna in the West RFA Region

The decline of species can be largely attributed to the impacts of disturbances, both directly on the species and indirectly on essential components of their habitat. Disturbances which have negative effects (direct or indirect) on a species are referred to as threatening processes.

A review of the current state of knowledge of aquatic species, and of threatening processes was conducted to provide information to help set priorities for management, research and surveys, during the development of the West RFA. The review covered priority aquatic species (Table 7.9) in the region, and was based on existing scientific literature and expert opinion.

A number of activities occurring within catchments have either been shown to, or have the potential to have serious impacts on aquatic ecosystems, and therefore on aquatic species. However, a distinction must be made between the activities, and the environmental changes that arise as a result of the activity (Table 7.10). It is the environmental change that has a direct bearing on aquatic species. It should be noted that it is mostly of little relevance which disturbance activity creates the disturbance impact (e.g. sedimentation from timber harvesting and roads would produce the same impact on aquatic fauna as sedimentation from recreation or other sources). However, the intensity of the effect may differ between the sources, with, for example, weir cleaning producing very high levels of turbidity and deposited sediment for a short time, while roads may produce lower levels but extended over time.

The most common environmental change caused by land use activities in the catchments is an increase in sediment accession to rivers and streams (resulting from 9 of the 13 activities in Table 7.10). Increased sedimentation of rivers is a listed Potentially Threatening Process under the *Flora and Fauna Guarantee Act* 1988.

Increased levels of sediment can adversely affect all aspects of freshwater ecosystems by reducing water quality and degrading or destroying habitat. Increased turbidity can have adverse physical, physiological and behavioural effects on stream dwelling plants and animals. Sediment is harmful to the gills, causing abrasion to the epithelial cells and excess production of mucus. Both processes lead to a decrease in oxygen transfer across the gills and eventual asphyxiation. Fish that feed by visually locating prey can also be affected by the reduced visibility in the water column caused by increased turbidity.

In addition, elevated levels of deposited sediment can smother stream beds, reducing variation, and exposing fish to increased predation and stress. High levels of sediment can fill in deep pools, destroying habitat for some species. Crevices in the substrate between rocks or bits of wood serve as critical habitat for fish, mainly as egg deposition sites and rearing areas for juveniles. Sediment settling out can fill these spaces and subsequently destroy important habitat.

Other disturbances potentially alter the natural stream chemistry by increasing levels of nutrients (fire, logging, grazing, waste disposal) or toxic chemicals (fire control, pest control, mining, waste disposal). Introduction of toxic material into rivers is a Potentially Threatening Process listed under the *Flora and Fauna Guarantee Act* 1988.

The construction and operation of dams and weirs represent a major disturbance to aquatic systems. Where low level off-takes are used (many older dams) water temperature can be lowered substantially. Storage and release of water at different times also changes the natural flow regimes. Dams can also present a barrier to migratory fish species. Altered temperature regimes, altered flow regimes of rivers, and barriers to fish passage are all listed Potentially Threatening Process under the *Flora and Fauna Guarantee Act* 1988. Increased sedimentation can occur either during construction or cleaning.

Introduced species can have serious impacts on stream fauna through increased competition for space and food, or through direct predation on native species.

Table 7.10. Broad disturbance category (activity) with associated Environmental Change that have potentially significant impacts on aquatic ecosystems

Activity	Major Environmental Change
Fire	• Increased sedimentation and turbidity • Increased nutrient concentrations in water
Fire control	• Increased sedimentation and turbidity • Increased toxic chemical concentrations in water
Timber harvesting	• Increased sedimentation and turbidity • Increased nutrient concentrations in water
Pest control	• Increased pesticide concentrations
Grazing of stock	• Stream bed and bank degradation • Increased sedimentation and turbidity • Increased nutrient concentrations in water • Reduction of swamp/headwater habitat
Introduced species	• Increased competition with native species • Increased predation on native species
Harvesting/Collecting	• Reduction in population numbers
Recreation	• Stream bed and bank degradation • Increased sedimentation and turbidity
Clearing of vegetation	• Stream bed and bank degradation • Increased sedimentation and turbidity
Roading	• Stream bed and bank degradation • Increased sedimentation and turbidity
Mining/Quarrying	• Increased sedimentation and turbidity • Increased toxic chemical concentrations in water
Waste disposal	• Increased nutrient concentrations in water • Increased toxic chemical concentrations in water
Dams	• Alterations to flow regimes • Increased sedimentation and turbidity • Decreased water temperature • Barriers to fish passage

While the potential impacts of these activities and associated environmental changes are well established, few scientifically derived data (i.e. valid field studies) are available that directly relate the impact of most activities to any of the priority aquatic species. In most cases, the impact on priority species has been predicted from the results of similar studies conducted elsewhere.

For example, a significant reduction in the population of River Blackfish *Gadopsis marmoratus* in Armstrong Creek (the upper Yarra River catchment), was attributed to increased sedimentation due to weir cleaning (Doeg and Koehn 1994). It is therefore likely that a similar increase in sedimentation in the West RFA Region would have the same impact on local blackfish populations.

No direct data are available on the impact of timber harvesting on the two priority Galaxias species (*G. olidus* and *G. truttaceus*). However, Graynoth (1979) showed that clearfelling without buffers in New Zealand severely reduced numbers of the local species *G. divergens* in streams, concluding it was probably through increased sedimentation (Table 7.10) The Code of Forest Practices for Timber Production requires that all streams be buffered from timber harvesting to minimise any impacts associated with increased sedimentation.

Numerous other studies exist where good data are available on the broad impacts of various activities or environmental change, but not necessarily involving the priority species in the West RFA Region. Changed sediment regimes were implicated in the decline of many invertebrate species in the Thomson River below the Thomson Dam (Doeg *et al*. 1987), and changed flow and temperature regimes were likely to be responsible for the decline in native fish in the Mitta Mitta River below Dartmouth Dam (Koehn *et al*. 1995). Laboratory studies have shown that light coatings of silt can significantly increase the mortality of eggs of the Common Galaxias (J. Koehn, NRE, unpublished data).

Hence, while specific data relating activities or disturbances and the impacts on priority species may not exist, sufficient information is available to adequately predict the likely impacts on priority species in the West region. With these considerations in mind, priority species affected by each of the eleven environmental changes listed in Table 7.10 are presented in Table 7.11.

Table 7.11. Species affected by each of the major environmental changes listed in Table 7.10.

Environmental change	Species Affected	Comments
Increased sedimentation and turbidity	*Edelia obscura, Gadopsis marmoratus, Geotria australis*, *Galaxias olidus*, *Galaxiella pusilla, Nannoperca australis, Nannoperca variegata, Neochanna cleaveri, Prototroctes maraena*, *Tandanus tandanus* *Euastacus armatus, Euastacus bispinosus* *Hyridella glenelgensis, Orphinotrichia justini, Taskiria otwayensis, Archeophylax canarus*, *Plectrotarsus gravenhorsti*	Fish which lay demersal eggs Decapod crustacea which live in-stream Stream dwelling non-decapod invertebrates
Increased nutrient concentrations	No data	
Increased pesticide concentration	No specific data	Unlikely that species would be affected by herbicides, Likely that most species would be affected by other biocides
Stream bed degradation	All species affected	
Stream bank degradation	All species indirectly affected	
Competition with or predation on native species	*Edelia obscura, Galaxias olidus*, *Galaxias truttaceus*, *Galaxiella pusilla, Prototroctes maraena, Nannoperca australis, Nannoperca variegata, Neochanna cleaveri* *Euastacus armatus, Euastacus bispinosus*	Predation on juveniles and adults, competition with adults
Increased toxic chemical concentrations	No specific data	However, likely that all species affected, depending on nature of toxin
Changed flow regimes	*Galaxias truttaceus, Macquaria ambigua, Neochanna cleaveri, Prototroctes maraena.* May also affect *Hyridella glenelgensis.*	Species known to require floods, other fish species also likely to be affected
Changed water temperatures	*Edelia obscura, Gadopsis marmoratus, Macquaria ambigua, Nannoperca variegata*	Breeding temperature dependant
Barriers to fish passage	*Galaxias truttaceus, Galaxias maculatus, Geotria australis, Macquaria ambigua, Neochanna cleaveri, Prototroctes maraena*	Migratory species
Reduction of swamp/headwater habitat	*Boekella nyoraensis*	Primarily swamp dwelling crustacea
Reduction in population through harvesting	*Euastacus armatus, Euastacus bispinosus, Hyridella glenelgensis*	

Information is lacking regarding the degree of environmental change required before there are significant impacts on aquatic species. For example, pest control may introduce pesticides into the water, but the actual amount of pesticide will vary between individual operations, depending on a number of factors such as operator skill or even the weather on the particular day of operation. While it is clear that large volumes of pesticides will have serious implications for aquatic biota, it is not clear whether there is an "acceptable" level, below which no significant impact will occur.

Similarly, all activities that increase sedimentation in streams will do so at different levels. Weir cleaning and dam construction results in significant increases, with demonstrated impacts. Less well established is the impact of lower levels, or indeed, the level of increase which causes no long-term impact.

7.5 Conservation Guidelines for fish and aquatic macroinvertebrates

A range of conservation measures are currently in place or proposed for the protection of streams and catchments in the West RFA Region.

Following the Land Conservation Council's (LCC) Rivers and Streams Special Investigation (LCC 1991) the Government declared the corridors of the Goulburn (below Lake Eildon), Lerdederg, Aire and Glenelg (below Dartmoor) Rivers to be Heritage River Areas because of their significant natural, scenic, cultural heritage and

recreational values. Draft management plans for these heritage rivers have been produced and include strategies to protect significant environmental values in each river (Table 7.12, NRE 1997a).

Table 7.12. Environmental values to be protected in Heritage River corridors in the West RFA Region (from LCC 1991)

Heritage River	Environmental values to be protected
Goulburn River	• Macquarie Perch habitat above Goulburn Weir; • Recreational fishing for native species.
Lerdederg River	• Riparian forest
Aire River	• Australian Grayling and Australian Mudfish habitat; • Native fish diversity.
Glenelg River	• Native fish diversity; • Riparian communities • Recreational fishing for native species.

With possible significance, the LCC did not recognise any catchments within the West RFA Region as Essentially Natural Catchments, indicating the widespread level of disturbance throughout the region.

General conservation measures are in place for the protection of streams and catchments. These include the Code of Forest Practices for Timber Production and Roading Prescriptions (e.g. NRE 1996a). The Code of Forest Practices contains a number of measures to protect water quality, including:

- the retention of a buffer strip at least 20m wide around permanent streams, permanent springs, swampy ground and bodies of standing water. Increased minimum buffer widths apply for low permeability soils on low slopes (30m) and low permeability soils on higher slopes (40m).
- the retention of a filter strip at least 10m wide around temporary streams and drainage lines (15m minimum on low permeability soils on higher slopes);
- the application of slope limits;
- standards for the design, construction, maintenance and rehabilitation of roads, tracks, bridges, log landings and log dumps; and
- the suspension of activities during wet weather.

Other indirect protection for some species is afforded under Forest Management Zoning for other values in the Otway Ranges (DCE 1992a) and the Midland Forest Management Area (e.g. Special Protection Zones for Powerful Owl habitat and linear reserves - NRE 1996b).

However, few conservation guidelines have been produced for the priority aquatic species (Table 7. 13). These are generally *Flora and Fauna Guarantee Act* 1988 restrictions to collection, and fishing regulations, mainly bag and size limits, and closed seasons during breeding (NRE 1997b).

Table 7.13. Specific conservation guidelines and activities for priority aquatic species. FFG listed species are covered by FFG collecting restrictions. Fishing regulations from NRE 1997b).

Species Name	Conservation guidelines or activity
Fish	
Edelia obscura	FFG collecting restrictions
Gadopsis marmoratus	Fishing regulations: Size limit of 22cm, closed season 1 September-31 (south of the GDR only)
Galaxias olidus	
Galaxias truttaceus	
Galaxiella pusilla	FFG collecting restrictions
Geotria australis	
Macquaria ambigua	Fishing regulations: no netting between last Sunday in August and last Friday in November
Nannoperca variegata	FFG collecting restrictions
Neochanna cleaveri	FFG collecting restrictions
Prototroctes maraena	FFG collecting restrictions; Fishing regulations: no netting allowed
Tandanus tandanus	FFG collecting restrictions
Decapod Crustacea	
Euastacus armatus	Fishing regulations: 10 per day bag limit, 9 cm size limit, restrictions on catching females and newly moulted animals.
Euastacus bispinosus	Fishing regulations: 5 per day bag limit, 10 cm size limit, restrictions on catching females and newly moulted animals.
Other invertebrates	
Hyridella glenelgensis	
Plectrotarsus gravenhorsti	
Archeophylax canarus	FFG collecting restrictions
Orphinotrichia justini	
Taskiria otwayensis	
Boekella nyoraensis	
Fibulacamptus gracilor	

7.6 Data Gaps

7.6.1 Fish

There are no significant data gaps in fish distributional data from the West RFA Region following the sampling of an additional 61 sites under the RFA research and survey program. However, many rivers and streams have still only been sampled at a single site or on only one occasion, and many historical survey sites fall into 'hot spot' areas where survey intensity has been very high due to specific projects. Consequently there is extensive knowledge of fish from only a few areas within the RFA Region.

By comparison, Jackson and Davies (1983) surveyed 115 sites in the Grampians region, an area approximately 25% of the total West RFA Region, while Cadwallader (1979) surveyed 60 sites in one river system (Seven Creeks). It is considered that these scales of intensity are required to give excellent survey coverage. If the whole of the West RFA Region was to be surveyed with the same intensity to that conducted in the Grampians, approximately 460 sites with full surveys would be required, and more importantly, these sites would need to be more spatially orientated than previously, for better coverage. The current number of full survey sites (219) represents only 47% of this value.

Significant data gaps exist on life history and population characteristics for most priority fish species. Much of the current information is derived from casual observations during other research, rather than well-conducted scientific surveys and research. In particular, the most significant gaps relate to spawning behaviour, including induction cues and location of egg laying sites in the stream (Table 7.14). Preferred larval habitats, and tolerances to turbidity and temperature are also particularly poorly known (Table 7.15).

Table 7.14. Summary of missing or inadequate spawning data for fish species

Species Name	Age at spawning	Breeding cues	Egg laying site	Location in catchment	Number of eggs laid	Incubation time of eggs
Edelia obscura						
Gadopsis marmoratus						
Galaxias olidus						
Galaxias truttaceus						
Galaxiella pusilla						
Geotria australis						
Macquaria ambigua						
Nannoperca variegata						
Neochanna cleaveri						
Prototroctes maraena						
Tandanus tandanus						

Shaded - no data; horizontal - conflicting or incomplete data (e.g. based on only a single observation). Based on Koehn and O'Connor (1990).

Table 7.15. Summary of adequacy of movement, habitat preference and tolerance (turbidity and temperature) data for fish species.

Species Name	Migratory	Movement trigger	Larvae habitat	Adult habitat	Turbidity tolerance	Temperature tolerance
Edelia obscura						
Gadopsis marmoratus						
Galaxias olidus						
Galaxias truttaceus	+					
Galaxiella pusilla						
Geotria australis	+					
Macquaria ambigua	+					
Nannoperca variegata						
Neochanna cleaveri	+					
Prototroctes maraena	+					
Tandanus tandanus						

Shaded - no data; horizontal - incomplete data (e.g. based on only a single observation). Based on Koehn and O'Connor (1990).

Little data is available relating priority fish species to particular disturbances. The most serious gap is the lack of data on reactions to increased sedimentation and turbidity from a number of disturbances (Table 7.10). Tolerances to increased turbidity are generally unknown (Table 7.15). For species where egg laying sites are unclear (Table7.14), the impact of deposited sediment cannot be determined.

7.6.2 Aquatic Macroinvertebrates

There are still considerable gaps in the knowledge of aquatic macroinvertebrates in the West RFA Region. As with the entire Victorian aquatic macroinvertebrate fauna, there has been no effort to produce comprehensive species lists or distributions for the region.

While only seven non-decapod aquatic macroinvertebrate taxa are included in the priority list (Table 7.9), there are likely to be many more taxa in the region that are rare, restricted in their distribution, or have undergone serious declines that would make them suitable for inclusion in a priority list. The lack of adequate distributional and historical data makes the identification of these species impossible.

Even where a conservation status has been determined, the distribution of the majority of the priority aquatic macroinvertebrates is known only in relatively general terms. There has been no effort to accurately define the limits of their distribution with specific surveys (similar to that done for the Otway Stonefly for example).

Taxonomically, the aquatic macroinvertebrate fauna of the West RFA Region fauna is poorly studied. A few groups (decapod crustacea in particular) are well known, but common groups (eg. most of the aquatic Diptera) are only known to the generic level. In other groups, aerial adults are well described, but there has been limited work done on the more often collected aquatic larval phases of the life cycle. This is improving for a number of groups (e.g. mayflies, stoneflies and caddisflies) as a result of taxonomic work conducted through Monash University and the Victorian EPA. However, the general lack of taxonomic work severely hampers any attempt to identify any other priority species with restricted or rare distributions.

Almost no comprehensive data are available for life histories of priority aquatic macroinvertebrate taxa (and most other macroinvertebrate taxa as well).

In addition, the impacts of disturbance and different levels of environmental change are not well known and, in most cases, has been inferred from related research. Possibly more important, while data on broad tolerances or preferred habitat are available for some species (see above), for almost all of the impacts associated with activities in the West RFA Region, adequate data to determine "no effect" levels do not exist. While criteria or suggested maximum levels of environmental change are quoted for numerous chemical or physical parameters (e.g. ANZECC 1992), these are by necessity broadly based, and designed for general ecosystem protection. The level of impact on priority species will depend on the sensitivity of each of those species to the actual degree of environmental change caused by the activity, and this aspect is not well known for aquatic systems.

In light of the above assessment, further survey and research is required in order to fill data gaps and there is a need to establish monitoring programs relevant to aquatic species. As new information on the distribution of threatened species, important components of life cycles, or the impact of disturbance becomes available, management prescriptions need to be reviewed in a timely fashion.

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SAC (1991) *Final recommendation on a nomination for listing (Pterostylis cucullata) under the Flora and Fauna Guarantee Act, 1998*. Scientific Advisory Committee, Department of Natural Resources and Environment: Victoria.

SAC (1991) *Final recommendation on a nomination for listing (Pterostylis truncata) under the Flora and Fauna Guarantee Act, 1998*. Scientific Advisory Committee, Department of Natural Resources and Environment: Victoria.

SAC (1991) *Final recommendation on a nomination for listing (Pultenaea graveolens) under the Flora and Fauna Guarantee Act, 1998*. Scientific Advisory Committee, Department of Natural Resources and Environment: Victoria.

SAC (1991) *Final recommendation on a nomination for listing (Senecio macrocarpus) under the Flora and Fauna Guarantee Act, 1998*. Scientific Advisory Committee, Department of Natural Resources and Environment: Victoria.

SAC (1991) *Final recommendation on a nomination for listing (Swainsona brachycarpa) under the Flora and Fauna Guarantee Act, 1998*. Scientific Advisory Committee, Department of Natural Resources and Environment: Victoria.

SAC (1991) *Final recommendation on a nomination for listing (Thelymitra epipactoides) under the Flora and Fauna Guarantee Act, 1998*. Scientific Advisory Committee, Department of Natural Resources and Environment: Victoria.

SAC (1992) *Nomination for a taxon (Ptilotus erubescens) for listing under the Flora and Fauna Guarantee Act, 1998.* Scientific Advisory Committee, Department of Natural Resources and Environment: Victoria.

SAC (1992) *Final recommendation on a nomination for listing:* Alteration to the natural flow regimes of rivers and streams. Department of Natural Resources and Environment, Victoria.

SAC (1992) *Final recommendation on a nomination for listing (Cyathea cunninghamii) under the Flora and Fauna Guarantee Act, 1998*. Scientific Advisory Committee, Department of Natural Resources and Environment: Victoria.

SAC (1992) *Preliminary recommendation on a nomination for listing:* Alteration to the natural temperature regimes of rivers and streams. Department of Natural Resources and Environment, Victoria.

SAC (1993) *Nomination for a taxon (Eucalyptus aggregata) for listing under the Flora and Fauna Guarantee Act, 1998.* Scientific Advisory Committee, Department of Natural Resources and Environment: Victoria.

SAC (1993) *Nomination for a taxon (Glycine latrobeana) for listing under the Flora and Fauna Guarantee Act, 1998*. Scientific Advisory Committee, Department of Natural Resources and Environment: Victoria.

SAC (1993) *Nomination for a taxon (Prasophyllum diversiflorum) for listing under the Flora and Fauna Guarantee Act, 1998*. Scientific Advisory Committee, Department of Natural Resources and Environment: Victoria.

SAC (1993) *Nomination for a taxon (Prasophyllum subbisectum) for listing under the Flora and Fauna Guarantee Act, 1998*. Scientific Advisory Committee, Department of Natural Resources and Environment: Victoria.

SAC (1993) *Nomination for a taxon (Thelymitra matthewsii) for listing under the Flora and Fauna Guarantee Act, 1998.* Scientific Advisory Committee, Department of Natural Resources and Environment: Victoria.

SAC (1993) *Nomination for a taxon (Thelymitra merraniae) for listing under the Flora and Fauna Guarantee Act, 1998.* Scientific Advisory Committee, Department of Natural Resources and Environment: Victoria.

SAC (1993) *Final recommendation on a nomination for listing: Pseudomys shortridgei (*Thomas 1907*) Heath Rat Nomination No. 260.* Scientific Advisory Committee, Flora and Fauna Guarantee. Department of Conservation and Environment, Victoria.

SAC (1993) *Final recommendation on a nomination for listing (Eucalyptus aggregata) under the Flora and Fauna Guarantee Act, 1998*. Scientific Advisory Committee, Department of Natural Resources and Environment: Victoria.

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SAC (1995) *Nomination for a taxon (Asterolasia phebaloides) for listing under the Flora and Fauna Guarantee Act, 1998*. Scientific Advisory Committee, Department of Natural Resources and Environment: Victoria.

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SAC (1996) *Nomination for a taxon (Diuris palustris) for listing under the Flora and Fauna Guarantee Act, 1998.* Scientific Advisory Committee, Department of Natural Resources and Environment: Victoria.

SAC (1996) *Nomination for a taxon (Isolepis congrua) for listing under the Flora and Fauna Guarantee Act, 1998.* Scientific Advisory Committee, Department of Natural Resources and Environment: Victoria.

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