Biodiversity Assessment Technical Report

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Foreword

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

Map numbers referred to in this report followed by (S) indicate that they are to be found in the summary document. Maps not so designated are to be found bound at the back of this report.

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1 Introduction

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 1992).

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 criteria have been developed to guide the establishment of a national system of Comprehensive, Adequate and Representative (CAR) forest reserves (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, (e.g. 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 results provide 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 CRA 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 Central Highlands forests for the CRA required a review of the conservation status of threatened taxa, their susceptibility to 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.

Victorian Flora and Fauna Guarantee Act 1988

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.

Victorian National Parks Act 1975

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.

Other relevant legislation includes the *Crown Land (Reserves) Act 1978*, *the Forests Act 1958* 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 Central Highlands CRA Summary Report and in the statewide assessment of Ecologically Sustainable Forest Management.

2 Biodiversity assessment

2.1 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.

Analysis of data involves the following:

- Information identifying survey intensity for flora and selected faunal taxonomic groups in relation to different environmental strata across the Region;

- generation of maps of the current distribution of Ecological Vegetation Classes (EVCs) in the Central Highlands 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 are at present no well-defined faunal ecosystems. Floristic ecosystems are dealt with in detail in the EVC mapping component of the CRA (see Chapter 4).

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, analysis of available data. It also points to deficiencies in existing information.

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

2.2 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 datasets are largely unavoidable, but their impact can be minimised if deficits 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 Central Highlands 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.

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 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 are derived directly from the photo interpretation typing coverage, which is forest structure based on canopy height and canopy 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 and expert knowledge. This component of the assessment was, however, impossible to validate in the field in most places.

3 Audit of existing biological data

3.1 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 biodiversity were undertaken in the Central Highlands 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 were used to highlight gaps in information and identify those areas which still require further survey work.

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 which meet required standards of accuracy, precision and reliability. This allows a degree of confidence when analysing the distribution of species.

The next step involves assessing environmental and geographic representation by sites from accredited data sets is to stratify the region. The environmental variables on which the stratification procedure should be based are those thought to 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 have 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 & 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).

3.1.2 Methods

A data audit methodology toolkit was developed by the Environment Forest Group within the Department of the Environment, Sport and Territories to assist assessment of the quality of data to be used in regional biodiversity assessments. The toolkit 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 toolkit 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

The process for identifying potential stratification variables and deciding on a final set of variables and their respective cut-off points was achieved through a joint Victoria-Commonwealth Workshop involving both flora and fauna specialists. This process was aided by the examination of hard-copy colour A3 maps of all of the variables being considered for the stratification and summary statistics and frequency histograms relating to each of the variables. Ideally, a number of different stratifications could be produced and assessed. However, for the Central Highlands, only one stratification was developed for the region as a tool for assessing spatial bias in the available flora and fauna site data. The stratification of the Central Highlands region was based on spatial estimates of climate and substrate (lithology). 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^{o} 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 the Central Highlands region were calculated for each cell in the nine second elevation grid using the software package ANUCLIM (McMahon *et al*., 1995). Of the 24 climatic variables calculated for the Central Highlands region, mean annual precipitation (with a range of 559 to 1,802 mm), mean maximum temperature of the warmest month (17.4 to 29.4^{o}C) and mean minimum temperature of the coldest month (minus 4.4 to plus 6.4^{o}C) were selected for use in the stratification of the region. Each of these climatic variables was then divided into even intervals within the range exhibited in the Central Highlands (Table 3.1).

Lithology (rock type)

Using the Land Systems coverage of Victoria at a 1:250,000 scale , lithological types were aggregated in an attempt to lump those geological groups which showed the greatest effect on vegetation distribution, that is fertility, drainage and landform**.** Seven of these classifications were represented in the Central Highlands (see Table 3.1). An eighth category for areas of undescribed lithology was also included.

Deriving the regional stratification

The environmental stratification was based on the three climate attributes and one lithology attributes described above and estimated for each 250 x 250 metre grid cell. A total of 288 individual units or strata are possible when the four classes of annual precipitation, three classes of minimum temperature of the coldest month, three classes of maximum temperature of the warmest month and 8 classes of lithology are combined. Of the potential 288 strata, only 80 occurred in the Central Highlands, ranging in area from 4 to more than 100,000 hectares. Clipping strata classes with an overlay of a forest/non-forest classified coverage reduced the number of applicable strata to 68. The spatial arrangement of these strata across the Region is shown in Map 2S. This environmental stratification was subsequently used for the analyses of flora and fauna databases presented here.

Table 3.1: Attributes and classes used in the Central Highlands environmental stratification.

Variable	*Classes*
mean annual precipitation Central Highlands range = 559 - 1802mm	Low = 559 - 870mm Moderate = 871 - 1180mm High = 1181 - 1491mm Very high = 1492 - 1802mm
mean minimum temperature of coldest month Central Highlands range = minus 4.6 - 6.4°C	Low = minus 4.60 - minus 0.94°C Moderate = minus 0.93 - 2.74°C High = 2.75 - 6.40°C
mean maximum temperature of warmest month Central Highlands range = 17.4 - 29.4°C	Low = 17.4 - 21.4°C Moderate = 21.5 - 25.4°C High = 25.5 - 29.4°C
lithology	a = coarsely textured unconsolidated deposits: low fertility b = coarsely textured unconsolidated deposits-finely textured unconsolidated deposits: low fertility c = finely textured unconsolidated deposits: highest fertility d = finely textured unconsolidated deposits/coarsely textured unconsolidated deposits: moderate fertility e = sedimentary, volcanic/sedimentary, sedimentary/granites and gneisses, volcanic/sedimentary/granites and gneisses/finely textured unconsolidated deposits, sedimentary/volcanic: low fertility (mostly acid volcanic) f = granites and gneisses, volcanic/granites and gneisses, granites and gneisses/sedimentary: moderate fertility g = volcanic, volcanic/finely textured unconsolidated deposits: highest fertility (mostly basic volcanics) ? = undescribed

3.2 Flora survey data review

3.2.1 Methods

For flora, the site-based biological data sets used in this assessment were drawn from the Flora Information System of Victoria and the Victorian Rare or Threatened Plant Population database (VROTPOP). A description of these databases is given in a separate report. The flora core data fields extracted were reference: (quadrat) number; date; latitude longitude; and species code. The latitude/longitude is accurate to 100 metres.

More than 4,300 sites (quadrats) have been sampled for vascular plants in the Central Highlands since 1979. The sites sampled have been collected in a consistent manner as part of a range of studies including: region-wide studies; pre-logging flora and fauna studies based on forest blocks (e.g. Brown *et al.* 1989, Lobert *et al* 1991) intensive sampling of experimental areas (e.g. Mueck 1987); and other studies based on targeted sampling of particular habitats, such as rainforests and heathlands. The quadrat sampling has been largely undertaken by DNRE 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 1 and is discussed below in relation to the environmental strata of the region (Map 2S).

Of the 68 strata generated from the stratification, the 12 strata which occupied less than 100 hectares have not been evaluated in the following discussion. The remaining 56 strata were classified on the basis of flora survey intensity (none, low, moderate, high and very high - see Map 1). The geographic locations referred to in the discussion below relate primarily to the Geographic Representation Units identified in the Proposed Central Highlands Forest Management Area Plan.

3.2.2 Results and discussion

Strata with very high flora survey site density (> 100 sites per 10,000 hectares)
Strata with very high site densities occupied 72,489 hectares or 10% of the total forested land area. The largest of these strata were 1 (in the Yarra and Disappointment geographic units), 39 (in the Bunyip, La Trobe and Thomson geographic units), and 42 (in the Bunyip geographic unit).

Strata with high flora survey site density (40-100 sites per 10,000 hectares)
Strata with high site densities comprised 331,157 hectares or 46% of the total forested land area. The largest of these strata were 36 (throughout the region), 20 (in the Acheron, Marysville and Alexandra geographic units), and 45 (in the Bunyip, Acheron, La Trobe and Alexandra geographic units).

Strata with moderate flora survey site density (10-40 sites per 10,000 hectares)
Strata with moderate site densities comprised 257,778 hectares or 36% of the total forested land area. The largest of these strata were 10 (in the Acheron, Thomson, Matlock, Big, Marysville and Alexandra geographic units), 43 (in the Yarra, Bunyip, Acheron, La Trobe, Thomson, Matlock, Big, Alexandra geographic units), 15 (in the Acheron, Thomson, Matlock, Big geographic units) and 9 (in the Acheron, La Trobe, Thomson, Matlock/Big, Alexandra, Disappointment geographic units).

Strata with low flora survey site density (1-10 sites per 10,000 hectares)
Strata with low site densities comprised 46,639 hectares or 7% of the total forested land area. The largest of these strata is 8 (in the Matlock/Big, Alexandra, Disappointment geographic units).

Strata without flora survey sites

The strata without flora survey sites comprised 7,572 hectares or 1% of the total forested land area. The strata were generally small and scattered, occurring either in the drier, more remote parts of the region, or in the fragmented landscape of the private land/public land interface. The largest strata without flora survey sites were 5 (in the Disappointment geographic unit) and 70 (in the La Trobe geographic unit).

Survey density in largest strata (by area)
Of the 16 strata occupying more than 10,000 hectares each, all but one fell within the moderate, high or very high site density categories, the exception being stratum 8 (in the Matlock, Big, Alexandra, Disappointment geographic units) which fell in the low density category.

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.

The results obtained from this analysis broadly match these predictions, with 89% of the region, comprising 23 strata, having probabilities that the next species is new below 10%. If this threshold is raised to 20%, 95% of the region comprising 28 strata, are included. The largest strata with probabilities greater than 20% are stratum 2 (5,969ha, 40%) and stratum 41 (4,289ha, 66%).

Probability that next species is new (%)	Percentage of Area included (%)	Number of strata included
< 1	89	23
<20	95	28

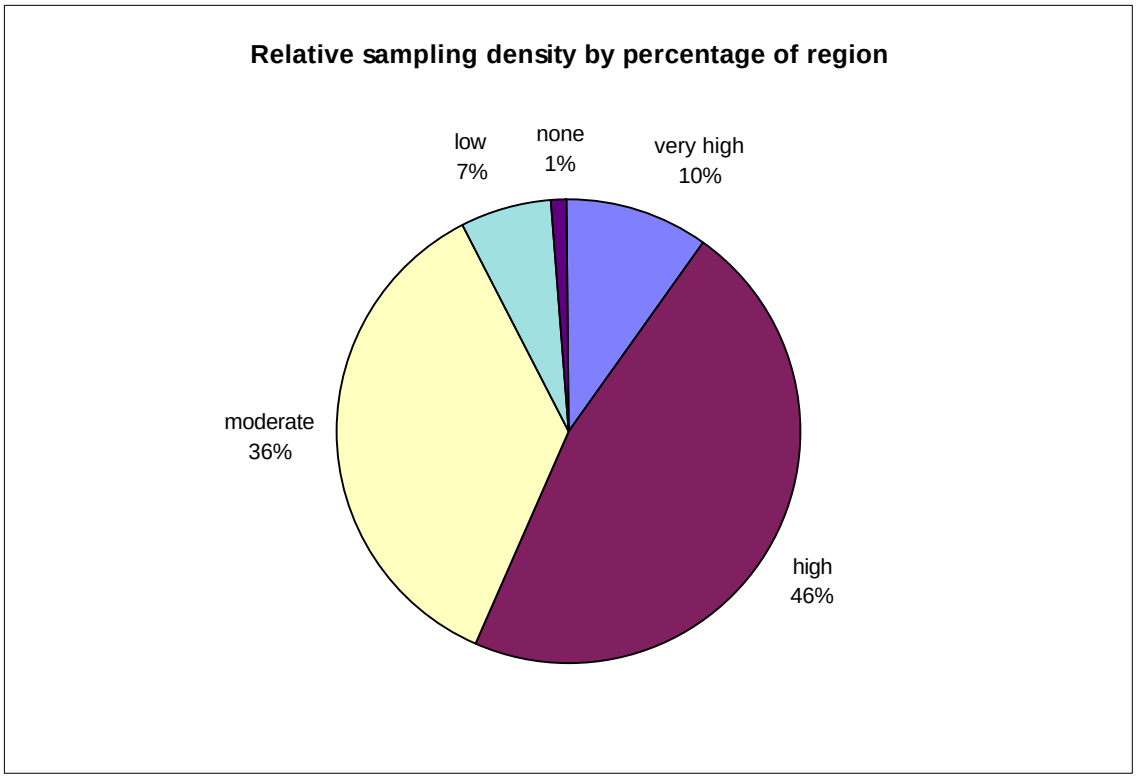
Summary

The level of flora survey in the Central Highlands is high compared to other forested regions in Australia. The most intensively surveyed areas are those which have been specifically targeted - the higher rainfall mountain areas which have been the focus of pre-logging surveys, the Dandenong Ranges and the Baw Baw Plateau.

Those areas within the Central Highlands which have relatively low sampling density are in the north-east, including the Matlock and Big River geographic units, and around the public land / private land interface, especially in the Alexandra, Disappointment and La Trobe Geographic Representation Units.

In general, the distribution of flora sites, while highly clustered in timber production areas, is representative of the variation across the region, although additional survey effort in less well sampled environments would improve the overall value of the database.

The following chart shows the percentage of the region in the various sampling density categories for flora:



3.3 Fauna survey data review

3.3.1 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; it simply means that the information was not appropriate for use in this analysis. All biological records over an area as large and diverse as the Central Highlands 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.

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. A description of these data sets is given in a separate metadata report.

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 (i.e. greater than two minutes of latitude or longitude), were also excluded. Invertebrate fauna were also not included in the review.

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 (i.e. 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 confined to the 20 most extensive strata which range from 15% to 0.8% of the area (totalling 93% of the area).

3.3.2 Results and discussion

The results of the survey site analysis for each fauna functional group are shown in Table 3.4b, Maps 2 to 10 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 1,371 sites has been surveyed, including 212 in stratum 20, 155 in stratum 29 and 133 in stratum 1. Stratum 27 has not been surveyed and is the only one of the 20 largest stratum with the probability of detecting a new species being greater than 20%. Large unsurveyed areas occur in strata 26 and 27 on Mt Baw Baw.

Large Mammal Surveys

A total of 251 sites have been surveyed. Of the 20 most extensive strata, numbers 44 and 53 have not been survey and only strata 10, 15, 25, and 45 have sufficient samples to reduce the probability of new species in the next survey to ≤5%. Survey effort is concentrated with strata 29, 10, 25 and 39 having 18%, 10%, 10% and 9% respectively of the samples. Poorly sampled strata include 44 and 53 (both with no survey sites), as well as 1, 8, 11, 20, 42 and 43. There have been very few sites surveyed west of Toolangi.

Small Ground Mammal Surveys

A total of 1,995 sites have been surveyed for small ground mammals in the Central Highlands. Only one of the 20 most extensive strata (strata 53) has not been surveyed. Of the other strata with sufficient survey sites to make a calculation, strata 2 and 8 have probabilities >5% of a new species being detected. Surveyed sites are generally well distributed across the area although large areas of stratum 10 in the north-east, strata 9, 10 and 15 near Mount Gordon, stratum 10 south east of Glenburn, strata 1 and 56 on the western slopes of Mt Disappointment, strata 36, 43, 45, 53 and 70 south of Mt Baw Baw and strata 27 on Mt Baw Baw remain unsurveyed.

Bat Surveys

A total of 738 sites have been surveyed for forest bats. Of the 20 most extensive strata, strata 2, 27 and 53 have not been surveyed and of the others, only stratum 42 has a probability >5% of a new species being detected. Areas with low survey effort occur in strata 27, 29 and 56 on Mt Baw Baw, 10 in the north-east, 10, 11 and 20 in the Toolangi area, various strata in the Cathedral Range, stratum 1 in the far west and various strata in the Noojee Sate Forest.

Diurnal Bird Surveys

A total of 933 sites have been surveyed for diurnal birds. Two strata have been intensively surveyed, stratum 20 with 248 survey sites and stratum 36 with 166 survey sites. Surveys have been conducted in 17 of the 20 most extensive strata, with strata 2, 27 and 53 having no survey sites. Strata 8, 9 and 59 have probabilities >5% of a new species being detected in the next site surveyed. Areas with low survey site intensity include strata 26 and 27 on Mt Baw Baw.

Nocturnal Bird Surveys

A total of 1,119 sites have been surveyed, generally being well distributed across the region. The main exception is stratum 27 which has no surveyed sites. There are however several strata which still have high probabilities of a new species being detected in the next site survey - these are 2, 8, 10, 11, 24, 42, and 59.

Large Forest Owl Surveys

A total of 733 sites have been surveyed for large forest owls, representing all but one of the 20 most extensive strata (stratum 27 has no surveyed sites). However, several of these strata had only low numbers of surveyed sites which prevented any meaningful analyses for these. Stratum 11 still has a high probability of new species being detected.

Reptile Surveys

A total of 943 sites have been surveyed for reptiles. Of the 20 most extensive strata, 17 have been surveyed and of these six (9, 11, 20, 39, 45 and 59) having low probabilities (≤5%) of new species being detected. Strata 42, 44 and 53 have not been surveyed. Surveys have been concentrated in the south-east. Large areas with low survey intensity include stratum 10 in the east, the area between Alexandra and Eildon, east of Mt. Disappointment (stratum 56), Acheron Valley (strata 43 and 50), south of Mt Baw Baw (strata 6, 8, 36, 53 and 70), north and west of Mt Baw Baw (strata 10, 25, 26, 27 and 29) and the Dandenongs.

Amphibian Surveys

A total of 957 sites have been surveyed, including 17 of the 20 most extensive strata. However, only strata 9, 20, 39 and 45 have been surveyed intensively enough to reduce the probability of a new species in the next site surveyed to below 5%. Strata 1, 44 and 53 have not been surveyed. Despite several of the strata having 50 or more surveyed sites, many of these still have high

probabilities of new species being detected Areas with low survey intensity include strata 26, 27 and 29 in the north-west and Mt Baw Baw, strata 10 in the north-east, 15, 43 and 44 in the Acheron Valley, 36 in the west and all strata in the Dandenongs.

Table 3.2: 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 68 strata with survey sites	41	26	36	31	33	38	36	29	29
Number of the 20 largest strata with survey sites	19	18	19	17	17	19	19	17	17
Number of the 20 largest strata with low probability (≤5%) of new species in next survey	13	4	16	16	13	9	8	6	4

Of the 20 largest strata generated by the stratification of the Central Highlands region, between 17 and 19 were surveyed for each of the fauna groups considered. Bats and small ground mammals are the groups most comprehensively surveyed across the region, based on them having the most large strata with low probabilities of new species being detected. Future surveys for reptiles, amphibians and large mammals are most likely to detect species not previously recorded in formal surveys - this is so for the majority of largest strata. Site survey intensities appear adequate for many of the strata and fauna groups. However, a number of survey gaps have been identified at substrata level in different parts of the region.

4 Forest Ecosystem Assessment

4.1 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 proposed 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;
- identification of refugia for flora and fauna; and
- a description of disturbances and management actions relevant to forest ecosystems and refugia.

4.1.1 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 *sensu* Forbes *et al.* (1981) and forest types (Land Conservation Council studies) is discussed in Woodgate *et. al.* 1994.

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

Most EVCs within the study area have already been characterised in the LCC Melbourne 2 Study Area report (LCC 1991) and these are largely confined to the forested public land of the Great Dividing Range and the associated foothills. Descriptions of EVCs occurring in the Central Highlands is given in Appendix C. On the adjacent foot slopes of the Great Divide and on the plains beyond, only the less fertile habitats have remained substantially intact. Those EVCs

which have not been previously identified in the study area (because they were confined to private land), or those requiring more characterisation are described in Appendix D.

4.2 Pre-1750 extent of Ecological Vegetation Classes

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

New EVCs/complexes which have not been recorded in the previous public land vegetation mapping of the study area (Appendix D) occur either on fertile lowland plains or rolling hills which have been largely cleared for agriculture, or they occur on less fertile areas that have been subsequently been cleared for urban development on the fringes of Melbourne

4.2.1 Methods

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. Table 4.1 shows the attributes used, listed in their order of importance for each EVC. Further EVC attributes are presented in Appendices C and D. Table 4.1 describes the attributes used for those EVCs that occur on private land in the region.

Table 4.1: Physical attributes used to model and map the pre-1750 extent of EVCs.

Ecological Vegetation Class	Attributes
Clay Heath	Soils, drainage, slope, rainfall
Lowland Forest	Geology, elevation, geomorphology, rainfall
Riparian Scrub Complex	Stream morphology, soil, stream gradient, elevation
Riparian Forest	Stream morphology, alluvial terrace development, stream gradient, soil drainage, frequency and duration of flooding, rainfall
Heathy Dry Forest	Aspect, slope, elevation, soil depth, rainfall, fire history
Grassy Dry Forest	Aspect, soils, slope, elevation, rainfall
Herb-rich Foothill Forest	Aspect, low to moderate rainfall, elevation

Table 4.1 cont'd

Ecological Vegetation Class	Attributes
Damp Forest	Aspect, moderate rainfall, elevation
Wet Forest	Aspect, high rainfall, elevation
Shrubby Foothill Forest	Aspect, rainfall, elevation
Valley Grassy Forest	Geomorphology, geology, soils, rainfall, slope
Heathy Woodland	Soils, site drainage and seasonality, slope, geomorphology, rainfall, elevation
Wet/Swamp Heathland	Soils, site drainage and seasonality, slope, geomorphology, rainfall, elevation
Swamp Scrub	Soils, site drainage and seasonality, slope, geomorphology
Box Woodland	Soils, rainfall, slope, geomorphology
Plains Grassy Woodland	Geology, soils, rainfall
Floodplain Riparian Woodland	Stream morphology, alluvial terrace development, stream gradient, soil drainage, frequency and duration of flooding, rainfall
Riparian Thicket	Stream morphology, geology, stream gradient, elevation
Box Ironbark Forest	Geology, rainfall, aspect, slope, elevation,
Riverine Escarpment Scrub	Geology, slope, proximity to streams, geomorphology
Swampy Riparian Woodland	Stream morphology, alluvial terrace development, stream gradient, soil drainage, frequency and duration of flooding, rainfall
Grassland	Geology, soils, rainfall, fire regimes
Grey Clay Drainage Line Complex	Geology, soils, geomorphology, rainfall
Plains Grassy Wetland	Geology, soils, geomorphology, rainfall
Swampy Riparian Complex	Stream morphology, alluvial terrace development, stream gradient, soil drainage, frequency and duration of flooding, rainfall
Valley Heathy Forest	Geomorphology, geology, soils, rainfall, slope
Grassy Forest	Geomorphology, geology, soils, rainfall, slope
Riverine Forest	Stream morphology, alluvial terrace development, stream gradient, soil drainage, frequency and duration of flooding, rainfall
Damp Sands Herb-rich Woodland	Soils, soil drainage characteristics, rainfall

In the time since the EVCs were mapped in the Central Highlands for the LCC's Melbourne Area District 2 Review, the names for some EVCs have been updated in order to be consistent with the Statewide typology for EVCs. Table 4.2 provides the current names and synonyms from the previous LCC mapping.

Table 4.2. LCC Melbourne 2 Study EVC names and current EVC names.

Previous name	Current name
Dry Sclerophyll Forest	Grassy Dry Forest
Heathy Foothill Forest	Lowland Forest
Damp Sclerophyll Forest	Damp Forest
Wet Sclerophyll Forest	Wet Forest
Sub-alpine Wet Heathland/Damp Heathland/Dry Shrubland	Treeless Sub-alpine Complex
Valley Forest	Valley Grassy Forest
Swampy Riparian Forest	Swampy Riparian Woodland
Coastal Grassy Forest	Damp Sands Herb-rich Woodland
Floodplain Wetland Complex	Wetland Formation*

Note: * incorporated in Floodplain Riparian Woodland

The inherent reliability of mapping produced at 1:100 000 scale using current technology is adequate for the assessment. However the certainty of this mapping is related to the quality of the underlying data sets used to define the vegetation boundaries.

Table 4.3 outlines the regional reliability of mapping of pre-1750 vegetation in Central Highlands against three categories:

1. High reliability: EVC mapping used both geological and topographic data which were available at 1:100 000 and or complete field checking;

2. Moderate reliability: EVC mapping did not use geological or land system data, relying on topographic data (eg. aspect or elevation) which were available at the presentation scale of 1:100 000; and or extensive field checking;

3. Low reliability: EVC mapping used land system and/or geological mapping which was only available at 1:250 000. The definition between important attributes (eg. fertility) was inadequate and map units in general were poorly registered to base features such as rivers and roads. Alternatively the area was modelled and required the use of coarse information or was not accessible for field checking.

Table 4.3 Pre-1750 EVC and mapping reliability.

High	Moderate	Low
EVC mapping north of the Yarra (all areas field checked)	EVC mapping south of the Yarra (extensive field checking)	EVC mapping in reservoirs (poor access and no contour information) eg Cardinia Reservoir
	EVC mapping on the Yea spur (little remaining vegetation and poor access, but remotely field checked)	EVC mapping just west of Neerim South (poor access combined with complicated and ecotonal vegetation patterns)
		EVC mapping north west of Labertouche (narrow private land area, poor access combined with complicated and ecotonal vegetation patterns)

4.2.2 Results

The results of the Pre-1750 EVC analysis are presented in Table 4.4. These data have also been used to ascertain the rarity and threatened status of EVCs within the study area.

The extent of representation of EVCs in both conservation reserves and in parts of the State forest Special Protection Zone (SPZ) has been used as the basis for evaluating the current reservation status of forest ecosystems in the region.

The SPZ includes the following sub-categories of protected areas:

(a) Mostly large and contiguous areas designed for conservation of specific values and with boundaries based on reserve design principles;

(b) A network of connecting areas (200-400 m width) based around riparian zones (including Heritage River corridors) but also including wildlife corridors on ridges and crossing between catchments;

(c) Narrow linear reserves of less than 200 m width and small areas less than 5 ha; and

(d) Areas protected by forest management prescriptions. These include all permanent streams and all rainforest stands plus adjacent buffers of at least 20 m width, and all heathland EVCs plus a buffer of at least 40 m.

Table 4.4 : Representative conservation (percentage reservation status) of EVCs in the Central Highlands study area based on Pre-1750s vegetation mapping.

Ecological Vegetation Class		Area (ha)		Percent remaining	Conservation	Percent of EVC (pre-1750 extent) in each land category: State Forest Management Zones								Other Parks & Reserve	Other Public Land	Private land
						SPZ				SMZ		GMZ				
		Pre 1750	Current			Area	Broad	Narrow	CFP	Other	Timber	Other	Timber			
7	Clay Heathland	27	27	99.2								19.9				79.3
16	Lowland Forest	78,992	42,805	54.2	13.6	1.4	0.5	0.0	1.0	0.0	0.0	3.9	10.9	0.4	3.8	18.7
17	Riparian Scrub Complex	9,992	2,695	27.0	0.8	0.0			0.1	0.0	0.1	0.0	0.3		2.0	23.7
18	Riparian Forest	43,059	31,801	73.9	15.5	9.8	9.4	0.1	6.0	0.1	0.5	2.3	9.4	0.8	11.0	9.0
20	Heathy Dry Forest	15,025	14,436	96.1	26.6	32.9	1.2	0.4	2.6	0.6	0.8	14.1	8.2		3.4	5.3
22	Grassy Dry Forest	73,892	41,579	56.3	19.2	4.0	0.0	0.0	0.4	0.1	0.0	3.4	1.4		3.6	24.2
23	Herb-rich Foothill Forest	168,346	123,049	73.1	11.6	8.8	0.4	0.1	3.2	0.2	0.9	12.0	18.8	0.1	1.4	15.6
27	Rocky Outcrop Scrub	311	227	73.1	62.9											10.2
28	Rocky Outcrop Shrubland	19	5	28.0												28.0
29	Damp Forest	198,726	162,307	81.7	16.6	7.3	1.5	0.1	5.0	0.3	3.0	4.8	31.4	0.6	1.8	9.3
30	Wet Forest	123,752	120,068	97.0	28.7	8.3	3.3	0.1	6.9	0.5	3.8	2.9	35.5	0.9	1.1	5.0
31	Cool Temperate Rainforest	12,984	12,970	99.9	43.8	22.5	7.2	1.4	6.6	0.1	0.5	1.0	15.2	0.8	0.2	0.6
36	Montane Dry Woodland	7,087	7,050	99.5	3.2	48.5	0.8	0.7	3.4	0.0	0.0	21.8	21.1			
38	Montane Damp Forest	20,506	20,150	98.3	7.7	13.7	0.5	0.2	8.2	0.2	2.0	11.6	53.5	0.2	0.4	0.1
39	Montane Wet Forest	50,319	49,678	98.7	33.6	7.7	1.4	0.2	5.1	0.1	1.2	2.8	45.4		1.2	
41	Montane Riparian Thicket	3,056	3,056	100.0	33.3	7.3	8.9	0.5	18.5	0.1	0.3	4.0	24.1	0.1	2.9	
43	Sub Alpine Woodland	7,262	7,259	100.0	78.9	6.3	0.4	0.2	0.6	0.2	0.1	5.8	4.2		3.2	0.1
44	Treeless Sub Alpine Complex	1,855	1,825	98.4	84.9	0.2	6.8	0.0	1.9	0.0	0.0	0.7	2.3		1.6	
45	Shrubby Foothill Forest	50,296	35,482	70.5	22.4	3.6	0.6	0.0	0.8	0.2	1.9	2.9	21.5	1.1	2.0	13.5
47	Valley Grassy Forest	64,452	7,201	11.2	1.6	0.0						0.0	0.0		0.7	8.9
48	Heathy Woodland	17,876	6,684	37.4	21.4	1.7	0.0		0.3	0.0	0.0	2.1	1.5		2.9	7.5
49	Wet/Swamp Heathland	6,250	3,779	60.5	47.1				0.2		0.0	0.8	1.2		1.5	9.7
53	Swamp Scrub	5,655	429	7.6											6.2	1.4
54	Box Woodland	25,339	328	1.3	0.2										0.1	1.0
55	Plains Grassy Woodland	44,369	1,474	3.3	0.2	0.0			0.0			0.0			1.9	1.2

Table 4.4 cont'd

Ecological Vegetation Class		Area (ha)		Percent remaining	Conservation	State Forest Management Zones								Other Parks & Reserve	Other Public Land	Private land
						SPZ				SMZ		GMZ				
		Pre 1750	Current			Area	Broad	Narrow	CFP	Other	Timber	Other	Timber			
56	Floodplain Riparian Woodland	18,016	2,463	13.7	4.7	0.1		0.0	0.0			0.0			7.5	1.4
59	Riparian Thicket	1,726	1,006	58.3	4.1	0.3	17.5	11.1	0.0			0.0	0.0		8.2	17.1
61	Box Ironbark Forest	1,449	711	49.1	1.8										9.7	37.6
72	Granitic Hills Woodland	1,258	215	17.1											0.8	16.3
82	Riverine Escarpment Scrub	765	241	31.5										0.1	27.3	4.1
83	Swampy Riparian Woodland	2,530	964	38.1	15.5										13.0	9.6
120	Grassland	7,982	15	0.2												0.2
700	Gray Clay Drainage Line Complex	560	0	0.0												
701	Plains Grassy Wetland	354	4	1.2											1.2	
704	Swampy Riparian Complex	50,889	5,945	11.7	0.8	0.0	0.0		0.0	0.0	0.0	0.0	0.0		1.5	9.4
705	Valley Heathy Forest	4,155	347	8.4											0.6	7.8
713	Grassy Forest	10,059	2,682	26.7	0.3							0.0			1.7	24.7
714	Swamp Formation	12	1	10.7												10.7
715	Damp Sands Herb-rich Woodland	162	46	28.4									0.0	3.7	19.8	4.9
716	Riverine Forest	210	4	1.9											0.6	1.3
720	Rock	23	23	98.4	37.2										2.5	58.7
58	Cleared Land		405,145													
998	Water Bodies	4	13,776													
	Total	**1,129,953**	**1,129,953**													

4.3 Reservation status of Ecological Vegetation Classes

Information on the current reservation status of EVCs for the Central Highlands is provided in Table 4.4. All forest EVCs with their current extent mainly confined to public lands are well represented in the existing reserve system. Three woodland EVCs and two wetland EVCs whose current extent is predominantly on public land are, however, not well-represented in the current reserve system. Many of the EVCs which are rare or considered to be endangered or vulnerable as a result of depletion (Table 4.9), are not well represented in the reserve system, with much of their extant distribution occurring in 'other public land' or on 'private land'. This reflects the historic demarcation between public land and the selection of arable lands for farming associated with private land.

4.3.1 Sub-regional reservation Ecological Vegetation Classes

Eleven geographic Representation Units (GRUs) have been identified across the Central Highlands which reflect the landscape scale variation across the region (see Map 1S). These are based on similar land form, geology, vegetation and climate. Table 4.5 lists the geographic regional units and the attributes that characterise them. The overall reservation status of each EVC for all reserve types was undertaken by overlaying the reserve system with the EVC coverage using a Geographic Information System (GIS).

Table 4.5: Geographic Representation Units of the Central Highlands and their attributes.

Geographic Representation Unit (GRU)	Attributes
Aberfeldy	Steeply dissected ranges in a rainshadow from the Baw Baw Massif.
Acheron	The southern portion of the Blue Range consisting of high rainfall areas associated with the Devonian acid volcanic and granitic massifs and steeply dissected Devonian sediments south of the Great Divide
Alexandra	Moderate to low rainfall foothills and ranges to the north of the Great Divide consisting of Devonian sediments and smaller areas of contact metamorphics
Big River	Steeply dissected ranges north of the Great Divide, consisting of Devonian and Silurian sediments in low rainfall areas
Bunyip	Rolling hills and small ranges of Devonian granitoids and acid volcanics in moderate to high rainfall zones south of the Great Divide
Disappointment	The moderate to high rainfall areas of the Hume Range with the Devonian granitic massif of Mt. Disappointment and the surrounding foothills of Devonian and Silurian sediments
Latrobe	Foothill country of moderate to high rainfall and varied geology (sediments, outwash, alluviums, and basalts) south of the Great Divide on the margins of the Latrobe Valley
Marysville	The northern portions of the Blue Range and all of the Roysten Range straddling the Great Divide and largely composed of Devonian acid volcanics and granitoid massifs under moderate to high rainfall regimes. This GRU has small areas of sub-alpine county
Matlock	Steeply dissected ranges south of the Great Divide, consisting of Devonian and Silurian sediments in low to moderate rainfall areas
Thomson	Very high rainfall areas based on the Devonian granitic massifs of the Baw Baw Range steeply dissected mountains south of the Great Divide, reaching sub-alpine elevations in places.
Yarra	Low elevation rolling hills and river plains of the Yarra and its tributaries south of the Great Divide

Note: Rainfall is classified as low (<700mm), moderate (700-1000mm), high (1000-1200m) or very high (>1200mm). For geographic extent see NRE 1996b).

The results of the analysis of representation of EVCs by Geographic Representation Unit are presented in Table 4.6.

Table 4.6: Representative conservation (percentage reservation status) of pre-1750 EVCs in the Central Highlands region by Geographic Representation Unit.

Representative conservation (percentage reservation status) of pre-1750 EVCs in the Central Highlands region by Geographic Rep

Ecological Vegetation Classes	Pre 1750 Area (ha)	ABERFELDY (iii)		ACHERON		ALEXANDRA		BIG RIVER		BUNYIP		DISAPPOINTMENT		LATROBE		MARYSVILL	
		Area (ha)	% Prot	Area (ha)	Prot %	Area (ha)	Prot %	Area (ha)	Prot %	Area (ha)	Prot %	Area (ha)	Prot %	Area (ha)	Prot %	Area (ha)	Pr
Clay Heathland	27									22	0			5	0		
Lowland Forest	78,992			5,365	4					29,071	16	488	78	37,131	17	560	
Riparian Scrub Complex	9,992			833	0					4,035	0			3,020	2	12	
Riparian Forest	43,059	6	0	5,938	42	2,049	18	2,510	49	4,247	33	4,919	16	4,189	33	5,332	
Heathy Dry Forest	15,025	212	71	42	0	22	0	741	57			1,796	52	90	65	718	
Grassy Dry Forest	73,892					19,383	26	13,109	63	416	43	16,811	7	72	32	3,338	
Herb-rich Foothill Forest	168,346	584	77	3,898	27	26,330	13	21,342	52	2,376	2	50,506	14	32	0	28,822	
Rocky Outcrop Scrub	311			9	100					15	79	112	0			175	
Rocky Outcrop Shrubland	19											19	0				
Damp Forest	198,726	1,040	66	31,921	26	1,379	23	8,542	26	33,632	18	16,192	43	27,180	13	22,505	
Wet Forest	123,752			46,602	55			1,192	16	12,449	29	3,865	76	2,724	11	19,048	
Cool Temperate Rainforest (ii)	12,984			6,406	90			73	57	212	74	311	100			4,161	
Montane Dry Woodland	7,087	4	26					1,277	56							22	
Montane Damp Forest	20,506			148	52			1,122	53							3,036	
Montane Wet Forest	50,319			7,383	87			1,031	23							14,129	
Montane Riparian Thicket	3,056			18	100			24	89							1,106	
Sub-alpine Woodland	7,262			13	60			316	94							1,434	
Treeless Sub-alpine Complex	1,855							3	100							161	
Shrubby Foothill Forest	50,296	437	48	6,312	15					13,002	18	2,920	1	8,882	10	1,410	
Valley Grassy Forest	64,452			274	0	20,369	2	241	1	2,350	0	13,586	0			187	
Heathy Woodland	17,876			1,317	1					12,687	24			3,696	30		
Wet/Swamp Heathland	6,250			378	0					3,585	42			2,249	65		
Swamp Scrub	5,655									706	0			4,469	0		
Box Woodland	25,339					13,542	1					9,920	0				
Plains Grassy Woodland	44,721					16,689	0	134	1			6,693	0			35	
Floodplain Riparian Woodland	18,016			373	0	9,999	7	65	44	55	0	4,425	1	1,395	0	148	
Riparian Thicket	1,726			505	18					678	1					518	
Box Ironbark Forest	1,449																
Granitic Hills Woodland	1,258											1,117	0				
Riverine Escarpment Scrub	765																
Swampy Riparian Woodland	2,530			40	11					1,549	26						
Grassland	7,982									335	0						
Gray Clay Drainage Line Complex	560																
Plains Grassy Wetland	354					10	0										
Swampy Riparian Complex	50,889			1,538	1	3,645	0			10,731	1	3,291	0	7,291	0	2,423	
Valley Heathy Forest	4,155									275	0	988	0	2,304	0		
Grassy Forest	10,059			38	0					5,892	1						
Swamp Formation	12																
Damp Sands Herb-rich Woodland	162																
Riverine Forest	210																
Water Bodies	4							4	0								

4.3.2 Representation within reserves of floristic variation across EVCs

An assessment of the representation of floristic variation across EVCs is described in this section.

The assessment compared the reserve system with the distribution (quadrat information) representing the floristic communities for all EVCs. Floristic communities were derived from a PATN analysis of all quadrat data within the study area. Because floristic community distribution data is point-based, an accurate percentage area representation within the reserve system cannot be determined. However, the coincidence of floristic communities and reserves can be assessed.

The results of the analysis show that eleven of the forty EVCs occurring in the region area had more than one floristic community. Those EVCs with more than one floristic community are Cool Temperate Rainforest (2), Montane Wet Forest (3), Wet Forest (6), Damp Forest (6), Shrubby Foothill Forest (2), Herb-rich Foothill Forest (3), Valley Grassy Forest (2), Grassy Dry Forest (6), Heathy Dry Forest (7), Lowland Forest (7), and Riparian Forest (4). The remaining EVCs consist of only a single community within the study area. Those floristic communities which are not represented in reserves are Heathy Dry Forest (DHDF3) which occurs on poorer site quality areas north of the Great Divide, mainly in the Matlock area; and Grassy Dry Forest (DGDF2), which was once more common on private land in the urban part of the Lower Yarra valley.

4.3.3 Reservation status of Ecological Vegetation Class growth stages

In addition to the representation of EVCs and old growth forest in reserves, the representation of the range of different forest growth stages in each EVC has been considered. Such an analysis enables an evaluation of the reservation status of the various successional stages in the forest at the present time. Appropriate representation of a range of age-classes in reserves improves the likelihood that a greater suite of associated biodiversity will be protected and reduces the risk of stochastic events (such as wildfire) eliminating all recruitment to older growth stages for extended periods.

Woodgate *et al*. (1994) identified the following forest disturbance class growth stages which can be used for this assessment:

1. Old-growth Forest - see old-growth section of this report;
2. Negligibly Disturbed Forest - Forest which has less than 10% of the oldest trees (senescing) growth stage and less than 10% of its youngest (regrowth) growth stage in the upper stratum, and where the effects of any disturbance are negligible or non-existent;
3. Significantly Disturbed Forest - Forest which has greater than 10% of its youngest (regrowth) growth stage in the upper stratum, and has been subject to natural disturbances (i.e. wildfire); and
4. Other Forest - Includes forest that has greater than 10% of regrowth forest in the upper stratum originating from unnatural disturbances (timber harvesting etc.) and other forest where the type and level of disturbance is unknown.

The data used in the assessment derive from the LCC Melbourne 2 Study Area EVC coverage, the Central Highlands old growth forest study and land tenure/forest management zone data layers held by the Department of Natural Resources and Environment. The forest management

zones have been developed as part of the Proposed Central Highlands Forest Management Plan (DCNR 1996).

The area by EVC of old-growth forest, negligibly and significantly disturbed forest and other forest is presented in Table 4.7.

Table 4.7: Extent and level of protection for different forest growth stages and disturbance categories in the Central Highlands region.

Ecological Vegetation Classes	Total Area	Old-growth Forest		Negligibly Disturbed		Significantly Disturbed		Other Forest	
	ha	ha	% Prot (ii)	ha	% Prot (ii)	ha	% Prot (ii)	ha	% Prot (ii)
Lowland Forest	26858	22	100	11812	38	14723	52	303	21
Riparian Forest	27375	130	100	7974	67	16958	56	2314	8
Heathy Dry Forest	13871	9214	77	3080	48	1531	38	42	10
Grassy Dry Forest	22625	7	100	16136	74	6417	70	65	72
Herb-rich Foothill Forest	94776	77	85	29629	60	64841	25	229	53
Rocky Outcrop Scrub	195			135	100	60	100		
Damp Forest	143126	547	99	55658	47	86506	27	416	23
Wet Forest	113281	5083	99	37321	61	70677	31	205	47
Cool Temperate Rainforest	12918	1690	100	7722	74	3493	66	13	98
Montane Dry Woodland	7072	4040	71	1940	31	1091	25		
Montane Damp Forest	20130	75	100	10237	25	9813	19	5	
Montane Wet Forest	49677	940	100	22290	58	26448	29		
Montane Riparian Thicket	3056	10	94	1677	63	1369	33		
Sub-alpine Woodland	7254	3	100	3007	88	4240	84		
Shrubby Foothill Forest	27983	32	100	13652	65	14094	26	204	69
Valley Grassy Forest	1136	696	71	430	72	8	100	2	94
Heathy Woodland	5137	3427	89	1491	51	193	42	26	69
Wet/Swamp Heathland	3095			2920	96	163	82	12	36
Box Woodland	33			30	100			3	100
Plains Grassy Woodland	271			259	14	13			
Floodplain Riparian Woodland	1472			19	24	157	65	1296	40
Riparian Thicket	524			299	100	225	100		
Sub-alpine Complex	1825			838	94	986	93		
Total	**583690**	**25993**	**92**	**228556**	**63**	**324006**	**53**	**5135**	**49**

Notes: (a) This table excludes private land, EVCs occurring entirely on private land and those for which it is not possible to determine the growth stage. (b) Percent of area protected is based on area in conservation reserves and SPZ categories a and b as defined in Section 4.2.2.

The area figures in Table 4.7 represent the total area of each forest category on public land for each EVC. The corresponding percent protection figure refers to the proportion of the total area protected in conservation reserves or in the Special Protection Zone (components ('a' and 'b' - see 4.2.2) Other SPZ components were not included in the analysis and fall into the category 'other forest'.

Some refinements to the EVC layers (both current and pre-1750 layers) have been made during the pre-1750 mapping exercise for the CRA. However the growth stage and disturbance information has not been updated and, as indicated above, the original old growth data layers have been used to derive Table 4.7. Consequently there are minor differences in the total EVC areas on public land shown in this table and in Table 4.4.

4.3.4 Endangered, vulnerable and rare forest ecosystems

The conservation status of EVCs in the region have 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.

EVCs which are classified as rare, vulnerable or endangered according to the national reserve criteria (Table 4.8) are presented in Table 4.9. This assessment is relevant to Criteria 2 and 3 which pertain to levels of desired reservation.

Table 4.8: 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% lost (depletion). 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. Subject to continuing threatening processes.
Endangered	E1. Distribution has contracted to less than 10% of original range. E2. Less than 10% of original area remaining. E3. 90% of area is in small patches subjected to threatening processes.

Most of the EVCs listed in Table 4.9 are confined to private land in the region (see also Section 4.2).

Table 4.9: Endangered, vulnerable and rare Ecological Vegetation Classes in Central Highlands

			Current Management		
EVC	**Criteria**	**Threatening Processes**	**Management Action**	**% Reservation**	**Research**
Swamp Scrub	E2, E3	• habitat loss and fragmentation from agricultural clearing • weed invasion through fragmentation from agricultural clearing	• Native Vegetation Retention Controls (NVR)	0	
Box Woodland	E2, E3	• habitat loss and fragmentation from agricultural clearing • weed invasion through fragmentation from agricultural clearing	• NVR • intensive reserve management, minimisation of disturbance, monitoring fire regimes	0.2	
Plains Grassy Woodland	E2, E3	• habitat loss and fragmentation from agricultural clearing • weed invasion through fragmentation from agricultural clearing	• NVR • Land for Wildlife • intensive reserve management, minimisation of disturbance, monitoring fire regimes	0.2	• Socioeconomic research into value of maintaining native vegetation on farms
Grassland	E1, E2, E3	• habitat loss and fragmentation from agricultural clearing • weed invasion through fragmentation from agricultural clearing	• NVR • Land for wildlife	0	• Socioeconomic research into value of maintaining native vegetation on farms • Effects of fire in maintaining biodiversity and weed control • Weed control
Grey Clay Drainage Line Complex	E1, E2, E3	• altered drainage • weed invasion		0	
Plains Grassy Wetland	E1, E2, E3, R3	• altered drainage • grazing • weed invasion		0	
Valley Heathy Forest	E2, E3	• habitat loss and fragmentation from agricultural clearing • weed invasion through fragmentation from agricultural clearing	• NVR	0	

Table 4.9 Cont'd.

			Current Management		
EVC	**Criteria**	**Threatening Processes**	**Management Action**	**% Reservation**	**Research**
Grassy Forest	E3 V1, V2	• habitat loss and fragmentation from agricultural clearing • weed invasion through fragmentation from agricultural clearing	• NVR	0.3	
Riverine Forest	E1, E2, E3	• habitat loss and fragmentation from agricultural clearing • weed invasion through fragmentation from agricultural clearing and grazing • altered flooding regimes	• NVR • intensive reserve management, minimisation of disturbance, monitoring fire regimes	0	
Valley Grassy Forest	E3 V1, V2	• habitat loss and fragmentation from agricultural clearing • weed invasion through fragmentation from agricultural clearing	• NVR • Land for wildlife	1.6	
Damp Sands Herb-rich Woodland	E3 V1, V2	• habitat loss and fragmentation from agricultural clearing • weed invasion through fragmentation from agricultural clearing	• NVR	0	• monitoring • developing appropriate fire regimes
Granitic Hills Woodland	E3 V1, V2	• habitat loss and fragmentation from agricultural clearing • weed invasion through fragmentation from agricultural clearing	• NVR	0	
Swampy Riparian Complex	E3 V1, V2	• habitat loss and fragmentation from agricultural clearing • weed invasion through catchment disturbance and recreation access	• NVR	0.8	
Floodplain Riparian Woodland including Wetland formation	E3 V1, V2, E2, E3, R3	• habitat loss and fragmentation from agricultural clearing • weed invasion through fragmentation from agricultural clearing and grazing • altered flooding regimes • wetland draining for agricultural development	• NVR • Land for wildlife	4.8	
Riparian Scrub Complex	V1	• habitat loss and fragmentation from agricultural clearing • weed invasion through grazing	• NVR	0.8	
Rocky Outcrop Shrubland	V1, R3		• NVR	0	
Riverine Escarpment	V1, R3	• weed invasion through catchment	• NVR	0	

Scrub		disturbance			
Rocky Outcrop Scrub	R3	• denudation through recreation use	• NVR	62.9	
Clay Heathland	R3	• Cinnamon Fungus	• NVR	0	
Cool Temperate Rainforest	R3	• Myrtle Wilt disease through disturbance associated with forest activities • Permanent edge effects associated with roading along and across rainforest stands	• Reservation of most important stands • Remainder excluded from timber harvesting through exclusion zones • Seminar and field training days in rainforest protection for regional staff.	74.8	• Abiotic and biotic variables in rainforest edges • Monitoring Myrtle Wilt

Note: All Cool Temperate Rainforest on State forest is protected in the SPZ. Cool Temperate Rainforest extent has been somewhat exaggerated in the EVC mapping

4.3.5 Current management actions to address threatening processes

All forest communities are potentially affected, to a greater or lesser extent, by threatening processes. While these threats are generally unlikely to lead to the broad scale destruction or severe degradation of the vegetation community, they may be widespread or locally severe in their impacts. Understandably, the threats listed below overlap substantially with those that affect individual species, some of which are discussed in other sections of this report. Table 4.10 lists the major threats to forest communities in the Central Highlands and identifies the actions taken in response to each threat.

Table 4.10: Current management actions for threatening processes that affect forest ecosystems.

Potentially Threatening Process	Response
Clearing native vegetation causing: - habitat loss, - changes to structure and composition, - erosion, - soil compaction, - weed invasion	• The clearing of native vegetation on public land requires Ministerial or Departmental approval. Planning permission may also be required in some cases. Major developments, including many mining and extractive industry developments, are the subject of Environmental Effects Statements, in which the impacts on native flora are considered. The taking of protected flora associated with clearing requires authorisation under the *Flora and Fauna Guarantee Act*. • The clearing of native vegetation on private land requires planning permission from the local planning authority in most cases. For parcels of land greater than 10 ha in area, NRE approval is required.
Planned fire causing: - habitat loss, - changes to structure and composition,	• The conduct of planned fire in the Central Highlands is governed by the Department of Natural Resources and Environment Code of Fire Practices, Regional Fire Management Plans and Regional Prescriptions in the case of fuel reduction and regeneration burns. • Ecological burns are usually initiated by management plans or Action Statements for specific species, communities or sites.

Table 4.10 Cont'd

Potentially Threatening Process	Response
Timber harvesting and associated activities causing: - habitat loss, - changes to structure and composition, - erosion, - soil compaction, - weed invasion - spread of fungal pathogens	• 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, the relevant Forest Management Area Plan, regional prescriptions and the annual Wood Utilisation Plans. The Code Of Forest Practices For Timber Production and Forest Management Area 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. • The indirect taking of protected flora associated with timber harvesting requires authorisation under the *Flora and Fauna Guarantee Act*. • Operational trials of "understorey islands", areas within coupes in which machinery is excluded, are continuing, with the view to routine implementation where feasible. These trials have been initiated because of the demonstrated impact harvesting has on species which regenerate by resprouting or those which are obligate seed regenerators but take decades to mature. • Buffers for rainforest and vegetation containing Myrtle Beech • Field days and seminars for regional and operational staff designed to minimise the risk of spread of Myrtle Wilt as the result of forest management activities
Grazing causing: - habitat loss, - changes to structure and composition, - erosion, - soil compaction, - weed invasion	• Grazing of private land remnant native vegetation is not subject to regulation. Licensed grazing of native vegetation on public land is subject to periodic review, with the option of specifying licence conditions which may include protection of native flora. • Pest animals are subject to active management to control or eradicate populations, especially adjacent to agricultural lands and where impacts are most severe. Targeted pest management is applied in a few cases where grazing is a threat to one or more threatened plant species as a component of an Action Statement or Recovery Plan. • The recent release of the Rabbit Calicivirus Disease is a major initiative in rabbit control. • While the overall impact of introduced game animals such as deer is relatively minor when compared to domestic stock and rabbits, significant localised impacts are recorded (especially in riparian vegetation). • Overbrowsing by native species is generally dealt with by issuing permits to reduce specific populations of native browsers.
Road construction and maintenance - habitat loss, - changes to structure and composition, - erosion, - soil compaction, - weed invasion - spread of fungal pathogens	• Vicroads is responsible for the highways throughout Victoria. Vicroads has recently published an environmental strategy which includes objectives and commitments relating to the conservation of native flora. • Local municipalities are responsible for road construction and maintenance for other roads, excluding those managed by Department of Natural Resources and Environment and some other organisations such as utilities on public land, and those managed by private landholders on their land. Individual councils are developing strategies for roadside conservation. • Road construction and maintenance conducted on public land as part of the management of State forests or major conservation reserves is generally planned and implemented as part of a coordinated management plan. The Code Of Forest Practices For Timber Production includes standards and guidelines for road construction in State forest. In all cases, efforts are made to reduce the environmental impacts, consistent with safety considerations, traffic levels and engineering requirements. • Regional field days for staff to minimise impact of roading on Myrtle Wilt

Table 4.10 Cont'd

Potentially Threatening Process	Response
Recreation	• Pleasure driving, fishing, hunting, camping and sightseeing is managed through the relevant planning process - Forest Management Area Plan or National Park Management Plan - on public land. Effort is generally made to encourage activities in appropriate zones in which they are compatible with overall management objectives, or where impacts can be minimised. • Skiing and associated resort development is at present managed by the Alpine Resorts Commission in cooperation with the Department of Natural Resources and Environment.
Environmental weed invasion	• The management of environmental weed invasions is the responsibility of the land manager. For 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, is currently investigating the significance of the environmental weed problem in general, including specific reference to environmental weeds. • Environmental weed invasion has been listed as a potentially threatening process under the *Flora and Fauna Guarantee Act*. • The Commonwealth, in consultation with State and Territory agencies, has recently completed the National Weeds Strategy, which outlines actions to address environmental weed problems. • Current management of environmental weeds across public and private land is generally acknowledged as being deficient. Limited resources and a general lack of strategic planning, tactical planning, follow-up, monitoring and experimental management are largely responsible for the deficiencies.

Rainforest

Cool Temperate Rainforest is the only Rainforest EVC occurring in the Central Highlands. Most significant rainforest stands are located along gullies and rivers. Rainforest in the Central Highlands is protected in dedicated reserves and the SPZ and the balance is protected through the Code of Forest Practices for Timber Production (The Code). The Code requires that rainforest and associated buffer of non-rainforest vegetation be excluded from timber harvesting. The Proposed Central Highlands Forest Management Plan includes all rainforest and their associated buffers in the Special Protection Zone.

In a review of rainforest protection measures, Burgman and Ferguson (1995) proposed a number of areas of improvement in rainforest management. The CSIRO recently reviewed the Victorian Code of Forest Practices and proposed that:

- areas of rainforest must be defined and a strategy for their management must be included as part of planning for conservation of flora and fauna in Forest Management Plans and/or in the relevant prescriptions. The most important rainforest areas should be accorded the highest protection;
- rainforest areas must be shown on the Forest Coupe Plan and buffers identified in the field; and

- there should be an increasing degree of protection commensurate with increasing significance of the rainforest stand. Pending the results of further research, interim minimum levels of protection relevant to the Central Highlands are as follows:
  ⇒ for stands of lesser significance: 40 metre buffers or 20 metre exclusion plus a 40m modified harvesting strip (greater than 40% of basal area retained, low machine disturbance, minimal burning); and
  ⇒ for stands containing nationally significant rainforest sensitive to management operations: the highest degree of protection, generally sub-catchment level, except where full protection can be provided by other measures, which are/will be outlined in approved plans.

The revised Code of Forest Practices, which was ratified by the Victorian Parliament in 1997, incorporates these amendments. Furthermore, the Proposed Central Highlands Forest Management Plan identifies a range of protection measures from sub-catchment protection to specified buffer widths, depending on the significance of the stand.

Mixed Forest

This EVC occurs with the Wet Forest EVC (as currently mapped) and contains rainforest elements in the understorey with an overstorey of eucalypts and, in the Victorian vegetation typology, it is called Cool Temperate Mixed Forest. Within the Central Highlands, Cool Temperate Mixed Forest is widely distributed but uncommon. Even though no mapping is currently available across the study area it is known that the largest areas (and the majority of this EVC's occurrence) is reserved in the Yarra Ranges National Park.

Refugia

The identification of Refugia is related to three broad concepts. These are:

- evolutionary refugia - areas in the landscape in which certain types or suites of organisms are able to persist during a period in which most of the original geographic range becomes uninhabitable because of climate change;

- ecological refugia - areas in the landscape in which a species or suite of species persist for short periods when large parts of their preferred habitats become uninhabitable because of unsuitable climatic or ecological conditions (eg. drought, flooding or biologically driven collapses in food supply); and

- refugia for threatened biota - areas in the landscape in which a species has retreated because of factors ultimately to do with environmental changes set in train by European settlement (Morton *et al.* 1995).

Techniques for identifying refugia in the landscape include:

- reconstruction of the spatial pattern of past major disturbance events (eg. glaciation);
- analysis of plant and animal distributions, particularly for endemic and phylogenetically distinct species and/or species groups, linked to refugia;

- development of explicit landscape process models (Nix 1993; Mullens 1995) and correlation of predicted refugia distributions with plant and animal distributions.

An analysis of refugia was undertaken for the Central Highlands National Estate assessment. The determination of flora refuge areas was a three stage process that incorporated:

1. The identification of relictual (primitive and Gondwanic) flora. Those vegetation classes in the Central Highlands are either dominated by, or containing large proportions of species which are phylogenetically primitive or Gondwanic in origin were considered refuge dependent EVCs;

2. The identification of ice age refuges identified as undisturbed areas of refuge dependent EVCs that occupy a climatic or topographic location that retains elements of the climatic regime of the last Ice Age (40 000 - 10 000 years BP); and

3. The identification of refuges from frequent fire that have reduced fire frequency or intensity compared with the majority of areas in Central Highlands.

Eleven flora refuge areas were identified across the region, ranging from aggregations of small patches of rainforest through to substantial tracts of montane and alpine areas. The total area of flora refuges identified in the region was 52,344 hectares.

The fauna refuge areas identified were likely to function as refuges during periods of major environmental or climatic stress (eg. glaciation events), and during periods of medium term environmental stress for individuals or populations such as during wildfire or severe drought. These refuges included:

- Riparian Forest, Scrub and Shrubland (EVCs 17, 18 19);
- Undisturbed Wet Forest and Montane Wet Forest (EVCs 30, 39);
- Cool Temperate Rainforest (EVCs 31, 32, 33); and
- Permanent Wetlands.

5 Flora species assessment

5.1 Introduction

Assessment of the Central Highlands flora has involved an analysis of the distribution and viability of individual species 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 species are maintained throughout their natural range in the region;
- representative populations of each species 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.

A total of approximately 2,000 species of vascular plants have been recorded for the Central Highlands region, including 67 species of conservation significance and 500 exotic species.

5.1.1 Priority flora species

The focus of assessment of flora species in the Central Highlands has been on those taxa which have been identified as being at risk because of rarity, depletion or the continued action of threatening processes. Rare or threatened species are often at the forefront of the debate regarding the balance between conservation and resource utilisation. They are significant because their intrinsic value as unique forms of life and their potential utility is enhanced by their rarity and the higher likelihood of their permanent loss. In addition, the fate of rare or threatened species 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.

Rare or threatened plants may exhibit a range of life histories, life-forms, reproductive strategies and distribution patterns. Included among the plants considered rare or threatened in the Central Highlands region are:

- long-lived trees and short-lived herbs;
- endemics which may be locally abundant but occur in a restricted area and those which occur over a large area but are rarely common;
- sub-alpine and lowland species;
- forest-dependent species, grassland species, heathland species; and
- species which are naturally rare but appear stable and species which were more common at the time of European settlement but which have declined significantly since, usually as a result of habitat loss or degradation.

This review of the conservation of rare or threatened species in the Central Highlands region addresses:

- plants listed as threatened under the Victorian *Flora and Fauna Guarantee Act* 1988 (FFG Act),
- plants listed as presumed extinct, endangered or vulnerable under the Commonwealth *Endangered Species Protection Act* 1992 (ESP Act),
- plants included in the Victorian Rare or Threatened Species list for plants (VROTS), and

- plants included in the national list of Rare or Threatened Australian Plants (ROTAP) (Briggs and Leigh 1995).

Non-vascular plants have not been considered in this assessment, nor have those taxa where their continuing occurrence within the Central Highlands could not be confirmed in terms of accurate identification or location, or where they are hybrids.

5.2 Life history and population parameters for priority flora species

5.2.1 Assessment methods

For each of the plants evaluated in this review, the following questions were considered:
- how abundant is the plant, in which habitat(s) does it occur, and what is its pattern of distribution;
- how vulnerable is it to further decline and extinction; and
- what management action has taken place, or is envisaged, to protect the taxon.

NRE databases, expert opinion and available scientific literature were used to compile the following information for each species: conservation status (according to each of the lists mentioned above); the approximate proportion each species' total Australian range that occurs within the Central Highlands region; the number of Victorian and Central Highlands records held within NRE databases; the number of populations and individuals known to occur in the Central Highlands region; any trends which may be apparent in the demography of the plant; the geographic range of the plant within the Central Highlands region; the locations of the largest number and the second largest number of individuals in regard to land tenure, (based on records confirmed within past 10 years) within the Central Highlands region.

The land tenure categories used are conservation reserves (National Parks, State Parks, Flora Reserves, Flora and Fauna Reserves), other public land (State forest including Special Protection Zone, Special Management Zone and General Management Zone, public land reserved for other purposes and uncommitted public land), and private land.

These data are presented in Table 5.1. More details for plants listed under the FFG Act or ESP Act can be found in Appendix E.

It should be noted that while a number of species are listed as being found on 'other public land', the Ecological Vegetation Class in which they occur are not suitable for timber harvesting or are riparian vegetation types which are excluded from timber harvesting.

5.2.2 Patterns of abundance, distribution and habitat

Several distinct groups of plants emerge when considering abundance, distribution and habitat:

Plants of sub-alpine habitats which are highly localised and naturally rare

In the Central Highlands, sub-alpine habitats are restricted to the Baw Baw Plateau, Lake Mountain, Mt Bullfight and Mt Torbreck. Such habitats are also relatively uncommon in Victoria and Australia in general, and therefore tend to support a higher proportion of rare or threatened

plants than more common and/or extensive habitats. In the Central Highlands, such plants include *Richea victoriana, Tasmannia vickeriana, Monotoca oreophila, Coprosma moorei, Coprosma perpusilla* var *perpusilla, Brachyscom obovata, Erigeron pappocromus* var *oblongata, Epacris glacialis, Epacris coriacea, Lycopodium scariosum, Juncus antarcticus* and *Mitrasacme montana.*

Plants of moist forests which are endemic to the Central Highlands and which may be locally common

Any region of the size of the Central Highlands is likely to contain the major populations of plants which have adapted to the prevailing environmental conditions to the point where they may be locally common, but which are nevertheless considered rare on a statewide basis. Included in this category are *Persoonia arborea, Wittsteinia vacciniacea, Carex alsophila, Oxalis magellanica* and *Lastreopsis hispida.*

Table 5.1: Conservation Status and Distribution of Rare or Threatened Plants in the Central Highlands Regional Forest Agreement region

(a) Plants listed as threatened under the Commonwealth Endangered Species Protection Act 1992

Plant	Conservation Status				Victorian distribution		Central Highlands distribution			Tenure of Central Highlands population	
	ESP	ROTAP	FFG	VROTS	no of Vic records	Victorian range (km)	no of CH records	regional range (km)	% of Aust range	Largest proportion of population	Next largest proportion of population
Astelia australiana	V	V	yes	v	45	279	37	41	75-100	other public land	-
Caladenia rosella	E	E	yes	e	7	291	3	2	25-50	private land	conservation reserve
Eucalyptus crenulata	E	E	yes	e	34	250	33	108	75-100	conservation reserve	private land
Lepidium hyssopifolium	E	E	yes	e	32	452	6	30	0-25	other public land	-
Senecio laticostatus	V	V	no	v	3	158	3	158	50-75	private land	-
Senecio macrocarpus	V	V	yes	e	34	600	3	74	0-25	other public land	-

Note: ESP categories are endangered (E) or vulnerable (V)

(b) Plants listed as threatened under the Victorian Flora and Fauna Guarantee Act 1988 (in addition to those listed above).

Plant	Conservation Status				Victorian distribution		Central Highlands distribution			Tenure of Central Highlands population	
	ESP	ROTAP	FFG	VROTS	no of Vic records	Victorian range (km)	no of CH records	regional range (km)	% of Aust range	Largest proportion of population	Next largest proportion of population
Amphibromus pithogastris	No	K	yes	e	3	200	1	0	50-75	private land	-
Bracteantha sp. aff. subundulata	No	-	yes	v	11	440	2	62	25-50	other public land	-
Caladenia concolor	No	V	yes	v	11	447	3	40	0-25	private land	-
Carex tasmanica	No	V	yes	v	20	371	11	11	0-25	private land	-
Cullen tenax	No	-	yes	e	15	460	4	17	0-25	private land	-
Cyathea cunninghamii	No	R	yes	r	175	700	28	34	0-25	other public land	-
Grevillea barklyana ssp. barklyana	No	R	yes	r	37	43	37	43	75-100	other public land	conservation reserve
Phebalium wilsonii	No	R	yes	v	12	47	12	47	75-100	conservation reserve	-
Thismia rodwayi	No	R	yes	v	1	0	1	0	0-25	conservation reserve	-

Table 5.1 Cont'd

(c) Other Victorian Rare Or Threatened Species

Plant	Conservation Status				Victorian distribution		Central Highlands distribution			Tenure of Central Highlands population	
	ESP	ROTAP	FFG	VROTS	no of Vic records	Victorian range (km)	no of CH records	regional range (km)	% of Aust range	Largest proportion of population	Next largest proportion of population
Acacia howittii	No	R	no	r	42	856	7	148	0-25	private land	-
Asplenium terrestre ssp. terrestre	No	-	no	r	96	321	2	3	0-25	other public land	-
Astrotricha parvifolia	No	R	no	r	15	136	1	0	0-25	conservation reserve	-
Beyeria viscosa	No	-	no	r	39	240	0	0	0-25	conservation reserve	-
Brachyscome obovata	No	-	no	r	25	253	17	62	25-50	conservation reserve	-
Burnettia cuneata	No	R	no	r	43	904	21	85	0-25	private land	-
Caladenia flavovirens	No	-	no	r	14	807	2	4	25-50	private land	-
Caladenia lindleyana	No	K	no	r	8	334	8	39	50-75	conservation reserve	private land
Carex alsophila	No	-	no	r	60	86	60	86	75-100	other public land	conservation reserve
Coprosma moorei	No	-	no	r	10	117	4	8	25-50	other public land	conservation reserve
Coprosma perpusilla ssp. perpusilla	No	-	no	r	13	11	13	11	25-50	conservation reserve	other public land
Desmodium varians	No	-	no	r	63	516	20	128	0-25	private land	-
Epacris coriacea	No	-	no	r	3	228	1	0	0-25	other public land	-
Epacris glacialis	No	-	no	r	37	155	2	1	0-25	other public land	-
Epilobium pallidiflorum	No	-	no	d	80	883	42	161	0-25	private land	conservation reserve
Erigeron pappocromus var. oblongatus	No	-	no	v	3	1	3	1	0-25	other public land	conservation reserve
Eucalyptus alligatrix ssp. alligatrix	No	R	no	r	34	567	7	123	0-25	conservation reserve	other public land
Eucalyptus neglecta	No	R	no	r	52	239	6	13	0-25	other public land	-
Eucalyptus pauciflora ssp. acerina	No	-	no	r	5	7	5	7	75-100	conservation reserve	other public land
Eucalyptus strzeleckii	No	V	no	v	27	81	16	60	0-25	private land	-
Eucalyptus yarraensis	No	R	reject	r	63	835	25	79	0-25	private land	other public land
Euchiton umbricolus	No	-	no	r	21	324	4	48	0-25	other public land	private land

Fimbristylis velata	No	-	no	r	3	586	2	0	0-25	other public land	-
Gahnia grandis	No	-	no	v	10	136	5	15	0-25	conservation reserve	private land

Table 5.1 Cont'd

Plant	Conservation Status				Victorian distribution		Central Highlands distribution			Tenure of Central Highlands population	
	ESP	**ROTAP**	**FFG**	**VROTS**	**no of Vic records**	**Victorian range (km)**	**no of CH records**	**regional range (km)**	**% of Aust range**	**Largest proportion of population**	**Next largest proportion of population**
Grevillea repens	No	R	no	r	42	328	23	68	50-75	conservation reserve	other public land
Huperzia australiana	No	-	no	r	21	245	13	60	0-25	other public land	conservation reserve
Huperzia varia	No	-	no	v	13	663	3	5	0-25	other public land	-
Hypsela tridens	No	-	no	v	6	202	2	0	0-25	other public land	-
Juncus antarcticus	No	-	no	v	3	146	1	0	0-25	conservation reserve	-
Lastreopsis hispida	No	-	no	r	61	275	10	17	0-25	other public land	-
Lindsaea microphylla	No	-	no	r	60	368	1	0	0-25	conservation reserve	other public land
Lomandra longifolia ssp. exilis	No	-	no	r	253	1083	1	0	0-25	private land	-
Lycopodium scariosum	No	-	no	r	15	148	11	13	0-25	conservation reserve	other public land
Pultenaea weindorferi	No	R	reject	r	40	182	32	44	50-75	conservation reserve	other public land private land
Mitrasacme montana	No	-	no	r	12	79	7	5	0-25	conservation reserve	other public land
Monotoca oreophila	No	R	no	r	7	84	6	10	75-100	other public land	conservation reserve
Oxalis magellanica	No	-	no	r	47	603	39	81	50-75	other public land	conservation reserve
Ozothamnus rogersianus	No	-	no	r	4	532	1	0	25-50	other public land	conservation reserve
Persoonia arborea	No	-	reject	r	205	92	205	92	75-100	other public land	conservation reserve
Poa labillardieri var. acris	No	-	no	k	21	706	11	107	0-25	other public land	conservation reserve
Prasophyllum lindleyanum	No	-	reject	v	40	867	14	95	0-25	conservation reserve	-
Pteris comans	No	-	-	r	3	70	3	70	0-25	conservation reserve	private land
Pterostylis grandiflora	No	-	no	r	25	472	12	127	0-25	other public land	conservation reserve
Richea victoriana	No	-	no	r	1	0	1	0	75-100	conservation reserve	-
Spiranthes sinensis	No	-	no	d	18	708	3	79	0-25	private land	other public land

Table 5.1 Cont'd

	ESP	ROTAP	FFG	VROTS	no of Vic records	Victorian range (km)	no of CH records	regional range (km)	% of Aust range	Largest proportion of population	Next largest proportion of population
Taraxacum aristum	No	R	reject	r	23	298	2	55	0-25	other public land	private land
Tasmannia vickeriana	No	R	no	r	1	0	1	0	75-100	conservation reserve	-
Tetratheca stenocarpa	No	R	no	r	80	147	79	125	75-100	conservation reserve	other public land
Thelymitra circumsepta	No	-	no	v	12	625	1	0	0-25	other public land	-
Tmesipteris elongata ssp. elongata	No	-	no	v	12	321	1	0	0-25	other public land	-
Tmesipteris ovata	No	-	no	r	54	478	4	35	0-25	other public land	private land
Wittsteinia vacciniacea	No	-	no	r	132	76	133	76	75-100	other public land	conservation reserve

Notes: 'reject' in FFG column indicates species considered for listing but rejected by the FFG Committee as not meeting criteria.

ROTAP categories: R - rare; V - vulnerable; E - endangered; K - insufficiently known.

VROT categories: e - endangered; v - vulnerable; r - rare; d = depleted; k - insufficiently known.

Plants which are widespread but rarely common

Wet forests and rainforest

These plants typically have narrow habitat requirements - fern gullies, rainforests - but may occur in other regions where these habitats are found, such as East Gippsland, the Otways and Tasmania. Included in this category are *Tmesipteris* spp, *Huperzia varia*, *Cyathea cunninghamii*, *Thismia rodwayi* and *Gahnia grandis.*

Dry and damp forests

Several rare or threatened species of dry forest habitats occur sparsely in the Central Highlands: *Ozothamnus rogersianus, Lindsaea microphylla, Acacia howittii, Eucalyptus neglecta, Eucalyptus alligatrix* and *Pteris comans.*

Plants of moist forests which are Central Highlands endemics and occur in a few, scattered populations

Some of the rare or threatened plants of the Central Highlands appear never to have been common, even though their preferred habitat appears to be relatively common. Subtle but critical habitat differences may in part explain this phenomenon, as might elimination from suitable habitat by one or a series of catastrophic events. Included in this group are *Eucalyptus crenulata, Astelia australiana, Grevillea barklyana* ssp. *barklyana* and *Phebalium wilsonii.*

Plants of a variety of habitats which are marginal to the Central Highlands

Habitats such as grasslands, grassy woodlands and riverine plains occur within the Central Highlands region, but are marginal to it, being more widespread beyond the region. Several of the rare or threatened species being considered here occur in these habitats including - *Senecio macrocarpus, Senecio laticostatus, Hypsela tridens, Carex tasmanica, Cullen tenax* and *Amphibromus fluitans.*

Plants of habitats which have been depleted in the Central Highlands

At the time of European settlement, the Central Highlands contained a range of vegetated habitats such as river valleys and lower slopes which have been substantially cleared in the intervening period. Notable in this context are the lower sections of the Yarra, Goulburn (including the Yea and Acheron valleys) and La Trobe Rivers. Plants which occurred in these habitats are more likely to be rare or threatened species as a result of the clearing. Included in this category are *Eucalyptus yarraensis, Eucalyptus strzeleckii, Epilobium pallidiflorum, Pultenaea weindorferi* and *Burnettia cuneata.*

5.2.3 Review of reservation status of Central Highlands rare or threatened plants

This review is particularly relevant to National reserve criteria 5 and 6 as outlined in Chapter 1 (box 1). The critical issues in this review are the importance of the Central Highlands in terms of the each taxon's overall Australian distribution and the tenure of the population of each taxon in the Central Highlands.

Further issues relate to the viability of reserved populations, their replication within the reserve system (both in the Central Highlands and throughout their distribution), and the representativeness of the range of variants (if any) which may occur. This has only been undertaken for taxa listed under the FFG Act or ESP Act.

The approach used in this review differs from that employed in the East Gippsland Comprehensive Regional Assessment, where database records were intersected with maps of land tenure using a geographic information system (GIS) to produce percentages of records by land tenure. This approach was limited in that it did not account for variation in the size of sub-populations or for multiple records from the same sub-population, nor did it take account of biases in the data available for each species. It also has not identified historical records (eg. herbarium specimens) for which the source populations are now extinct. This factor is particularly important when dealing with an area such as the Central Highlands, where clearing has eliminated large areas of native vegetation.

This review is based on a qualitative rather than quantitative analysis, largely 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 species was evaluated according to the proportion of its Australian distribution that occurs within the Central Highlands (0-25%, 25-50%, 50-75%, 75-100%), and the tenure of the land on which the largest proportion of its Central Highlands population (in terms of individuals rather than area or number of sub-populations) and the next largest proportion of its Central Highlands population occurred.

Of the 67 species being considered, 25 had more than 25% of their geographic range within the Central Highlands. Of these, 11 occurred wholly within, or had the largest proportion of their Central Highlands population within, biological conservation reserves.

Ten species had the largest proportion of their Central Highlands population on other public land, where the risk posed by permanent clearing is very low. Of these, eight had the next largest proportion of their Central Highlands population in biological conservation reserves. The remaining two species occurred either wholly on other public land, or with minor occurrences on private land.

Of the species with most or all of their Central Highlands population on other public land, rainforest or riparian species such as *Oxalis magellanica, Carex alsophila* and *Wittsteinia vacciniacea* are generally protected by the rainforest or stream buffer prescriptions, while *Astelia australiana* is the subject of species-specific prescriptions, including the protection of three sub-catchments in the Special Protection Zone of State forest.

Three species, *Amphibromus pithogastris, Caladenia flavovirens,* and *Senecio laticostatus* are confirmed only on private land in the Central Highlands. One species, *Caladenia rosella,* has the largest proportion of its Central Highlands population on private land and the next largest proportion in a conservation reserve.

Of the 42 species for which the Central Highlands contains less than 25% of their geographic range, eleven had the largest proportion of their Central Highlands population within biological conservation reserves. A further four species had the largest proportion of their Central Highlands population on other public land plus the next largest proportion in biological conservation reserves. Thirteen species were known only from other public land, three had the largest proportion of their population on other public land plus minor occurrences on private land.

Eight species only occurred on private land (*Caladenia concolor, Eucalyptus strzeleckii, Lomandra longifolia* ssp. *exilis, Acacia howittii, Burnettia cuneata, Desmodium varians, Carex tasmanica* and *Cullen tenax),* while a further three had the largest proportion of their population on private land plus minor occurrences on public land (*Epilobium pallidiflorum, Eucalyptus yarraensis* and *Spiranthes sinensis*).

The viability, replication and representativeness of the reserved populations of FFG and/or ESP listed taxa may be summarised as follows: the reserved sub-population of *Caladenia rosella* consists of a single location, contains very few individuals, exhibits low recruitment and is prone to ongoing threats. The reserved sub-populations of *Eucalyptus crenulata* include the majority of naturally-occurring individuals. Poor recruitment and habitat management continue to present management challenges, but there is no evidence to suggest that the sub-populations are not viable. The reserved sub-populations of *Grevillea barklyana* ssp. *barklyana* appear to be viable, and exist as several discrete stands. Recruitment appears adequate. The single reserved population of *Phebalium wilsonii* constitutes the entire known population of this species, but appears viable, comprising hundreds of individuals and showing evidence of recruitment. No information on population size and recruitment is available for *Thismia rodwayi*.

5.2.4 Vulnerability assessment

The vulnerability assessment is designed to identify those rare or threatened plants that are at greatest risk of further significant decline and extinction as a result of activities, ongoing threatening processes and catastrophic events in the Central Highlands. Note that this assessment is confined to each taxon's Central Highlands 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 5.1).

Where reliable information on the demography of rare or threatened plants is available, application of quantitative criteria such as those developed by the IUCN (IUCN 1994) to assign threat status is the most appropriate for a vulnerability analysis. In the absence of such information, estimation and qualitative judgements can be used, but will necessarily deliver a less reliable result.

For each of the rare or threatened taxa included in this review, available information for the Central Highlands has been collated and classified as follows:

Distribution pattern - taxa were classified as *localised* if their continuing presence was confirmed from fewer than 3 locations, or if their area of occupancy was less than 10km^2. Otherwise they were classified as *widespread*, or *unknown*, if insufficient information was available.

Distribution trend - the trend of distribution over the last 10 years is classified as *stable, suspected contraction, demonstrated contraction, suspected expansion* or *demonstrated expansion*, based on database records, expert opinion and the literature.

Habitat breadth - taxa restricted to one habitat type were classified as *narrow*, taxa occurring in more than one habitat type were classified as *broad*.

Number of sub-populations - an estimate of the number of sub-populations (as opposed to the number of records, which may reflect repeated sampling, or a lack of sampling) was classified into orders of magnitude: <10, 10-100, 100-1,000, 1,000-10,000, >10,000.

Number of individuals - an estimate of the number of individual plants was classified into orders of magnitude: <10, 10-100, 100-1,000, 1,000-10,000, >10,000.
Population trend - the trend of population is classified as *stable, suspected decline, demonstrated decline, suspected increase* or *demonstrated increase*, based on database records, expert opinion and the literature.

Population variability - taxa whose population size fluctuates significantly are classified as *high*, taxa whose population size remains more or less stable are classified as *low*, based on expert opinion. In cases such as many of the terrestrial orchids, observed variability may be a function of season, when plants are dormant.

Longevity - an estimate of the average longevity of individuals of each taxon, classified into <1 year, 1-5 years, 5-10 years, 10-50 years, >50 years.

Reproductive output - taxa are classified as having *high* or *low* effective reproduction (ie. achieving germination and establishment as juveniles under normal conditions, rather than seed production alone) based on qualitative inferences regarding age of reproductive maturity, frequency of flowering, quantity of seed production, observed recruitment and observed vegetative spread, where relevant.

The results of this assessment are presented in Table 5,2. As can be seen, a large number of gaps remain for many attributes and for many species.

Vulnerability may be seen as a function of a number of variables, which alone or together may increase the risk of a taxon experiencing further decline, possibly to the point of extinction in the wild. Fundamentally, a taxon's probability of survival (and conversely extinction) depend on its current population size, the extent to which it is threatened and its capacity to reproduce.

The significance of population size is in the immediate security that a large population size may afford from loss due to catastrophic events, either natural or human-induced. Additional protection is afforded where a population is comprised of several geographically isolated sub-populations, which serves to reduce the risk of catastrophic loss. In general, large population size also provides a greater source of genetic variability and reduced risk of inbreeding depression, increasing the evolutionary potential of the taxon and its responsiveness to environmental changes. However, plant populations do not necessarily follow these "rules", as the greater variety of breeding systems and genetic systems, and the capacity for vegetative reproduction in many taxa, introduce additional variables.

However, overall population size is significant for most plant taxa. From the table, the taxa at most risk due to small population size are *Amphibromus pithogastris, Caladenia concolor, Caladenia rosella, Lepidium hyssopifolium, Lindsaea microphylla, Lomandra longifolia* ssp. *exilis, Prasophyllum lindleyanum, Thismia rodwayi* and *Tmesipteris elongata* ssp. *elongata.*

Taxa at most risk due to low numbers of sub-populations are *Acacia howittii, Amphibromus pithogastris, Asplenium terrestre* ssp. *terrestre, Beyeria viscosa, Bracteantha* sp. aff. *subundulata, Burnettia cuneata, Caladenia concolor, Caladenia flavovirens, Caladenia lindleyana, Caladenia rosella, Carex tasmanica, Coprosma moorei, Cullen tenax, Cyathea cunninghamii, Epacris coriacea, Epacris glacialis, Erigeron pappocromus* var. *oblongatus, Eucalyptus alligatrix, Eucalyptus crenulata, Eucalyptus neglecta, Eucalyptus pauciflora* ssp. *acerina, Eucalyptus strzeleckii, Euchiton umbricolus, Fimbristylis velata, Gahnia grandis, Huperzia varia, Hypsela tridens, Juncus antarcticus, Lepidium hyssopifolium, Lindsaea microphylla, Lomandra longifolia* ssp. *exilis, Mitrasacme montana, Monotoca oreophila, Ozothamnus rogersianus, Phebalium wilsonii, Poa labillardieri* var. *acris, Prasophyllum lindleyanum, Pteris comans, Pterostylis grandiflora, Richea victoriana, Senecio laticostatus, Senecio macrocarpus, Spiranthes sinensis, Taraxacum aristum, Thelymitra circumsepta, Thismia rodwayi, Tmesipteris elongata* ssp. *elongata* and *Tmesipteris ovata.*

High population variability also increases risk of extinction, as it tends to be associated with taxa whose life histories or reproductive strategies are based around pulses of reproduction, occurring either periodically or sporadically, often in response to environmental stimuli such as fire. To use a disturbance coloniser such as *Lepidium hyssopifolium* as an example, a short life span and reliance on soil stored seed for recruitment following disturbance renders this species vulnerable to a natural or imposed change in site conditions which prevents the necessary disturbance for a period greater than the effective life span of the soil stored seed. Taxa exhibiting high population variability are *L. hyssopifolium* and *Pultenaea weindorferi.*

Other factors related to population size and extent are the pattern of distribution and breadth of habitat. Of the 66 rare or threatened plants assessed, 41 display a localised distribution pattern and occupy a narrow range of habitats.

Changes, particularly declines, in both the size of populations and the extent of their distribution is usually an indication that threatening processes are acting on the taxon. While some declines may be part of natural, cyclic variation, most are assumed to be part of the extinction process, and attributable to environmental changes and human disturbances since European settlement.

Taxa whose distribution has been demonstrated to have declined, or is suspected to have declined, are *Lepidium hyssopifolium, Eucalyptus crenulata, Cyathea cunninghamii, Pultenaea weindorferi, Amphibromus pithogastris, Caladenia rosella, Carex tasmanica, Bracteantha* sp. aff. *subundulata, Caladenia concolor, Caladenia flavovirens, Caladenia lindleyana* and *Cullen tenax.*

Taxa whose population size has been demonstrated to have declined, or is suspected to have declined, are *Lepidium hyssopifolium, Eucalyptus crenulata, Pultenaea weindorferi, Cyathea cunninghamii, Amphibromus pithogastris, Caladenia rosella, Carex tasmanica, Gahnia grandis, Senecio macrocarpus* and *Epilobium pallidiflorum*. Longevity in plants tends to be associated with a life history strategy based on resisting or tolerating the range of environmental conditions

which may occur (including cyclic variation and stochastic events of climate, fire, predation and disease). Longevity therefore affords some additional security from rapid decline and extinction (especially during relatively benign environmental conditions) when compared to relatively short-lived taxa, but only if reproduction and recruitment is sufficient to compensate for mortality. Relatively short-lived taxa (1-10 years) include *Carex tasmanica, Epilobium pallidiflorum, Cullen tenax, Carex alsophila, Lepidium hyssopifolium* and *Brachyscome obovata.* Relatively long-lived taxa include *Eucalyptus crenulata, Cyathea cunninghamii, Grevillea barklyana* ssp. *barklyana, Persoonia arborea, Eucalyptus strzeleckii, Eucalyptus yarraensis, Eucalyptus neglecta, Phebalium wilsonii, Eucalyptus alligatrix* and *Eucalyptus pauciflora* ssp. *acerina.*

Reproductive output is considered to be low in *Astelia australiana* (sporadic flowering with poor seed set, although its ability to reproduce vegetatively may compensate), *Cyathea cunninghamii* and *Persoonia arborea* (both appearing to reach reproductive maturity only at advanced age).

While the preceding discussion indicates that a large number of taxa exhibit one or more of the characteristics of vulnerability, the highest priority should be given to taxa whose populations are small and declining further, with receding or degrading habitat and with little evidence of recruitment. Included in this category are *Caladenia rosella* (other *Caladenia* species could also be included) *Carex tasmanica, Amphibromus pithogastris, Cullen tenax, Cyathea cunninghamii, Lepidium hyssopifolium* and *Senecio macrocarpus*. Species dependent on Cool Temperate Rainforest are also of high priority given its sensitivity to environmental changes since European settlement, for example fire frequency.

Table 5.2: Vulnerability analysis for Central Highlands rare or threatened plants

Taxon	*distribution pattern*	*distribution trend*	*habitat breadth*	*no. of sub-populations*	*no. of individuals*	*population trend*	*population variability*	*Longevity*	*Reproductive output*
Acacia howittii	localised	-	narrow	<10	-	-	-	10-50	high
Amphibromus pithogastris	localised	suspected decline	narrow	<10	<10	suspected decline	-	-	-
Asplenium terrestre ssp. terrestre	localised	-	narrow	<10	-	-	-	10-50	-
Astelia australiana	localised	stable	narrow	10 to 100	1000 to 10000	stable	low	10-50	low
Astrotricha parvifolia	localised	-	narrow	-	-	-	-	10-50	-
Beyeria viscosa	localised	stable	narrow	<10	100 to 1000	stable	low	10-50	-
Brachyscome obovata	localised	-	narrow	10 to 100	10 to 100	-	-	1-5	-
Bracteantha sp. aff. subundulata	localised	suspected decline	narrow	<10	100 to 1000	-	-	-	-
Burnettia cuneata	localised	-	narrow	<10	-	-	-	-	-
Caladenia concolor	localised	suspected decline	narrow	<10	<10	-	-	-	-
Caladenia flavovirens	localised	suspected decline	-	<10	10 to 100	-	-	-	-
Caladenia lindleyana	localised	suspected decline	-	<10	-	-	-	-	-
Caladenia rosella	localised	suspected decline	narrow	<10	<100	suspected decline	-	-	-
Carex alsophila	widespread	-	wide	10 to 100	100 to 1000	-	-	5-10	high
Carex tasmanica	localised	suspected decline	narrow	<10	-	suspected decline	-	5-10	high
Coprosma moorei	localised	-	narrow	<10	10 to 100	-	-	10-50	-
Coprosma perpusilla ssp. perpusilla	localised	-	narrow	10 to 100	10 to 100	-	low	10-50	-
Cullen tenax	localised	suspected decline	wide	<10	-	-	-	5-10	high
Cyathea cunninghamii	localised	demonstrated decline	narrow	<10	10 to 100	suspected decline	low	>50	low
Desmodium varians	localised	-	narrow	100 to 1000	-	-	-	-	high

Table 5.2 cont'd

Taxon	*distribution pattern*	*distribution trend*	*habitat breadth*	*no. of sub-populations*	*no. of individuals*	*population trend*	*population variability*	*Longevity*	*Reproductive output*
Epacris coriacea	localised	-	narrow	<10	10 to 100	-	-	10-50	-
Epacris glacialis	localised	-	narrow	<10	10 to 100	-	low	10-50	-
Epilobium pallidiflorum	widespread	-	wide	10 to 100	100 to 1000	suspected decline	-	5-10	high
Erigeron pappocromus var. oblongatus	localised	-	narrow	<10	10 to 100	-	-	-	-
Eucalyptus alligatrix	localised	-	-	<10	10 to 100	-	-	>50	high
Eucalyptus crenulata	localised	demonstrated decline	narrow	<10	1000 to 10000	demonstrated decline	low	>50	high
Eucalyptus neglecta	localised	-	narrow	<10	10 to 100	-	-	>50	-
Eucalyptus pauciflora ssp. acerina	localised	-	-	<10	10 to 100	-	-	>50	high
Eucalyptus strzeleckii	localised	-	-	<10	10 to 100	-	low	>50	high
Eucalyptus yarraensis	widespread	-	narrow	10 to 100	10 to 100	-	low	>50	high
Euchiton umbricolus	localised	-	narrow	<10	10 to 100	-	-	-	-
Fimbristylis velata	localised	-	-	<10	-	-	-	-	-
Gahnia grandis	localised	-	narrow	<10	10 to 100	suspected decline	-	10-50	high
Grevillea barklyana ssp. barklyana	localised	stable	narrow	10 to 100	100 to 1000	stable	low	>50	high
Grevillea repens	widespread	-	narrow	10 to 100	-	-	low	10-50	-
Huperzia australiana	localised	-	narrow	10 to 100	100 to 1000	-	low	-	-
Huperzia varia	localised	-	narrow	<10	10 to 100	-	low	-	-
Hypsela tridens	localised	-	narrow	<10	-	-	-	-	-
Juncus antarcticus	localised	-	narrow	<10	10 to 100	-	low	10-50	-
Lastreopsis hispida	localised	-	narrow	10 to 100	100 to 1000	-	low	10-50	-
Lepidium hyssopifolium	localised	demonstrated decline	narrow	<10	<10	demonstrated decline	high	1-5	high

Table 5.2 cont'd

Taxon	*distribution pattern*	*distribution trend*	*habitat breadth*	*no. of sub-populations*	*no. of individuals*	*population trend*	*population variability*	*Longevity*	*Reproductive output*
Lindsaea microphylla	localised	-	wide	<10	<10	-	low	-	-
Lomandra longifolia ssp. exilis	localised	-	narrow	<10	<10	-	-	-	high
Lycopodium scariosum	localised	-	narrow	10 to 100	100 to 1000	-	-	-	-
Mitrasacme montana	localised	-	narrow	<10	-	-	-	-	-
Monotoca oreophila	localised	-	narrow	<10	-	-	-	10-50	-
Oxalis magellanica	widespread	-	wide	10 to 100	100 to 1000	-	-	10-50	-
Ozothamnus rogersianus	localised	-	narrow	<10	-	-	-	10-50	high
Persoonia arborea	widespread	stable	wide	100 to 1000	>10000	-	low	>50	low
Phebalium wilsonii	localised	-	narrow	<10	100 to 1000	-	-	>50	high
Poa labillardieri var. acris	localised	-	narrow	<10	10 to 100	-	-	10-50	high
Prasophyllum lindleyanum	localised	-	-	<10	<10	-	-	-	-
Pteris comans	localised	-	narrow	<10	10 to 100	-	-	10-50	-
Pterostylis grandiflora	localised	-	wide	<10	10 to 100	-	-	-	-
Pultenaea weindorferi	widespread	suspected decline	wide	10 to 100	1000 to 10000	susp. decl.	high	10-50	high
Richea victoriana	localised	-	narrow	<10	-	-	-	10-50	-
Senecio laticostatus	localised	-	-	<10	-	-	-	-	high
Senecio macrocarpus	localised	-	narrow	<10	-	suspected decline	-	-	high
Spiranthes sinensis	localised	-	wide	<10	10 to 100	-	low	-	-
Taraxacum aristum	localised	-	-	<10	10 to 100	-	-	-	high
Tetratheca stenocarpa	widespread	-	wide	10 to 100	-	-	-	10-50	high
Thelymitra circumsepta	localised	-	-	<10	-	-	-	-	high
Thismia rodwayi	localised	-	-	<10	<10	-	-	-	-
Tmesipteris elongata ssp. elongata	localised	-	narrow	<10	<10	-	-	10-50	-
Tmesipteris ovata	localised	-	wide	<10	10 to 100	-	-	10-50	-
Wittsteinia vacciniacea	widespread	-	wide	100 to 1000	1000 to 10000	-	low	10-50	-

Note: In this table, a dash (-) indicates that no information was available.

5.2.5 Management review

Management planning

Both the Commonwealth *Endangered Species Protection Act* (ESP Act) and the Victorian *Flora and Fauna Guarantee Act* (FFG Act) include provisions for the preparation of management plans for listed taxa. Table 5.3 summarises the status of management planning for Central Highlands rare or threatened plants. Recovery Plans and Action Statements outline the actions necessary to maximise the long-term prospects of survival for the species in the wild. It should be noted that the implementation of management actions is dependent on available resourcing and priorities within and between species.

Table 5.3 : Status of management planning for Central Highlands rare or threatened plants.

Taxon	*Recovery Plan under the ESP Act*	*Action Statement under the FFG Act*
Amphibromus pithogastris	not listed	in preparation
Astelia australiana	draft research plan completed	published and implemented
Bracteantha sp. aff. subundulata	not listed	in preparation
Bracteantha sp. aff. subundulata	not listed	in preparation
Caladenia concolor	not listed	none
Caladenia rosella	yes*	in preparation
Carex tasmanica	not listed	in preparation
Cyathea cunninghamii	not listed	in preparation
Eucalyptus crenulata	none	published and implemented
Grevillea barklyana spp. barklyana	not listed	in preparation
Lepidium hyssopifolium	none	in preparation
Phebalium wilsonii	none	in preparation
Senecio laticostatus	none	not listed
Senecio macrocarpus	none	published
Thismia rodwayi	not listed	none

Note: * This recovery plan has yet to be formally approved by the Commonwealth Environment Minister

Monitoring

Of the 67 species considered in this review, only three are the subject of regular monitoring to determine population trends and evaluate threats across most or all populations. These species are *Astelia australiana, Caladenia rosella* and *Eucalyptus crenulata*. Other readily recognisable or high profile species such as *Phebalium wilsonii, Grevillea barklyana* ssp *barklyana, Cyathea cunninghamii* and *Pultenaea weindorferi* are the subject of opportunistic monitoring by professional botanists or amateur field naturalists.

The Department of Natural Resources and Environment has developed a simple monitoring form for rare or threatened plants populations. It is envisaged that the use of this form and the database in which the data collected are stored will expand to the point where the major populations of all threatened species will be regularly monitored, either by field staff, community groups or botanists.

Active habitat management

Active habitat management, in the form of environmental weed control, exclusion of predators or browsers and ecological burning, is the most common form of rare or threatened plant management being implemented for species whose habitat is degrading or where direct external threats are operating. Among the species considered in this review, only *Eucalyptus crenulata*, *Cyathea cunninghamii*, *Astelia australiana* and *Caladenia rosella* are the subject of active habitat management designed to improve their survival and recruitment. Other rare or threatened plants may benefit indirectly from active, landscape-scale threat management.

Active population management

Where populations of threatened plants have declined to critical levels, active population management techniques, such as population reinforcement, reintroduction, translocation and artificial pollination are sometimes recommended. Of the species considered in this review, only *Eucalyptus crenulata* and *Caladenia rosella* have been the subject of such techniques.

5.3 Review of disturbances and their implications for plant taxa in the Central Highlands

5.3.1 Introduction

The interpretation of key life history attributes is a useful means of highlighting the potential threats that individual plant taxa or groups of taxa may face. In this review, particular life history attributes are used to indicate possible or likely sensitivity to the impacts of a range of natural and human-induced disturbances which occur in forest areas.

The major constraint on this review is the lack of detailed information on ecological attributes for most native species.

Appendix F presents a list of the species used in this review, comprising mainly rare or threatened species, but including 22 species which are not rare or threatened but which represent a range of taxonomic groups and life-forms. Coded spreadsheets for all of the species considered in this review has not been reproduced in this report.

The link between a disturbance and any decline or extinction, either locally or globally, of particular species, is best understood by considering the separate components and evaluating their relationship. In this review, examples of species most likely to be (but not necessarily) threatened by a disturbance are identified on the basis of ecological attributes which predispose them to a particular potentially threatening process which is associated with a disturbance.

The strength of the association between disturbances and potentially threatening processes is variable. For simplicity, these relationships are classed as strong, weak or non-existent, based on the scientific literature and expert opinion. A strong association is one where the potentially threatening process is usually or always associated with the disturbance, while a weak

association is one where the potentially threatening process is sometimes associated with the disturbance.

A number of other categories of disturbance have not been considered in this review, either because they do not have a significant impact on native flora or because they constitute variations on disturbances which have been considered. For example, fire suppression activities can include the clearing of native vegetation for vehicle or helicopter access, the use of back-burning to retard the intensity and rate of advance of the fire front, and the use of fire retardant chemicals. Rather than duplicate information, the component activities of fire suppression are dealt with under clearing, planned fire and pollution.

5.3.2 Methods

Each disturbance has been evaluated to determine the extent of its occurrence within the Central Highlands, the potentially threatening processes which are associated with it, the strength of that association, the overall significance of the threat to native flora in the Central Highlands, the ecological, life-history and life-form attributes which might predispose a taxon to significant negative impacts, and examples of the 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 reviewed and summarised. The adequacy of existing information on the extent and impacts of the disturbance is also reviewed. The results are presented as text with each disturbance considered in turn.

Data collection

Species attributes: Data were obtained from the literature when available or was estimated by a botanical consultant based on previous experience.

Habitat attributes: Quadrat data stored in the NRE Flora Information System was analysed to determine the Ecological Vegetation Classes (EVC) where the species were most commonly found. For each species up to 10 randomly selected quadrats were chosen and the EVC for each quadrat established by comparative analysis. In total, over 700 quadrats were categorised. On average a widespread species had 169 quadrats in which they occurred and categorised (6% of all the point records for that species) while a rare or threatened plant had 8 quadrats in which they occurred and categorised (32% of all the point records for that species). This information was summarised for each species.

Soil moisture, soil fertility and landform data was extracted from the literature, NRE databases or was estimated by the consultant based on previous experience.

Disturbance categories: Disturbance categories for a species was based on published literature, NRE databases or was estimated by the consultant based on previous experience.

5.3.3 Results

Clearing of native vegetation

Clearing of native vegetation occurs as part of agricultural, industrial, urban, utilities or tourism development, or mining or extractive industry development. Clearing of native vegetation is not occurring at a significant rate within the Central Highlands, although the loss of vegetation on private land, particularly on the outskirts of Melbourne, is significant in some local areas. Permanent clearing on public land is confined to very small areas mainly for the development of recreation facilities or as part of the installation of infrastructure, such as radio telephone towers. Historically, however, clearing of native vegetation has been the single most important and widespread cause of decline, local extinction and regional extinction of species and communities in the Central Highlands.

Potentially threatening processes associated with clearing of native vegetation include the total loss or severe modification of habitat. While this is strongly associated with clearing of native vegetation; its overall significance is considered moderate, despite being high in some areas/environments, given the localised nature of clearing. Other potentially threatening processes associated with clearing of native vegetation include the direct damage or loss of individuals, which is strongly associated with this disturbance, but which is considered to be of low significance overall.

No specific attributes predispose a taxon to threat from clearing of native vegetation as most if not all native plants are susceptible. 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 (ie. weedy species) can tolerate such disturbance, its impacts are likely to be greatest on species with relatively low reproductive output.

The clearing of native vegetation on public land requires Ministerial or Departmental approval. Planning permission may also be required in some cases. Major developments, including many mining and extractive industry developments, are the subject of Environmental Effects Statements, in which the impacts on native flora are usually considered. The taking of protected flora associated with clearing requires authorisation under the *Flora and Fauna Guarantee Act*. The clearing of native vegetation on private land requires planning permission from the local planning authority in most cases. For parcels of land greater than 10ha in area, NRE approval is required.

In cases such as mining and extractive industry activities where rehabilitation is carried out following utilisation of the resources concerned, significantly less long term loss of biodiversity may occur, depending on the effectiveness of the rehabilitation.

Since the introduction of planning restrictions on the clearing of native vegetation on private land in 1989, the rate of vegetation loss has decreased tenfold in Victoria. However, it is possible that applications to clear will increase in coming years, including proposals for plantation establishment.

Information on the rate and location of major vegetation clearing is generally good. Record keeping for cases requiring formal planning approval is good, while the use of satellite imagery allows for detailed comparison between current and past extent of native vegetation. 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.

Timber harvesting

The following discussion of timber harvesting refers to the clearfall harvesting system most commonly employed in the Central Highlands, including the felling, snigging and loading of logs, and the preparation of the coupe for regeneration burning, which is discussed separately in the "Planned Fire" section. In some cases, coupes are mechanically disturbed rather than burnt.

Clearfelling is the timber harvesting system most commonly used in the Central Highlands. It involves the felling of all canopy trees except for designated habitat and seed trees. In practice, many non-eucalypt trees and shrubs in the understorey are also felled to facilitate harvesting and improve safety on site. Once felled, the heads (upper trunk and smaller branches) are removed from the logs and the logs are towed via snig tracks to a landing where they are graded and loaded onto trucks. Following the completion of harvesting, log landings are ripped to reduce soil compaction. The heads plus any unwanted logs and non target species, are usually bulldozed into windrows or heaps in preparation for the regeneration burn.

Timber harvesting is widespread in moister forests throughout the Central Highlands, mainly in State forest, but also on private land. Some 36% of the public native forest is suitable and available for timber harvesting.

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, and

3. the impacts of a cycle of harvesting (in this case, every 60-120 years) on forest structure, ecology and biodiversity

A key issue in evaluating the ecological impacts of timber harvesting has been the extent to which clearfall harvesting mimics the effect of naturally-occurring wildfire. An attempt will be made to identify similarities or differences between the impacts of clearfelling (including regeneration burning) and wildfire on native flora in the following discussion.

The potentially threatening processes directly associated with the clearfelling operation include damage or loss of individuals, particularly as a result of machinery use and falling trees, disturbance to the superficial soil structure, disturbance of soil-stored seedbanks, compaction of the soil surface on snig tracks and log landings. These potentially threatening processes are strongly associated and of moderate overall significance. 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 (eg. *Dicksonia antarctica, Cyathea australis, Olearia argophylla, Nothofagus cunninghamii, Persoonia arborea*). The direct physical damage to the plants above, at or immediately below the soil surface and disturbance or compaction of the soil itself caused by the use of heavy machinery does not broadly mimic the impact of wildfire. Also

potentially at risk are species which rely on soil stored seed for reproduction (eg. *Wittsteinia vacciniacea*, *Persoonia arborea*, *Bedfordia arborescens*, *Grevillea barklyana* ssp. *barklyana*, *Phebalium wilsonii*).

The potentially threatening processes indirectly associated with harvesting operation 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 be strongly associated with timber harvesting and of moderate overall significance. It should be noted that in the Central Highlands no harvesting of old growth occurs in Mountain Ash forest and little in other forest types. In this context, the actual impacts on senescent forest as a result of timber harvesting are limited.

One major impact of this is the alteration of microclimatic conditions both on the coupe and in adjoining vegetation (strongly associated, generally of low overall significance, but highly significant in some vegetation types, eg. Cool Temperate Rainforest). The creation of sharp boundaries between the coupe and adjoining vegetation leads to increased exposure and alteration to the humidity, light and temperature conditions in the adjoining vegetation at least until the regrowth canopy reaches that 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 species which rely on stable, low light, high humidity, moderate temperature regimes (eg. *Hymenophyllum* spp, *Tmesipteris* spp., *Polyphlebium venosum*, *Lastreopsis hispida*, *Thismia rodwayi*). For a review of edge effects and microclimatic changes, see Burgman and Ferguson 1995. The Code of Forest Practices and the Proposed Central Highlands Forest Management Plan provide a range of mechanisms designed to protect rainforest and other gully vegetation from exposure and edge effects.

On the coupe itself, the microclimatic changes following harvesting are radical. While these changes may be similar to the impacts of wildfire in some circumstances, the impact of wildfire may be less extreme in some cases where some vegetation remains after the fire, including burnt or scorched leaves and braches in the canopy or understorey (Keely Ough, pers. comm., Ough and Murphy in prep). Furthermore, it is postulated (Ough and Murphy 1997) that the dense treefern layer (which is present in most ash forests) responds rapidly (ie. within a few weeks) following wildfire to produce a new frond canopy, which has the effect of reducing wind and light, increasing humidity and attenuating temperature extremes at the soil surface and beneath the layer of fronds. These authors have demonstrated a significant increase in treefern mortality following harvesting, when compared to areas burnt by wildfire. Other groundferns and shrubs also resprout more quickly and completely following wildfire than following timber harvesting, hastening the re-establishment of more moderate microclimates (Ough pers. comm).

In addition to the microclimatic amelioration, treeferns may also play a role in the germination and establishment of other forest species, including *Pittosporum bicolor*, *Coprosma quadrifida*, *Tasmannia lanceolata* and *Olearia argophylla*. Treefern trunks are also the substrate for a suite of epiphytic ferns (eg. *Hymenophyllum* spp., *Tmesipteris* spp.) and other epiphytes (eg. *Fieldia australis*). Other understorey shrubs and trees also provide substrate for epiphytes such as *Microsorum pustulatum*, as well as a wide variety of non-vascular plants such as mosses and liverworts.

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.

A further indirect potentially threatening process associated with timber harvesting is the facilitation of spread of fungal spores, specifically *Chalara australis* (the fungal pathogen responsible for Myrtle Wilt disease) via wounds to sensitive species such a *Nothofagus cunninghamii* (see plant pathogens discussion below, Kile *et al* 1989). This threat is strongly associated with timber harvesting in some circumstances, although it is known to occur in Cool Temperate Rainforest throughout the Central Highlands, including areas not subject to timber harvesting. Damage occurs naturally through events such as branch fall, but timber harvesting and road construction are also sources of damage. The threat is therefore of moderate significance and discussed in a later section on plant pathogens. The Proposed Central Highlands Forest Management Plan specifies measures aimed at preventing or minimising the spread of the disease and to rehabilitate infected stands where appropriate.

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. This potentially threatening process is strongly associated with timber harvesting, although its severity may vary greatly from site to site. Its overall significance is considered to be low for plants. Species potentially affected include small forest understorey plants such as *Thismia rodwayi* and species of mountain stream margins such as *Carex alsophila, Wittsteinia vacciniacea, Astelia australiana, Lastreopsis hispida, Huperzia varia, Huperzia australiana* and *Oxalis magellanica.* The Code of Forest Practices specifies provisions to minimise erosion and sedimentation arising from harvesting operations.

The potentially threatening processes associated with a 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 60-120 years applied consistently across the harvested areas of State forest would progressively eliminate mature and oldgrowth growth stages from these areas. 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 oldgrowth stands are likely to experience a decline concomitant with the decline in the growth stages themselves (eg. *Dicksonia antarctica*, *Hymenophyllum* spp, *Tmesipteris* spp., *Polyphlebium venosum, Thismia rodwayi*). Species which require a long period to reach full reproductive maturity may also be at risk (eg. *Persoonia arborea*). The threatening processes discussed above would be strongly associated with a cycle of clear fall timber harvesting of 60-120 years, were this to be applied, or where a combination of timber harvesting and natural wildfire resulted in a comparable frequency and intensity of disturbance. The overall significance of this is considered to be moderate in the Central Highlands, given that no mature or old growth forest is harvested and timber harvesting is confined to less than 45% of the public mountain ash forest type.

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, the relevant 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 indirect taking of protected flora associated with timber harvesting requires authorisation under the *Flora and Fauna Guarantee Act*.

Records of timber harvesting have been well maintained since the 1960s. A considerable body of research on the silviculture of forests, particularly ash forests in the Central Highlands, has been undertaken.

More recently, ecological studies carried out by the Department of Natural Resources and Environment have focused on the structural, floristic and ecological impacts of timber harvesting regimes on native forests (Griffiths and Muir 1991, Mueck and Peacock 1992, Ough and Ross 1992, Ough and Murphy 1997, Ough and Murphy in prep).

Detailed, long-term monitoring of harvested areas and comparisons to similar un-harvested areas is not currently being undertaken and the long-term impact of current harvesting systems on the majority of native plants is not well understood.

Planned fire and the planned absence of fire

Fire is a fundamental element of the Australian environment. Most native terrestrial plants have evolved reproductive mechanisms in response to fire. For a general introduction, see Gill *et al* 1981. Several forms of deliberate fire management are undertaken in the Central Highlands, with a variety of characteristics and impacts.

Ecological burning

Ecological burning is generally undertaken to produce an ecologically desirable outcome, including the production of gaps, the reduction in biomass/cover of particular dominant species or to provide a reproductive or growth stimulus to particular target species. Ecological burns vary in intensity, season and frequency depending on the desired outcome. Ecological burns occur very rarely in the Central Highlands, and usually affect very small areas.

The immediate, direct impact of planned fire for ecological purposes is damage or loss of sensitive species. This impact is strongly associated with ecological burning and increases with increasing fire intensity.

Other potentially threatening processes associated (usually weakly associated) with ecological burning tend to become more significant where ecological burning is carried out repeatedly according to a regime which is tailored to narrow outcomes, rather than to maintaining overall diversity. For example, a species may fail to reproduce adequately in a given season. In other situations, the frequency, intensity or season of the fire may be unsuitable, fire may result in the absence of suitable conditions for establishment, or competition from native or introduced species better suited to fire regime may have an impact.

The impacts of ecological burning are of low significance overall, as ecological burning affects only a small proportion of native vegetation and is generally used in vegetation types which are more or less fire tolerant and which have not been burnt for some time. In addition, all ecological burns are the subject of specific plans aimed at the protection of sensitive values on the site.

Fuel reduction burning

This type of burning is undertaken to reduce or remove fuel from the forest floor with the objective of reducing wildfire hazard. Fuel reduction burns are usually of low to moderate intensity, and are undertaken mainly in autumn, when conditions are optimal for maximum effectiveness with low risk of escape or excessive damage to living trees. Frequency varies, with high priority areas (especially near townships and valuable assets) subject to burning every 2 - 5 years, while remaining areas are burnt less frequently, or not at all. Fuel reduction burning is widespread in the drier forests of the Central Highlands, especially in the vicinity of townships, assets such as high tension power lines, pine plantations and in strategic locations in the landscape to protect fire-sensitive vegetation, such as ash forests.

As for ecological burning, the impacts of fuel reduction burning include the direct impact of the fire itself plus the indirect impacts of an imposed fire regime which may differ from the "natural" (pre-European) fire regime.

The direct impact of a fuel reduction burning event is the damage or loss of sensitive species. While this impact is strongly associated with fuel reduction burning, it is of low significance as the vegetation types most frequently burnt are largely comprised of fire resistant or fire tolerant species which are adapted to regenerate by whatever means following fire.

The indirect impacts of an imposed fire regime (mentioned above under ecological burning) while not always strongly associated with fuel reduction burning, may nevertheless be moderately significant overall, and of high significance locally. Detailed burn plans are required to take these issues into account.

Regeneration burning

Regeneration burning is a standard component of forest management in most harvesting operations in the Central Highlands. 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 throughout the Central Highlands where clearfall harvesting systems are employed.

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 during harvesting. At greatest risk are fire sensitive species on the coupe and in the surrounding vegetation. Where the coupe is bounded by gullies,

as is often the case in the Central Highlands, regeneration burns can impact upon the gully vegetation (which might include the ecological vegetation classes Cool Temperate Rainforest, Montane Riparian Thicket, Riparian Thicket or Riparian Forest) which tends to comprise a greater proportion of fire sensitive species than other vegetation types. Given also the typically linear configuration of Cool Temperate Rainforest in the Central Highlands, any intrusion of fire has the potential to modify microclimatic conditions (again tending to reinforce changes associated with harvesting itself) to allow the establishment of non-rainforest species. Incremental contraction of rainforest stands may result if the overall pattern of fire favours non-rainforest species, although permanent loss as a result of a single catastrophic wildfire remains the most significant cause of rainforest decline (see Burgman and Ferguson 1995, Cameron 1992, McMahon 1987).

Assuming a harvesting cycle of 60-120 years, the longer-term, indirect impacts of a regime of regeneration burning (failure to reproduce adequately, where the frequency, intensity or season are unsuitable, absence of suitable conditions for establishment as a result of fire regime and competition from native or introduced species better suited to fire regime) are likely to affect only those species which are adapted to fire frequencies greater than 120 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.

The Code of Forest Practices and the Proposed Central Highlands Forest Management Plan contain specific guidelines to prevent damage to surrounding vegetation from regeneration burns, particularly in relation to rainforest and riparian vegetation.

Deliberate exclusion 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. The deliberate exclusion of fire is particularly associated with remnant vegetation on the outer urban fringes in areas where fuel reduction burning may not be regularly undertaken, and where wildfires have been successfully prevented or suppressed.

The threatening processes associated with the long-term absence of fire are the same as those indirect impacts of the types of planned fire discussed above—failure to reproduce adequately, where the frequency, intensity or season are unsuitable, absence of suitable conditions for establishment as a result of fire regime and competition from native or introduced species better suited to fire regime—except that the impacts stem from the lack of fire. Thus the species most likely to be affected are those which are dependent on fire occurring more frequently or more intensely than it does. The vegetation types which are most prone to structural and floristic changes in the absence of fire are lowland heathlands, grasslands and some dry forests.

Predisposing ecological attributes

The preceding discussion considered some of the major impacts of altered fire regimes on native plants. Each species has ecological attributes which may predispose it to threat. The following are examples of species dependent on fire for reproduction, or whose reproduction is greatly enhanced by fire: *Lepidium hyssopifolium, Caladenia rosella, Burnettia cuneata, Caladenia concolor, Spiranthes sinensis* and *Blechnum cartilagineum*. *Astelia australiana* requires very long fire intervals. Some species which are killed by fire are nevertheless dependent on fire to

achieve or enhance reproduction, including *Banksia spinulosa and Hakea sericea,* while others appear to reproduce without the intervention of fire, including *Ozothamnus rogersianus* and *Phebalium wilsonii. Caladenia rosella and Caladenia concolor* both require low intensity fire but are killed by high intensity fire

Pultenaea weindorferi, Hymenophyllum cupressiforme, Grevillea repens and *Dicksonia antarctica* all require long fire intervals, while *Astelia australiana* and *Tmesipteris elongata* are restricted to fire sensitive habitats (Cool Temperate Rainforest). Some species are sensitive to fire season, with *Burnettia cuneata* and *Acacia howittii* being sensitive to spring fires, while *Spiranthes sinensis* and *Cassinia trinervia* are sensitive to summer fires.

The conduct of planned fire in the Central Highlands is governed by the Department of Natural Resources and Environment Code of Fire Practices, Regional Fire Management Plans and Regional Prescriptions in the case of fuel reduction and regeneration burns. Ecological burns are initiated by management plans or Action Statements for specific species, communities or sites.

Records are generally well maintained for ecological burns and regeneration burns. Records for fuel reduction burns generally include the boundary of the burnt area but not the patchiness of the burn. It is therefore difficult to interpret the impact of fuel reduction burning retrospectively.

The Department of Natural Resources and Environment is undertaking long-term research on fuel reduction burns in the Wombat State Forest, which includes vegetation types which are found in the Central Highlands.

In view of the sensitivity of rainforest to fire and the fact that many fire sensitive species occur in rainforest stands, strict controls are placed on burning adjacent to such stands. The Code of Forest Practices provides a buffer of non-rainforest vegetation around each stand to minimise the impacts described above. Less than 15% of all Cool Temperate Rainforest in the Central Highlands occurs in areas that may be subject to planned burning activities.

Grazing or browsing

Domestic stock, feral and naturalised exotic animals, and native browsers are the major agents of grazing or browsing of native vegetation in the Central Highlands.

Grazing of native vegetation by domestic stock is generally undertaken as a supplement to grazing of exotic pasture on private land. In the Central Highlands, it mainly involves grazing by cattle of native vegetation remnants on private land. Very limited stock grazing occurs on public land in the Central Highlands. Historically, one of the major exceptions to this were grazing licences issued over part of the Baw Baw plateau. However, grazing is now excluded from this area. Grazing may also occur along roadsides, especially where droving of stock is being undertaken.

Grazing or browsing by feral and naturalised exotic animals includes the impact of animals which have escaped or been released and have since established significant naturalised populations in the Central Highlands. Included are game animals such as deer, pest animals such as rabbits, pigs and goats, and escaped or abandoned domestic animals such as horses. Grazing or browsing by game and pest animals is widespread in the Central Highlands, with deer mainly occurring in the moister forests of the region. Rabbits are widespread where soil conditions are

suitable and the understorey is relatively open. They are not a significant problem in the Central Highlands.

Browsing by native herbivores is only considered as a disturbance in this review where it is significantly beyond the natural range of impact (over-browsing). This is usually restricted to cases where populations of native browsers become concentrated beyond carrying capacity in confined or isolated areas of native vegetation. Over-browsing by native herbivores is virtually unknown in the major blocks of public land, but may be a significant problem in some public land blocks and on private land in the northern parts of the region.

The major threatening process strongly associated with grazing or browsing is the direct damage or loss of plants as a result of browsing and/or trampling, and the potential for reduced reproductive output, especially where reproductive structures are significantly affected by grazing. The less direct potentially threatening processes associated with grazing are habitat modification in the form of soil disturbance or erosion, particularly where grazing or trampling is intense, or where site conditions exacerbate the impact, for example, on steep sites, in drainage lines or on particular soil types (heavy clays - pugging; sands, silts and gravels - erosion; peats - physical fragmentation). Another less direct potentially threatening process associated with grazing is environmental weed invasion (see below), where soil disturbance is combined with animals acting as seed dispersal vectors, via seed in manure or adhering to hooves or coats.

The ecological attributes which predispose plants to threat from grazing include palatability (mainly herbaceous species, but may include woody species when young, such as Orchidaceae, some *Eucalyptus* spp, some *Acacia* spp, *Coprosma* spp) and occurrence in habitats which tend to be grazed more frequently or heavily, such as grassy habitats (examples include *Lepidium hyssopifolium, Senecio macrocarpus, Cullen tenax, Amphibromus pithogastris, Senecio laticostatus).*

The current overall significance of the threatening processes associated with grazing or browsing in the Central Highlands forests is considered to be low, but significantly higher in the habitats which are most affected, principally the predominantly grassy and forb-rich ecological vegetation classes such as Plains Grassland, Plains Grassy Woodland, Box Woodland, Floodplain Riparian Woodland, Grassy Dry Forest and Valley Grassy Forest, and associated wetlands. The historical combination of alienation, grazing and clearing has resulted in these ecological vegetation classes being scarce on public land (with the exception of Grassy Dry Forest) and are often present as more or less degraded remnants on private land.

Grazing of private land remnant native vegetation is a management practice carried out by many landholders. It is not subject to regulation. Licensed grazing of native vegetation on public land is subject to periodic review, with the option of specifying licence conditions. As indicated above very little public land in the Central Highlands is licensed for domestic stock grazing.

Pest animals such as rabbits are subject to active management to control or eradicate populations, especially adjacent to agricultural lands and where impacts are most severe. Targeted pest management is applied in a few cases where grazing is a threat to one or more threatened species as a component of an Action Statement or Recovery Plan. The recent release of the Rabbit Calicivirus Disease is a major initiative in rabbit control. Its effectiveness will come to light once the results of monitoring programs are published.

Game animals such as deer are neither actively controlled nor encouraged. Their impact is relatively minor when compared to domestic stock and rabbits.

Overbrowsing by native browsers is generally dealt with by issuing permits to reduce the relevant populations.

The impacts of grazing are poorly understood, with most inferences being drawn from anecdotal or incidental observation. Further investigation of the impacts of grazing, particularly regarding the resilience of the native vegetation, its role in environmental weed spread and fuel management is warranted.

Road construction and maintenance

Road construction and maintenance may involve the clearing of vegetation, major earthworks to form the road pavement and batters, and works to construct bridges, culverts and drains. A variety of classes of roads and tracks are constructed on public land, both in conservation reserves and State forest to provide access for commercial timber harvesting, fire management, catchment management and recreation.

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.

Road construction and maintenance is widespread throughout the Central Highlands, but particularly in timber harvesting areas, where there is a requirement for a well constructed and maintained network of roads capable of carrying heavy vehicles. However, in terms of overall length, narrow tracks, which are generally constructed and maintained by bulldozers, constitute the majority or the road and track network in the Central Highlands.

The potentially threatening processes associated with road construction and maintenance include direct damage or loss of plants by machinery (strongly associated, but generally of low overall significance), habitat loss and/or fragmentation (strongly associated, but generally of low overall significance), habitat modification - erosion and sedimentation (strongly associated, but generally of moderate overall significance), habitat modification - altered micro-climatic and light conditions (strongly associated, but generally of moderate overall significance), introduction of soil or gravel contaminated with weed seed or fungal spores (strongly associated and of high overall significance) and facilitation of weed spread due to continual disturbance of road margins (strongly associated but of moderate overall significance).

The potentially threatening processes based on habitat modification (soil erosion, sedimentation, microclimatic changes) are most significant in the vicinity of gullies in the steeper, higher-rainfall, mountainous parts of the Central Highlands. Thus, species of wet gullies are likely to be most susceptible to these threats, including *Astelia australiana, Lastreopsis hispida, Huperzia varia, Hymenophyllum cupressiforme* and *Phebalium wilsonii.* Species which are sensitive to increased exposure may also be threatened, including *Euchiton umbricolus, Blechnum wattsii, Tmesipteris elongata* var *elongata* and *Gahnia grandis.*

The impact of road construction and maintenance, particularly its role in the spread of weeds and disease, and its association with a range of edge effects, has not been thoroughly investigated.

Species sensitive to weed invasion include *Grevillea barklyana* ssp. *barklyana, Oxalis magellanica, Pterostylis grandiflora* and *Pultenaea weindorferi,* whilst those sensitive to plant disease include *Grevillea repens, Banksia spinulosa* var. *cunninghamii, Hakea sericea* and *Persoonia arborea.*

Vicroads (a Victorian Government agency) is responsible for the highways throughout Victoria. Vicroads has recently published an environmental strategy which includes objectives and commitments relating to the conservation of native flora.

Local municipalities are responsible for road construction and maintenance for other roads, excluding those managed by Department of Natural Resources and Environment and some other organisations such as utilities on public land, and those managed by private landholders on their land.

Road construction and maintenance conducted on public land as part of the management of State forests or major conservation reserves is planned and implemented as part of a coordinated management plan. The Code Of Forest Practices For Timber Production includes standards and guidelines for road construction in State forests, particularly in relation to gully and riparian vegetation. In all cases, efforts are made to reduce the environmental impacts consistent with safety considerations, traffic levels and engineering requirements. Such factors will affect the extent to which desired environmental outcomes can be accommodated. Road construction and maintenance is generally well planned, and as a result, records are well maintained.

Recreation

A wide range of recreational pursuits take place in the Central Highlands, but the most significant are vehicle based activities such as fishing, hunting, camping and tourism, and skiing.

The impacts of vehicle based activities include the localised disturbance of habitats in the vicinity of focal points such as camping areas and features, such as waterfalls, views, and historic places, and localised erosion and sedimentation, particularly of streams and stream banks at crossing points, especially in areas where there are high levels of vehicle use, especially four wheel drive vehicles. Vehicle use can also result in the transport of soil, potentially carrying plant diseases and weed propagules.

Vehicle-based activities are widespread throughout the Central Highlands. The impacts are greatest in localised areas of the major river valleys, such the Yea, Acheron, Murrindindi, Royston, Big, Goulburn, Thomson, Aberfeldy, Tyers, Tanjil, Bunyip and Yarra, especially when they occur in the riparian zone.

Snow sports (including down hill and cross country skiing and snow play) and associated development of facilities is a significant, albeit highly localised, form of recreation in the Central Highlands. Its impacts include clearing, habitat fragmentation and habitat disturbance during in the construction and maintenance of facilities (runs, trails, lifts, buildings, utilities infrastructure),

pollution (particularly from sewerage systems) and associated indirect impacts such as the spread of environmental weeds.

Snow sport and associated resort development are confined to the Baw Baw plateau (Baw Baw Village: downhill and cross-country skiing, Mt St Gwinear: cross-country skiing), Lake Mountain (cross-country skiing) and Mt Donna Buang (sightseeing, tobogganing).

The potentially threatening processes associated with recreation activities are habitat loss (strongly associated but highly localised and of low overall significance), habitat degradation (strongly associated, localised and of low overall significance), introduction of environmental weeds (strongly associated and of high significance), introduction of plant pathogens (strongly associated and of moderate overall significance) and pollution/eutrophication of subalpine wetlands and streams (weakly associated and of low overall significance).

The species likely to be at greatest risk from recreational activities include species of riparian zones (eg. *Eucalyptus crenulata, Burnettia cunetata, Gahnia grandis, Epilobium pallidiflorum, Huperzia varia, Astelia australiana),* species which are sensitive to weed invasion *(eg. Eucalyptus crenulata, Epilobium pallidiflorum, Eucalyptus neglecta, Astelia australiana),* species which are sensitive to plant pathogens *(eg. Grevillea repens, Banksia spinulosa* var. *cunninghamii, Hakea sericea, Persoonia arborea)* and species of wet subalpine heathlands *(eg. Coprosma moorei, Juncus antarcticus, Epacris glacialis, Mitrasacme montana, Lycopodium scariosum).*

Vehicle-based activities such as pleasure driving, fishing, hunting, camping and sightseeing are managed through the relevant planning process—Forest Management Area Plan or National Park Management Plan—on public land. Effort is generally made to encourage activities in appropriate zones in which they are compatible with overall management objectives, or where impacts can be minimised.

Snow sport and associated resort development at Mount Baw and Lake Mountain Alpine Resorts are managed by the Alpine Resorts Commission (ARC). The Commission is required to take into account a range of legislation including provisions of flora and fauna guarantee and local planning requirements. The LCC recommendations (Land Conservation Council 1994) specify that ski trail works be undertaken in accordance with guidelines agreed by ARC and NRE, and that a development and management plan be agreed by ARC and NRE for further new major works at Lake Mountain. For major developments an EIS can be required which would consider flora and fauna values of the area. Environmental management plans are currently being developed by the ARC for alpine resorts.

Environmental weed invasion

Environmental weed invasion is not a direct, human-induced disturbance in most cases - it is a phenomenon which would in all likelihood now continue without any of the direct disturbances that it normally accompanies. It 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 the habitat can become grossly modified, with particular niches being lost altogether.

Environmental weeds are widespread throughout the Central Highlands, occurring in all habitats and areas. Among the most destructive or aggressive exotic weeds are Blackberry (*Rubus fruticosus* spp. agg.), St Johns Wort (*Hypericum perforatum*), Blue Periwinkle (*Vinca major*), Quaking Grasses (*Briza* spp.), Japanese Honeysuckle (*Lonicera japonica*), Himalayan Honeysuckle (*Leycesteria formosa*), Holly (*Ilex aquifolium*), English Ivy (*Hedera helix*), English Broom (*Cytisus scoparius*), Cotoneaster (*Cotoneaster* spp.), Yorkshire Fog (*Holcus lanatus*) and Canary Grasses (*Phalaris* spp.). The native species of greatest concern are Sweet Pittosporum (*Pittosporum undulatum*) and Cootamundra Wattle (*Acacia baileyana*).

The potentially threatening processes associated with environmental weed invasion are competition and habitat modification (both strongly associated and of high significance). Species likely to be at greatest risk from environmental weed invasion are those which occupy weed prone habitats, such as riparian zones, relatively fertile soil types and fragmented habitats in close proximity to weed sources, such as waste disposal areas and agricultural lands. Examples of species likely to be most affected include *Caladenia rosella, Desmodium varians, Epilobium pallidiflorum, Eucalyptus crenulata, Eucalyptus neglecta, Eucalyptus strzeleckii, Eucalyptus yarraensis, Euchiton umbricolus, Grevillea barklyana* ssp. *barklyana, Lepidium hyssopifolium, Lindsaea microphylla, Oxalis magellanica, Pterostylis grandiflora, Pultenaea weindorferi, Senecio laticostatus, Senecio macrocarpus, Taraxacum aristum and Wittsteinia vacciniacea.*

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, is currently investigating the significance of the weed problem in general, including specific reference to environmental weeds. Environmental weed invasion has been listed as a potentially threatening process under the *Flora and Fauna Guarantee Act*.

The Commonwealth, in consultation with State and Territory agencies, has recently completed the National Weeds Strategy, which outlines strategies to address major issues. Current management of environmental weeds across public and private land is generally acknowledged as being deficient. Limited resources and a general lack of strategic planning, tactical planning, follow-up, monitoring and experimental management are largely responsible for the deficiencies.

The distribution of environmental weeds is generally well understood, as a result of their inclusion in floristic surveys conducted in the Central Highlands. A considerable amount of research on the ecology and management of particular environmental weeds, especially those which 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.

Plant pathogens

Like environmental weed invasion, the introduction, spread and disease caused by plant pathogens is not a direct, human-induced disturbance, although it can be exacerbated by other disturbances. The most important plant pathogens in the Central Highlands are the introduced Cinnamon Fungus (*Phytophthora cinnamomi*), which is responsible for dieback disease, and the apparently endemic fungus *Chalara australis* which causes Myrtle Wilt, a disease of the rainforest tree Myrtle Beech (*Nothofagus cunninghamii*).

Dieback disease caused by Cinnamon Fungus (*Phytophthora cinnamomi*)

Cinnamon Fungus is widespread in the Central Highlands. However, dieback disease and its consequent impact on vegetation tends to be more localised. Cinnamon Fungus was previously thought only to lead to significant disease occurrence in susceptible species under particular soil conditions (warm and moist), and was therefore a threat only in particular areas, such as low elevation heathlands with impeded drainage. However, recent research from Tasmania (Podger and Brown 1989, Podger *et al* 1989) suggests that the disease may pose a threat in mountain areas where soils tend to be moist, well-drained but generally substantially cooler than those at lower elevations.

Dieback disease caused by Cinnamon Fungus leads to the morbidity or mortality of some or all infected individuals of susceptible species, including members of the Proteaceae family such as *Banksia spinulosa* var *cunninghamii, Hakea sericea, Grevillea repens* and *Persoonia arborea.* It has been reported that Cinnamon Fungus may affect *Astelia australiana,* but the most recent investigation (Turner *et al* 1996) suggests that "although a variety of potentially pathogenic fungi, including *Phytophthora cinnamomi,* were located throughout the Central Highlands habitat of *A. australiana,* their distribution did not correlate with an increased incidence of dead and sick plants".

The proportion of a population of a species that is susceptible to dieback disease and the reproductive output of the species will largely determine whether the onset of the disease acts as a transient selection pressure or a catastrophic epidemic which decimates and possibly eliminates the population. Where structurally-dominant species are affected (such as eucalypts), dieback disease can modify the habitat to the extent that some species may be threatened, although this has not been widely reported from the Central Highlands. The overall significance of the threat posed by dieback disease in the Central Highlands forest is considered to be low and moderate for other vegetation types such as heaths and heathy woodland.

Dieback disease caused by Cinnamon Fungus (*Phytophthora cinnamomi*) is managed by a combination of measures including quarantine of disease-affected areas, hygiene procedures designed to remove infected soil from vehicles and kill spores, research and monitoring of infected sites and affected species.

The West Australian Department of Conservation and Land Management, in consultation with relevant Commonwealth, State and Territory agencies, is currently preparing a National Threat Abatement Plan for *Phytophthora*.

Mytle Wilt

Myrtle Wilt disease is widespread in the Central Highlands, with most catchments supporting Myrtle Beech -dominated Cool Temperate Rainforest exhibiting low levels of disease symptoms, a few hotspots, and a few apparently disease-free areas (Cameron and Turner 1996). Myrtle Wilt disease leads to mortality in all cases. Infection occurs via wounds and root grafts between individuals. In many cases, the disease appears to occur naturally at low levels of infection and in equilibrium. However, disturbance of rainforest stands has been shown to elevate the incidence of the disease (Kile *et al* 1989, Neyland and Brown 1994). The most significant threat associated with elevated incidence of Myrtle Wilt is habitat modification in the form of the creation of gaps in the rainforest canopy. The gaps may become so large as to fragment the mainly linear stands found in the Central Highlands. In combination with fire and permanent roading, this may lead to a significant contraction and fragmentation of rainforest stands. The species at greatest risk from this process are those dependent on rainforest habitats, and include *Astelia australiana, Huperzia varia, Huperzia australiana, Tmesipteris elongata* ssp. *elongata, Tmesipteris ovata, Hymenophyllum cupressiforme* and *Lastreopsis hispida*

The Code of Forest Practices for Timber Production specifies additional buffering of rainforest stands where Myrtle Beech comprise more than 20% of the canopy is required and any road construction adjacent to rainforest areas is to be avoided wherever possible. Specific management prescriptions for rainforest and guidelines for Myrtle Wilt management are outlined in the Proposed Central Highlands Forest Management Plan.

Current management of Myrtle Wilt on public land focuses on monitoring disease incidence and the nature of the regeneration in gaps created by the disease. Further research is recommended to determine the relationship between disturbance and disease and the critical environmental factors which limit or facilitate its spread.

Other disturbances

The following disturbances are considered to be relatively minor in their impact on native flora in the Central Highlands.

Pollution

Input of pollutants to native vegetation may come from a variety of sources, including herbicides used in pest control, agricultural fertilisers, sewage, spillage of industrial chemicals and use of fire retardant chemicals. Of these, excessive nutrient input probably has the most significant impact, especially where it is associated with vegetation types which are adapted to low nutrient soils. It may facilitate the spread of environmental weeds in some circumstances.

Genetic pollution

Genetic pollution of natural populations of native flora is most likely to occur 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 tended to occur more frequently in the past. Although potentially significant, major impacts have not been revealed by research to date.

Deliberate collection

Deliberate collection is a significant disturbance or threat to a small number of taxa which are considered to be desirable by collectors. Most collectors are believed to be amateurs acting alone rather than commercially-motivated (cf. deliberate collection of fauna). Most at risk are the native orchids, particularly terrestrial orchids including *Caladenia* spp., *Diuris* spp., *Calochilus* spp. and *Prasophyllum* spp., and epiphytic orchids such as *Sarcochilus australis*.

5.3.4 Relationship between human-induced and natural disturbances

The distinction between natural disturbances and the processes of evolutionary change is blurred. For the purposes of this review, natural disturbances are those events which are random or cyclic but which occur relatively frequently (in the tens or hundreds of years) as opposed to changes which are irreversible and tend to form longer-term trends over thousands of years.

A range of natural disturbances affect native flora in the Central Highlands, the most notable being:

- wildfire
- windstorms
- floods
- landslides and other geomorphological changes
- drought
- extreme cold
- insect attack

Each of these natural disturbances, either alone or combined, has the potential to cause significant changes in the floristic composition and structure of native vegetation, including the decline or extinction of species at a local or regional level.

Generally speaking, little or no effort is expended to protect native flora from the impacts of natural disturbances. Where the impacts of such disturbances are mitigated, it is usually incidental to efforts to protect human life, property and commercial assets.

However, the interactions between natural and human-induced disturbances are likely to be significant in many cases, and warrant further investigation and consideration when attempting to ameliorate the impacts of human-induced disturbances.

6 Terrestrial Fauna Species Assessment

6.1 Introduction

The terrestrial fauna assessment was directed at accumulating sufficient information such that the legislative and policy requirements in relation to fauna conservation can be fully accommodated in the development of the Regional Forest Agreement for the Central Highlands. This involved the collation of all relevant information of the distributional, biological and life history characteristics of species, known threats and current management actions.

Data were gathered from an extensive search of the literature, from existing datasets, from experts and from new information generated by specialist projects. Critical attributes and parameters were developed with the assistance of local and national experts in the field of population ecology. The information collected fell into two groups:

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

The information on life history, population parameters, habitat components, disturbance and response to disturbance is stored in a working database. The database contains much more information than is possible to present in this background report.

The database can be incorporated into a relational system that would be a useful tool for obtaining access to, displaying, modelling and predicting species' responses to various impacts and disturbances. This would allow appraisal and refinement of management action and be of considerable value in the medium and long-term monitoring of species.

6.1.1 Priority species

The assessment techniques described below were not intended to be applied to all fauna species. Even if this were thought desirable, minimal quantitative data exist for many species, particularly invertebrates. Long-term survival for the majority of taxa is assumed to be effected through the conservation of their habitat by appropriate representation of EVCs in the CAR reserve system. The assessment of terrestrial fauna presented is therefore based largely on an agreed list of priority species found in the Central Highlands whose conservation needs require specific attention. These priority species includes those listed under the Victorian *Flora and Fauna Guarantee Act* 1988 (FFG Act), the Commonwealth *Endangered Species Protection Act* 1992 (ESP Act) and the Threatened Fauna of Victoria (TFV) list (CNR 1995a). The terrestrial species included are shown in Table 6.1 with conservation status, the existence of Action Statements (for species listed on the FFG Act) and Recovery Plans (for species listed on the ESP Act), and whether the species is secure on other listings. As noted in Section 5.2.5, the existence of action statements or recovery plans does not imply that all recommended management actions have been implemented.

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 6.1: Terrestrial fauna species included in the assessment.

Species Name	Common Name	TFV	FFG Status	Action State-ment (Vic)	ESP Status	Recovery Plan (C'wlth)	Secure in Other States
Mammals							
Gymnobelideus leadbeateri	Leadbeater's Possum	E	L	Yes	E	In Prep	N/A
Dasyurus maculatus	Spot-tailed Quoll	V	L	Yes			No
Petaurus norfolcensis	Squirrel Glider	V	L	In prep			No
Mastacomys fuscus	Broad-toothed Rat	R					No
Pseudomys fumeus	Smoky Mouse	V					No
Antechinus minimus	Swamp Antechinus	R					No
Phascogale tapoatafa	Brush-tailed Phascogale	R	L	In prep			No
Sminthopsis murina	Common Dunnart	R					Yes
Canis familiaris dingo	Dingo	K					Yes
Rhinolophus megaphyllus	Eastern Horseshoe-bat	RC	L	No			Yes
Myotis macropus	Large-footed Myotis	R					No
Miniopteris schreibersii blepotis	Common Bent-wing Bat	RC	L	In prep			Yes
Pteropus poliocephalus	Grey-headed Flying-fox	RC					Yes
Birds							
Lathamus discolor	Swift Parrot	E	L	In prep	V	Yes*	No
Lichenostomus melanops cassidix	Helmeted Honeyeater	E	L	Yes	E	Yes*	No
Grantiella picta	Painted Honeyeater	R	L	No			No
Xanthomyza phrygia	Regent Honeyeater	E	L	Yes	E	Yes*	No
Pomatostomus temporalis	Grey-crowned Babbler	E	L	Yes			No
Burhinus grallarius	Bush Stone-curlew	V	L	In prep			No
Lophoictinia isura	Square-tailed Kite	V					No
Accipiter novaehollandiae	Grey Goshawk	R					No
Haliaeetus leucogaster	White-bellied Sea-eagle	R	L	Yes			No
Ninox connivens	Barking Owl	R	R				No
Ninox strenua	Powerful Owl	R	L	In prep			No
Tyto novaehollandiae	Masked Owl	R	L	In prep			No
Tyto tenebricosa	Sooty Owl	R	L	In prep			No
Reptiles							
Pseudemoia cryodroma	Alpine Bog Skink	V	R				No
Egernia coventryi	Swamp Skink	R					No
Pseudemoia rawlinsoni	Glossy Grass Skink	K					No

Table 6.1 (cont'd)

Species Name	Common Name	TFV	FFG Status	Action State-ment (Vic)	ESP Status	Recovery Plan (C'wlth)	Secure in Other States
Amphibians							
Litoria spenceri	Spotted Tree Frog	E	L	Yes	E	In prep	No
Philoria frosti	Baw Baw Frog	E	L	Yes	V	Yes*	No
Heleioporus australiacus	Giant Burrowing Frog	V	L	Yes			No
Litoria verreauxii alpina	Alpine Tree Frog	K					No

Notes: **Threatened Fauna of Victoria List (TFV):** E - endangered, K - insufficiently known, RC - restricted colonial breeding or roosting, R - rare, V - vulnerable;
Flora and Fauna Guarantee Act (**FFG):** L - Listed, R - recommended for listing;
Commonwealth Endangered Species Protection Act (**ESP):** E - endangered, V - vulnerable.
* Although recovery plans have been prepared for asterisked species, none have formally been approved by the Commonwealth Environment Minister.

6.2 Life history and population parameters for priority fauna species

A number of biological characteristics may predispose a species or population to decline or 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 (Rabinowitz 1981). Species or populations most predisposed to extinction are those which 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 (Caughley 1994).
3. Spatial dynamics, or metapopulation dynamics, is the interaction between colonisation and extinction of sub-populations that make up a population (Hanski and Gilpin 1991). 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 (Turin and den Boer 1988).
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 (Pimm *et al.* 1988).

6.2.1 Assessment methods

Each species listed in Table 6.1 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, geographic range within the Central Highlands was classified for each species as large, medium or small, based on a measure or estimate of range size, and the proportion of the Central Highlands in which the species is found (large >30%, medium 10 to 30%, small <10% of Central Highlands). Range size was calculated by summing the area of each Atlas of Victoria grid cell containing a record for each species. This is likely to overestimate geographic range as the area of a grid cell is usually larger than the home range of a particular species. As an additional check, the amount of potentially suitable habitat for each species was calculated by summing the area of each EVC in which a species is likely to occur. Abundance within the Central Highlands was classified as high, medium or low, based the number of records on the Atlas of Victorian Wildlife and on expert opinion. Habitat specificity was classified as narrow or wide, based on expert opinion of the proportion of habitats used or likely to be used within the region.

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 broad 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 than species and populations that are declining. Species whose status is stable but dependent on active management intervention (such as predator control), are assumed to be more likely to be at risk of extinction, than those that do not depend on management intervention. 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 who have maintained a stable abundance since their discovery by Europeans. Population trends since European settlement were classified by experts, and were generally based on the change in the amount of each species' habitat within the Central Highlands.

Spatial dynamics is 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 are 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 and so minimise the threat of extinction due to accidents.

Species that are long-lived tend to be less susceptible to accidental extinction 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 limited and classifications could not be made. Parameters with no information were either classified as unknown, or a classification assigned by experts, based on the most likely estimate.

6.2.2 Results and discussion

Detailed information on the life history and population dynamics for each species is included in Appendix G. The available life history and population dynamics information for the species reviewed is summarised in Table 6.2. 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.

The ratings for each species in relation to geographic range, abundance, and habitat specificity are presented in Table 6.2. Most of the species assessed had small geographic ranges in the Central Highlands. The geographic range size of the Regent Honeyeater and White-bellied Sea-Eagle are unknown but were classified as large due to the widely scattered nature of records contained on the Atlas of Victorian Wildlife and because both these species are highly mobile and known to range widely. Atlas of Victorian Wildlife records for both the Sooty Owl and Powerful Owl indicate both species have large geographic ranges within the Central Highlands; the Central Highlands is a stronghold of the Sooty Owl. Although there are only 12 Atlas of Victorian Wildlife records of the Square-tailed Kite within the Central Highlands, the records indicate the species occupies a large geographic range. Most Atlas of Victorian Wildlife records of Dingoes are not distinguishable from records of feral domestic dogs and their hybrids and as a result its geographic range is unknown.

As expected for a group of species selected because there is some documented concern for their status, most had low abundance. Only Leadbeater's Possum was classified as having a medium abundance. This species is mainly confined to the montane ash forests of the Central Highlands, where its distribution is patchy. In areas of suitable habitat, Leadbeater's Possum can be locally common (Macfarlane *et al.* 1995). Most of the species were rated as habitat specific with the exception of the Spot-tailed Quoll, Dingo, Regent Honeyeater, Square-tailed Kite, Grey Goshawk, White-bellied Sea-Eagle, and Powerful Owl. Most of these species are highly mobile and occupy large home ranges.

Five species of mammal (Squirrel Glider, Swamp Antechinus, Common Dunnart, Eastern Horseshoe Bat and Grey-headed Flying Fox), five species of bird (Swift Parrot, Helmeted Honeyeater, Painted Honeyeater, Grey Crowned Babbler and Bush Stone-curlew), the three reptile species (Alpine Bog Skink, Swamp Skink and Glossy Grass Skink), and three of the four amphibian species assessed (Spotted Tree Frog, Alpine Tree Frog and Baw Baw Frog) have small geographic range sizes, a low abundance and are habitat specific. Consequently, of the species assessed, these are more predisposed to the threat of decline or extinction within the

Central Highlands. Based on the rarity parameter, these species should be given particular consideration in developing priorities for management action. Of these species, the Squirrel Glider, Grey-headed Flying-fox, Swift Parrot, Painted Honeyeater and Bush Stone-curlew are on the edge of a more extensive distribution outside the Central Highlands region. The Grey-crowned Babbler and Swamp Antechinus are known from only single populations within the Central Highlands; no individuals of either species have been recorded since 1983 and both populations may now be extinct. The Broad-toothed Rat, while rated as having a 'medium' geographic range size, has a restricted distribution and a recent study (Jelinek *et al*, 1997) failed to locate it in wet sub-alpine heathlands (a favoured habitat) in the Lake Mountain area, despite intensive trapping and searching.

The ratings for species according to population variability, mobility, reproductive output and longevity are shown in Table 6.2. Species such as Leadbeater's Possum, Spot-tailed Quoll, Dingo, Common Bent-wing Bat, Barking Owl, Powerful Owl, and Sooty Owl have favourable spatial dynamic attributes that reduce the threat of extinction due to metapopulation collapse. Species such as the Smoky Mouse, Swamp Antechinus, Common Dunnart and Spotted Tree Frog, have high population variability and low powers of dispersal which render them more vulnerable to the threat of extinction through metapopulation collapse. The population variability of several species including Squirrel Glider, Square-tailed Kite, Grey Goshawk, Masked Owl, Giant Burrowing Frog and Alpine Tree Frog is unknown and the powers of dispersal of the Large-footed Myotis, Bush Stone-curlew and Baw Baw Frog are also unknown. For these species, there is no indication of vulnerability to metapopulation collapse based on the spatial dynamics parameter and highlights the need for basic biological information for a number of species. Similarly, the longevity of the Spot-tailed Quoll, Painted Honeyeater, Regent Honeyeater, Grey Goshawk, Alpine Bog Skink, Glossy Grass Skink, Giant Burrowing Frog, Alpine Tree Frog is unknown. The longevity of the Broad-toothed Rat, Swift Parrot, Barking Owl and Swamp Skink is also unknown but a classification was assigned based on the most likely estimate.

The Swift Parrot, Helmeted Honeyeater, and Grey-crowned Babbler have a high reproductive output and longevity, making them less predisposed to extinction. In contrast, Leadbeater's Possum, the only species known to have a low reproductive output and longevity, is particularly vulnerable in this regard. The Regent Honeyeater, Grey Goshawk, Alpine Bog Skink, Glossy Grass Skink and Alpine Tree Frog have a low reproductive output but an unknown longevity and no assessment of vulnerability to extinction based on life history parameters could be made.

The population trend since European settlement for each species is detailed in Appendix G. 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. In contrast, the Common Bent-wing Bat and Eastern Horseshoe Bat are thought to have increased since European settlement. Both species have narrow roost requirements and are dependent on a limited number of suitable sites. Since European settlement and the construction of mineshafts, the number of suitable sites has increased and may have led to an increase in these two species (L. Lumsden pers. comm.). The Grey-headed Flying-fox and Dingo are also thought to have increased since European settlement. The Grey-headed Flying Fox has most likely increased as a result of an increase in food sources. In the Central Highlands the species mostly feeds on the fruit of cultivated fruit trees (Menkhorst 1995, L. Lumsden pers. comm.). Nothing is known of the diet of the Dingo in the Central Highlands. However, a study of the diet of wild dogs in East Gippsland indicated non-native species (mainly rabbit) made up only a small proportion of the diet (Brown and Triggs 1990). However, rabbits may provide an alternative food source,

particularly when native prey is scarce (Corbett 1995). Although the Dingo has been the subject of control measures since European settlement, such measures may have led to an increase in numbers by disrupting the social organisation of packs resulting in an increase in the number of breeding females (Corbett 1995).

Population trends are the clearest indicators of a species likelihood of extinction. However, for a range of species, the population trend in the past 10 years could not be determined (Table 6.2). This highlights the need for further biological information on a large number of the species assessed. Of the species whose population trend in the past 10 years could be determined, the majority have decreased. The Helmeted Honeyeater has increased over this time period, mainly as a result of an intensive recovery program. Although the Powerful Owl, Swamp Skink and Glossy Grass Skink populations have decreased since European settlement, they are thought to have stabilised over the past 10 years. Within the Central Highlands, reported sightings of the Powerful Owl have remained relatively constant, and the number of known pairs on the outskirts of Melbourne have not decreased and it is likely the population is relatively stable (R. Loyn pers. comm.). The stable status of the Powerful Owl population is considered to be partly dependent on management, particularly the protection of known and potential nest sites. Although very little is known of the population trend of the Swamp Skink and Glossy Grass Skink over the past 10 years, processes which most likely caused population declines in the past (including clearing and draining of favoured swampland and heathland habitats) are now much less widespread. As a result, populations of both species are now in a relatively stable state which is unlikely to be dependent on management (P. Robertson pers. comm.).

Table 6.2 : Summary of life history and population dynamics information.

Species	Population trend in the last 10 years	Rarity Scores			Spatial Dynamics Scores		Life History Parameters Scores	
		Geogra-phic Range	Abun-dance	Habitat Specificity	Population Variability	Powers of Dispersal	Reprod-uctive Output	Longevity
Leadbeater's Possum	*stable/declined	medium	medium	narrow	low	high	low	short
Spot-tailed Quoll	unknown	medium	low	wide	low	high	high	unknown
Squirrel Glider	*declined	small	low	narrow	unknown	high	low	long
Broad-toothed Rat	unknown	medium	low	narrow	* low	low	low	* long
Smoky Mouse	unknown	medium	low	narrow	high	* low	high	short
Swamp Antechinus	unknown	small	low	narrow	high	low	high	short
Brush-tailed Phascogale	declined	medium	low	narrow	high	high	high	short
Common Dunnart	unknown	small	low	narrow	high	low	high	short
Dingo	unknown	unknown	* low	wide	low	high	low	long
Eastern Horseshoe Bat	declined	small	low	narrow	low	low	low	long
Large-footed Myotis	unknown	medium	low	narrow	low	unknown	low	long
Common Bent-wing Bat	declined	medium	medium	narrow	low	high	low	long
Grey-headed Flying-fox	increased	small	low	narrow	high	high	low	long
Swift Parrot	declined	small	low	narrow	high	high	high	* long
Helmeted Honeyeater	increased	small	low	narrow	low	low	high	long
Painted Honeyeater	unknown	small	low	narrow	high	high	high	unknown
Regent Honeyeater	declined	*large	low	wide	high	high	low	unknown
Grey Crowned Babbler	declined	small	low	narrow	low	low	high	long
Bush Stone-curlew	declined	small	low	narrow	low	unknown	low	long
Square-tailed Kite	unknown	large	low	wide	unknown	high	low	long
Grey Goshawk	unknown	medium	low	wide	unknown	high	low	unknown
White-bellied Sea-Eagle	unknown	*large	low	wide	low	high	low	long
Barking Owl	unknown	medium	low	narrow	low	* high	low	* long
Powerful Owl	stable	large	low	wide	low	high	low	long
Masked Owl	unknown	small	low	unknown	unknown	high	low	long
Sooty Owl	unknown	large	low	narrow	low	high	low	long
Alpine Bog Skink	*declined	small	low	narrow	low	low	low	unknown
Swamp Skink	*stable	small	low	narrow	low	low	low	* long
Glossy Grass Skink	*stable	small	low	narrow	low	low	low	unknown
Giant Burrowing Frog	unknown	unknown	low	* wide	unknown	high	high	unknown
Spotted Tree Frog	declined	small	low	narrow	high	low	low	long
Alpine Tree Frog	declined	small	low	narrow	unknown	low	low	unknown
Baw Baw Frog	declined	small	low	narrow	high	unknown	low	long

Note: * unknown, but most likely classification

6.2.3 Notable threatened vertebrate species

The following taxa, which are either wholly confined to the Region or significantly represented there, are listed under the *Endangered Species Protection Act* and are noteworthy both in terms of conservation concern and their high public profile.

Leadbeater's Possum

Leadbeater's Possum is a small possum found only in the Central Highlands of Victoria. Previously thought to be extinct, it was rediscovered in 1961 and is considered nationally

endangered. It is currently found mainly in mountain forests dominated by Mountain Ash, Alpine Ash and Shining Gum and has recently been recorded in Snow Gum woodland at Lake Mountain. A small population also exists in Yellingbo State Nature Reserve, in lowland swamp forest.

Wildfires in 1939 burnt approximately 84% of the Central Highlands ash-eucalypt forests. A wattle understorey provides important feeding habit for Leadbeater's Possum and the fire-killed remnants of mature forest and resultant regrowth from the 1939 fires has provided abundant feeding and nesting habitat for the species during the past 30 years. However, as the fire-killed nest trees decay and fall, the extent of this type of habitat is diminishing.

Even if timber harvesting were excluded from the regrowth ash forests, they will not be capable of providing suitable nest sites for a further 150 years - assuming that Ash trees must be about 200 years old before they can provide suitable nest sites. It therefore follows that the existing older-aged forest must continue to provide habitat for at least another 150 years.

More details on this species are provided in Box 2 (Section 6.4.2).

Baw Baw Frog

Until recently the Baw Baw Frog was believed to be confined to the Baw Baw Plateau, within an area of 80 km^2, which is primarily within the Baw Baw National Park. The species has recently been recorded at lower elevations (1100-1300 m) in forest areas available for timber harvesting. A continued decline in Baw Baw Frog numbers on the Plateau has meant that conservation of these lower-elevation populations is now very important to the survival of the species. Ongoing monitoring of these lower altitude populations are being conducted. Adults of this species are known to use habitat adjacent to and some distance from breeding sites. Very little is known of movements of juveniles and sub-adults.

Spotted Tree Frog

The Spotted Tree Frog is known to occur in only thirteen discrete populations - eleven in Victoria and two in New South Wales. These are mainly on the north-west side of the Great Dividing Range between the Central Highlands in Victoria and Mt Kosciusko in New South Wales. Survey results suggest the species has suffered a significant decline during the past 20 years. Tadpole development occurs in upland streams, with adjacent stream-side vegetation being used by adults for sheltering and basking.

6.2.4 Other important vertebrate species

There are a number of other vertebrate fauna species which, while not formally listed as threatened, are considered by some researchers to require monitoring and possible management intervention because of perceived population declines in the Central Highlands. These include:

Yellow-bellied Glider (*Petaurus australis*)
Greater Glider (*Petauroides volans*)
Mountain Brushtail Possum (*Trichosurus caninus*)
Dusky Antechinus (*Antechinus swainsonii*)
Peregrine Falcon (*Falco peregrinus*)

Gang Gang Cockatoo (*Callocephalon fimbriatum*)
Yellow-tailed Black Cockatoo (*Calyptorhynchus funereus*)
Wonga Pigeon (*Leucosarcia melanolcuca*)
Azure Kingfisher (*Alcedo azurea*)
Tree Goanna (*Varanus varius*)

Some of these species, for example the Yellow-bellied Glider, are dependent on large tree hollows for shelter and breeding. A shortage of large, old trees with hollows in the Central Highlands regrowth forests is likely to have implications for the conservation of the Yellow-bellied Glider and other hollow-dependent fauna (Lindenmayer, D.B. *et al*, in press). Other threatening processes such as predation, and water quality might be implicated in the concern over some of these species, however for most of them, insufficient information is available to assign probable threats.

6.2.5 Terrestrial invertebrates

Terrestrial invertebrates, which actually comprise the vast majority of faunal species in the region, have not been systematically surveyed. This lack is a constraint on the formulation of comprehensive management designed to conserve species-level biodiversity. Experience elsewhere suggests that many invertebrate species are likely to have localised distributions and/or be vulnerable to a range of disturbances. Many rely on the maintenance of microclimates which are readily disrupted. Old-growth forests with an abundance of ground litter and rotting logs are often a rich source of moisture-loving species.

Little is known of the appropriateness of management techniques designed for vertebrates—such as the provision of wildlife corridors—on invertebrates, particularly those species having low vagility. Planned fire regimes of a frequency and intensity believed to be tolerated by vertebrates may be incompatible with the reproductive and mobility capacities of invertebrates (and their resultant ability to recolonise areas). It is an area deserving of further research, particularly given the acknowledged importance of invertebrates in sustaining the ecological processes of forests.

In the short term, the representative conservation of Ecological Vegetation Classes and protection of old growth provided by the existing conservation estate and as outlined in the Proposed Central Highlands Forest Management Plan (NRE 1996b) is expected to be important for the protection of terrestrial invertebrate diversity in the absence of detailed information on this group. This technique has limitations because of the widespread phenomenon of local endemism and a generally poor correlation between vegetation communities and the distribution of invertebrates the medium and longer-term, directed research offers the only means of delivering the data necessary to make informed decisions affecting this important component of the fauna.

A list of all insects recorded at the Australian National Insect Collection (ANIC) from the region is at Appendix H. A number of these species are known only from the region. In such cases, this status may represent a real geographic restriction or be an artefact of incomplete sampling.

Among notable non-insect invertebrates are at least 2 species of Onycophora (velvet-worms). *Ooperipatus centunculus* is known only from the Mt Donna Buang-Warburton area and *O. pulchellus* appears to be restricted to Mt Baw Baw (Reid, 1996).

Land-snails known to have distributions largely restricted to the study area include *Discocharopa inexpectata ,Rhopodon problematica, Pillomena marysvillensis* (all from litter and under decaying timber in wet sclerophyll forest) and *Victaphanta atramentaria* (deep litter in temperate rainforest). The conservation status of these species is uncertain.

A number of earthworm species (many from the genus *Diporochaeta s. lat*.) are also recorded from the area. Some, originally described by W Baldwin Spencer last century, have not been recorded since.

6.3 Fauna species reservation analysis

6.3.1 Methods

A reservation analysis has been undertaken to assess the extent to which terrestrial vertebrate species in the Central Highlands 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 land tenure category (see Table 6.3). Categories used were Reserve, Non-Reserve and Partially Reserved areas (see table footnote for explanation). Table 6c also indicates whether the majority (>50%) of the species' known range is within the Central Highlands.

The results will tend to underestimate the level of protection provided to species by the reserve system because it has had fewer formal surveys.

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.

6.3.2 Results and discussion

The results of the assessment are presented in Table 6.3. Most species which have their major occurrence in the Central Highlands appear to have populations sampled to a moderate to high degree by the reserve system. The exception is the Glossy Grass Skink, for which only 11% of known records occur in reserves.

Table 6.3: Reservation analysis of priority species in the Central Highlands

Group/Species	n	Res	% Res	Non-Res	% Non-Res	Part Res	% Part Res	Most Range in CH
Mammals								
Leadbeater's Possum	277	153	55	113	41	11	4	Yes
Spot-tailed Quoll	8	3	38	4	50	1	13	No
Squirrel Glider	1	0	0	1	100	0	0	No
Broad-toothed Rat	47	31	66	15	32	1	2	Yes
Smoky Mouse	26	14	54	9	35	3	12	No
Swamp Antechinus	3	3	100	0	0	0	0	No
Brush-tailed Phascogale	80	14	18	66	83	0	0	No
Common Dunnart	23	1	4	22	96	0	0	No
Dingo	2	1	50	1	50	0	0	No
Eastern Horseshoe-bat	13	6	46	7	54	0	0	No
Large-footed Myotis	20	13	65	7	35	0	0	No
Common Bent-wing Bat	48	21	44	27	56	0	0	No
Grey-headed Flying-fox	0	0		0		0		No
Birds								
Swift Parrot	33	0	0	33	100	0	0	No
Helmeted Honeyeater	16	5	31	11	69	0	0	Yes
Painted Honeyeater	3	1	33	2	67	0	0	No
Regent Honeyeater	29	2	7	27	93	0	0	No
Grey Crowned Babbler	0	0		0		0		No
Bush Stone-curlew	1	0	0	1	100	0	0	No
Square-tailed Kite	6	1	17	5	83	0	0	No
Grey Goshawk	12	1	8	11	92	0	0	No
White-bellied Sea-eagle	10	1	10	9	90	0	0	No
Barking Owl	43	7	16	36	84	0	0	No
Powerful Owl	159	74	47	83	52	2	1	No
Masked Owl	12	3	25	9	75	0	0	No
Sooty Owl	164	124	76	29	18	11	7	No
Reptiles								
Alpine Bog Skink	3	2	67	1	33	0	0	Yes
Swamp Skink	10	5	50	5	50	0	0	No
Glossy Grass Skink	18	2	11	16	89	0	0	Yes
Amphibians								
Spotted Tree Frog	17	16	94	1	6	0	0	Yes
Baw Baw Frog	108	86	80	20	19	2	2	Yes
Giant Burrowing Frog	0	0		0		0		No
Alpine Tree Frog	14	10	71	3	21	1	7	No

Notes: (a) Reserves include National Parks and Special Protection Zones.

(b) Partially Reserved areas include Special Management Zones and Code of Forest Practice exclusion areas.

(c) Most records from within the Non-Reserve category are from private land.

(d) Only records post 1970 and with an accuracy of one minute or better were used in this analysis.

(e) Records of individuals over water bodies (mostly birds and bats) have been omitted.

6.4 Review of disturbances and their implications for fauna in the Central Highlands

The decline of species can be largely attributed to the impacts of disturbances, both directly on 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.

6.4.1 Methods

A review of the current state of knowledge of forest species and threatening processes was conducted to provide information to assist in setting priorities for future management, research and surveys. The review covers priority forest dwelling species (Table 6.1) in the Central Highlands, and was based on existing scientific literature and expert opinion.

For each species, the likely effects of each threatening process was documented, and a score assigned according to whether the threat was unknown, insignificant, minor, moderate or major for each species (see explanation below). A source was recorded for all information. These large primary data tables are not reproduced in this report.

The assessment of threatening processes was made in the following context:

- Application of the ratings is for the Central Highlands only.
- The ratings are assigned assuming no management actions are in place
- Threatening processes which potentially affect more than one component of a species life-cycle or habitat scored a higher rating than another threat which affects fewer life-cycle or habitat components.

A range of mechanisms has been implemented or planned to address threatening processes which affect individual species in the Central Highlands. These include:

- an extensive conservation reserve system covering a range of habitats on public land;
- specific protection afforded by threatened species strategies in the Proposed Central Highlands Forest Management Plan;
- requirements under the *Flora and Fauna Guarantee Act 1988* and the *Endangered Species Protection Act 1992*; and
- a range of provisions in the Code of Forest Practices for Timber Production and the Code of Fire Practices which address a number of the threatening processes operating in the region.

Other threatening processes on private land are addressed under the provisions of the *Planning and Environment Act 1987* and the *Catchment and Land Protection Act 1994*. These are referred to in the assessment below, where relevant.

Threatening processes were scored for each species as follows:

- **-** Effect unknown; no information available on the effect of the process on the species;
- **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; and
- **3** Process is a major threat, which if not checked poses a significant risk to the viability of the species in the Central Highlands.

6.4.2 Results and discussion

The combined score for each threatening process provides an indication of the relative importance of different threatening processes affecting fauna in the Central Highlands. In a number of cases, species are only known from the study area by a small number of records in the Atlas of Victorian Wildlife, and threatening processes were ranked by experts on the often limited knowledge of the species from other areas. For species whose occurrence and habitat is marginal within the Central Highlands, threatening processes which may be significant in other areas of the range but not within the Central Highlands, did not receive high rankings. Table 6.4 provides a summary of threatening processes for threatened forest fauna in the Central Highlands. Overall, unplanned fire was the highest scoring threat, followed by timber harvesting and introduced species. Timber harvesting was identified as a major threat to the greatest number of species. Overall, non-forestry clearing affected the greatest number of species, followed by timber harvesting and unplanned fire.

Table 6.4: summary of impacts of threatening processes on priority fauna species

	THREATENING PROCESS																		
SPECIES	Fire (planned)	Fire (unplanned)	Timber Harvesting	Predation/competition by introduced species	Pest Control	Grazing	Disease	Harvesting of fauna by humans	Clearing for agric. & development	Mining/Quarrying	Roading	Recreation	Vandalism/Disturbance by Humans	Interspecific Competition	Climate Change	Firewood Collection	Eucalypt Dieback	Dams/Imp/Hydroelec	Mineshaft Collapse/Overgrown Entrances
MAMMALS																			
Leadbeater's Possum	2	3	3	1	0	0	0	0	0	0	1	0	0		2				
Spot-tailed Quoll	1	2	3	2	2	-	0	0	1	-	1	0	0						
Squirrel Glider	2	1	0	2	0	2	-	0	2	0	2	0	0						
Broad-toothed Rat	1	1	1	3	2	2	0	0	1	0	0	0	0						
Smoky Mouse	2	2	1	1	0	0	-	0	1	-	1	1	0						
Swamp Antechinus	1	3	0	2	0	1	-	0	0	0	0	2	0						
Brush-tailed Phascogale	1	2	1	3	1	1	1	0	3	1	1	0	0						
Common Dunnart	1	2	0	1	1	2	-	0	2	0	1	1	0						
Dingo	1	1	1	2	2	1	-	0	0	0	0	0	0						
Eastern Horseshoe Bat	-	-	-	2	2	0	0	0	0	2	0	0	3						3
Large-footed Myotis	1	1	2	1	2	0	-	0	1	2	2	1	1						
Common Bent-wing Bat	-	-	-	2	2	0	0	0	1	2	0	0	3						3
Grey-headed Flying-fox	0	0	0	0	1	0	-	0	1	0	0	0	0						
BIRDS																			
Swift Parrot	-	-	1	-	-	-	-	0	1	-	-	0	-			1	1		
Helmeted Honeyeater	0	3	1	1	0	1	2	0	1	0	0	1	1	3	2		2		
Painted Honeyeater	-	-	1	-	-	1	-	-	1	-	-	-	-	1			1		
Regent Honeyeater	-	1	1	-	-	1	-	0	2	-	1	-	-	2		2	1		
Grey-crowned Babbler	1	1	1	1	-	1	-	-	1	-	1	-	1			1	1		
Bush Stone-curlew	-	-	1	1	1	1	-	1	1	-	-	-	1			1			
Square-tailed Kite	1	2	1	0	0	1	-	1	1	-	1	0	1						
Grey Goshawk	1	1	2	0	2	-	-	-	1	-	1	1	1						
White-bellied Sea-Eagle	-	-	1	0	1	-	-	0	1	-	-	1	2	-					
Barking Owl	-	-	-	0	1	2	-	0	2	-	-	-	-						
Powerful Owl	1	2	3	1	0	1	1	0	3	1	-	0	1						
Masked Owl	1	1	2	3	2	1	-	0	3	1	-	0	1						
Sooty Owl	1	2	3	0	1	0	-	0	1	1	1	0	1		2				
REPTILES																			
Alpine Bog Skink	2	3	0	1	0	3	-	0	2	0	3	3	0		3				
Swamp Skink	1	1	1	1	0	1	-	0	1	-	1	0	0		2				
Glossy Grass Skink	1	1	1	1	0	2	-	0	2	-	1	0	0		2			1	
FROGS																			
Giant Burrowing Frog	2	2	2	1	1	0	0	0	-	-	1	1	0						
Spotted Tree Frog	2	2	3	3	2	1	-	0	0	2	3	2	1		3			3	
Alpine Tree Frog	-	-	-	-	0	2	0	0	2	0	-	2	0		3			1	
Baw Baw Frog	0	3	3	1	0	2	1	0	2	0	1	2	0		3				
TOTAL SCORE	**27**	**43**	**40**	**37**	**26**	**30**	**5**	**2**	**41**	**12**	**24**	**18**	**18**						
NO. OF SPECIES AFFECTED																			
Major threat	0	5	6	4	0	1	0	0	3	0	2	1	2						
Moderate threat	6	9	4	6	9	7	1	0	8	4	2	4	1						
Minor threat	15	10	14	13	8	13	3	2	16	4	14	7	10						
Not a threat	3	1	5	6	12	8	7	28	5	11	7	16	16						
Unknown threat	9	7	4	4	4	4	22	3	1	14	8	5	4						
Total no. affected	**21**	**24**	**24**	**23**	**17**	**21**	**4**	**2**	**27**	**8**	**18**	**12**	**13**						

Notes: (a)The ratings provided in this table assume no management arrangements in place to address threatening processes; (b) the ratings are relevant to the Central Highlands region only.

In this context, considerable resources are committed to the prevention and suppression of unplanned fires and a key element of forest management in the region is the development and implementation of threatened species strategies and detailed provisions to mitigate the effects of threatening processes operating in forests.

An explanation of each threatening process follows, with a discussion of the key species affected in the Central Highlands and the current or proposed management actions taken to mitigate the effects of each threatening process.

Fire (planned)

This category includes the effects of fire prevention activities such as fuel reduction burning within forested areas and ploughing, slashing and burning along roadsides, as well as the effects of regeneration burning following timber harvesting. Fuel reduction burns are largely carried out in foothill mixed species forests in the Central Highlands (LCC 1991a), not in wet forests and alpine areas. Within the Central Highlands, planned fire is recognised as a threat to 21 species; it was classified as a moderate threat to six species and a minor threat to 15 species. It is not considered a threat to three species, and its impact is unknown for nine species (Table 6.4).

The effects of fire on fauna vary depending on the fire regime, including the frequency, intensity and season of burns (Wilson 1994). Inappropriate burning regimes, such as too frequent or too infrequent burning, can alter vegetation floristics and structure and may affect the habitat suitability for some species of fauna. The response of species to fire depends on their habitat and food requirements. Some fauna species may be specially adapted to certain successional stages of vegetation. Particular fire regimes may create unsuitable successional vegetation stages. The Smoky Mouse appears reliant on understorey vegetation components strongly influenced by the frequency and intensity of fires (Menkhorst 1995). An inappropriate fire regime is a moderate threat to the Smoky Mouse in the Central Highlands. However, there is a lack of information on the ecological requirements of this species, particularly in relation to fire (Lee 1995). Planned fire can also result in the loss of habitat components such as den sites for Spot-tailed Quolls (C. Belcher pers. comm.) and may represent a threat if it occurs near, and subsequently spreads into, fire-sensitive habitat.

Planned fire is classified as a moderate threat to the Alpine Bog Skink and Spotted Tree Frog. The Alpine Bog Skink occurs in subalpine to alpine heathlands, areas which are not subjected to fuel reduction burning. However, a number of records of the species are close to areas where fuel reduction burning may be undertaken (P. Robertson pers. comm.). Although the species may be more widespread than current records indicate, its distribution is disjunct and populations may be lost if a fuel reduction burn spreads into suitable habitat.

Fire management in the Central Highlands is guided by the Code of Practice for Fire Management on Public Land (CNR 1995d), which outlines general principles and guidelines for fuel reduction burning, and Regional Fire Protection Plans (Dandenong Region, Central Gippsland Region and draft Alexandra Region Fire Protection Plans). Each fire protection plan includes a fuel management strategy, based on five zones. Fuel-reduction burns are undertaken in three of the strategically located zones to maintain fuel at defined levels. 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 plan. This plan details ecological issues including the known or likely presence of rare or threatened fauna in or near the area to be burned, and particular habitats needing protection. Such plans must take into account prescriptions developed for the protection of threatened species (CNR 1995a). Action statements include fire management prescriptions for species which are threatened by this process. However, for the majority of species, the effect of fuel reduction burning is unknown. Monitoring of populations is required to determine the effectiveness of prescriptions which are often developed with a limited knowledge of a species' ecology, the habitat effects of the process, and the impact on populations. The Proposed Central Highlands Forest Management Plan (NRE 1996b) provides for a review of fuel reduction burn operations in areas containing fire sensitive biological values when the Regional Fire Protection Plans are revised.

Fuel reduction burning is known to have been undertaken within the catchments of several known sites of the Spotted Tree Frog. While the effects of this activity are still unclear, it may result in changes to vegetation adjacent to streams which could potentially affect populations (G. Gillespie pers. comm., Robertson in prep.). In addition, the effect of too frequent fuel reduction burns in catchments upstream from Spotted Tree Frog habitat may cause changes to the water quality of streams which may detrimentally affect breeding (Robertson in prep.). Although recognised as a potential threat, the effect of burning practices on the species is unknown (Watson *et al.* 1991, P. Robertson in prep, G. Gillespie pers. comm.). It is not known how far Spotted Tree Frogs move away from streams into the adjacent forest - this information is required for maintaining appropriate fire management prescriptions (P. Robertson pers. comm.). Until this critical habitat zone adjacent to streams is known, a 300m Special Protection Zone buffer on both sides of streams has been proposed for confirmed and potential frog locations within State forests of the Central Highlands region (NRE 1996b).

Fire prevention techniques used in remnants of native vegetation along roadsides include bulldozing and grading, slashing, ploughing, grazing and burning. These activities may result in the degradation and loss of habitat of species reliant on roadside remnants. Such species include Squirrel Gliders and Grey-crowned Babblers (Davidson and Robinson 1992, Adam and Robinson 1996, J. Alexander pers. comm.). Too frequent burning can limit the regeneration of tree species and thereby limit habitat suitability in the long-term for species such as the Squirrel Glider which require tree hollows for nesting and roosting. Such activities are a moderate threat to the Squirrel Glider within the Central Highlands (J. Alexander pers. comm.). The Central Highlands is the southerly extension of the known range of the Squirrel Glider; there is very little suitable habitat within the region and it has only been recorded from one locality (Atlas of Victorian Wildlife). The current status of the species is unknown in this region.

High intensity burning of the debris left following timber harvesting is a management practice used to remove fuel, reduce fire hazards, and is the preferred technique for seedbed preparation in the Central Highlands Ash forests (Jeremiah and Roob 1992). Of the trees retained on coupes as wildlife habitat, dead trees (stags) generally collapse following regeneration burns, and live trees, particularly ash-eucalypts (Alpine and Mountain Ash and Shining Gum), are often killed (Jeremiah and Roob 1992). Although still able to provide habitat for hollow-dependent fauna, dead trees are more susceptible to collapse due to windthrow and are unlikely to provide habitat for the length of the rotation (Lindenmayer *et al*. 1990, Macfarlane and Seebeck 1991, Milledge *et al.* 1991). This process is identified as a moderate threat to Leadbeater's Possum and a minor threat to the Sooty Owl. Current Leadbeater's Possum management strategies address the loss of

retained hollow-bearing trees during regeneration burns. In accordance with the Action Statement (Macfarlane and Seebeck 1991; Macfarlane *et al*. 1995) protective measures used to aid the continuing survival of trees retained on logging coupes include using fire retardants and the provision of fuel breaks around such trees. Furthermore, strategically retaining groups of trees adjacent to buffer strips, or on the margin of coupes where there is adjoining forest, are practices employed to aid continuing survival of trees retained on coupes. The survival of retained trees and their subsequent use by wildlife requires monitoring to assess how effective this management technique is at providing wildlife habitat, and over what time period. Other management strategies pertaining to the conservation of Leadbeater's Possum are outlined in the following timber harvesting sub-section.

Fire (unplanned)

Wildfire is an integral part of the ecology of forests, however wildfire can have a significant effect on vegetation and the distribution and abundance of fauna. The frequency and intensity of wildfire strongly influences the floristics of the understorey as well as the structure and age composition of the overstorey (Ashton 1981). The wildfires of 1939 burnt large areas of Mountain Ash forest within the Central Highlands, and in areas where the fire was most intense, stands of even-aged forest regenerated in place of old-growth forest (LCC 1991). The steepness and heavily forested nature of some of the Central Highlands makes it highly vulnerable to wildfire (CNR and AHC 1994). Fire can cause direct mortalities of animals, and may eliminate critical habitat components and entire populations. Mortalities may also result from food shortages and predation following fire (Wilson 1994). Species occurring in small, disjunct populations, or species with narrow habitat requirements, are particularly vulnerable to wildfire.

In the Central Highlands, severe wildfire is considered a major threat to Leadbeater's Possum, Swamp Antechinus, Helmeted Honeyeater, Alpine Bog Skink and Baw Baw Frog. The 1983 Ash Wednesday wildfires are thought to have caused extinction of local populations of the Helmeted Honeyeater (Menkhorst and Middleton 1991, Menkhorst 1992, McCarthy 1996). The Swamp Antechinus is only known to occur in one State park within the Central Highlands; a wildfire in this park could result in elimination of the species from the region. Although wildfire is uncommon on the Baw Baw Plateau (DCE 1992a), the current low numbers of the Baw Baw Frog means that wildfire is a major threat, as it has the potential to affect the entire population. During the summer and autumn, adult Baw Baw Frogs are known to shelter amongst vegetation and litter in snow-gum woodland and montane wet forest; fires at this time are likely to have the greatest impact on the species (Hollis 1996). Wildfire is also considered a moderate threat to nine priority species and a minor threat to ten of the priority species. (Table 6.4).

The Department of Natural Resources & Environment has the responsibility for prevention and suppression of fire in State Forest, National Park, and all protected public land. The Code of Practice for Fire Management on Public Land (CNR 1995d) and regional fire protection plans include strategies for fire prevention, preparedness, fire suppression and recovery after wildfire. 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.

Timber harvesting

This category includes the potential effects of timber harvesting, excluding associated activities such as regeneration burning and road construction and use. Some 36% of the forested public land in the Central Highlands is suitable and available for timber harvesting.

In the Central Highlands, timber harvesting is considered a major threat to Leadbeater's Possum, Spot-tailed Quoll, Powerful Owl, Sooty Owl, Spotted Tree Frog and Baw Baw Frog, a moderate threat to Large-footed Myotis, Giant Burrowing Frog, Grey Goshawk and Masked Owl, and a minor threat to 14 of the priority species (Table 6.4). A detailed discussion of Leadbeater's Possum is provided in box 2, below.

Box 2 Profile of an endangered species: Leadbeater's Possum

A small possum endemic to the Central Highlands of Victoria, Leadbeater's Possum is classified as Endangered (CNR 1995a, ANZECC 1991). It is currently found mainly in mountain forests dominated by Mountain Ash, Alpine Ash and Shining Gum and has recently been recorded in Snow Gum woodland at Lake Mountain (Jelinek et. al. 1995). A small population also exists in Yellingbo State Nature Reserve, in lowland swamp forest. The habitat requirements of the species are primarily determined by:

- nest-tree abundance and distribution
- food availability, particularly wattle in the understorey
- vegetation structure which allows the possum to move freely through the forest in search of food.

The 1939 fires burnt approximately 84% of the Central Highlands ash-eucalypt forests. Young regeneration resulting from these fires, or uneven-aged ash-eucalypt forest, that contains wattles and an ample supply of hollow-bearing trees is ideally suited for the species. The fire-killed remnants of mature forest and resultant regrowth from the 1939 fires has provided abundant feeding and nesting habitat during the past 30 years. However, as the fire-killed nest trees decay and fall, the extent of this type of habitat is diminishing. Loss of further potential nest trees in Leadbeater's Possum habitat due to timber harvesting would further reduce the ability of the species to survive.

Available information indicates that preferred nest trees are collapsing naturally at an average annual rate of more than 3.6% which will mean that, in the next 50 - 100 years, their availability for Leadbeater's Possum will be significantly diminished.

Furthermore, even if timber harvesting were excluded, the regrowth ash forests will not be capable of providing suitable nest sites for a further 150 years - assuming that ash trees must be about 200 years old before they can provide suitable nest sites. It therefore follows that the existing older-aged forest must continue to provide habitat for at least another 150 years, unless alternative silvicultural systems can be applied at an operation level (LCC 1994).

Of the 23,900 ha of older-aged forest in the Central Highlands, almost 10,000 is within the Yarra Ranges National Park, with the remaining 14,000 ha in State forest. The objective of the Leadbeater's Possum Action Statement (CNR 1995B) is to conserve the species over its known range. To achieve this, timber harvesting is excluded from all Zone 1A possum habitat (see table below) that is, ash forest containing a certain density of mature and senescing trees. As a result, the 14,000 ha of older-aged forest in State forest referred to above has been included in the Special Protection Zone (SPZ) in the proposed Central Highlands Forest Management Plan. Zone 1B habitat, as defined in the table below is also protected from timber harvesting at least until it no longer provides suitable Leadbeater's Possum habitat.

Leadbeater's Possum habitat Zones

Zone	*Density of hollow-bearing trees*[1]	*Hollow-bearing tree*[1] *type*	*Wattle density*[2]	*Management*
1A	> 12 per 3 ha in patches > than 3 ha	Living trees containing hollows	n/a	Conservation Reserves Special Protection Zone
1B	> 12 per 3 ha in patches greater than 10 ha	Dead or living trees containing hollows	> 5 m^2/ha	Conservation Reserves General Management Zone but excluded from timber harvesting while Zone 1B attributes remain.
2	n/a	n/a	n/a	Conservation Reserves General Management Zone

Notes:
1. Hollow-bearing trees are Mountain Ash, Alpine Ash or Shining Gum, either living or dead.
2. Density is expressed as basal area - the sum of the cross-sectional area of the boles of the trees.

Source NRE (1996)

Analysis of the forest containing suitable habitat is based on 21 Leadbeater's Possum Management Units (LMUs) which have been delineated across the Central Highlands based on the extent and spatial distribution of ash-eucalypt type forest . Each LMU generally contains between 6000 ha and 10 000 ha of ash-type forest and is composed of one or more adjacent forest management blocks, containing contiguous patches of ash-eucalypt forest. The target for the conservation of Leadbeater's Possum will be to maintain viable populations of the species in all LMUs. The LMU boundaries may be revised following completion of mapping of the ash-eucalypt forest across the Central Highlands being undertaken under the Statewide Forest Resource Inventory.

The Proposed Forest Management Plan protects all Zone 1A habitat (important for the long-term conservation of the species) according to the principles set down in the Leadbeater's Possum Action Statement (Macfarlane *et al*. 1995). In addition, timber harvesting will continue to be excluded from Zone 1B habitat in State forest until either of the Zone 1B habitat attributes (the presence of dead mature or senescing trees, or wattle understorey) no longer exist.

The Plan also achieves the target of retaining patches of ash-eucalypt forest totalling 600 ha per LMU in 15 of the LMUs. Ash-eucalypt forest in the six remaining LMUs is primarily 1939 regrowth. This forest will not start to develop Zone 1A habitat characteristics for another 50 to 100 years. By the year 2100, at least 44% of the total area of ash-eucalypt forest in the Central Highlands will be over 150 years old (see Table below). This future relative abundance provides significant opportunity to adapt the Leadbeater's Possum reserve system to future management requirements. (NRE 1996).

Area by age-class distribution of ash-eucalypt forest included in conservation reserves or the SPZ in the Central Highlands from 1996 to 2146

	1996	***2046***	***2096***	***2146***
Ash-eucalypt forest less than 100 years old	61 400 ha	4900 ha		
Ash-eucalypt forest 100 to 150 years old		56 500 ha	5100 ha	500 ha
Ash-eucalypt forest more than 150 years old	23 900 ha	23 900 ha	80 200 ha	84 800 ha

Notes:

1. Areas are expressed to the nearest 100 ha.
2. The total area of ash-eucalypt forest in the Central Highlands is 181 000 ha. Of this, 89 500 ha or 49% is in conservation reserves or the SPZ (includes 4200 ha of ash-eucalypt forest which is considered unstocked from a commercial point of view).
3. Assumes no wildfires
4. Assumes that existing 'mature' forest is over 150 years old
5. Assumes that unstocked ash-eucalypt forest in conservation reserves and the SPZ will not be restocked
6. Excludes ash-eucalypt forest in GMZ - Other and in Other Public Land

To analyse areas of forest which would form the most appropriate future system of retained habitat for Leadbeater's possum a computer model is being used. In the model, the forest is ranked according to its suitability for Leadbeater's Possum habitat, using age class, density of live and dead hollow-bearing trees and slope data, for each patch of forest. The model will produce a series of options of suitable habitat. Within each LMU, patches (generally greater than 50 ha) of ash-eucalypt forest will be retained (with a target of at least 600 ha in each LMU). On completion of the modelling and subsequent field authentication, the zoning system established in the Proposed Forest Management Plan will be reviewed in the light of the options provided by the model. Where possible, the patches will be linked through the linear reserve system. In State forest, the patches will form part of the SPZ (NRE 1996).

NRE is also continuing research into, and operational trial of, the retained overwood silvicultural system in regrowth stands adjacent to stands of veteran trees with the aim of promoting mixed-aged forest that could benefit Leadbeater's Possum.

Other detailed prescriptions relating to the management of habitat for Leadbeater's Possum in timber production forests in the Central Highlands are outlined in the Action Statement (Macfarlane *et al*. 1995), and the proposed Forest Management Plan. A Recovery Plan is currently in the final stages of preparation.

Timber harvesting threatens a range of fauna species through its short-term effect of habitat removal, and more importantly, by its 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 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). Many species, including arboreal mammals and forest birds, require hollow-bearing trees for roosting or nesting (Smith and Lindenmayer 1988, Davey 1993). For species such as the Sooty Owl and Powerful Owl which utilise large tree hollows for nesting, have large home-ranges and are partly dependent on hollow-dependent prey, loss of hollow-bearing trees as a result of timber harvesting operations is a major threat (Milledge *et al.* 1991). The 1939 fires significantly reduced the availability of hollow bearing trees and old growth forests in the Central Highlands. Timber harvesting is therefore confined to regrowth stands to ensure protection of remaining mature and old growth forest in Ash forests. No harvesting of old growth in mixed species forests is permitted in the Central Highlands.

The Central Highlands Proposed Forest Management Plan (DNRE 1996b) management guideline for Powerful, Sooty and Masked Owls provides for the maintenance of good quality habitat for at least 60% of the species' estimated populations occurring across the Central Highlands. Both conservation reserves and State forest contribute to conservation of owl habitat.

Forest reserved specifically for owls may include: areas surrounding known owl breeding sites; areas with confirmed sightings of owls over the last five years; and areas containing suitable habitat. Areas of habitat reserved for each species includes: Powerful Owl 500-800 ha in the SPZ; Sooty Owl - 300 to 500 ha in SPZ; Masked Owl: 500 ha in SPZ. Other conservation measures include: a 250 m radius SMZ around nesting or residence sites for trees used within the last 5 years, within which nest trees and all trees within a radius of 100 m from the nest tree will be protected and within which timber harvesting operations, road construction and other activities likely to disturb breeding activity will be excluded during the breeding season; retention of ash eucalypts originating before 1900 in timber harvesting coupes; protection of a minimum of 30% of each EVC; and protection of at least 60% of old-growth forest. In reality, virtually all old growth forest is protected under the Central Highlands Proposed Forest Management Plan except for some of the drier forest types in the north-east of the region where at least 60% is protected but none is used for timber production.

Alteration of forest structure by timber harvesting can cause some areas of forest to become sub-optimal. Species may need to expend more energy to forage in sub-optimal habitat, the ability to reproduce and dispersal may be curtailed, 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). The Code of Forest Practice for Timber Production (NRE 1996a) (Code) 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 operational planning, reservation of appropriate areas and vegetation corridors. Riparian and other vegetation must be retained within at least 20m of a permanent stream and at least 10m 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 Large-footed Myotis and Broad-toothed Rat. The Code also provides for retention of wildlife habitat at the coupe level. Prescriptions have been developed to link protected areas and reserves with wildlife movement corridors, to retain habitat trees, to retain and protect biologically significant habitats and to modify harvesting.

Loss and fragmentation of habitat as a result of timber harvesting, particularly clearfell logging, is potentially a major threat to the Spot-tailed Quoll (C. Belcher pers. comm.). There is a lack of detailed ecological information concerning this species and very little is known of its occurrence in the Central Highlands. There are very few records and there have been no systematic surveys making appropriate management difficult (Mansergh and Belcher 1992). Management actions for Spot-tailed Quoll specified within the Proposed Central Highlands Forest Management Plan are: approximately 500 ha to be included in the SPZ within a 3 km radius from the record site; no threatening poisons to be used within 1 km of a record less than 5 years old; identification of 50 sites in the Central Highlands before review of the management plan; and a minimum 200 m buffer around denning/latrine sites (NRE 1996b).

The Giant Burrowing Frog is known to use a wide range of forested environments and has been recorded substantial distances from likely breeding sites (Mazzer 1994). The effect of fragmentation of the forest environment on this species is unknown although it may be significant (G. Gillespie pers. comm.). Intended management actions outlined in the Action Statement for this species (Mazzer 1994) are only relevant to post 1980 records. There is only

one historic breeding record of the Giant Burrowing Frog within the Central Highlands; it has not been recorded since and the status of this cryptic species is unknown.

Timber harvesting may lead to increased levels of sediment in streams which in turn can impact on species reliant on instream habitat. Furthermore, regrowth Ash forest which regenerates following timber harvesting operations may potentially alter stream flow and perenniality within catchments. Loss of forest cover may increase light reaching streams and thereby stream temperatures (Campbell and Doeg 1989). Given these implications, timber harvesting is considered a major threat to the Spotted Tree Frog. Populations may be detrimentally affected by altered streambed conditions and changes to water quality and flow. Changes in flow rates and increased sedimentation may affect the viability of eggs, the survival of tadpoles and the availability of egg deposition sites (Gillespie and Hollis 1996, Robertson in prep.). The full range of habitats used by the Spotted Tree Frog during different growth stages and different seasons is unknown. The provisions of the Proposed Central Highlands Forest Management Plan provides for a 300m special protection zone buffer, which excludes timber harvesting either side of streams with confirmed or potential Spotted Tree Frog localities.

The Large-footed Myotis feeds on aquatic insects and fish; altered stream conditions as a result of timber harvesting operations may indirectly impact on this species by affecting its prey (L. Lumsden pers. comm.). The Proposed Central Highlands Forest Management Plan management actions specify that known colonies of this species are protected by a 100 m riparian buffer on both sides of streams.

Until recently the Baw Baw Frog was believed to be confined to the Baw Baw Plateau, within an area of 80 km^2 (Malone 1985), which is primarily within the Baw Baw National Park. The species has recently been recorded at lower elevations (1100-1300 m) from Montane Wet Forest (*Eucalyptus delegatensis* and *E. nitens*) in areas available for timber harvesting (G. Gillespie pers. comm.). Adults of this species are known to use habitat adjacent to and some distance from breeding sites. Very little is known of movements of juveniles and sub-adults (Hollis 1996). Timber harvesting activities have the potential to affect local populations of the Baw Baw Frog, destroy sheltering sites, affect prey abundance, alter micro-climates, fragment habitat and allow the invasion of exotic weeds and predators (Gillespie and Hollis 1996, Hollis 1996). A survey of areas of potential Baw Baw Frog habitat in the Montane Wet forest and Subalpine Wet Heathland within State forest on the south-west face of the Baw Baw escarpment was conducted in October 1996-March 1997. Until the results of the survey become available, the Proposed Central Highlands Forest Management Plan excludes timber harvesting from areas containing potential habitat for the Baw Baw Frog in Montane Wet Forest above an altitude of 1100m (NRE 1996b).

Predation and competition by introduced species

This category covers predation by introduced species (e.g. feral cat, fox, trout) as well as competition by introduced species for resources such as food or shelter. It does not include predation or competition by native species.

Foxes and cats are widespread throughout Victoria, occurring in most habitat types. Predation by introduced animals (primarily foxes and cats) is recognised as a major threat to the Brush-tailed Phascogale (Soderquist 1993) and the Broad-toothed Rat. Broad-toothed Rats occur in highly localised, disjunct populations in the Central Highlands and are therefore particularly susceptible

to population declines from predation (Menkhorst 1995). Predation of the eggs and tadpoles of Spotted Tree Frogs by trout represents a major threat to this species in the Central Highlands. Trout may be the most abundant fish species in streams within the Central Highlands (T. Raadik pers. comm.). Predation by introduced species is considered a moderate threat to five species, including Swamp Antechinus, Squirrel Glider, Eastern Horseshoe Bat and Common Bentwing Bat. Squirrel Gliders require continuous tree cover for movement, and may cross open ground in fragmented habitat, making them more susceptible to predation (Alexander 1981). Predation by introduced species is considered a minor threat to 11 species.

Competition by introduced species for food and nest hollows is recognised as a major threat to Masked Owl, Spot-tailed Quoll and Dingo. Foxes may compete with Masked Owls for rabbit prey. While it is not known how important introduced prey is to the diet of the Masked Owl, competition for prey with foxes may be a major threat to the species (R. Loyn pers. comm.). There is some degree of dietary overlap between cats, foxes, feral dogs and Spot-tailed Quolls, however, the effect of these introduced predators on Spot-tailed Quoll populations is unknown (Mansergh 1984, Mansergh and Belcher 1992, Mansergh 1995c). There is also some dietary overlap between foxes and Dingoes (Brown and Triggs 1990). Although Dingoes generally feed on larger prey, competition with foxes particularly when prey is scarce, may impact on the Dingo population. The feral European honeybee is known to occupy hollow trees, and may compete for this resource with several native species which use hollows. Preferred sites for honeybees are generally within drier mixed-species eucalypt forests and may have an impact on species such as the Brush-tailed Phascogale (T. Soderquist pers. comm.).

Current predator control programs within the Central Highlands are mainly limited to trapping, shooting and baiting for wild dogs (Jeremiah and Roob 1992). Pest animal control programs within the Central Highlands include programs coordinated with adjacent landowners (Good Neighbour Program) and, where feasible, targeted programs throughout the region. The Proposed Central Highlands Forest Management Plan recognises Foxes, feral cats and wild dogs as being of particular importance for control within the region.

Pest Control

This category includes mortality of native species from feeding on poison baits (non-target poisoning) and secondary poisoning as a result of ingestion of poisoned prey. It also includes the potential impact of loss of significant food sources following control programs for introduced species such as Rabbits. Spraying of herbicides for weed control, pesticides for insect control, and food chain contamination by heavy metals are also included within this category. Pest control is recognised as a moderate threat to nine species and a minor threat to eight priority species. (Table 6.4).

Trapping, shooting and baiting of wild Dogs occurs in the Central Highlands (Jeremiah and Roob 1992); this represents a moderate threat to Dingoes and Spot-tailed Quolls. The effect on the Central Highlands Dingo population is unknown but studies from other areas have shown the effects can be intense, reducing local population numbers where control efforts are high. However, it may result in the fracture of social groups thereby resulting in an increase in breeding females (Corbett 1995). The effect of control measures on Dingoes requires monitoring and research. There is virtually no information on the Spot-tailed Quoll within the Central Highlands; there are few records of the species and the effect of wild Dog control methods are limited to research in East Gippsland (Belcher 1995c). Control of foxes using 1080 poison baits is also problematic for carnivores such as the Spot-tailed Quoll because of the risk of non-target poisoning, which can result in death of individuals or local populations (Mansergh and Belcher 1992, Belcher 1995b). Very little is known of the effects of pest control programs on the majority of species; monitoring and research is required to determine the most appropriate methods of control. Burying baits has been used as a remedial measure to reduce the incidence of non-target poisoning of species such as the Spot-tailed Quoll (Mansergh and Belcher 1992). However, studies have shown the species will dig up and ingest buried baits (Belcher 1995b). Within State forest in the Central Highlands region it is proposed that no threatening poisons are to be used within 1 km of Spot-tailed Quoll records less than 5 years old. The Proposed Central Highlands Forest Management Plan management guidelines states that resources directed to particular pest species should take into account the potential impact on the conservation of rare or endangered fauna, and programs should be monitored to ascertain effects on non-target species (NRE 1996b).

The Spot-tailed Quoll may also be susceptible to secondary poisoning by ingestion of poisoned Rabbits (Mansergh and Belcher 1992, Belcher 1995b). The Masked Owl is known to prey on Rabbits although the proportion of Rabbit prey in the diet of this species is unknown; the importance of loss of prey due to control programs including baiting and the calicivirus is unknown. There is also the risk of secondary poisoning following control programs (Peake *et al.* 1993, R. Loyn pers. comm.).

Insectivorous bats such as the Common Bent-wing Bat and Eastern Horseshoe Bat may be susceptible to poisoning through accumulation of pesticides (Dunsmore *et al.* 1994). Top order predators such as the Grey Goshawk may also be susceptible to contamination by pesticides (Mooney and Holdsworth 1988). Pesticides and herbicides may drain into streams which could impact on the Large-footed Myotis which feeds on aquatic invertebrates and fish (L. Lumsden pers comm) and Spotted Tree Frog (G Gillespie pers comm). The use of pesticides is not undertaken in public native forests in the Central Highlands. However, the use of chemicals for control of vegetation underneath powerlines in an area of known habitat of the Broad-toothed

Rat is a moderate threat to this species. Vegetation management at this site is being addressed in the management of the Bunyip State Park.

Grazing

Grazing of vegetation can limit or prevent vegetation regeneration and can alter the structure and floristics of vegetation. It may result in simplification of vegetation which can be detrimental to species which require a complexity of understorey and ground layers (eg. Glossy Grass Skink). Vegetation structure and floristics can be important in terms of shelter and as a food source. Plant species may be selectively grazed, and vegetation may have different tolerances to grazing and varying abilities to recover. Grazing can also include associated problems such as trampling of vegetation, soil compaction and the spread of weeds. It may also affect the health and longevity of existing trees due to increased nutrient levels which may lead to dieback (Landsberg *et al.* 1990). Grazing is considered a major threat to Alpine Bog Skink, a moderate threat to the Broad-toothed Rat, Squirrel Glider, Common Dunnart, Barking Owl, Glossy Grass Skink, Alpine Tree Frog, and Baw Baw Frog, and a minor threat to 13 species. It is not considered a threat to eight species, while its significance is unknown for four species (Table 6.4).

The Broad-toothed Rat exhibits a disjunct and localised distribution which is probably a reflection of its specialised habitat requirements. Loss of habitat as a result of grazing and trampling is considered a moderate threat; however the species security has probably increased in recent years through protection of riparian forest sites and cattle being excluded from alpine sites and many other sites in which the species is found are in National Parks (eg. Baw Baw National Park) and proclaimed catchment areas (eg Upper Yarra catchment) (Menkhorst 1995). A small and increasing number of feral cattle are present on the Baw Baw Plateau (DCE 1992a). Sambar Deer are also present in the vicinity of the Baw Baw Plateau, particularly in montane forest and montane riparian thicket. Cattle graze within frost hollows, grassy sub-alpine woodland and cleared areas on the plateau and damage to vegetation and soil, although localised, is significant (Hollis 1996). This has the potential to affect Baw Baw Frog, Alpine Bog Skink and Alpine Tree Frog. The impact of grazing on the Baw Baw Frog and its habitat is unknown (Hollis 1996, G. Gillespie pers. comm.). The Alpine Bog Skink has a limited, disjunct distribution and its habitat is particularly susceptible to reduction and modification, caused by erosion, arising from grazing and trampling ; therefore, grazing is considered a major threat (P. Robertson pers. comm.). Trampling of breeding sites by cattle has the potential to cause declines of the Alpine Tree Frog however, the impact is unknown (Gillespie *et al*. 1995). Control of feral cattle from the Baw Baw National Park is being addressed as part of the management plan priorities for the park.

Grazing of stock on Crown land is prohibited in alpine areas in the region. Elsewhere, currently 114 ha of State forest and 127 ha of Bunyip State Park are held under grazing licences. These licences specify conditions for depasture of stock within the licensed area. Grazing licences in Bunyip State Park are not in areas where Broad Toothed Rat and Swamp Antechinus have been recorded, and in accordance with LCC recommendations, will ultimately be phased out.

Grazing on private property which contains suitable habitat for Common Dunnart and Glossy Grass Skink is a moderate threat to these species. The habitat of the Glossy Grass Skink is characterised by dense vegetation within which animals bask and forage (Hutchinson and Donnellan 1988). Grazing and trampling by cattle may simplify the structure of the vegetation, making it less suitable as habitat (P. Robertson pers. comm.).

Throughout Victoria, Squirrel Gliders are restricted to isolated remnants of habitat amid extensive farmland. In some areas the species is restricted to narrow discontinuous strips of habitat along roads or streams. In the Central Highlands the species is known from one locality near the Goulburn River. Grazing of eucalypt and acacia seedlings may limit the regeneration and development of suitable habitat for species such as the Squirrel Glider (Menkhorst 1995, J. Alexander pers. comm.). The *Heritage Rivers Act* 1992 provides for the protection of Squirrel Glider habitat along the Goulburn River.

Disease

The significance of disease is largely unknown for most species, and is only noted as a threat for four species. The extreme vulnerability of the Helmeted Honeyeater makes it susceptible to any such events. Similarly, the Baw Baw Frog has an extremely restricted distribution making it potentially vulnerable to disease. Disease is also considered a minor threat to Brush-tailed Phascogales and Powerful Owls. Moribund Powerful Owls are occasionally recorded, although the cause of illness is unknown (R. Loyn, pers. comm.)

Harvesting of fauna by humans

This category covers direct interference to animals by humans in the form of collection or deliberate hunting, poisoning, or trapping. Overall this threat is considered as a minor threat to the Bush Stone-curlew and Square-tailed Kite in the Central Highlands.

Clearing for agriculture or development

Extensive clearing of native vegetation for agriculture and settlement has been a significant factor in the decline of many species and is partially responsible for the current threatened status of some species. Clearing affects species directly through loss of habitat and indirectly through fragmentation and isolation of habitat; many species are now confined to small isolated remnants of habitat. As a result, local populations are more vulnerable to extinction from catastrophic events such as wildfire and more susceptible to threatening processes including predation and interspecific competition. Habitat remnants are susceptible to degradation from agricultural activities in the surrounding farmland, firewood collection, and fire protection activities. Clearing is now confined to relatively small areas on private land. If suitable habitat for particular species is largely restricted to private land, then loss of habitat may be considered significant. Clearing is classified as a major threat to Brush-tailed Phascogale, Powerful Owl and Masked Owl, a moderate threat to eight priority species and a minor threat to 16 priority species. (Table 6.4).

The impact of vegetation clearance on the biology and ecology of the Baw Baw Frog is not well understood. The Mount Baw Baw Alpine Resort is within the species distribution stronghold and clearance of vegetation for resort development is a moderate threat (Gillespie *et al*. 1995, Hollis 1996, G. Gillespie pers. comm.). Clearing for resort development is also classified as a moderate threat to the Alpine Bog Skink (P. Robertson pers. comm.). The Baw Baw Frog Flora and Fauna Guarantee Action Statement (James and Morey 1993) provides for NRE input into any proposed development or improvement within the Mount Baw Baw Alpine Resort that may affect Baw Baw Frog habitat.

The Brush-tailed Phascogale is known to occur in the mixed rural, urban and forested land north-east of Melbourne. Clearing for urban development causes loss and fragmentation of the species' habitat and is a major threat (T. Soderquist pers. comm.). The Common Dunnart is also recorded around the northern outskirts of Melbourne and clearing for urban development, and the associated habitat modification, is a moderate threat to this species in the Central Highlands (J. Seebeck pers. comm.). Similarly, urban development is a threat to the Powerful Owl, particularly in forested areas close to Melbourne (R. Loyn pers. comm.) although the current population appears stable. The Barking Owl is often recorded in habitat with moderate tree cover including wooded farmland near forests or along ecotones of large forest blocks. The species is known to utilise broad strips of riverine forest along major creeks. However, isolated, narrow strips of linear habitat do not appear to be used (Robinson 1994). Clearing for agriculture and the associated fragmentation of habitat is a major threat to this species (R. Loyn pers. comm.).

This threat is significantly mitigated by the implementation of native vegetation retention controls under the *Planning and Environment Act* 1987. Permits are required from local municipalities to clear native vegetation.

Mining/Quarrying

Mining within the Central Highlands has, in the past, been mainly for gold with minor associated metals including stibnite and cobalt and rare occurrences of quartz (Jeremiah and Roob 1992). Several products including rock, gravel, sand, clay, and soil have also been quarried from surface and river deposits. Poorly sited quarries and borrow pits can have adverse effects on water quality (NRE 1996b). Although mining is considered a threatening process, past mining activities would have had greater impact on species than modern mining activities which are regulated through a range of mechanisms.

Mining/quarrying is a moderate threat to Eastern Horseshoe Bat, Common Bent-wing Bat, Large-footed Myotis and the Spotted Tree Frog and a minor threat to three priority species. For most of the threatened species covered by this review, the effect of mining/quarrying is either unknown or it is not classed as a threat (Table 6.4).

Mining and eductor dredging in and around upland streams can cause deterioration of upland riparian habitats. Eductor dredging is believed to alter the natural ecology of streams (Watson *et al*. 1991). Effects can include an increase in turbidity of water downstream of an operation, mobilisation of chemicals such as mercury, local bank erosion and increased bed erosion (Parliament of Victoria Environment & Natural Resources Committee 1994). Most of the rivers in the Central Highlands with road access are believed to have been dredged in the past. Disappearances and declines of Spotted Tree Frog populations appear to be linked to eductor dredging activities which can have deleterious effects on frog embryos, larvae and adults (Watson *et al.* 1991). Impacts on populations may not be restricted to the area dredged but also to habitats downstream (Gillespie and Hollis 1996). Eductor dredging activities are currently illegal in Victoria.

Species which are dependent on streams, such as the Large-footed Myotis, may also be affected by mining and extraction activities in and around streams (L. Lumsden pers. comm) if these activities affect water quality with subsequent effects on the instream fauna on which this species depends.

It is likely that the creation of mines in the Central Highlands region in the past led to an expansion in the distribution of the Eastern Horseshoe Bat and Common Bent-wing Bat. Renewed interest in reworking old mines represents a potential threat to bats which rely on such sites (Lumsden *et al.* 1991). It is proposed that known colonies of Eastern Horseshoe Bat are to be protected within the Central Highlands region by a 100m buffer (NRE 1996b). There are, however, mines within the region which have not been surveyed for the presence of these species. There is the potential that there is an Eastern Horseshoe Bat maternity colony in the Central Highlands. (Lumsden *et al.* 1991).

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 the National Parks Act consents. 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 can address environmental considerations such as biodiversity conservation. Similarly, extractive industries require a work plan and a consent of the relevant Minister for extractive operations. The Proposed Central Highlands Forest Management Plan (NRE 1996b) specifies that consent to extraction activities should be based on: consideration of the impact of the proposal on the existing zoning scheme, the availability of alternative resources on freehold land or other sites, and the environmental and other impacts of the proposal. No new extraction activity will be permitted within the Special Protection Zone (SPZ) unless it will make a significant contribution to the regional economy, and unless the values within the SPZ can be maintained or provided elsewhere. As a minimum, licence conditions, Work Plans and proposed NRE managed extraction activities should address biodiversity considerations, protection of catchments and streams, rehabilitation and revegetation of the land and impacts on other forest values including recreation and tourism, sawlog resources, cultural and landscape values and maintenance and management of roads (NRE 1996b).

Roading

This category includes habitat destruction and alteration of hydrological regimes by roading. Roading can directly destroy habitat, create barriers to movement, increase the potential of erosion and weed invasion, and increase water turbidity and siltation if associated with creek crossings (Lumsden *et al*. 1991). There is evidence that introduced predators such as Foxes utilise tracks as pathways (May and Norton 1996). The principal sources of sedimentation are likely to be associated with unsealed roads and tracks. Of greatest concern are roads and tracks that are close to streams, and poorly constructed or maintained tracks on erodible soils, especially at stream crossings. Extra attention is now paid to planning the road and track network to avoid threatened species habitat, minimise environmental damage and provide high standard stream crossings. All new roads and tracks used for timber production must be built to standards outlined in the Code of Forest Practices for Timber Production (NRE 1996a). However, many roads and tracks were built prior to introduction of the Code and do not meet today's standards, and accordingly this is a significant threat. Roading is considered a major threat to the Alpine Bog Skink and Spotted Tree Frog, a moderate threat to the Squirrel Glider and Large-footed

Myotis, and a minor threat to a further 14 species. Its impact is unknown for eight species and it is not considered a threat for seven species (Table 6.4).

The Alpine Bog Community, habitat of the Alpine Bog Skink, is particularly vulnerable to disturbance. This community is listed as threatened under the *Flora and Fauna Guarantee Act* 1988. Construction of roads may impact on the Alpine Bog Skink directly through habitat destruction and indirectly through the diversion of water and the introduction of pathogens and non-bog plant species (P. Robertson pers. comm.). The likelihood of road construction within the Alpine Bog community, the habitat of Alpine Bog Skink, is low. However, there are a range of processes (eg Code of Forest Practice for Timber Production) in which flora and fauna values are addressed prior to the approval of the construction of new roads within public land.

The Large-footed Myotis is largely dependent on aquatic prey. A decline in aquatic prey as a result of disturbance from roading is a moderate threat to this species in the Central Highlands.

Construction of roads and tracks results in the exposure of soil which is then vulnerable to erosion and weed invasion and can cause increased sedimentation of streams and alteration of riparian habitats. Roads adjacent to streams 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). These changes can be detrimental to the Spotted Tree Frog by affecting the growth and survival of eggs and tadpoles or by changes to the general characteristics of the riparian habitat which may affect adult recruitment, breeding or survival (Watson *et al.* 1991). The Central Highlands Proposed Management Plan (NRE 1996b) management prescription for Spotted Tree Frog includes the following actions relating to roads and tracks in catchments where the Spotted Tree Frog has been recorded: new roads or stream crossings should be constructed according to recommendations outlined in O'Shaughnessy (in prep.); all roads or tracks not required for management, harvesting or fire protection purposes should be progressively closed and rehabilitated; and roads or tracks which are retained should be upgraded to standards outlined in O'Shaughnessy (in prep.), and where appropriate seasonally closed; and the number of stream crossings over permanent and temporary streams or drainage lines should be minimised. Furthermore, the management prescription states no new roads or stream crossings should be constructed within 1 km upstream of confirmed and potential localities of the species (NRE 1996b).

In State Forest, all new roads and tracks must be built to comply with the Code of Forest Practices for Timber Production which includes goals and guidelines for planning, location, design, construction, maintenance and use of timber extraction roads and stream crossings. These guidelines include measures to minimise risks to environmental values such as soil and water quality. The Proposed Central Highlands Forest Management Plan (NRE 1996b) includes management guidelines for the determination of the road network to be maintained in State forest. Priority areas include catchments containing threatened fauna that are susceptible to increases in stream sedimentation; catchments known to contain the Spotted Tree Frog are highlighted. Guidelines are also outlined for road and track closures. NRE will prepare in consultation with water catchment authorities an annual road works plan that specifies the maintenance requirements of roads and tracks in restricted access catchments (NRE 1996b).

Due to extensive clearing in the past, much of the habitat of the Squirrel Glider is confined to narrow strips along roads or streams (Menkhorst, 1995). The species requires continuous tree

cover for movement; gaps can prevent access to adjoining habitat and Gliders attempting to cross open space on the ground are highly vulnerable to predation. Road maintenance and widening can result in loss of canopy connectivity, and loss and degradation of isolated remnants of suitable habitat and is a moderate threat to the species in the Central Highlands (Alexander 1989, J. Alexander pers. comm.). The only Central Highlands record of this species is from the riverine forests along the Goulburn River (which is designated as a Heritage River) and therefore the potential threat described above is unlikely to be significant.

Recreation

A range of recreational activities which can damage or destroy habitat or disturb fauna. This includes use such as 4-wheel driving, trail bike riding, cross country and downhill skiing, hiking, fishing, horse riding and camping. Such activities can directly remove or trample vegetation, cause soil compaction, pollution and sedimentation of streams, erosion and the spread of weeds. Recreation activity is considered a major threat to the Alpine Bog Skink, a moderate threat to the Swamp Antechinus, Spotted Tree Frog, Alpine Tree Frog and Baw Baw Frog, and a minor threat to seven species. The majority of species covered by the review are not considered threatened by recreation, and it is an unknown threat for five species (Table 6.4).

The habitat of the Alpine Bog Skink includes subalpine heath and sphagnum bog communities. These communities are easily damaged and take a long time to recover due to the brief growing season and harsh climate of Alpine areas (James and Morey 1993). Recreation activities including vehicular use, snow sports, slope grooming and lift construction and trampling by humans can cause loss and degradation of the habitat of the Alpine Bog Skink and is a major threat to the species (P. Robertson pers. comm.). The impact of recreational activities, particularly skiing and hiking on populations of the Baw Baw Frog, is unknown. The Baw Baw Plateau is traversed by a network of bushwalking tracks and ski trails. The placement of some trails, particularly in wetland habitats, has in the past resulted in loss and degradation of vegetation during construction and through use has altered drainage patterns. This damage may be detrimental to local breeding populations. In addition, existing large areas of cleared trails and ski areas may impede dispersal and movement and result in increased predation (Hollis 1996). The Alpine Tree Frog is restricted to high montane, subalpine and alpine altitudes. The development of snow sport facilities, including ski trails, in areas of this species distribution is likely to adversely affect this species through modification of breeding sites and non-breeding habitats (Gillespie *et al.* 1995).

The Baw Baw National Park Management Plan (DCE 1992a) recommends that high priority be given to the protection of the Wet Alpine Heathland by relocating walking tracks away from this community or providing boardwalks where necessary on the Alpine Walking Track, and relocation of nordic ski trails when snow cover is insufficient to protect vegetation. Provision of boardwalks along the Australian (Alpine) Walking Track has been undertaken on the majority of this track in the Park, and an ongoing system of discouraging visitor use of ski trails where snow cover is insufficient to protect vegetation is implemented within the Baw Baw National Park. The park management plan also recommends that Baw Baw Frog populations will be protected by: conducting surveys to confirm the distribution and ecology of the species, protecting large populations in Special Protection Areas and monitoring the range of habitat on the plateau. Intended management actions outlined in the Action Statement for the Baw Baw Frog include monitoring and management of the effects of recreation on the species and its habitat (James and Morey 1993). The Actions Statement also provides for NRE input into any proposed

development or improvement within the Mount Baw Baw Alpine Resort that may affect Baw Baw Frog habitat. These actions may also benefit populations of the Alpine Bog Skink and Alpine Tree Frog.

All records of the Swamp Antechinus within the Central Highlands are from Bunyip State Park. Recreational use of vehicles including 4-wheel drives and trail bikes are popular in the park and may cause habitat degradation through heavy use of roads and tracks which in turn may impact on the swamp habitat of this species; this is thought to be a moderate threat to the Swamp Antechinus (D. Drangsholt pers. comm.). A management plan is currently being prepared for this park.

Recreational activities including camping, fishing, horse riding and vehicle use occur at many of the sites from which the Spotted Tree Frog has disappeared (Gillespie and Hollis 1996). Recreational fishing and bait collection, which includes using the frogs as bait and disturbing stream habitat while in search of other live bait, may be a significant cause of Spotted Tree Frog population declines (Watson *et al*. 1991). The Proposed Central Highlands Forest Management Plan, in addition to providing for determination of the road network to be maintained in State forest, proposes to close and rehabilitate the Taponga River camping ground which is adjacent to a known population of the Spotted Tree Frog (NRE 1996b).

Vandalism/Disturbance by Humans

This category includes direct human disturbance of fauna. It is a major threat to the Common Bent-wing Bat and Eastern Horseshoe Bat, a moderate threat to the White-bellied Sea-Eagle and a minor threat to a further 10 species. This category is not considered a threat to 16 of the species covered by this review and its effect is unknown for four species (Table 6.4).

Human disturbance of roost sites of the Common Bent-wing Bat and Eastern Horseshoe Bat may cause the bats to abandon the site. 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). It is proposed that known colonies of Eastern Horseshoe Bat are to be protected within the Central Highlands region by a 100m buffer (NRE 1996b). 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 will be discouraged and nest sites will be kept confidential. There is only one known nest site of this species in the Central Highlands.

Other

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

Interspecific Competition

This category refers to competition for resources such as food and shelter with other native species. Competition from introduced species is discussed in another section. Interspecific competition has been recognised as a threat to honeyeater species within the Central Highlands. Bell Miners actively exclude Helmeted Honeyeaters from areas of suitable habitat; habitat is quickly reoccupied if Bell Miners are removed (Pearce *et al*. 1995, B. Quin, pers. comm.). This

is considered a major threat to Helmeted Honeyeater and control of Bell Miners is a management action outlined in the Helmeted Honeyeater Recovery Plan and Action Statement (Menkhorst and Middleton 1991, Baker-Gabb 1992). Loss of high quality sites and fragmentation can also lead to increased competition for limited resources between Regent Honeyeaters 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). The effect 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 in prep.). The Painted Honeyeater is a specialist mistletoe feeder. Displacement by the generalist Mistletoe-bird *Dicaeum hirundinaceum* and exclusion by Noisy Miners *Manorina melanocephala* are likely to have contributed to the decline of the species across its range (Robinson 1994). As this species is marginal to the Central Highlands, interspecific competition is classified as a minor threat (D. Robinson pers. comm.).

Climate Change

The Enhanced Greenhouse Effect is the increase of greenhouse gases caused by human activities and the resultant warming of the atmosphere (Bennett *et al.* 1991). Species particularly at risk from this phenomenon if it occurs include those with small and genetically impoverished populations, those with disjunct or peripheral populations, coastal, montane and alpine species, species with narrow habitat requirements, and restricted habitats, and those that are poor dispersers. A further problem relates to the depletion of the ozone layer resulting in increased amounts of ultraviolet radiation reaching the earth. There is direct evidence that the Alpine Tree Frog is detrimentally affected by ozone layer depletion (G. Gillespie, pers. comm.). Increased ultraviolet radiation may also be a potential threat to the Baw Baw Frog (Hollis 1996).

Greenhouse-related climate change is recognised as a major threat to the Spotted Tree Frog, Alpine Tree Frog, Baw Baw Frog and Alpine Bog Skink, and a moderate threat to the Leadbeater's Possum, Helmeted Honeyeater, Sooty Owl, Glossy Grass Skink and Swamp Skink. It may well be a long term issue for many threatened species. An examination of the potential effects of Enhanced Greenhouse climate change 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.

Firewood Collection

Firewood from the Central Highlands' forests is in demand from domestic and commercial users from both local communities and suburban Melbourne. Firewood collection areas are open to the public during the drier months of the year. Firewood can be supplied from: site clearing prior to reforestation operations, residual material remaining after timber harvesting operations, salvage operations, thinning operations, Timber Stand Improvement works and roadside clearing works (NRE 1996b). Firewood collection is a threat to species whose habitat is limited to small remnants. It is classified as a moderate threat to Regent Honeyeater and a minor threat to three species. Cutting timber for firewood can result in the loss of important habitat components, including older trees. It can also lead to simplification of the ground layer and the reduction of available foraging habitat for species such as the Grey-crowned Babbler. Habitat management

on public land for this species must include the retention of large logs within the home ranges of families and minimising disturbance of roadside ground layers. Firewood collection can also remove standing stags and cause loss of remnant tree hollows, especially in rural areas where roadside reserves are important fauna corridors.

Regent Honeyeater has primarily been recorded in three localities in northern Victoria, outside of the Central Highlands. Suitable habitat for Regent Honeyeater in the Central Highlands is scarce, accordingly loss or degradation of existing habitat by firewood collection is a potential moderate threat to this species. The majority of records for Regent Honeyeater in the Central Highlands are in the vicinity of Melbourne. Suitable habitat occurs primarily in the foothill country to the north and east of Melbourne, and the lower slopes and upper terraces of the Goulburn River. The Plenty Gorge Park, Fraser National Park and Lake Eildon National Park also have potentially suitable habitat.

Firewood collection is permitted in most parks in the Central Highland for use in the park by visitors. Park management plans define the areas in which firewood collection may be permitted and which are to be set aside under the Park Regulations for that purpose. The cutting of live timber is not permitted in parks and, where firewood collection is permitted, hollow logs are retained for wildlife habitat. Firewood collection in forests does not permit the public to cut standing timber such as habitat trees. The cutting of timber, which subsequently may be available for firewood collection, is undertaken by licensed operators that are required to comply with the Code of Forest Practices for Timber Production (Code) and relevant timber harvesting operating prescriptions. With respect to flora and fauna conservation the Code specifies that one of the approaches which should be considered is the retention of habitat trees and old-age understorey elements in appropriate numbers and configurations. A permit is required for firewood collection for domestic purposes from public land. The permit system provides for consideration of biodiversity values and sensitive fauna habitats are avoided.

Eucalypt Dieback

A number of factors including altered drainage patterns, increased salinity, increased foliar nutrients, insect attack and soil compaction, are thought to contribute to eucalypt dieback (Davidson and Robinson 1992). Increased nutrient levels resulting from leaching of fertilisers from surrounding agricultural land in and around Yellingbo reserve, habitat of the Helmeted Honeyeater, is a potential cause of eucalypt dieback. Dieback may result in deterioration of Helmeted Honeyeater habitat through lowered invertebrate prey and deteriorating health of affected trees. Such trees may produce less flowers, manna and honeydew (Menkhorst and Middleton 1991, Baker-Gabb 1992). Research into the causes of eucalypt dieback within this species' range is an objective of the Helmeted Honeyeater recovery plan (Menkhorst and Middleton 1991). Woodland remnants, particularly those used for grazing, are particularly susceptible to dieback resulting from increased foliar nutrient levels which can lead to an increase in defoliating insects (Landsberg *et al.* 1990). The defoliation of eucalypts, particularly *Eucalyptus sideroxylon*, causes the death of the parasitic mistletoe which results in a decrease in Painted Honeyeater numbers (Eddy 1961). Other species, including the Regent Honeyeater, Swift Parrot and Grey-crowned Babbler, may be similarly affected by eucalypt dieback.

Dams/Impoundments/Hydroelectric Facilities

Potential stream works including water diversions, impoundments and water storage maintenance activities can have an adverse effect on species such as the Spotted Tree Frog. The disappearance of the Thomson River population is thought to have been caused by inundation from the reservoir. Dams and aqueducts upstream from Spotted Tree Frog sites result in alteration of stream flow regimes and water temperature. A reduction of water in streams or an excess of water from releases, may result in reduced breeding opportunities or reduced survival of eggs and tadpoles (Watson *et al.* 1991, Gillespie *et al.* 1995). Water storage maintenance activities including de-silting, may result in changes to the water quality of streams and adversely affect populations of this species (Robertson in prep.).

Mineshaft Collapse/Overgrown Entrances

Mineshaft collapse and mineshaft entrances becoming overgrown are recognised as major threats to the Eastern Horseshoe Bat and the Common Bent-wing Bat, reducing available habitat and inhibiting bat access. These species are dependent on caves and mineshafts for roosting and breeding. The National Estate Values of the Central Highlands (CNR and AHC 1994) recognise all mines used by colonial breeding or roosting bats as key fauna habitat which should be maintained across the project area. Known colonies of Eastern Horseshoe Bat in State forest are to be protected by a 100 m buffer (NRE 1996b).

7 Aquatic fauna species assessment

7.1 Introduction

The aquatic species assessment provides an analysis of information on fish and aquatic macroinvertebrates which can be used to address the issue of the viability of maintaining populations of aquatic native species throughout their natural ranges.

To meet this objective, the following assessment outputs are required:

- 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, and a description of the current management action designed to mitigate those effects;
- 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.

The quality of aquatic habitats within and beyond forested areas is influenced by the activities within the catchment. Information and results from past surveys of aquatic species and ecosystems have been reviewed to identify major gaps in information.

7.1.1 Fish and Aquatic Macroinvertebrates of the Central Highlands Region

Fish

Twenty-three native freshwater fish have been recorded from the Central Highlands to date (Victorian Fish Dataset). Of these, 12 are listed as threatened fauna in the state (CNR 1995a) of which six are listed on the State's *Flora and Fauna Guarantee Act* 1988 (Table 7.1). The region is bisected by the Great Dividing Range (GDR) which separates the aquatic habitat into northern flowing streams (draining into the Murray River) and southern flowing (coastal) streams, with 11 and 16 naturally occurring native species of fish in each area respectively.

The fish fauna of the region can be further divided into three distinct groups, one consisting of five species restricted to the upland streams north of the Great Dividing Range, 13 species restricted to the south, and four wide-ranging species which occur on both sides of the GDR (see Raadik 1995).

Three of the northern species (27% of the native fish fauna) and eight of the southern species (50%) are known to migrate as part of their life cycle (Table 7.1), indicating that migration, and unimpeded instream passage, are important issues.

Table 7.1: Native freshwater fish species in the Central Highlands Region.

Scientific name	Common Name	Conservation Status	FFG/ESP Act status	Migratory
Geotria australis	Pouched Lamprey	Rare		+
Mordacia mordax	Short-headed Lamprey			+
Anguilla australis	Short-finned Eel			+
Anguilla reinhardtii	Long-finned Eel			+
Retropinna semoni	Australian Smelt			+**?**
Prototroctes maraena	Australian Grayling	Vulnerable	FFG,ESP Act Listed	+
Galaxias brevipinnis	Broad-finned Galaxias			+
Galaxias cleaveri	Australian Mudfish	Vulnerable	FFG* Act Listed	+**?**
Galaxias fuscus	Barred Galaxias	Endangered	FFG**, ESP√ Act Listed	
Galaxias maculatus	Common Galaxias			+
Galaxias olidus	Mountain Galaxias	Ins. Known		
Galaxias rostratus	Flat-headed Galaxias	Rare		
Galaxias truttaceus	Spotted Galaxias	Rare		+
Galaxiella pusilla	Dwarf Galaxias	Vulnerable	FFG Act Listed	
Maccullochella peelii peelii	Murray Cod	Vulnerable	FFG* Act Listed	+
Macquaria ambigua	Golden Perch	Rare		+
Macquaria australasica	Macquarie Perch	Vulnerable	FFG Act Listed	+
Gadopsis bispinosus	Two-spined Blackfish			
Gadopsis marmoratus	River Blackfish	Ins. Known		
Pseudaphritis urvillii	Tupong			+
Hypseleotris klunzingeri	Western Carp Gudgeon			
Philypnodon grandiceps	Flat-headed Gudgeon			
Philypnodon sp. nov.	Dwarf Flat-headed Gudgeon			

Notes: FFG - *Flora and Fauna Guarantee Act* 1988 ; ESP - Endangered Species Protection Act 1992. * - FFG Action Statement draft; ** - FFG Action Statement completed. ? - migratory habit suspected but not shown; √ - a recovery plan has been prepared but it is yet to be formally approved by the Commonwealth Environment Minister.

Aquatic Macroinvertebrates

While the total number of aquatic macroinvertebrate species in the Central Highlands region cannot be determined, a number of aquatic macroinvertebrates known from the area have been listed under the *Flora and Fauna Guarantee Act* 1988, or are included in the NRE list of threatened Victorian fauna (CNR 1995a - Table 7.2). Adequate distributional information,

however, exists for only 4 of these species (*Hemiphlebia mirabilis* - Trueman *et al*. 1992; *Austrogammarus australis* and *A. haasei* - Doeg *et al*. 1996; and *Riekoperla darlingtoni* - Neumann and Morey 1984) while the distribution of the remaining taxa remains insufficiently known in the Central Highlands.

Table 7.2: Aquatic macroinvertebrates in the Central Highlands region.

Scientific Name	Class, Order	Conservation Status	FFG/ESP Act Status
Hemiphlebia mirabilis	Insecta, Odonata	Vulnerable	FFG** Act Listed
Archeophylax canarus	Insecta, Trichoptera	Rare	FFG Act Listed
Plectrotarsus gravenhorsti	Insecta, Trichoptera	Ins. Known	
Riekoperla darlingtoni	Insecta, Plecoptera	Vulnerable	FFG Act Listed
Tanjistomella verna	Insecta, Trichoptera	Vulnerable	
Thaumatoperla robusta	Insecta, Plecoptera	Rare	
Austrogammarus australis	Crustacea, Amphipoda	Ins. Known	FFG** Act Listed
Boekella nyoraensis	Crustacea, Copepoda	Rare	
Canthocampus dedeckkeri	Crustacea, Copepoda	Ins. Known	
Canthocampus mammillifurca	Crustacea, Copepoda	Ins. Known	
Canthocampus sublaevis	Crustacea, Copepoda	Ins. Known	
Austrogammarus haasei	Crustacea, Amphipoda		FFG Act Listed

Notes: FFG - *Flora and Fauna Guarantee Act* 1988 ; ESP - Endangered Species Protection Act 1992. * - FFG Action Statement draft; ** - FFG Action Statement completed

The decapod crustacea (crayfish and prawns) fauna of the area are better known, having been the focus of taxonomic studies (Morgan 1986; Horwitz 1990) and have been included as part of fish surveys conducted since 1990 (see below). Numerous incidental records also exist. Species known to occur in the region are shown in Table 7.3.

Table 7.3: Native freshwater decapod crustacea in the Central Highlands.

Scientific name	Common name	Conservation Status	FFG/ESP Act status
Parastacidae			
Cherax destructor	Common Yabby		
Engaeus affinis	Central Highlands Burrowing Cray		
Engaeus cunicularius	Granular Burrowing Cray		
Engaeus curvisuturus	Curve-tail Burrowing Cray		
Engaeus cymus	North-eastern Burrowing Cray		
Engaeus hemicirratulus	Gippsland Burrowing Cray		
Engaeus laevis	Richards Burrowing Cray		

Table 7.3 cont'd

Scientific name	Common name	Conservation Status	FFG/ESP Act status
Engaeus lyelli	Upland Burrowing Cray		
Engaeus phyllocerus	Narracan Burrowing Cray	Rare	FFG* Act Listed
Engaeus quadrimanus	Lowland Burrowing Cray		
Engaeus sternalis	Warragul Burrowing Cray	Endangered	FFG* Act Listed
Engaeus tuberculatus	Tubercle Burrowing Cray		
Engaeus urostrictus	Dandenong Burrowing Cray		
Engaeus victoriensis	Foothill Burrowing Cray		
Euastacus armatus	Murray Spiny Cray	Ins. Known	
Euastacus kershawi	Gippsland Spiny Cray		
Euastacus woiwuru	Central Highlands Spiny Cray		
Euastacus yarraensis	Southern Victorian Spiny Cray		
Atyidae	**Shrimps**		
Paratya australiensis	Freshwater Shrimp	common	

Notes: FFG - *Flora and Fauna Guarantee Act* 1988 ; ESP - Endangered Species Protection Act 1992. * - FFG Action Statement draft; ** - FFG Action Statement completed

7.2 Review of existing site-based data

The data review process involves assessment of existing databases to determine the adequacy of existing site-based biological data for use in subsequent analyses. The outputs of the review can be used to identify priority areas and data gaps to be filled through future survey work. The data review relies on expert knowledge and professional judgment.

The distribution of survey sites where adequate data on fish and aquatic macroinvertebrates is shown in Map 11.

7.2.1 Fish

Intensive inventory surveys of fish assemblages in the Central Highlands have been primarily 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 Central Highlands region, and prior to 1970, records were sporadic, consisting of observations of individual species from only a few locations. The first survey of fish assemblages was undertaken in 1973 at seven sites on the La Trobe River (Tunbridge 1974). Between 1973 and 1990, a total of 11 recognised major surveys occurred in the area contributing 164 new sites (Table 7.4), exclusive of resampled sites.

Five of these surveys were fisheries orientated, targeting larger, recreational species and using techniques (e.g. netting with large mesh sizes) not designed to capture all fish species. These types of surveys are referred to in this report as "partial surveys". Consequently, smaller fish

species were not sampled by these surveys, and they were generally conducted in the larger reaches of the main rivers in lowland to foothill areas only.

Table 7.4: Major surveys conducted for freshwater fish in the Central Highlands prior to 1989.

Date	Area surveyed	Sites surveyed	Source
1973	La Trobe catchment	7	Tunbridge 1974
1973-1974	Yarra River and tributaries	38	Jackson *et al*. 1980
1975	Bunyip catchment	15	Barclay 1975
1975	Thomson River	10	Tunbridge *
1978-1984	Goulburn, La Trobe and Bunyip catchments	24	Baxter 1985 *
1984	Plenty River system	9	Closs 1984
1985	Bunyip catchment	10	Koehn 1986b
1987	Goulburn catchment	8	Baxter *at al* 1988 *
1988	Goulburn and La Trobe catchments	7	Baxter *at al* 1989 *
1988	La Trobe catchment	7	Hall 1989
1988	Plenty River system	23	McKenzie *et al*. 1989
1989	Goulburn, La Trobe and Yarra catchments	6	Baxter *et al*. 1990 *

Note: * indicates fisheries surveys.

All sampling of fish in the region has been sporadic pre-1990 and non-systematic. 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, mainly due to intensive sampling of specific areas, with 282 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. Much useful information was collected by Peter Unmack from 70 sites across the region (Table 7.5) though unfortunately nearly all of these collections are rated as a partial survey as the equipment used would generally not have sampled all species present (eg. seine net, dipnet, and angling).

Both Raadik (unpublished data) and Saddlier (unpublished data) have intensively surveyed a total of 144 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). Many of these sites were surveyed for the nationally threatened Barred Galaxias (*Galaxias fuscus*), as were the 13 sites sampled by Shirley (1991). Koehn *et al*. (1991) also details various miscellaneous surveys conducted in the region. No systematic survey of the

aquatic habitat across this region has been undertaken, with most information being derived from specific intensive surveys for specific projects.

Table 7.5: Major surveys conducted for freshwater fish in the Central Highlands since 1990.

Date	Area surveyed	Sites surveyed	Source
1990	Goulburn catchment	5	Koehn 1990
1990	Yarra catchment	9	Baxter *et al*. 1991 *
1990-1994	Goulburn, Bunyip and Yarra catchments	70	Unmack
1990-1996	Goulburn, Thomson, Latrobe, Bunyip and Yarra catchments	58	Raadik
1990-1996	Goulburn, Thomson, La Trobe, Bunyip and Yarra catchments	76	Saddlier
1990-1991	Goulburn, La Trobe and Yarra catchments	51	Koehn *et al*. 1991
1991	Goulburn and Yarra catchments	13	Shirley 1991

Note: * indicates fisheries surveys.

The number of freshwater survey sites in the Central Highlands is 572, with 264 located north of the divide in the Goulburn River catchment and 308 in the four catchments to the south (Table 7.6). Of these, 400 sites are considered to be fully surveyed (full coverage of species diversity) which provide adequate data quality, 145 north of the GDR and 255 in the south.

There is generally wide spatial coverage of the aquatic habitat across the Region, though many survey sites fall into `hot spot' areas where survey intensity has been very high in a few areas due to specific projects such as the Barred Galaxias project (see earlier). Consequently, there is a very extensive knowledge of fish from only a few areas within the Region.

Table 7.6: Summary of information on fish survey sites in the Central Highlands from 1973-1994.

Land tenure	**State forest**		**Private land and other Public land**		**Conservation reserves**		
Survey Type Catchment	Full	Partial	Full	Partial	Full	Partial	**Total**
Goulburn	91	50	38	48	16	21	**264**
Thomson	6	1	3	2	2	0	**14**
La Trobe	32	3	11	2	1	0	**49**
Bunyip	7	0	22	4	11	1	**45**
Yarra	46	7	90	17	27	13	**200**
Sub total	182	61	164	73	57	35	
Total sites	**243**		**237**		**92**		**572**
% of total	42.5		41.4		16.1		

Notes: Full - all fish species recorded; Partial - only larger, recreational species collected.

By comparison, Jackson and Davies (1983) surveyed 115 sites in the Grampians region, in an area approximately 15% the size of the Central Highlands, and 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 Central Highlands were to be surveyed with

the same intensity to that conducted in the Grampians, approximately another 360 sites would be required, and more importantly, these sites would need to be more spatially orientated than previous ones to provide better coverage. Table 7.6 shows that survey sites have been concentrated in State forest, other public land and private land, with significantly less sites sampled in conservation reserves The current number of quality sites (400) comprises some 52% of the coverage required if survey intensity in this region were to match the two surveys described above.

Some 92 sites (16.1%) have been located in areas set aside for conservation purposes, 237 (41.4%) were located in private land and other areas of public land (eg. licensed stream frontages). Two hundred and forty three sites (42.5%) have been located in State Forest and many of these have been surveyed since 1990, or were surveyed approximately 15 to 25 years ago.

7.2.2 Aquatic macroinvertebrate fauna

Inventory surveys of aquatic macroinvertebrates in the Central Highlands have been primarily conducted by a number of Government Departments and Monash University. Some investigations which incidentally recorded invertebrate species (e.g. as part of taxonomic studies) have been conducted by universities or private individuals.

Pre-1990 macroinvertebrate surveys

Department of Water Resources (1989) recorded 131 sites where aquatic macroinvertebrate surveys have been conducted in the Central Highlands prior to 1990 (Table 7.7). These were sampled as part of several studies, primarily investigating the impact of human disturbance on stream systems, but included 13 graduate and post-graduate projects at Monash University. Studies associated with the construction of the Thomson Dam (Malipatil and Blyth 1982; Doeg *et* al. 1987; Marchant 1989), eductor dredging in the Goulburn Rivers (Doeg 1987) and the release of the former State Electricity Commission cooling waters into the Latrobe River (Metzeling *et al*. 1984; Marchant *et al*. 1984) were all conducted by the Museum of Victoria. The impact of the construction of Blue Rock Dam was conducted by the EPA (Chessman *et al*. 1982) and the effect of mercury contamination was studied in the upper Goulburn River through Rusden College (Ealey *et al*. 1983).

The Yarra catchment has been the most extensively surveyed with 45 sites sampled prior to 1990. Of these, 12 sites were part of Monash University graduate and post-graduate projects, but the remaining 33 sites were part of a more extensive monitoring program (Campbell *et al*. 1982; Pettigrove 1985).

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

Table 7.7: Major surveys conducted for aquatic macroinvertebrates in the Central Highlands prior to 1990.

Date	Catchment	Sites surveyed	Institutions responsible
1975-1980	Goulburn	27	Monash University, Museum of Victoria
1979-1981	Thomson	7	Museum of Victoria
1979-1984	Latrobe	21	Museum of Victoria, EPA, Monash University
1975-1982	Bunyip	21	Monash University, Rusden College, Dandenong Valley Authority
1976-1986	Yarra	45	Ministry for Conservation, Monash University, Rural Water Commission

Post-1990 macroinvertebrate surveys

Since 1990, various surveys have continued in some catchments. A number of graduate and post-graduate projects at Monash University have continued, primarily in the upper Goulburn River catchment (Taggerty, Steavensons and Acheron Rivers), while a few studies have been conducted in the Yarra catchment (Saddlier and Doeg 1996). No new major surveys have been conducted in the Latrobe, Thomson or Bunyip catchments.

As part of the Monitoring River Health Initiative (MRHI), 40 sites are currently being monitored in the Central Highlands region (L. Metzeling, EPA, pers. comm. - Table 7.8). An additional 47 sites have also been sampled in the urban sections of the Yarra River. Melbourne Water also conducts an extensive community based monitoring program for aquatic macroinvertebrates in the Yarra River.

Table 7.8: Number of sites sampled as part of the MRHI after 1990 in each catchment in the Central Highlands.

Catchment	Number of sites
Goulburn	6
Thomson	2
Latrobe	13
Bunyip	4
Yarra	15

There has been no comprehensive or systematic study of the aquatic macroinvertebrate fauna of the entire Central Highlands Region. Numerous individual studies have been conducted for specific purposes. The recent introduction of 40 sites surveyed under the MRHI program will provide some baseline data for the region. The data from these are being used to construct a national predictive model, allowing the invertebrate fauna to be predicted on the basis of the river characteristics (e.g. water quality, altitude, bed structure). However, an overall survey intensity at a greater density than 40 sites in the Central Highlands will be required. The number of additional sites required for accurate localised modelling cannot be estimated, but a further 50 sites in the Central Highlands would contribute significantly to the input of suitable models.

7.3 Life history and population parameters for aquatic species

7.3.1. Priority Species

A priority list of 27 aquatic species (Table 7.9) was compiled for inclusion in the more detailed assessment of species' response to disturbance, and life history and population dynamics. The list consisted of species which occurred in the Central Highlands and were listed under the Victorian *Flora and Fauna Guarantee Act* 1988 (FFG Act), the Commonwealth *Endangered Species Protection Act* 1992 (ESP Act) or the Threatened Fauna of Victoria (TFV) list.

Table 7.9: Priority aquatic species included in the life history and population parameter assessment.

Species Name	Common Name
Fish	
Geotria australis	Pouched Lamprey
Prototroctes maraena	Australian Grayling
Galaxias cleaveri	Tasmanian Mudfish
Galaxias fuscus	Barred Galaxias
Galaxias olidus	Mountain Galaxias
Galaxias rostratus	Flat-headed Galaxias
Galaxias truttaceus	Spotted Galaxias
Galaxiella pusilla	Dwarf Galaxias
Maccullochella peelii peelii	Murray Cod
Macquaria ambigua	Golden Perch
Macquaria australasica	Macquarie Perch
Gadopsis marmoratus	River Blackfish
Philypnodon sp. nov.*	Dwarf Flat-headed Gudgeon
Decapod Crustacea	
Engaeus phyllocerus	Narracan Burrowing Cray
Engaeus sternalis	Warragul Burrowing Cray
Euastacus armatus	Murray Spiny Cray
Non-decapod invertebrates	
Hemiphlebia mirabilis	Damselfly
Archeophylax canarus	Caddisfly
Plectrotarsus gravenhorsti	Caddisfly
Riekoperla darlingtoni	Mt Donna Buang Wingless Stonefly
Tanjistomella verna	Caddisfly
Thaumatoperla robusta	Stonefly
Austrogammarus australis	Dandenong Freshwater Amphipod
Austrogammarus haasei	Amphipod
Canthocampus dedeckkeri	Copepoda
Canthocampus mammillifurca	Copepoda
Canthocampus sublaevis	Copepoda

Note: * a newly discovered species likely to be soon listed under the FFG Act

7.3.2 Results

Fish

Basic life history and population characteristics for fish species was obtained primarily from Cadwallader and Backhouse (1983) and Koehn and O'Connor (1990). Further information on species not covered in those sources on *Galaxias fuscus* was from Raadik *et al.* (1996) and on *Philypnodon* sp. nov. (T. Raadik, MaFRI, pers. comm.).

Geotria australis (Pouched Lamprey)
A small (adults to 60 cm) migratory species, located south of the GDR. Adults live in loose gravel in upland habitats. Spawning occurs in freshwater during late spring. Spawning trigger is unknown. Adult females (age unknown) lay up to 60,000 eggs in a nest of stones in small headwater streams. Incubation time is unknown. Larvae live in soft mud for 3-4 years, then migrate to sea to mature in winter, stay for an unknown number of years, then move upstream in spring.

Prototroctes maraena (Australian Grayling)
A small (adults to 20 cm and 500 gm) migratory species located south of the GDR. 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.

Galaxias cleaveri (Tasmanian Mudfish)
A small (adults to 14 cm) species, located south of the GDR. Adults live in swamps and ditches that may dry for part of the year. Spawning occurs in freshwater during winter or spring. Spawning trigger is unknown. Adult females (age unknown) lay an unknown number of eggs. Very little is known of the life history.

Galaxias fuscus (Barred Galaxias)
A small (adults to 15 cm) non-migratory species, located north of the GDR. Adults live in slow flowing pools in stony fast-flowing upland streams. Spawning occurs in freshwater during winter/spring, triggered by increasing day length and water temperature. Adult females (age unknown) lay about 500 eggs, possibly adhering them to boulders. Incubation time is unknown.

Galaxias olidus (Mountain Galaxias)
A small (adults to 15 cm) non-migratory species, located both sides of the GDR. 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.

Galaxias rostratus (Flat-headed Galaxias)
A small (adults to 15 cm and 26 gm) non-migratory species, located north of the GDR. Adults live in still, gently flowing water. Spawning occurs in freshwater during spring. Spawning trigger is unknown. Adult females (unknown age) lay 1,000-7,000 eggs into the water column which settle. Eggs hatch after 9 days.

Galaxias truttaceus (Spotted Galaxias)
A small (adults to 20 cm) migratory species, located south of the GDR. 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 old) lay a few thousand eggs

attached to the substrate. Eggs hatch after 4-6 weeks. Larvae are washed to sea after hatching and juveniles move upstream in spring/summer.

Galaxiella pusilla (Dwarf Galaxias)
A small (adults to 4 cm) non-migratory species, located south of the GDR. 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 attached to the substrate. Eggs hatch after 2-3 weeks. Movement patterns are unknown.

Maccullochella peelii peelii (Murray Cod)
A large (adults to 1800 cm and 100 kg) migratory species, located north of the GDR. Adults live among wood debris in deep holes in lowland reaches of major rivers. Spawning occurs in freshwater during spring after an upstream adult migration, triggered by high flows. Adult females (maturity occurs at 4-6 years old) lay many eggs (10,000-200,000 depending on adult size) attached to the substrate (although the egg deposition site is not known). Eggs hatch after 1-2 weeks. Larvae drift downstream to mature and adults migrate downstream after spawning.

Macquaria ambigua (Golden Perch)
A large (adults to 76 cm) migratory species, located north of the GDR. Adults live in slow flowing water. Spawning occurs in freshwater during spring to summer after an adult upstream 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.

Macquaria australasica (Macquarie Perch)
A moderate sized (adults to 46 cm) migratory species, located north of the GDR (although a population was translocated to the Yarra River). Adults live in deep holes in slow flowing waters. Spawning occurs in freshwater during late spring after an adult upstream migration, triggered by rising water temperatures. Adult females (maturity occurs at 2-4 years old) lay up to 100,000 eggs into the water column which settle. Eggs hatch after 1-3 weeks (depending on temperature). Larvae are washed downstream and adults migrate downstream after spawning.

Gadopsis marmoratus (River Blackfish)
A moderate sized (adults to 60 cm) non-migratory species, located both sides of the GDR. 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 guards the eggs. Eggs hatch after about 2 weeks. Larvae are believed to live among leaf litter for at least 12 months.

Philypnodon sp. nov. (Dwarf Flat-headed Gudgeon)
A small (adults to 4 cm) non-migratory species, located both sides of the GDR. Very little is known of the life history, including spawning times and behaviour, larval and adult preferred habitats, fecundity or incubation times.

Aquatic macroinvertebrates

Little is known about the life history of most of the aquatic macroinvertebrates species listed in Table 7.9. Some specific information is known for some of the crustacea (Horwitz 1990), and a

few insects (e.g. *Hemiphlebia mirabilis* - Trueman *et al*. 1992; *Riekoperla darlingtoni* - Neumann and Morey 1984) although most of this has 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 (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. Eggs produced depend 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.

Engaeus phyllocerus (Narracan Burrowing Cray)
This species lives primarily in burrows on the small flood plain of tree fern gullies in wet sclerophyll forest or in the banks of flowing creeks. They appear to breed in spring, carrying eggs and larvae over the hot, dry months, presumably releasing juveniles in late summer.

Engaeus sternalis (Warragul Burrowing Cray)
This is a little known and rarely collected species. Almost nothing is known of its preferred habitat or ecology. It has been found in deep burrows in the clay banks of small creeks, where it may be a permanent burrow dweller (there is no detectable outlet to the burrow at the surface).

Austrogammarus australis (Dandenong Freshwater Amphipod)
An hermaphroditic crustacean, the Dandenong Freshwater Amphipod is restricted to the upper catchments of the Dandenong Ranges east of Melbourne. Appears restricted to sites with intact riparian native vegetation. No information is available about its life history or habitat requirements.

Austrogammarus haasei (Amphipod)
Austrogammarus haasei is restricted to a single stream in the Dandenong Ranges National Park east of Melbourne. No information is available about its life history or habitat requirements.

Canthocampus dedeckkeri (Copepoda)
A small crustacean known only from Mt Baw Baw and Lake Mountain. Appears to be restricted to *Sphagnum*. No specific information is available about its life history or habitat requirements.

Canthocampus mammillifurca (Copepoda)
A small crustacean known only from Lake Mountain. Found in a small stream full of leaf litter. No specific information is available about its life history or habitat requirements.

Canthocampus sublaevis (Copepoda)
A small crustacea known only from Mt Baw Baw. Appears to be restricted to *Sphagnum*. No specific information is available about its life history or habitat requirements.

Hemiphlebia mirabilis (Damselfly)
A small dragonfly living in the edge vegetation of riverine billabongs and swamps. Adults emerge in summer. Water may dry at some times of the year and the species may have resistant eggs or larvae.

Archeophylax canarus (Caddisfly)
Small alpine caddisfly. Nothing is known specifically of its life history or habitat requirements.

Plectrotarsus gravenhorsti (Caddisfly)
Caddisfly from the Yarra River and Goulburn River. Nothing is known specifically of its life history or habitat requirements.

Tanjistomella verna (Caddisfly)
Caddisfly from south of Mt. Baw Baw. Nothing is known specifically of its life history or habitat requirements.

Riekoperla darlingtoni (Mt Donna Buang Wingless Stonefly)
A small (adults 6-12 mm) flightless stonefly known only from the southern slopes of Mt Donna Buang. Spends 2-3 years as a nymph in small trickles of water at high altitude. Nymphs resist desiccation by burrowing into damp gravel if the stream dries. Adults emerge in spring and live for 3-6 weeks, mainly in curled up bark. Eggs hatch between February and May.

Thaumatoperla robusta (Stonefly)
A large stonefly species restricted to alpine areas. Probably spends a number of years as a nymph under rocks in flowing streams before emerging. Adults have poor powers of dispersion. Nothing is known specifically of its life history or habitat requirements.

7.4 Review of disturbances and the implications for aquatic fauna in the Central Highlands Region

7.4.1 Introduction

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 assist in setting priorities for management, research and surveys and the integration component of the Central Highlands CRA. The review covered priority aquatic species (Table 7.9) in the Central Highlands, and was based on existing scientific literature and expert opinion.

A number of processes can, or have the potential to have, serious impacts on aquatic ecosystems, and therefore on aquatic species. A list of broad disturbance categories and their major impact on aquatic ecosystems is shown in Table 7.10.

By far the most common effect of most disturbances is the increase in sediment accession to rivers and streams. While sediment in streams is part of the natural erosion process, and fauna are presumed to be adapted to natural variations in sediment levels (e.g. natural increases during high flows), several activities can lead to additional sediment inputs into streams.

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 gill structure, clogging gill mucus and causing asphyxiation. Fish that feed using vision to locate prey can also be affected by the reduced visibility in the water column caused by increased turbidity. Elevated levels of deposited sediment can smother stream beds, simplifying the habitat, and exposing fish to increased predation and stress. High levels of sediment can fill in deep pools, destroying the entire habitat for some species. Crevices in the substrate between rocks or debris 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. Increased sedimentation of rivers is a listed Threatening Process under the *Flora and Fauna Guarantee Act* 1988.

Other disturbances alter the natural stream chemistry, increasing levels of nutrients (fire, timber harvesting, grazing, waste disposal) or toxic chemicals (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.
Dams represent a severe disturbance to aquatic systems. Where low level offtakes are used (many older dams) water temperature can be lowered substantially. Storage and release of water at different times also changes 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 also occur either during construction or cleaning of storages.

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

It should be noted that some species can be affected by disturbances which occur some distance away. Additional sediment in a stream can gradually move downstream during floods. If severe, this can affect areas and species many kilometres from the source of the disturbance. Dams acting as fish barriers can affect large areas upstream. A barrier at the mouth of a river can effectively exclude species from the whole of the catchment upstream.

Table 7.10: Broad disturbance category with potential impacts on aquatic ecosystems

Broad disturbance category	Potential impacts on aquatic ecosystems
Clearing	• Stream bed and bank degradation • Increased sedimentation and turbidity • Increased nutrient concentrations in water • Increased pesticide concentrations
Fire	• Increased sedimentation and turbidity • Increased nutrient concentrations in water
Grazing	• Stream bed and bank degradation • Increased sedimentation and turbidity • Increased nutrient concentrations in water • Reduction of swamp/headwater habitat
Harvesting	• Reduction in population numbers
Introduced species	• Competition with native species • Predation on native species
Mining/Quarrying	• Increased sedimentation and turbidity • Increased toxic chemical concentrations in water
Pest control	• Increased pesticide concentrations
Recreation	• Stream bed and bank degradation • Increased sedimentation and turbidity
Roading	• Stream bed and bank degradation • Increased sedimentation and turbidity
Timber harvesting	• Increased sedimentation and turbidity • Increased nutrient concentrations in water
Water storages and instream buffers/Dams	• Changed flow regimes • Increased sedimentation and turbidity • Decreased water temperature • Barriers to fish passage
Waste disposal	• Increased nutrient concentrations in water • Increased toxic chemical concentrations in water

Few data are available directly relating the impact of most disturbance categories to aquatic species. In most cases, the impact on priority species has been predicted from the results of similar studies conducted elsewhere. For example, no data are available on the impact of

clearfelling on the four upland Galaxias species (*G. fuscus*, *G. olidus*, *G. rostratus* 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, probably through increased sedimentation. While clearfelling without streamside buffers in Victoria is not permitted, it is reasonable to assume that any similar increase in the amount of sedimentation in the Central Highlands (through any of the disturbance categories in Table 7.10) would produce a similar reduction in density of Galaxiids in Central Highlands streams. This is a primary reason why Victoria has implemented a Code of Forest Practices for Timber Production and other regulations designed to minimise or avoid significant sediment inputs to streams.

The one disturbance where good data are available is the impact of dams on aquatic fauna. Changed flow, temperature and sediment have all been implicated in the decline in native fish and invertebrate species in the Mitta Mitta River below Dartmouth Dam (Koehn *et al*. 1995), and in the Thomson River below the Thomson Dam (Doeg *et al*. 1987). Sedimentation due to weir cleaning reduced fish and invertebrate densities in Armstrong Creek in the upper Yarra River catchment (Doeg and Koehn 1995).

With these considerations in mind, species affected by each of the disturbance impacts listed in Table 7.10 are presented in Table 7.11. It should be noted that it is mostly of little relevance which disturbance activity creates the disturbance impact. However, the intensity of the effect may differ between the sources, with, for example, weir cleaning producing very high turbidity and deposited sediment levels for a short time, while drainage from roads may produce lower levels but extended over time.

Table 7.11: Species affected by each of the disturbance impacts listed in Table 7.10.

Disturbance impact	Species Affected	Comments
Increased sedimentation and turbidity	*Geotria australis*, *Galaxias rostratus*, *Galaxias olidus*, *Galaxias fuscus*, *Galaxiella pusilla*, *Prototroctes maraena*, *Maccullochella peelii peelii*, *Macquaria australasica*, *Gadopsis marmoratus* *Euastacus armatus* *Archeophylax canarus*, *Plectrotarsus gravenhorsti*, *Riekoperla darlingtoni*, *Tanjistomella verna*, *Thaumatoperla robusta*, *Austrogammarus australis*, *Austrogammarus haasei*	Fish which lay demersal eggs Decapod crustacea which live in-stream Stream dwelling non-decapod invertebrates
Increased nutrient concentrations	No data	

Table 7.11 cont'd

Disturbance impact	Species Affected	Comments
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	*Galaxias truttaceus, Engaeus phyllocerus, Engaeus sternalis*	All species indirectly affected *G. truttaceus* lays eggs outside watercourse
Competition with or predation on native species	*Galaxias fuscus, Galaxias olidus, Galaxiella pusilla, Galaxias fuscus, Galaxias rostratus, Prototroctes maraena*	Predation on juveniles and adults, competition with adults
Increased toxic chemical concentrations	No specific data	Likely that all species affected, depending on nature of toxin
Changed flow regimes	*Maccullochella peelii peelii, Macquaria ambigua, Galaxias truttaceus, Prototroctes maraena*	Species known to require floods, other fish species also likely to be affected
Changed water temperatures	*Maccullochella peelii peelii, Macquaria ambigua, Gadopsis marmoratus*	Breeding temperature dependant
Barriers to fish passage	*Geotria australis, Prototroctes maraena, Galaxias truttaceus, Maccullochella peelii peelii, Macquaria ambigua, Macquaria australasica*	Migratory species
Reduction of swamp/headwater habitat	*Hemiphlebia mirabilis, Canthocampus dedeckkeri, Canthocampus mammillifurca, Canthocampus sublaevis*	*Hemiphlebia* in wetlands, copepoda in *Sphagnum* or small headwaters
Reduction in population through harvesting	*Euastacus armatus*	

7.5 Conservation measures for fish and aquatic macroinvertebrates

A range of conservation measures are in place for the protection of streams and catchments in the Central Highlands. These include a conservation reserve system, incorporating specific conservation measures for the protection of aquatic habitats.

Following the Land Conservation Council's (LCC) Rivers and Streams Special Investigation (LCC 1991) the Government declared the corridors of the Yarra, Goulburn (below Lake Eildon), Big, Aberfeldy and Thomson Rivers to be Heritage River Areas because of their significant natural, scenic, cultural heritage and recreational values. Timber harvesting is excluded from the Heritage River corridors within this planning area. In State forest, these corridors are included in the Special Protection Zone (SPZ).

In its recommendations following the Melbourne Area District 2 Review (LCC 1994) identified a 'River Zone' along other rivers and streams in the Central Highlands which contain significant natural, scenic or recreational value. These are the upper Goulburn, Murrindindi, Acheron, Latrobe and Toorongo Rivers and Snobs Creek. The corridor to be protected along these rivers and streams varies according to local circumstances but generally extends between 100 m and 300 m from each bank. These areas are also included in the SPZ.

Other protection for some aquatic species is afforded under Forest Management Zoning for other values (Special Protection Zones and Special Management Zones) or management prescriptions for other species or communities (e.g. Spotted Tree Frog, Rainforest) outlined in the Central Highlands Proposed Forest Management Plan.

Under the provisions of the FFG Act 1988 and the ESP Act 1992, and as part of Park and Forest Management Plans, conservation guidelines can be developed and implemented to protect individual species and their habitats from threatening processes. Where biological information is adequate, quite specific guidelines can be developed. This has been done for the Barred Galaxias. For this species, extended minimum streamside buffer widths are proposed in the Central Highlands Proposed Forest Management Plan. Additionally, trout exclusion barriers have been established below a number of populations to control predation.

A lack of detailed scientific information has to date precluded development of more species-specific conservation guidelines for other priority aquatic species. These species rely on the more general habitat protection measures of the Code of Forest Practices, and the Proposed Forest Management Plan for protection.

Recreational fish species are protected by a variety of fishing regulations, mainly bag and size limits and closed seasons during breeding. Fishing regulations also exist for *Euastacus* species in Victoria.

Management strategies to protect riparian and instream values are also key elements of the Code of Forest Practices for Timber Production and the Proposed Central Highlands Forest Management Plan. The Code contains a number of measures aimed at minimising impacts on water quality and, by extension, instream values.

Linear reserves in Special Protection Zones (SPZs), extending 200 metres from each bank of the watercourse have been established in the Proposed Central Highlands Forest Management Plan along most major streams. Within the SPZ, construction of new roads within linear reserves is to be avoided wherever possible.

In the General Management Zone (GMZ) the Code of Forest Practices for Timber Production requires:

- the retention of a buffer strip at least 20m wide around permanent streams, permanent springs, swampy ground and bodies of standing water.
- the retention of a filter strip at least 5m wide around temporary streams and drainage lines;
- 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.

These mechanisms address a range of threatening process that potentially impact on aquatic fauna, as follows:

Threatening process	***Management action***
Alterations to the natural temperature of rivers and streams (FFG listed)	Minimum 20-m streamside reserves. Shading by riparian vegetation serves to minimise temperature variations that might otherwise result from additional exposure to the sun.
Alteration to the natural flow regimes of rivers and streams (FFG listed)	Stream and river channels will not be re-directed in State forest Addressed by the Code and the Roading Prescriptions for Timber Production in the Central Highlands
Prevention of passage of aquatic biota as a result of the presence of in-stream structures (FFG listed)	Addressed by the Code and the Roading Prescriptions for Timber Production in the Central Highlands
Increase in sediment input into rivers and streams due to human activities (FFG listed)	Minimum 20-m streamside reserves. Addressed by the Code, Forest Management Area (FMA) timber harvesting prescriptions and the Roading Prescriptions for Timber Production in the Central Highlands
Input of toxic substances into Victorian rivers and streams (FFG listed)	Addressed by the Code requirements for safe handling of fuel and lubricants which restricts the location and conduct of refuelling operations
Use of *Phytophthora*-infected gravel in the construction of roads, bridges and reservoirs (FFG listed)	Quarantine infected areas See Section 8.1
Degradation of riparian vegetation	Minimum 20-m streamside reserves. Control of weeds (particularly blackberries) at road or track crossings.

Table 7.12: Specific Conservation guidelines and activities (apart from the measures outlined above) for priority aquatic species. Fishing regulations from CNR (1995a).

Species Name	Conservation guidelines or activity
Fish	
Geotria australis	None
Prototroctes maraena	FFG collecting restrictions; Fishing regulations: no netting allowed
Galaxias cleaveri	FFG collecting restrictions
Galaxias fuscus	FFG collecting restrictions; Minimum streamside buffer widths extended to 30m and filter strip width to 10m for highly permeable soils; Minimum streamside buffer widths extended to 40m or 50m for soils with low permeability (extension depends on slope); progressive closure and rehabilitation of roads not required for forest management; Minimising stream crossings over permanent and temporary streams; Construction of weirs to exclude trout.
Galaxias olidus	None
Galaxias rostratus	None
Galaxias truttaceus	None
Galaxiella pusilla	FFG collecting restrictions
Maccullochella peelii peelii	FFG collecting restrictions; Fishing regulations: 2 per day bag limit, 50 cm size limit, closed season 1 September-30 November, no netting allowed
Macquaria ambigua	Fishing regulations: Closed season last Sunday in August-last Friday in November, no netting allowed
Macquaria australasica	FFG collecting restrictions; Fishing regulations: 10 per day bag limit, 25 cm size limit, closed season 1 October-18 December (Lake Dartmouth), no netting allowed
Gadopsis marmoratus	None
Philypnodon sp. nov.	None
Decapod Crustacea	
Engaeus phyllocerus	FFG collecting restrictions
Engaeus sternalis	FFG collecting restrictions
Euastacus armatus	Fishing regulations: 10 per day bag limit, 9 cm size limit, restrictions on catching females and newly moulted animals.
Other invertebrates	
Hemiphlebia mirabilis	FFG collecting restrictions
Archeophylax canarus	FFG collecting restrictions
Plectrotarsus gravenhorsti	None
Riekoperla darlingtoni	FFG collecting restrictions
Tanjistomella verna	None
Thaumatoperla robusta	None
Austrogammarus australis	FFG collecting restrictions
Austrogammarus haasei	FFG collecting restrictions
Canthocampus dedeckkeri	None
Canthocampus mammillifurca	None
Canthocampus sublaevis	None

7.6 Data gaps

Fish

The most crucial gaps in fish data from the Central Highlands region lie in the number of areas from which no data are available, and the lack of data on population dynamics and processes. Despite the increase in survey intensity over the past 6 years, many areas still require to be surveyed. In particular, data are not available from the areas listed in Table 7.13.

Table 7.13: Central Highlands areas where data on fish species are unavailable.

Catchment	Area with little or no fish data
Goulburn River	• Upper Sunday, Strath and King Parrot Creeks and tributaries upstream of Broadford, Strath Creek and Flowerdale respectively • Yea and Murrindindi Rivers and tributaries upstream of Devlin Bridge and Murrindindi respectively • Steavenson River and tributaries upstream of Marysville • Royston River and tributaries upstream of Rubicon • Big River system (including Taponga and Torbreck Rivers • Acheron River and tributaries upstream of Buxton • Rubicon River and tributaries upstream of Rubicon • Snobs Creek and tributaries upstream from falls • Goulburn River and tributaries upstream from Eildon Lake (including Black River system)
Thomson River	• Thomson River system and all accessible tributaries (eg. Jordan River and tributaries, all tributaries of Thomson Reservoir)
La Trobe River	• Tyers River and all accessible tributaries • Tanjil River and all accessible tributaries (eg. Icy Creek, Long Creek, Bull Beef Creek, etc.) • Upper La Trobe River and all accessible tributaries (eg. Toorongo River, Loch River, Deep Creek, Bernie Creek, Ada River, Pioneer Creek, etc.) • Upper Shady and Red Hill Creeks and all accessible tributaries
Bunyip River	• Tarago River and all accessible tributaries upstream of Tarago Reservoir • Upper Bunyip River and all accessible tributaries upstream from junction with Diamond Creek
Yarra River	• Upper Diamond, Running and Arthurs Creeks and all accessible tributaries • Upper Steele, Paul and Chum Creeks and all accessible tributaries • Little Yarra River system and all accessible tributaries • Yarra River tributaries upstream of Warburton (eg. Starvation, McMahons and Armstrong Creeks, O'Shannassy River etc.).

Significant data gaps exist on life history and population characteristics for all priority fish species. Much of the current information is derived from incidental observations during other research, rather than formal scientific surveys and research. In particular, the most significant gaps relate to spawning behaviour, including induction cues and location of egg laying sites, both

within the catchment and within the stream (Table 7.14). Cues for migration are generally poorly known, particularly for small upland species (Table 7.15), as are larval preferred habitat, and tolerances to turbidity and temperature.

Table 7.14: Summary of the adequacy of 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
Geotria australis	no data	no data				no data
Prototroctes maraena	incomplete	incomplete	incomplete			
Galaxias cleaveri	no data	no data	no data	no data	no data	no data
Galaxias fuscus	no data		no data		incomplete	no data
Galaxias olidus		no data	incomplete			no data
Galaxias rostratus	no data	no data	no data	no data		
Galaxias truttaceus		incomplete				
Galaxiella pusilla		no data				
Maccullochella peelii			no data	no data		
Macquaria ambigua			no data			
Macquaria australasica						
Gadopsis marmoratus						
Philypnodon sp. nov.	no data	no data	no data	no data	no data	no data

Notes:. Blank cells have adequate data (a number of consistent observations). Incomplete data means based on only a single incidental observation (i.e. not part of a formal scientific survey or experiment) or there are conflicting data. Based on information in 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
Geotria australis	+	no data	no data		no data	incomplete
Prototroctes maraena	+	no data	no data		incomplete	incomplete
Galaxias cleaveri	no data	no data	no data		no data	incomplete
Galaxias fuscus			no data		no data	no data
Galaxias olidus					no data	
Galaxias rostratus			no data		no data	no data
Galaxias truttaceus	+	no data	no data			no data
Galaxiella pusilla					no data	
Maccullochella peelii	+					
Macquaria ambigua	+					
Macquaria australasica	+				incomplete	no data
Gadopsis marmoratus			incomplete		incomplete	
Philypnodon sp. nov.	no data	no data	no data	no data	no data	no data

Notes: Blank cells have adequate data (a number of consistent observations). Incomplete data means based on only a single incidental observation (i.e. not part of a formal scientific survey or experiment) or there are conflicting data. Based on information in Koehn and O'Connor (1990).

Few data are available relating priority fish species to particular disturbances. The most significant 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 (Table 7.14), the impact of deposited sediment cannot be determined.

Aquatic Macroinvertebrates

There are still considerable gaps in the knowledge of aquatic macroinvertebrates in the Central Highlands. While sampling of most use to the RFA process has occurred at 40 sites in order to produce large scale models of distribution, it is likely that insufficient data are available to construct regional models. More sites would need to be sampled to allow the regional model to be produced (although it is currently not possible to calculate the number of required new sites).

The distribution of the majority of aquatic macroinvertebrates listed under the *Flora and Fauna Guarantee Act* 1988 or on the list of Victorian threatened fauna is not well known.

Taxonomically, the Central Highlands fauna is poorly studied. Only a few groups (decapod crustacea) are well known, while more common groups (eg. mayflies, stoneflies) are only known to the generic level. This severely hampers any attempt to identify species with restricted or rare distributions.

Almost no comprehensive data are available for life histories of aquatic macroinvertebrate taxa. Information has only been gained through casual observations, rather than formal scientific surveys and research, a situation common to many other forested regions.

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APPENDIX A: Central Highlands stratification and survey intensity analysis - flora

STRATA WITH VERY HIGH SAMPLING INTENSITY (>100 sites per 10,000ha)

Stratum No.	*mean ann. precip.*	*min. temp. coldest month*	*max. temp warmest month*	*lithology**	*# spp*	*# sites*	*probability next species new*	*area (ha)*	*% of Cent. High.*	*# polygons*	*site density (sites/10,000ha)*	*distribution (geographic units)*
1	low	high	high	e	677	278	2%	27042	3.78%	1089	102.80	Yarra, Disappointment
39	moderate	high	high	f	586	281	3%	25539	3.57%	345	110.03	Bunyip, La Trobe, Thomson
42	moderate	high	high	g	405	117	6%	10469	1.46%	483	111.76	Bunyip
27	very high	low	low	f	207	113	2%	5404	0.75%	14	209.10	La Trobe, Thomson
57	high	high	moderate	g	135	31	5%	1680	0.23%	56	184.52	Bunyip
6	low	high	high	f	93	7	37%	596	0.08%	57	117.45	Disappointment
52	moderate	high	high	?	161	9	25%	473	0.07%	192	190.27	Yarra, Thomson
30	high	moderate	low	f	130	13	9%	461	0.06%	31	282.00	La Trobe, Thomson
48	low	high	high	?	113	5	42%	376	0.05%	58	132.98	Bunyip,
16	low	high	high	g	265	24	7%	225	0.03%	77	1066.67	Yarra, Matlock/Big
3	low	high	high	c	47	3	44%	224	0.03%	92	133.93	Yarra
							Total	**72489**	**10.12%**			

* Key to lithology

a = coarsely textured unconsolidated deposits: low fertility

b = coarsely textured unconsolidated deposits-finely textured unconsolidated deposits: low fertility

c = finely textured unconsolidated deposits: highest fertility

d = finely textured unconsolidated deposits/coarsely textured unconsolidated deposits: moderate fertility

e = sedimentary, volcanic/sedimentary, sedimentary/granites and gneisses, volcanic/sedimentary/granites and gneisses/finely textured unconsolidated deposits, sedimentary/volcanic: low fertility (mostly acid volcanic)

f = granites and gneisses, volcanic/granites and gneisses, granites and gneisses/sedimentary: moderate fertility

g = volcanic, volcanic/finely textured unconsolidated deposits: highest fertility (mostly basic volcanics)

? = undescribed

STRATA WITH HIGH SAMPLING INTENSITY (40 - 100 sites per 10,000 ha)

Stratum No.	*mean ann. precip.*	*min. temp. coldest month*	*max. temp warmest month*	*lithology*	*# spp*	*# sites*	*probability next species new*	*area (ha)*	*% of Cent. High.*	*# polygons*	*site density (sites/10,000ha)*	*distribution (geographic units)*
36	moderate	high	high	e	859	483	1%	107575	15.02%	1668	44.90	all
20	very high	moderate	moderate	g	327	492	1%	51582	7.20%	33	95.38	Acheron, Marysville, Alexandra
45	high	high	high	f	382	228	1%	44973	6.28%	104	50.70	Bunyip, Acheron, La Trobe, Alexandra
29	very high	moderate	moderate	f	367	189	4%	32736	4.57%	62	57.73	Bunyip, Acheron, La Trobe, Thomson, Marysville
25	high	moderate	moderate	f	348	267	2%	28286	3.95%	160	94.39	Bunyip, La Trobe, Thomson, Alexandra
44	high	high	high	g	326	140	2%	17125	2.39%	256	81.75	Bunyip, Acheron
24	moderate	moderate	moderate	f	232	72	4%	15471	2.16%	17	46.54	La Trobe, Thomson, Disappointment
59	high	high	moderate	f	199	92	2%	12125	1.69%	165	75.88	Bunyip, Acheron, La Trobe
53	moderate	high	high	c	291	30	10%	6214	0.87%	589	48.28	Bunyip, La Trobe
7	moderate	moderate	high	f	304	26	10%	4778	0.67%	40	54.42	La Trobe, Thomson, Disappointment
26	very high	moderate	low	f	152	23	12%	3735	0.52%	53	61.58	La Trobe, Thomson
18	very high	low	low	g	119	23	4%	3127	0.44%	28	73.55	Marysville
50	very high	high	high	g	95	13	9%	1732	0.24%	87	75.06	Acheron
63	moderate	high	moderate	f	130	11	15%	1428	0.20%	33	77.03	La Trobe
47	very high	moderate	high	e	57	2	88%	270	0.04%	27	74.07	Alexandra
							Total	**331157**	**46.25%**			

STRATA WITH MODERATE SAMPLING INTENSITY (10 - 40 sites per 10,000ha)

Stratum No.	*mean ann. precip.*	*min. temp. coldest month*	*max. temp warmest month*	*lithology*	*# spp*	*# sites*	*probability next species new*	*area (ha)*	*% of Cent. High.*	*# polygons*	*site density (sites/10,000ha)*	*distribution (geographic units)*
10	high	moderate	moderate	e	383	153	2%	86564	12.09%	331	17.67	Acheron, Thomson, Matlock, Big, Marysville, Alexandra
43	high	high	high	e	463	141	2%	59252	8.27%	426	23.80	Yarra, Bunyip, Acheron, La Trobe, Thomson, Matlock, Big, Alexandra
15	very high	moderate	moderate	e	289	106	3%	54106	7.56%	159	19.59	Acheron, Thomson, Matlock, Big
9	high	moderate	high	e	286	29	10%	26546	3.71%	391	10.92	Acheron, La Trobe, Thomson, Matlock, Big, Alexandra, Disappointment
11	high	moderate	moderate	g	144	32	6%	8144	1.14%	94	39.29	Acheron, Marysville, Alexandra
2	low	moderate	high	e	110	6	40%	5969	0.83%	259	10.05	Matlock/Big
22	very high	moderate	low	g	91	13	8%	4363	0.61%	59	29.80	Acheron, Marysville
21	moderate	moderate	moderate	e	127	8	29%	4143	0.58%	87	19.31	Alexandra, Disappointment
58	high	high	moderate	e	60	3	52%	2342	0.33%	138	12.81	La Trobe
31	high	moderate	high	f	132	7	26%	2164	0.30%	55	32.35	Alexandra
19	very high	moderate	low	e	36	2	71%	1367	0.19%	62	14.63	Matlock, Big
40	moderate	moderate	high	d	57	3	33%	1196	0.17%	16	25.08	La Trobe
54	very high	high	moderate	g	37	2	?	791	0.11%	70	25.28	Acheron
62	very high	high	moderate	f	41	2	88%	580	0.08%	35	34.48	Acheron
49	very high	moderate	high	g	25	1	n/a	251	0.04%	30	39.84	Alexandra
							Total	**257778**	**36.00%**			

STRATA WITH LOW SAMPLING INTENSITY (1 - 10 sites per 10,000 ha)

Stratum No.	*mean ann. precip.*	*min. temp. coldest month*	*max. temp warmest month*	*lithology*	*# spp*	*# sites*	*probability next species new*	*area (ha)*	*% of Cent. High.*	*# polygons*	*site density (sites/10,000ha)*	*distribution (geographic units)*
8	moderate	moderate	high	e	367	39	8%	39674	5.54%	743	9.83	Matlock, Big, Alexandra, Disappointment
41	moderate	high	high	d	66	3	66%	4289	0.60%	148	6.99	La Trobe
12	high	moderate	high	g	58	2	59%	2676	0.37%	26	7.47	Marysville
							Total	**46639**	**6.51%**			

STRATA WITHOUT SAMPLE SITES

Stratum No.	*mean ann. precip.*	*min. temp. coldest month*	*max. temp warmest month*	*lithology*	*# spp*	*# sites*	*probability next species new*	*area (ha)*	*% of Cent. High.*	*# polygons*	*site density (sites/10,000ha)*	*distribution (geographic units)*
5	low	moderate	high	f	0	0	100%	2232	0.31%	47	0.00	Disappointment
70	moderate	moderate	high	c	0	0	100%	1688	0.24%	20	0.00	La Trobe
64	moderate	high	moderate	e	0	0	100%	956	0.13%	44	0.00	La Trobe, Thomson
55	high	high	high	c	0	0	100%	546	0.08%	24	0.00	Yarra
56	high	high	high	?	0	0	100%	477	0.07%	88	0.00	Thomson
33	high	moderate	low	e	0	0	100%	378	0.05%	12	0.00	Yarra
38	moderate	moderate	high	?	0	0	100%	306	0.04%	100	0.00	Matlock, Big
13	moderate	moderate	high	g	0	0	100%	294	0.04%	36	0.00	La Trobe
23	very high	low	low	e	0	0	100%	285	0.04%	18	0.00	Matlock, Big
17	low	moderate	high	?	0	0	100%	179	0.02%	52	0.00	Yarra
32	low	moderate	high	d	0	0	100%	118	0.02%	16	0.00	Yarra
4	low	high	high	d	0	0	100%	113	0.02%	40	0.00	Yarra
							Total	**7572**	**1.06%**			

STRATA OCCUPYING LESS THAN 100 HECTARES

Stratum No.	*mean ann. precip.*	*min. temp. coldest month*	*max. temp warmest month*	*lithology*	*# spp*	*# sites*	*probability next species new*	*area (ha)*	*% of Cent. High.*	*# polygons*	*site density (sites/10,000ha)*	*distribution (geographic units)*
51	very high	high	high	e	57	2	67%	96	0.01%	11	208.33	not determined
67	high	moderate	high	c	0	0		89	0.01%	6	0.00	not determined
78	moderate	high	moderate	c	0	0		63	0.01%	15	0.00	not determined
37	high	low	low	e	0	0		60	0.01%	9	0.00	not determined
61	very high	high	high	f	0	0		49	0.01%	7	0.00	not determined
65	high	high	moderate	c	0	0		30	0.00%	2	0.00	not determined
68	moderate	high	moderate	g	0	0		20	0.00%	8	0.00	not determined
66	high	moderate	moderate	c	0	0		18	0.00%	1	0.00	not determined
28	low	moderate	high	g	0	0		7.5	0.00%	3	0.00	not determined
60	very high	high	moderate	e	0	0		6	0.00%	1	0.00	not determined
71	moderate	high	moderate	d	0	0		6	0.00%	1	0.00	not determined
46	high	moderate	low	g	0	0		4	0.00%	1	0.00	not determined
							Total	**448.5**	**0.06%**			

APPENDIX B: Central Highlands stratification and survey intensity analysis - fauna

Probability (%) of the next species recorded for a particular fauna group in a particular stratum being new (ie not previously recorded in surveys for that fauna group in that stratum). Also shown are the area of each stratum, the % of the total forested area of the Central Highlands CRA Region, and the order from largest to smallest (1 is largest). Asterisks indicate too few samples (<6 survey sites) for accurate calculation and entries of 100% indicate no sites surveyed.

Strata No.	**Order**	**Area (ha)**	**% Area**	Arb-oreal Mamm	Large Mamm.	Small Ground Mamm.	Bats	Diurnal Birds	Noc-turnal Birds	Large Forest Owls	Rep-tiles	Amph-ibians
1	10	27,042	3.78	0	*	5	1	0	0	*	38	100
2	19	5,969	0.83	17	*	87	100	100	75	*	*	*
3	52	224	0.03	100	100	100	*	100	100	100	100	100
4	55	113	0.02	100	100	100	100	100	100	100	100	100
5	29	2,232	0.31	*	100	100	100	100	*	*	*	*
6	38	596	0.08	*	100	*	100	*	*	100	*	*
7	21	4,778	0.67	0	*	0	0	4	21	92	9	6
8	7	39,674	5.54	8	*	6	0	18	49	*	17	40
9	11	26,546	3.71	10	*	4	2	9	*	*	4	0
10	2	86,564	12.09	3	4	1	1	2	37	*	8	46
11	17	8,144	1.14	12	*	3	2	3	39	99	5	*
12	27	2,676	0.37	*	100	100	100	*	*	*	100	100
13	47	294	0.04	100	100	100	100	100	100	100	100	100
15	4	54,106	7.56	0	0	2	0	1	5	0	13	*
16	51	225	0.03	*	100	99	*	100	*	100	100	100
17	53	179	0.02	*	*	*	100	100	*	100	*	*
18	26	3,127	0.44	*	34	5	100	*	*	*	*	*
19	34	1,367	0.19	*	100	100	*	*	*	*	100	100
20	5	51,582	7.20	0	17	2	0	0	0	0	2	0
21	24	4,143	0.58	*	*	0	3	*	93	*	*	*
22	22	4,363	0.61	*	*	12	100	*	100	*	*	*
23	48	2,85	0.04	*	100	100	*	100	100	100	100	100
24	14	15,471	2.16	0	10	2	0	1	10	*	7	8
25	9	28,286	3.95	2	3	3	4	1	3	0	6	13
26	25	3,735	0.52	*	100	*	*	100	*	*	*	0
27	20	5,404	0.75	100	*	*	100	100	100	100	*	*
28	63	8	0.00	100	100	100	100	100	100	100	100	100
29	8	32,736	4.57	0	6	1	0	1	2	0	6	15
30	43	461	0.06	*	*	0	100	3	*	*	7	83
31	30	2,164	0.30	*	*	*	*	100	*	*	*	*
32	54	118	0.02	100	100	100	100	100	100	100	100	100
33	44	378	0.05	100	100	100	100	100	100	100	100	100
36	1	10,7575	15.02	0	7	1	1	0	5	*	11	8
37	58	60	0.01	100	100	100	100	100	100	100	100	100
38	46	306	0.04	100	100	100	100	100	100	100	100	100
39	12	25,539	3.57	2	7	0	0	1	0	0	1	2
40	35	1,196	0.17	100	100	100	100	100	100	100	100	100
41	23	4,289	0.60	*	100	100	100	100	*	*	100	100
42	16	10,469	1.46	0	*	0	8	*	21	*	100	*
43	3	59,252	8.27	5	*	1	1	2	6	*	12	31
44	13	17,125	2.39	3	100	0	0	5	0	0	100	100
45	6	44,973	6.28	2	0	1	1	2	5	1	1	2
46	65	4	0.00	100	100	100	100	100	100	100	100	100
47	49	270	0.04	100	100	*	100	100	100	100	100	100

Strata No.	**Order**	**Area (ha)**	**% Area**	Arb-oreal Mamm	Large Mamm.	Small Ground Mamm.	Bats	Diurnal Birds	Noc-turnal Birds	Large Forest Owls	Rep-tiles	Amph-ibians
48	45	376	0.05	100	100	100	*	100	100	100	100	100
49	50	251	0.04	100	100	100	100	100	100	100	100	100
50	31	1,732	0.24	*	100	*	*	*	*	*	100	100

Strata No.	**Order**	**Area (ha)**	**% Area**	Arb-oreal Mamm	Large Mamm.	Small Ground Mamm.	Bats	Diurnal Birds	Noc-turnal Birds	Large Forest Owls	Rep-tiles	Amph-ibians
51	56	96	0.01	100	100	100	100	100	100	100	100	100
52	42	473	0.07	*	100	*	*	*	*	*	100	100
53	18	6,214	0.87	*	100	100	100	100	*	*	100	100
54	37	791	0.11	*	100	100	100	*	*	*	100	100
55	40	546	0.08	100	100	100	100	*	100	100	100	100
56	41	477	0.07	100	100	0	*	*	100	100	31	*
57	32	1,680	0.23	*	100	*	*	100	*	100	100	100
58	28	2,342	0.33	*	100	100	100	100	*	*	100	100
59	15	12,125	1.69	6	6	4	3	6	12	1	5	20
60	64	6	0.00	100	100	100	100	100	100	100	100	100
61	59	49	0.01	100	100	100	100	100	100	100	100	100
62	39	580	0.08	*	100	*	100	*	*	*	100	100
63	33	1,428	0.20	0	*	0	2	4	0	*	0	15
64	36	956	0.13	100	100	100	100	100	100	100	100	100
65	60	30	0.00	100	100	100	100	100	100	100	100	100
66	62	18	0.00	100	100	100	100	100	100	100	100	100
67	57	89	0.01	100	100	100	100	*	100	100	100	100
68	61	20	0.00	100	100	100	100	100	100	100	100	100

APPENDIX C: Descriptions of Ecological Vegetation Classes occurring in the Victorian Central Highlands

Dry Sub-alpine Shrubland

Dry Sub-alpine Shrubland is a sparse to dense shrubland occurring on north-facing slopes and in saddles on the Baw Baw Plateau, often in the vicinity of granite tors. The shallow soils and the extreme exposure to wind may inhibit the establishment of trees and even shrubs on some sites. Characteristic shrubs include Dusty Daisy-bush (*Olearia phlogopappa*), Alpine Orites (*Orites lancifolia*), Cascade Everlasting (*Helichrysum secundiflorum*) and Mueller's Bush-pea (*Pultenaea muelleri*).

The herbaceous ground layer, which may be quite dense if the shrubs are sparse, is characterised by Mountain Woodruff (*Asperula gunnii*), Short-stem Sedge (*Carex breviculmis*), Silver Daisy (*Celmisia asteliifolia*), Alpine Wallaby-grass (*Danthonia nudiflora*) and Australian Carraway (*Oreomyrrhis eriopoda*).

Fire may have been a factor in generating this ecological vegetation class, which contains a curious mixture of herbs of higher altitudes in conjunction with shrubs normally from lower altitudes. The patchiness of the shrub layer reinforces this conclusion.

Damp Sub-alpine Heathland

Damp Sub-alpine Heathland usually occurs in an intermediate band between Dry Sub-alpine Shrubland and Wet Sub-alpine Heathland, or on raised areas within Wet Sub-alpine Heathland. The dense shrub layer includes Alpine Star-bush (*Asterolasia trymalioides*), Alpine Grevillea (*Grevillea australis*), Scaly Everlasting (*Helichrysum hookeri*), Snow Heath (*Epacris petrophila*) and Alpine Orites (*Orites lancifolia*). The soils, which are deeper and wetter than those of Dry Sub-alpine Shrubland, support a ground layer which includes Spreading Rope-rush (*Empodisma minus*), Soft Tussock-grass (*Poa hiemata*), Mountain Woodruff (*Asperula gunnii*) and Alpine Podolepis (*Podolepis robusta*).

Wet Sub-alpine Heathland

The wettest sites in the depressions and gully heads of the Baw Baw Plateau, Lake Mountain and Mt Bullfight support an open to very dense heathland characterised by the following shrubs: Candle Richea (*Richea continentis*), Swamp Heath (*Epacris paludosa*), Alpine Baeckea (*Baeckea gunniana*), Drumstick Heath (*Epacris breviflora*) and Mountain Daisy-bush (*Olearia algida*).

This ecological vegetation class would include most sites commonly known as alpine or Sphagnum bogs. The deep, peaty, sodden soils are usually covered by a layer of Sphagnum moss (*Sphagnum* spp.). Other characteristic ground layer species include Spreading Rope-rush (*Empodisma minus*), Matted Nertera (*Nertera granadensis*), Alpine Astelia (*Astelia alpina*) and Mountain Gentian (*Gentianella diamensis*). The underlying soils accumulate organic material due to slow rates of decomposition, which can be attributed to low temperatures and anaerobic conditions.

Large volumes of water are retained in the moss and peaty soil, seeping downslope until small trickles and streams form. Steeper-sided gullies frequently descend from the outlets of these bogs, often supporting Montane Riparian Thicket (see below).

Sub-alpine Woodland

This community forms a woodland or forest which occurs on slopes above 1200 m, on relatively free-draining soils. Usually dominated by Snow Gum (*Eucalyptus pauciflora*), the understorey may variously consist of a rich suite of grasses and herbs, or a dense layer of woody shrubs such as Mueller's Bush-pea (*Pultenaea muelleri*), Alpine Oxylobium (*Oxylobium alpestre*), Alpine Pepper (*Tasmannia xerophila*) and Lilac Berry (*Trochocarpa clarkei*).
An interesting variant of this community is found on Mt Useful, where the Ash-mallee (*Eucalyptus kybeanensis*) occurs with Alpine Wattle (*Acacia alpina*), Drooping Beard-heath (*Leucopogon gelidus*) and a rare, as yet unnamed species of Broom-heath (*Monotoca* sp. aff. *elliptica* [alps]). Another unusual record is of Spinning Gum (*Eucalyptus perriniana*), which occurs north of Mt Whitelaw.

Montane Dry Woodland

The drier, more exposed aspects of the mountain slopes support Montane Dry Woodland, a woodland or forest from 15 to 25 m in height.
Characteristic trees include Broad-leaf Peppermint (*Eucalyptus dives*), Candlebark (*Eucalyptus rubida*) and Narrow-leaf Peppermint (*Eucalyptus radiata*). Snow Gum (*Eucalyptus pauciflora*) is often present at higher altitudes.
Other notable eucalypts found in this community include Brittle Gum (*Eucalyptus mannifera*), which is at the western limit of its distribution, and the uncommon Bogong Gum (*Eucalyptus chapmaniana*), both of which are found in the Woods Point/upper Goulburn area.
Characteristic shrubs include Common Cassinia (*Cassinia aculeata*), Moth Daisy-bush (*Olearia erubescens*), and Gorse Bitter-pea (*Daviesia ulicifolia*). Frequently present in the ground layer are Prickly Starwort (*Stellaria pungens*), Spiny-headed Mat-lily (*Lomandra longifolia*), Pink-bells (*Tetratheca ciliata*), Austral Bracken (*Pteridium esculentum*), Grey Tussock-grass (*Poa sieberiana*) and Tasman Flax-lily (*Dianella tasmanica*).

Montane Damp Forest

The more protected mountain slopes support a tall forest up to 40m in height, dominated in its lower altitudinal range by Mountain Grey Gum (*Eucalyptus cypellocarpa*), Messmate (*Eucalyptus obliqua*), Narrow-leaf Peppermint (*Eucalyptus radiata*) and occasionally Manna Gum (*Eucalyptus viminalis*). At higher altitudes, Montane Damp Forest is often dominated by pure stands of Alpine Ash (*Eucalyptus delegatensis*). Montane Damp Forest is closely related to Damp Sclerophyll Forest, with which it intergrades between 800 and 1000 m in elevation.
Montane Damp Forest features a open to rather dense layer of tall shrubs, amongst which Silver Wattle (*Acacia dealbata*), Blackwood (*Acacia melanoxylon*), Mountain Hickory Wattle (*Acacia obliquinervia*), Elderberry Panax (*Polyscias sambucifolia*), Blunt-leaf Bitter-pea (*Daviesia laxiflora*) and Rough Coprosma (*Coprosma hirtella*) are prominent.
The ground layer is characterised by grasses and herbs, including Bidgee-widgee (*Acaena novae-zelandiae*), Sword Tussock-grass (*Poa ensiformis*), Mountain Cotula (*Leptinella filicula*), Derwent Speedwell (*Parahebe derwentiana*), Common Lagenifera (*Lagenifera stipitata*) and Ivy-leaf Violet (*Viola hederacea*). Mother Shield-fern (*Polystichum proliferum*) is common in moister sites.

Montane Wet Forest

Montane Wet Forest occupies the most protected, usually south-facing slopes and gullies. Here soils are deep, fertile and well-drained. The canopy may grow to more than 60 m, and consists of

pure or mixed stands of Alpine Ash (*Eucalyptus delegatensis*), and Shining Gum (*Eucalyptus nitens*).
Manna Gum (*Eucalyptus viminalis*) may be a co-dominant in the Blue and Royston Ranges, while significant occurrences of Tingaringy Gum (*Eucalyptus glaucescens*) and Errinundra Shining Gum (*Eucalyptus denticulata)* are recorded from Montane Wet Forest on the Baw Baw Plateau.
The tall second storey of Montane Wet Forest commonly includes Myrtle Beech (*Nothofagus cunninghamii*) and Forest Wattle (*Acacia frigescens*), which grow above a dense layer of Soft Tree-ferns (*Dicksonia antarctica*). At ground level, Hard Water-fern (*Blechnum wattsii*), Bat's-wing Fern (*Histiopteris incisa*) and Mother Shield-fern (*Polystichum proliferum*) are characteristic of this community.
Although this community is closely related to Wet forest, the floristic distinction lies in the substitution of most of the characteristic shrubs and trees. Notably absent in Montane Wet Forest are broad-leafed shrubs such as Hazel Pomaderris (*Pomaderris aspera*), Blanket-leaf (*Bedfordia arborescens*), Musk Daisy-bush (*Olearia argophylla*), Austral Mulberry (*Hedycarya angustifolia*), and Tree Lomatia (*Lomatia fraseri*), and the Rough Tree-fern (*Cyathea australis*).
On the north-eastern face of the Baw Baw massif, Mountain Ash (*Eucalyptus regnans*) ascends to approximately 1200 m in association with species characteristic of both Montane Wet Forest and Wet forest (see below). This unusually high-elevation occurrence may be a response to the tempering effect of the massif on the prevailing south-westerly winds, or to soil temperature variation due to insolation.
The presence of Myrtle Beech in the second storey reflects the strong association between Montane Wet Forest and Cool Temperate Rainforest. In protected sites, especially following a long fire-free period, stands of Myrtle Beech may achieve a degree of canopy closure sufficient for them to be considered Cool Temperate Rainforest, despite the presence of emergent eucalypts.

Montane Riparian Thicket

Dense thickets of Mountain Tea-tree (*Leptospermum grandifolium*) occur along drainage lines in montane and sub-alpine areas. Montane Riparian Thicket is associated with a number of other ecological vegetation classes, often arising at the outlets of sub-alpine heathlands, and descending to intergrade with Cool Temperate Rainforest or Riparian Thicket at lower altitudes.
The canopy of Montane Riparian Thicket may vary in height up to approximately 15m. Cool Temperate Rainforest dominants Myrtle Beech (*Nothofagus cunninghamii*) and Sassafras (*Atherosperma moschatum*) are frequently sub-dominant in this community.
Soils are similar to the often sodden, peaty soils of the Wet Sub-alpine Heathland. A thick substrate of Sphagnum is often present. The ground layer flora includes Alpine Water-fern (*Blechnum penna-marina*), Tall Sedge (*Carex appressa*), Forest Sedge (*Carex alsophila*), Pretty Grass-flag (*Libertia pulchella*) and Hard Water-fern (Blechnum wattsii). The Baw Baw Berry (*Wittsteinia vacciniacea*), although considered rare in Victoria (Gullan et al 1990), is frequently encountered as a low shrub within this community. It is endemic in the Victorian Central Highlands.
An unusual variant of this community occurs at Bellel Creek, south-east of Marysville, and at the Xylophone Bridge on the Murrindindi River. Here, Mountain Tea-tree is locally absent, but the ferns, herbs and sedges of the understorey remain to produce curious open bogs. The events or environmental factors leading to the establishment of such vegetation are unclear, although such sites frequently occur immediately upstream of the confluence of two streams.

Cool Temperate Rainforest

Cool Temperate Rainforest occurs in protected gully heads, on surrounding slopes and along streams throughout the wetter, mountainous parts of the Study Area. Moisture and the virtual absence of fire are the key determinants of its distribution.
Cool Temperate Rainforest is dominated by Myrtle Beech (*Nothofagus cunninghamii*) and Southern Sassafras (*Atherosperma moschatum*) which typically form a more or less continuous, dense canopy up to 40 m in height. Scattered emergent eucalypts may be present. Blackwood (*Acacia melanoxylon*) may form part of the closed rainforest canopy in some stands, but it is also widespread in other ecological vegetation classes.
The understorey features an array of ferns, including Soft Tree-fern (*Dicksonia antarctica*), Hard Water-fern (*Blechnum wattsii*) and Mother Shield-fern (*Polystichum proliferum*). The moist, sheltered conditions allow an number of epiphytic fern species to flourish, including Kangaroo-fern (*Microsorum diversifolium*), Filmy Ferns (*Hymenophyllum* spp.) and Long Fork-fern (*Tmesipteris billardieri*). Mosses and liverworts are abundant.
Several rare species occur in some Cool Temperate Rainforest stands in the upper Bunyip River catchment, notably Tall Astelia (*Astelia australiana*), Oval Fork-fern (*Tmesipteris ovata*), and Bristly Shield-fern (*Lastreopsis hispida*).

Wet Forest

Wet Forest is usually dominated by Mountain Ash (*Eucalyptus regnans*), forming the tallest forests in the study area. Occurring on the protected slopes of the ranges, plateaus and outlying hills, these sites tend to have abundant rainfall, deep, rich, well-drained soils, and offer some degree of fire protection.
The canopy may grow to 80 m in height. Beneath it, a second storey of trees including Silver Wattle (*Acacia dealbata*) and Blackwood (*Acacia melanoxylon*) may reach 35 m. The third storey comprises broad-leafed shrubs such as Hazel Pomaderris (*Pomaderris aspera*), Blanket-leaf (*Bedfordia arborescens*), Musk Daisy-bush (*Olearia argophylla*), Austral Mulberry (*Hedycarya angustifolia*), Tree Lomatia (*Lomatia fraseri*) and Banyalla (*Pittosporum bicolor*) grow to 20 m in height.
A dense layer of Soft Tree-fern (*Dicksonia antarctica*) and Rough Tree-fern (*Cyathea australis*) to 5m is characteristic. The moist, shaded ground layer supports Mother Shield-fern (*Polystichum proliferum*), Hard Water-fern (*Blechnum wattsii*), Shade Nettle (*Australina pusilla*) and White Elderberry (*Sambucus gaudichaudii*). In the wettest fern-gullies, Shiny Shield-fern (*Lastreopsis acuminata*) and Mother Spleenwort (*Asplenium bulbiferum*) are common.
Of particular note are the extensive areas in the Central Highlands where two extreme fires in succession (1926 and 1939) have led to the development of thickets, usually of Silver Wattle (*Acacia dealbata*) or Blackwood (*Acacia melanoxylon*), without a eucalypt overstorey. The interval between these fires was insufficient to allow eucalypt seed stores to be replenished.
While extremely severe and widespread fires such as Black Friday, 1939, and Ash Wednesday, 1983, may completely raze vast areas of forest, other less severe fires can produce a variety of localised effects which result in the development of mixed-age stands of Mountain Ash (*Eucalyptus regnans*). Although not extensive, these stands do occur in, for example, several of the Melbourne Water Catchment Areas.
Many Wet Forest species may also occur in stands which are transitional between this community and Cool Temperate Rainforest, having a consistent, dense understorey of Myrtle Beech (*Nothofagus cunninghamii*). This tends to occur in forests at the upper limit of elevation for this community, usually 700 - 1000 m. The transition to rainforest will continue only in the absence of fire or other major disturbance.
The following rare species are associated with Wet Forest in the Study Area: Butterfly Orchid (*Sarcochilus australis*) and Gully Grevillea (*Grevillea barklyana*) in the Bunyip River area, and Shiny Phebalium (*Phebalium wilsonii*) in the O'Shannassy Catchment.

Damp Forest

Damp Forest is a widespread ecological vegetation class occupying a range of sites on a variety of soils and aspects. It occurs from 200 to 1000 m in elevation. It differs from Wet forest in that it has a simpler structure without a distinct tree-fern layer, that characteristic shrubs usually have smaller, tougher leaves, and that the ground layer is much drier, supporting more herbs and grasses.

Messmate (*Eucalyptus obliqua*) and Mountain Grey Gum (*Eucalyptus cypellocarpa*) are the characteristic dominants in the overstorey, although Mountain Ash, Manna Gum, Silver-top (*Eucalyptus sieberi*) and Eurabbie (*Eucalyptus globulus* ssp. *bicostata*) may be locally dominant.

The species comprising the shrub layer of Damp Forest vary across the study area, although the following are widespread: Hazel Pomaderris (*Pomaderris aspera*), Prickly Coprosma (*Coprosma quadrifida*), Bootlace Bush (*Pimelea axiflora*), Prickly Moses (*Acacia verticillata*) and Snow Daisy-bush (*Olearia lirata*).

The ground layer is similarly variable across the study area, but characteristic species include Common Ground-fern (*Calochlaena dubia*), Ivy-leaf Violet (*Viola hederacea*), Rough Tree-fern (*Cyathea australis*), Mountain Clematis (*Clematis aristata*), Cinquefoil (*Geranium potentilloides*) and Tall Sword-sedge (*Lepidosperma elatius*).

Riparian Thicket

Dense thickets of Woolly Tea-tree (*Leptospermum lanigerum*) and/or Scented Paperbark (*Melaleuca squarrosa*) occur on broad beds of small streams or on the regularly flooded terraces of large streams and rivers. Soils are usually sandy or gravelly, but with high silt levels.

Woolly Tea-tree occurs throughout the study area, while Scented Paperbark is confined to areas south of the Divide.

The ground layer is usually dominated by tufts of Fishbone Water-fern (*Blechnum nudum*), in association with Soft Tree-fern, Red-fruit Saw-sedge (*Gahnia sieberiana*), Sedges (*Carex* spp.) and Spreading Fan-fern (*Sticherus lobatus*). One population of Tall Astelia (*Astelia australiana*) occurs within this community along the middle branch of Pioneer Creek, in the upper reaches of the La Trobe River. This species is considered vulnerable by Gullan et al (1990). It normally occurs in Cool Temperate Rainforest.

Riparian Thicket is structurally very similar to Montane Riparian Thicket, differing mainly in the floristic composition of the understorey. It frequently intergrades with Cool Temperate Rainforest, and Myrtle Beech (*Nothofagus cunninghamii*) often occurs as a sub-dominant species.

These three communities appear to occur along an environmental gradient, with Cool Temperate Rainforest occurring on the better-drained, fire-protected sites which are associated with the steeper slopes and deeper gullies, while Montane Riparian Thicket occurs in the high-altitude, peaty drainage lines. Riparian Thicket is found on the lower elevation stream banks and terraces. However, little data is available to explain fully the relationship between these communities; the explanation above is based on anecdotal evidence.

Riparian Forest

Riparian Forest is a tall forest of river banks and alluvial terraces. It tends to occur along quite swift-flowing streams. It is normally dominated by Manna Gum (*Eucalyptus viminalis*), with Silver Wattle (*Acacia dealbata*), Blackwood (*Acacia melanoxylon*), Hazel Pomaderris (*Pomaderris aspera*), Victorian Christmas-bush (*Prostanthera lasianthos*) and Prickly Coprosma (*Coprosma quadrifida*) in the shrub layer.

An abundance of moisture combined with fertile, well-drained soils explains the strong floristic links with Wet forest. The richness of the understorey of Riparian Forest is noteworthy, with a

wide variety of terrestrial species as well as a suite of semi-aquatic plants. Usually present are Fishbone Water-fern (*Blechnum nudum*), Tall Sedge (*Carex appressa*), Mother Shield-fern (*Polystichum proliferum*), Swamp Club-sedge (*Isolepis inundata*), Small-leaf Bramble (*Rubus parvifolius*) and Soft Tree-fern (*Dicksonia antarctica*).
Environmental weeds are a common component of Riparian Forest. This is due to a variety of factors, including the natural pattern of disturbance through flooding, the amenable environment, and the history of human activity along rivers.
A major variant of Riparian Forest occurs on saturated river flats, sometimes adjacent to a swiftly-flowing river. These sites are regularly flooded. Soils are silt-rich river sands and gravels in this situation, although sites with heavier clay soils may also support this variant. It is usually dominated by Swamp Gum (*Eucalyptus ovata*), although Mealy Stringybark (*Eucalyptus cephalocarpa*) and Messmate (*Eucalyptus obliqua*) may also be present, particularly in the La Trobe, Bunyip and Tarago River catchments.
The second storey includes Blackwood (*Acacia melanoxylon*), Woolly Tea-tree (*Leptospermum lanigerum*), Hazel Pomaderris (*Pomaderris aspera*) and, south of the Great Dividing Range, Scented Paperbark (*Melaleuca squarrosa*).
In the ground layer, Soft Tree-fern (*Dicksonia antarctica*), Red-fruit Saw-sedge (*Gahnia sieberiana*), Water-ferns (*Blechnum* spp.), Tall Sword-sedge (*Lepidosperma elatius*), Common Reed (*Phragmites australis*), and Brooklime (*Gratiola peruviana*) are common. Showy Willow-herb (*Epilobium pallidiflorum*), which is considered to be depleted, may be present if the area is not grazed.
This variant of Riparian Forest has strong affinities with Riparian Thicket, Riparian Forest, and Swamp Heath.
Examples include the stand of Buxton Gum (*Eucalyptus crenulata*) on river flats beside the Acheron River south of Buxton, where the atypical understorey combines elements of Wet Heathland and Floodplain Wetland Complex, as well as many of the usual species listed above.

Herb-rich Foothill Forest

Herb-rich Foothill Forest occurs mainly in the northern part of the Study Area. The canopy is usually 20 to 35 m tall, and is made up of Narrow-leaf Peppermint (*Eucalyptus radiata*) and Messmate (*Eucalyptus obliqua*) in the Big River, Black Range and Mt Disappointment areas, while Eurabbie (*Eucalyptus globulus* ssp. *bicostata*), Manna Gum (*Eucalyptus viminalis*) and Candlebark (*Eucalyptus rubida*) are more common in the Strathbogie Ranges, Tallarook State Forest and around Lake Eildon.
The sparse low shrub layer consists normally of two species: Common Cassinia (*Cassinia aculeata*) and Silver Wattle (*Acacia dealbata*).
The ground layer is dense and species rich. The following species are frequently present: Kidney-weed (*Dichondra repens*), Weeping Grass (*Microlaena stipoides*), Common Lagenifera (*Lagenifera stipitata*), Bidgee-widgee (*Acaena novae-zelandiae*), Cinquefoil (*Geranium potentilloides*), Ivy-leaf Violet (*Viola hederacea*), Grey Tussock-grass (*Poa sieberiana*), Soft Tussock-grass (*Poa morrisii*), Austral Bear's-ears (*Cymbonotus preissianus*) and Prickly Woodruff (*Asperula scoparia*).
Austral Bracken (*Pteridium esculentum*) is usually present, and may tend to dominate the ground layer if frequent disturbance, particularly by fire, occurs.

Shrubby Foothill Forest

Similar in structure to Herb-rich Foothill Forest, Shrubby Foothill Forest has a more dense and varied shrub layer, but tends to lack a diverse ground layer. It is widespread on higher slopes, particularly between 400 and 900 m in elevation, both north and south of the Great Dividing Range.

The dominant trees are Messmate and Narrow-leaf Peppermint, although Silver-top (*Eucalyptus sieberi*), Mountain Grey Gum (*Eucalyptus cypellocarpa*) and Scent-bark (*Eucalyptus ignorabilis*) may occur in this community in the Walhalla area.
A wide variety of shrubs characterise this community across its range. Common among these are Narrow-leaf Wattle (*Acacia mucronata*), Dusty Miller (*Spyridium parvifolium*), Handsome Flat-pea (*Platylobium formosum*), Prickly Bush-pea (*Pultenaea juniperina*), Rough Bush-pea (*Pultenaea scabra*), Varnish Wattle (*Acacia verniciflua*), Common Cassinia (*Cassinia aculeata*), Shiny Cassinia (*Cassinia longifolia*), Hop Goodenia (*Goodenia ovata*) and Pink-bells (*Tetratheca ciliata*).
The ground layer includes Ivy-leaf Violet, Common Raspwort (*Gonocarpus tetragynus*) and Grey Tussock-grass. Forest Wire-grass (*Tetrarrhena juncea*) and Austral Bracken (*Pteridium esculentum*) are commonly present, and sometimes dominant.

Lowland Forest

Lowland Forest is closely related to the two previous communities, although it tends to occur at lower elevations, on yellowish gradational soils and leached sands of low fertility. Examples are found mainly on the lower slopes in the La Trobe, Bunyip and Tarago catchments. It differs in having an understorey with strong floristic affinities with heathy woodlands and heathlands. The understorey
The canopy includes Silver-top, Yertchuk (*Eucalyptus consideniana*), and Messmate. Occasionally, White Stringybark (*Eucalyptus globoidea*) and Brown Stringybark (*Eucalyptus baxteri*) are present.
The density and species composition of the shrub layer is quite variable, but normally includes Prickly Tea-tree (*Leptospermum continentale*), Golden Bush-pea (*Pultenaea gunnii*), Wiry Bauera (*Bauera rubioides*), Bushy Hakea (*Hakea sericea*), Common Heath (*Epacris impressa*) and Broom Spurge (*Amperea xiphoclada*). Patches of Hairpin Banksia (*Banksia spinulosa*) are common.
The ground layer features Forest Wire-grass, Austral Bracken, Thatch Saw-sedge (*Gahnia radula*), Blue Dampiera (*Dampiera stricta*), Small Grass-tree (*Xanthorrhoea minor*) and Trailing Goodenia (*Goodenia lanata*).
Lowland Forest frequently occurs in conjunction with Heathy Woodland, Wet Heathland and Swamp Heathland (see below).

Valley Grassy Forest

Valley Grassy Forest is restricted to the lower slopes and valleys of the foothill country to the north-east of Melbourne, usually on acidic duplex soils and on southerly aspects. It is closely related floristically to Grassy Dry Forest and Herb-rich Foothill Forest
The overstorey is dominated by a mixture of Red Box (*Eucalyptus polyanthemos*), Red Stringybark (*Eucalyptus macrorhyncha*), Long-leaf Box (*Eucalyptus goniocalyx*) and Yellow Box (*Eucalyptus melliodora*). In low lying sites, often adjacent to seasonally inundated areas, Swamp Gum (*Eucalyptus ovata*) may be present.
The shrub layer tends to be rather sparse, often comprising a scattering of Burgan (*Kunzea ericoides*), Cherry Ballart (*Exocarpos cupressiformis*), Black Wattle (*Acacia mearnsii*), Sweet Bursaria (*Bursaria spinosa*) and Common Cassinia (*Cassinia aculeata*). Sweet Pittosporum (*Pittosporum undulatum*), although possibly indigenous to the Study Area, is an invasive environmental weed in this community. Also commonly present as a weed is Monterey Pine (*Pinus radiata*).
A rich array of native grasses and herbs occur in the low ground layer. Weeping Grass (*Microlaena stipoides*), Kangaroo Grass (*Themeda triandra*), Grey Tussock-grass (*Poa sieberiana*), and Silver-top Wallaby-grass (*Chionochloa pallida*) are common, in association

with Kidney-weed (*Dichondra repens*), Common Maidenhair (*Adiantum aethiopicum*) and Ivy-leaf Violet (*Viola hederacea*).

Heathy Dry Forest

There are three focuses for Heathy Dry Forest in the Study Area: the Kinglake area, upper Goulburn Valley and upper Thomson Valley. In most areas, it tends to occur on shallow stony soils of low fertility, with poor water retention capabilities. However, some sites in the Kinglake area appear to occur on the margins of acidic duplex soils, which may explain some floristic differences in these sites.

Generally, Heathy Dry Forest is dominated by a low canopy of Broad-leaf Peppermint (*Eucalyptus dives*). In the Kinglake area, Messmate (*Eucalyptus obliqua*), Long-leaf Box (*Eucalyptus goniocalyx*) and Mealy Stringybark (*Eucalyptus cephalocarpa*) may also be present. In the upper Thomson Valley, stunted Mountain Grey Gum (*Eucalyptus cypellocarpa*), Silver-top (*Eucalyptus sieberi*) and Yertchuk (*Eucalyptus consideniana*) may occur. In the upper Goulburn Valley, Broad-leaf Peppermint (*Eucalyptus dives*) often occurs at higher elevations with Candlebark (*Eucalyptus rubida*), indicating the close links between this community and Montane Dry Woodland. In fact, these two communities may intergrade for considerable distances on northerly slopes.

The understorey of Heathy Dry Forest features a number of species of the Australian heath family, the Epacridaceae, including Prickly Broom-heath (*Monotoca scoparia*), Common Heath (*Epacris impressa*), Daphne Heath (*Brachyloma daphnoides*) and Common Beard-heath (*Leucopogon virgatus*).

In the Kinglake area, other understorey species include Rosy Baeckea (*Baeckea ramosissima*), Wire Rapier-sedge (*Lepidosperma semiteres*), Austral Grass-tree (*Xanthorrhoea australis*), the rare Creeping Grevillea (*Grevillea repens*), Cat's Claws Grevillea (*Grevillea alpina*), Silver Banksia (*Banksia marginata*) and Bushy Hakea (*Hakea sericea*).

In the upper Goulburn and Thomson Valleys, common species, in addition to the heaths mentioned above, include Narrow-leaf Bitter-pea (*Daviesia leptophylla*), Gorse Bitter-pea (*Daviesia ulicifolia*) and Narrow-leaf Wattle (*Acacia mucronata*). These legumes respond vigorously following fire, regenerating either from seed or by re-sprouting from roots and butts. There is a likelihood that frequent fires in Heathy Dry Forest will lead to these species becoming dominant at the expense of the heaths.

Other common understorey species in the upper Goulburn and upper Thomson Valleys are Cluster-flower Geebung, (*Persoonia confertiflora*), Dwarf Geebung (*Persoonia chamaepeuce*), Heath Milkwort (*Comesperma ericinum*), and Common Hovea (*Hovea linearis*).

Throughout the range of Heathy Dry Forest, Silvertop Wallaby-grass (*Chionochloa pallida*) is a common, often dominant, member of the ground layer. Its dominance at some sites may reflect that the site has remained unburnt for a long period.

It is clear that fire regimes are of great importance to the understorey species composition of this community.

A number of ecological vegetation classes are closely allied to Heathy Dry Forest. Stands of vegetation which are intermediate between this and Grassy dry forest are common.

The Coranderrk Aqueduct south of Healesville winds through vegetation which is intermediate between Heathy Dry Forest and Heathy Woodland (see below).

Grassy Dry Forest

This community occurs on relatively exposed aspects, often on moderately fertile acidic duplex soils. Grassy Dry Forest is best developed in the hills to the north-east of Melbourne and in the foothills of the Goulburn Valley between Jamieson and Seymour.

It is dominated by the same suite of eucalypts as Valley Grassy Forest, with which it is often associated. These are Red Box (*Eucalyptus polyanthemos*), Red Stringybark (*Eucalyptus*

macrorhyncha), Long-leaf Box (*Eucalyptus goniocalyx*) and Yellow Box (*Eucalyptus melliodora*).
The understorey is open, grassy and rich in species. Commonly present are Grey Tussock-grass (*Poa sieberiana*), Silvertop Wallaby-grass (*Chionochloa pallida*), Velvet Wallaby-grass (*Danthonia pilosa*), Plume-grasses (*Dichelachne* spp.), Grey Guinea-flower (*Hibbertia obtusifolia*), Purple Coral-pea (*Hardenbergia violacea*), Stinking Pennywort (*Hydrocotyle laxiflora*), Blue Pincushion (*Brunonia australis*), Green Rock-fern (*Cheilanthes austrotenuifolia*), Cotton Fireweed (*Senecio quadridentatus*) and Common Raspwort (*Gonocarpus tetragynus*).
An unusual feature of some stands of Grassy Dry Forest are the dense thickets of Burgan (*Kunzea ericoides*). These may form following a particular sequence of fire events, and, once, established, prevent the previously dominant eucalypts from regenerating. They are frequently associated with a rich orchid flora. Good examples occur in the Cathedral Range State Park. Burgan thickets may also occur with a suite of understorey species common to Valley Grassy Forest, especially in riparian or rocky gorge situations.
Grassy Dry Forest is prone to invasion by a wide range of environmental weeds, particularly herbs and grasses. Fire frequency is likely to be quite high at sites supporting this community. If unburnt for long periods (25+ years), tussock grasses tend to predominate.

Rocky Outcrop Shrubland

Rocky outcrops are frequently of botanical interest because they contain a range of unusual micro-habitats, from highly exposed rock-faces, to damp, sheltered crevices.
Rather than being a discrete ecological vegetation class, Rocky Outcrop Shrubland commonly includes a number of rock-adapted species, with a suite of species from the surrounding vegetation which can tolerate the rocky outcrop environment.
For this reason, it is pertinent to discuss the vegetation of a number of prominent rocky outcrops in the Study Area separately. This is not a complete list.

Seven Acre Rock and Ben Cairn

These extensive granite outcrops support scattered Mountain Grey Gum (*Eucalyptus cypellocarpa*) and Silver-top (Eucalyptus sieberi) with Lemon Bottlebrush (*Callistemon pallidus*) and Long-leaf Wax-flower (*Eriostemon myoporoides*).

The Cathedral

The steeply uplifted sedimentary rock which forms the Cathedral Range supports vegetation with affinities to the surrounding Grassy dry forest. Stunted Red Stringybark, Broad-leaf Peppermint and, rarely, Snow Gum, occur along the crest. Common shrubs include Round-leaf Mint-bush (*Prostanthera rotundifolia*), Fairy Wax-flower (*Eriostemon verrucosus*) and Lemon Bottlebrush (*Callistemon pallidus*). The ground layer includes a wide range of grasses and herbs characteristic of dry forests.

Murchison - Strath Creek Falls

The broad, exposed rocky hillside to the east of Murchison Falls supports a sparse shrubland of Black Wattle (*Acacia mearnsii*), Clustered Everlasting (*Helichrysum semipapposum*), Kangaroo Grass (*Themeda triandra*) and a variety of herbs of dry sites.

Outcrops of Strathbogie Granite, Yea-Seymour area

Outcrops of granite occur quite frequently along the slopes above the Goulburn River in the Yea-Seymour area. On protected sites, these outcrops carry a dense, low moss-bed or herbfield, which may be very species rich. These have been inadequately sampled, but are nevertheless noteworthy.

Box Woodland

Box Woodland is an open, grassy woodland dominated by Grey Box (*Eucalyptus microcarpa*). Within the Study Area, it is restricted to the lower slopes and upper terraces of the Goulburn River. In the Alexandra area, the best examples can be seen along road reserves. The relatively fertile soils of these areas has led to a dramatic reduction in the extent of Box Woodland through clearing for agriculture, both in the Study Area, and throughout its range in Victoria.
A variant of this community which includes White Box (*Eucalyptus albens*), Red Box (*Eucalyptus polyanthemos*) and Yellow Box (*Eucalyptus melliodora*) occurs sporadically along the Goulburn Valley from the Merton area to Trawool. This variant has affinities with Grassy Dry Forest, and is reminiscent of dry forests of north-eastern Victoria..
The understorey of Box Woodland is dominated by Wallaby-grasses (*Danthonia* spp.) and Spear-grasses (*Stipa* spp.), with a scattering of Hedge Wattle (*Acacia paradoxa*).
Due to the fertility of the soils, a history of grazing and proximity to agricultural land, stands of Box Woodland usually contain a suite of introduced grasses, herbs and woody shrubs.

Plains Grassy Woodland

The most common components of this community are the River Red Gum (*Eucalyptus camaldulensis*) dominated grassy woodlands, occurring on seasonally water-logged clays and clay-loams.
These soils may be alluvial, or derived either from sedimentary rock or basalt. Plains Grassy Woodland may occur on lower slopes or swampy river flats, from Cardinia Creek in the south-east, to the Goulburn Valley in the north and the basalt plains around Wallan in the west.
A curious variant occurs in the Yan Yean catchment, where Candlebark (*Eucalyptus rubida*) and Snow Gum (*Eucalyptus pauciflora* [lowland ecotype]) dominate a characteristic understorey.

Plains Grassland

Dominated by Kangaroo Grass (*Themeda triandra*), Plains Grassland is a tussock grassland with a scattered and much depleted distribution, mostly on fertile, basalt-derived soils. It once occurred from Melbourne in the east to the Hamilton district in far south-western Victoria, but has largely been cleared or grossly modified for agriculture.
In addition to Kangaroo Grass, characteristic species include Pink Bindweed (*Convolvulus erubescens*), Common Bog-sedge (*Schoenus apogon*), Lemon Beauty-heads (*Calocephalus citreus*), Sheep's Burr (*Acaena echinata*) and Common Wallaby-grass (*Danthonia caespitosa*). A wide variety of environmental weeds, mainly grasses and herbs, are a feature of the remnants of this community.
It is important to note that Kangaroo Grass is widespread, being a character species of several other ecological vegetation classes. It should therefore not be assumed that all patches of Kangaroo Grass constitute Plains Grassland.
Plains Grassland is restricted in the Study Area to isolated occurrences, mainly on private land in the Somerton area, on the outskirts of metropolitan Melbourne. It occurs on public land at Epping Cemetery.

Floodplain Riparian Woodland

This community comprises the woodland vegetation which typically occurs along the banks of the larger, slower-moving rivers of the Study Area, including the Goulburn, Yea, Acheron, and Yarra River. It frequently occurs in conjunction with one or more floodplain wetland communities.

River Red Gum (*Eucalyptus camadulensis*) forms a tall, woodland canopy over a medium to tall shrub layer including Silver Wattle (*Acacia dealbata*), Tree Violet (*Hymenanthera dentata*), River Bottlebrush (*Callistemon sieberi*) and River Tea-tree (*Leptospermum obovatum*). The ground layer features Common Tussock-grass (*Poa labillardieri*) on the drier, elevated banks, with Club-sedges (*Isolepis* spp.), Rushes (*Juncus* spp.), Common Reed (*Phragmites australis*) and Water-ribbons (*Triglochin procera*) occupying the saturated or inundated soils at the water's edge.
Environmental weeds form a major component of this community in virtually all stands. Willows (*Salix* spp.) and a wide variety of pasture grasses are ubiquitous.

Grassy Wetland

Grassy Wetland occurs on small, seasonally-flooded depressions on fertile, basalt-derived soils, often as scattered patches amongst Plains Grassland. The dominant species include Veined Swamp Wallaby-grass (*Amphibromus nervosus*), Brown-back Wallaby-grass (*Danthonia duttoniana*), Common Spike-sedge (*Eleocharis acuta*), Small Spike-sedge (*Eleocharis pusilla*), Common Tussock-grass (*Poa labillardieri*) and Australian Sweet-grass (*Glyceria australis*).
In the Study Area, this community is restricted to private land and rail reserves in the Wallan district, in the head-waters of the Merri and Darebin Creek catchments.

Wetland Complex

Deep, permanent billabong

Deep, permanent billabongs occur along the floodplains of the Yarra and Goulburn Rivers. Typically, these billabongs have a dense fringe of vegetation, but, due to the greater depth of water in the centre, tend to include open water. This open water may support a carpet of Duckweed (*Lemna* spp.) and/or Azolla (*Azolla* spp.).
The fringing vegetation includes Tall Spike-sedge (*Eleocharis sphacelata*), Milfoils (*Myriophyllum* spp.), Water-ribbons (*Triglochin procera*), Cumbungi (*Typha orientalis*), Common Reed (*Phragmites australis*) and Rushes (*Juncus* spp.).

Shallow, seasonal billabong

Shallower billabongs which dry out in summer commonly support a herbfield including Common Spike-sedge (*Eleocharis acuta*), Slender Knot-weed (*Persicaria decipiens*), Lesser Joyweed (*Alternanthera denticulata*), Common Blown-grass (*Agrostis avenacea*) and Sneezeweeds (*Centipeda* spp.).
These billabongs may dry out due to the poorer water holding capabilities of the clay substrate, or the lack of recharge. Within the Study Area, such billabongs occur along the Yarra and Goulburn Rivers.

Floodplain wet flat

Floodplain wet flats occur on river flats where seepage or overflow is retained by the river-side levee banks. Characteristic vegetation includes Common Reed (*Phragmites australis*), Marsh Club-sedge (*Bolboschoenus medianus*), Tassel Sedge (*Carex fascicularis*), Tall Sedge (*Carex appressa*), Large Bindweed (*Calystegia sepium*) and Common Tussock-grass (*Poa labillardieri*).

Heathy Woodland

Heathy Woodland occurs on gentle, north-facing, lower slopes in the Gembrook, Tonimbuk, Tanjil and Moondarra areas. Soils are commonly sandy at the surface, with a clay or coffee-rock impeding layer at some depth. They may be seasonally wet, but dry out in the summer.

A low woodland of Narrow-leaf Peppermint (*Eucalyptus radiata*), Mealy Stringybark (*Eucalyptus cephalocarpa*), Messmate (*Eucalyptus obliqua*), and/or Yertchuk (*Eucalyptus consideniana*) occurs over a shrub layer including Hairpin Banksia (*Banksia spinulosa*), Bushy Hakea (*Hakea sericea*), Furze Hakea (*Hakea ulicina*), Dagger Hakea (*Hakea teretifolia*), Prickly Tea-tree (*Leptospermum continentale*) and Common Heath (*Epacris impressa*).
The ground layer includes a number of grass species: Wiry Spear-grass (*Stipa muelleri*), Kangaroo Grass (*Themeda triandra*) and Reed Bent-grass (*Deyeuxia quadriseta*). Other ground layer species include Thatch Saw-sedge (*Gahnia radula*), Common Raspwort (*Gonocarpus tetragynus*) and Wattle Mat-lily (*Lomandra filiformis*). Small Grass-tree (*Xanthorrhoea minor*) is also commonly present.
Similarly, the absence of species of Hakea in some stands contrasts with their virtual dominance in others. These species, which rely on seed germination for post-fire regeneration, may be suppressed by frequent, low-intensity fires, which favour species which re-sprout from rhizomes (eg. Wiry Spear-grass, Thatch Saw-sedge).

Wet Heathland

Wet Heathland normally occurs in depressions or on lower slopes where soils are saturated for considerable periods of the year. This may be due to the impeding layer in the soil being much closer to the soil surface than is the case for Heathy Woodland. Species characteristic of this community are therefore those which can tolerate saturated soils.
Mealy Stringybark forms a stunted, scattered canopy in some stands, but is absent from others. Scented Paperbark (*Melaleuca squarrosa*), Yellow Hakea (*Hakea nodosa*), Prickly Tea-tree and Pink Swamp-heath (*Sprengelia incarnata*) form a dense shrub layer. In the ground layer, Spreading Rope-rush (*Empodisma minus*), Hair-sedge (*Tetraria capillaris*), Square Twig-sedge (*Baumea tetragona*), Pouched Coral-fern (*Gleichenia dicarpa*) and Swamp Selaginella (*Selaginella uliginosa*) are prominent.
Wet Heathland occurs in the Bunyip, Hill End, Mt Tanjil and Moondarra areas.

Swamp Heathland

Swamp Heathland is a tall heathland dominated by Scented Paperbark (*Melaleuca squarrosa*). It occurs on drainage lines of deep, saturated siliceous sands, and frequently occurs with the outlets of Wet Heathland areas.
Other characteristic species include Rosemary Everlasting (*Helichrysum rosmarinifolium*), Red-fruit Saw-sedge (*Gahnia sieberiana*), Soft Water-fern (*Blechnum minus*), Coral-ferns (*Gleichenia* spp.), Centella (*Centella cordifolia*), Tassel Cord-rush (*Restio tetraphyllus*) and Running Marsh-flower (Villarsia reniformis).
There are significant floristic and structural affinities between Swamp Heathland and low elevation occurrences of Riparian Thicket, but, in general, the former has a much denser, sedge and rush-dominated groundlayer, the latter being more ferny..
The environmental differences which segregate stands of Swamp Paperbark dominated Swamp Scrub and Scented Paperbark dominated Swamp Heathland centre on soils, with the former tending towards heavy clays, while the latter occurs on sands or sandy clays.
Swamp Heathland occurs in the Bunyip, Tonimbuk, Tanjil, Woori Yallock and Moondarra areas.

APPENDIX D: EVCs recently described from the Central Highlands

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The following EVC descriptions are either from the work of Doug Frood and Biosis Research Pty. Ltd. who undertook the Pre-1750s vegetation mapping for the Central Highlands, or, from the old-growth report for the adjacent North East Victoria study area, as indicated with an asterisk (*).

Grassland

There were two grassland communities found in the study area pre-1750 and both have been listed under the Flora and Fauna Guarantee Act (1988). Western Basalt Plains Grassland on the fertile self-mulching clays derived from basalts under rainfall regimes of less than 600mm in the area between the west of the study area (south of the Great Divide) east to the Darebin Creek. It is at its eastern-most distribution in Victoria within the study area and was once much more extensive to the west on the western basalt plains. The overstorey was scattered, and if present, consisted of occasional River Red Gums *Eucalyptus camaldulensis* (in sites with poor drainage), Drooping Sheoke *Allocasuarina verticillata*, Lightwood *Acacia implexa* and tree-form Silver Banksia *Banksia marginata*. The ground layer was composed of a mosaic of grasses and forbs. The relative abundance of these life forms being dependant on the frequency and time since fire or other disturbance that could establish bare ground between the dense grass tussocks. The grasses and shrubs being favoured by infrequent fires with the forbs more abundant in more frequently or recently burnt or disturbed sites. The common grasses included: Kangaroo Grass Themeda triandra, ?Stipa, ?Poa. The forbs (daisies, lilies and orchids) are represented by a variety of genera and species including Bluebells *Wahlenbergia* spp., *Chrysocephalum apiculatum*, *Craespedia* spp. Lemon Beauty-heads *Calocephalus citreus*, Scaly Buttons *Leptorhynchus squamatus*, Bluebells *Wahlenbergia* spp., Blue Devil *Eryngium ovinum*, Pink Bindweed *Convovulus erubescens*.

South Gippsland Plains Grassland once occurred on the fertile silts and alluviums that also supported Swamp Scrub. Under frequent fire regimes it is believed that a disclimax community of grasses forbs and shrubs developed in place of the usually dense cover of Swamp Paperbark *Melaleuca ericifolia* which characterises Swamp Scrub. Very few examples now remain of this type of grassland with remnants being restricted to rail reserves and cemeteries largely outside the study area. The overstorey was scattered and only present where fire was less frequent or less intense consisting of Golden Spray *Viminaria juncea*, Blackwood *Acacia melanoxylon* and Drooping Sheoke *Allocasuarina verticillata*. The ground layer consists of a dense sward of graminoids including Common Tussock Grass *Poa labillardieri*, Mat Grass *Hemarthria uncinata*, Weeping Grass *Microlaena stipoides* and Blown Grasses *Agrostis* spp. various rushes *Juncus* spp. and Spiny-headed Wattle Mat-rush *Lomandra longifolia* var. *longifolia*. Forbs were not common in this community.

Grey Clay Drainage Line Complex

Three variants of this complex have been noted along the Merri Creek (NRE Ecological Survey Report 42). It occurs as brackish seasonal wetlands on ephemeral drainage lines on heavy basalt-

derived grey clays of the Merri and Darebin Creeks. They are separated from Plains Grassy Wetlands (see below) by the presence of species indicative of salinity. These species include: Salt Pratia *Pratia irrigata*, Sea Celery *Apium* spp., Australian Lilaeopsis *Lilaeopsis polyantha*, Australian Salt-grass *Distichlis distichophylla* and Shiny Swamp-mat *Selliera radicans*. Floristics vary with wetness, with Blown Grasses *Agrostis* spp., Salt Club-sedge *Bolboschoenus caldwellii*, Common Spike-sedge *Eleocharis acuta*, Common Tussock Grass *Poa labillardieri*, River Club-sedge *Schoenplectus validus* and locally common. The threatened Curly Sedge *Carex tasmanica* can be locally common in this vegetation.

Plains Grassy Wetland

These wetlands are shallow and non-saline and occur on volcanic tracts between the study area's western boundary east to the Plenty River and generally occur in areas of Plains Grassy Woodland. This unit is not entirely analogous to the vegetation mapped in the Inner Melbourne LCC study due to the inclusion of other wetland types which included Saltmarshes, Cane-grass and Lignum Swamps. Within the context of the study area, much of the wetland occurs as a grassy sward with varying combinations of Brown-back Wallaby-grass *Danthonia duttoniana*, Veined Swamp Wallaby-grass *Amphibromus nervosus*, Austral Sweet-grass *Glyceria australis*, Common Spike-sedge *Eleocharis acuta*, and Common Tussock Grass *Poa labillardieri*. Rush-sedge *Carex tereticaulis* was probably more prevelant before settlement. Tangled Lignum *Muelenbeckia florulenta* and River Red gum *Eucalyptus camaldulensis*, if present, were mostly confined to the periphery of these wetlands. These habitats can be very rich in herbaceous species, at least in shallower sites. The more common of these includes Pricklefoot *Eryngium vesiculosum*, Poison Lobelia *Lobelia pratioides*, Upright Millfoil *Myriophyllum crispatum*, White Purslane *Neopaxia australasica*, Swamp Starwort *Stellaria palustris* and River Buttercup *Ranunculus inundatus*. A range of species (noteably the daisies Swamp Everlasting *Bracteantha* aff. *subundulata*, Pale Swamp Everlasting *Helichrysum* aff. *rutidolepis* (Lowland Swamps), Yam Daisy *Microseris scapigera*, Swamp Groundel *Senecia psilocarpus*, and Swamp Billy Buttons *Craspedia paludicola*) which appear to have once been major components of at least the outer zones of these wetlands, are now virtually extinct.

Swampy Riparian Complex

This complex consists of a number of floristic entities as mapped by Biosis Research and Doug Frood: Gully Woodland, Swamp Forest and Swampy Woodland. Their composition and ecology is poorly defined due to a lack of extant examples. Ecologically it is likely that some of these entities may once have been distinct at the EVC or the floristic community level. Until better characterisation can be obtained, they are for the present study considered as a complex.
Gully Woodland can be loosely characterised as the wetter end of Valley Grassy Forest which was associated with gully lines. Swamp Gum *Eucalyptus ovata* was usually present, the nearer this entity was to the adjacent riparian vegetation, with Mountain Swamp Gum *Eucalyptus camphora* or Yarra Gum *Eucalyptus yarrensis* also locally common. A smattering of other eucalypts may be represented depending on the adjacent EVC. Major associated species include Common Tussock Grass *Poa labillardieri*, Black Wattle *Acacia mearnsii* and Rushes *Juncus* spp., with a range of wet site species variously present such as Lanky Goodenia *Goodenia elongata*, Centella *Centella cordifolia*, Shining Buttercup *Ranunculus glabrifolius*, Creeping Brooklime *Gratiola peruviana* and Common Reed *Phragmites australis*. Ponds may be present, but the water courses (if defined) are never-the-less intermittent. Ferns may also be present including Rough Tree-fern *Cyathea australis*, Tender Brake *Pteris tremula*, Rasp Ferns *Doodia* spp. and Rainbow Fern *Caloclaena dubia*.
This vegetation was once common in the gullies associated with the Heidelberg, Plenty Yarrambat areas.

Swamp Forest is virtually extinct within the study area apart from a few examples on wet flats which are ecotonal with Swampy Woodland (see below) and small areas of Wet Forest riparian terraces which probably had similar floristics. This floristic entity represents the Wet to Damp Forest extension into swampy habitats associated with low gradient drainage lines and seepage slopes, primarily on rich volcanic soils around the Warragul-Drouin area. The major tree species appears to have been Strzelecki Gum *Eucalyptus strzeleckii*, with Swamp Gum *Eucalyptus ovata* in the ecologically marginal sites. A poorly known small-fruited form of Mountain Ash *Eucalyptus regnans* may have originally been more widespread in this floristic entity. Messmate *Eucalyptus obliqua* and Mountain Grey Gum *Eucalyptus cypellocarpa* my be present on more marginal sites. Other woody species included Muttonwood Rapanea howittiana, Blackwood *Acacia melanoxylon* and Scented Paperbark *Melaleuca squarrosa*. Whilst a number of Wet Forest shrubs may be present, they would have been at low levels and often restricted to perched positions on tree-fern trunks. The ground layer appears to have been primarily ferny to sedgy in character, including mixtures of wet forest and swamp species. Possibly the only intact remnant (of the upper reaches of a gully) had virtually a closed canopy of Soft Tree-fern *Dicksonia antarctica* over a bed of peat (quadrats F32077-8). The understorey has a number of Water Ferns Blechnum spp. sedges Carex spp. and a range of herbs. Tall Sword-sedge *Lepidosperma elatius* is prevelant on the marginal wet flat remnants. The low gradients were largely spring or seepage-fed, and historical anecdotes indicate they were swampy and lacked defined drainage lines.

Swampy Woodland has been coined for this floristic entity in the broad sense to cover a range of communities on wet flats and in drainage basins. As the vast majority of these habitats have been drained and cleared for agriculture, the original floristics are often obscured. Swamp Gum *Eucalyptus ovata* is usually present but is occasionally replaced by Mountain Swamp Gum *Eucalyptus camphora* or Yarra Gum *Eucalyptus yarrensis*. Messmate *Eucalyptus obliqua*, Narrow-leaved Peppermint *Eucalyptus radiata*, Manna Gum *Eucalyptus viminalis*, Green Scentbark *Eucalyptus ignorabilis*, and Mealy Stringybark *Eucalyptus cephalocarpa* can also be present, particularly on more marginal sites. Buxton Gum *Eucalyptus crenulata* is a very rare component.

In the southern part of the study area, Swamp Paperbark *Melaleuca ericifolia* was often a major constant in the vegetation. Some areas mapped as Swampy Woodland were presumably a mosaic of Swampy Woodland, Swamp Scrub and wetlands dominated by Common Reed *Phragmites australis* and herbaceous species, but the original patterns have been long-erased, and any attempts at reconstruction of these patterns would require detailed site inspection. Some areas would have approached Wet Heath or Riparian Forest in composition. Blackwood *Acacia melanoxylon* and Tree Everlasting *Ozothamnus ferrugineus* were frequent woody species. The ground layer varied from grassy-herbaceous through to heathy-shrubby with Myrtaceous genera such as *Melaleuca* and *Leptospermum* present. Common Tussock Grass *Poa labillardieri* would have been a widespread component. Ferns (*Blechnum*, and *Dicksonia*) would have been common in cooler areas.

While Swampy Woodland often occurs on stream terraces, between the stream levee and the adjacent slopes, there are many instances where there is no defined channel, or the vegetation occurs on broad-acre wet flats lacking streams.

Valley Heathy Forest

Geographically this EVC occurs in several widely dispersed localities in the study area south of the Great Divide. In the Moe area Lowland Forest grades into this grassy vegetation with a different suite of eucalypts that includes *Eucalyptus ignorabilis*, Candlebark *Eucalyptus rubida*, Manna Gum *Eucalyptus viminalis*, Yellow Box *Eucalyptus melliodora* and Narrow-leaved Peppermint *Eucalyptus radiata*. Swamp Gum *Eucalyptus ovata* can also extend upslope in this vegetation. The understorey consists of Wallaby Grasses *Danthonia* spp. and the 'dry forest woodland species' Tree Violet *Hymemenathera dentata* and Black Wattle *Acacia mearnsii*.

Thatch Saw-sedge *Gahnia radula* and Prickly Ti-tree *Leptospermum continentale* appear to have been common, at least in the marginal sites. (*L. continetale* can be a component of grassy woodland on fertile Tertiary soils elsewhere in the State, with its relative abundance reflecting fire regimes. The distribution of this occurrence of Valley Heathy Forest appears to be mediated by both a rainshadow effect from the Strzlecki Ranges and the co-occurrence of Tertiary basalt-derived soils. Although the boundaries between Valley Heathy Forest and Lowland Forest can be difficult to define (given current clearing) the former is quite distinct from the latter.

In the Croyden-Bayswater area, the Yellow Box *Eucalyptus melliodora*-Candlebark *Eucalyptus rubida* association of Valley Grassy Forest is replaced by an open forest in which a wide range of other tree species may be present. These include: Mealy Stringybark *Eucalyptus cephalocarpa*, Messmate *Eucalyptus obliqua*, Narrow-leaved Peppermint *Eucalyptus radiata*, Long-leaf Box *Eucalyptus goniocalyx*, Yellow Box *Eucalyptus melliodora* and Manna Gum *Eucalyptus viminalis*. While this example is visually more sedgy than the area previously described with Thatch Saw-sedge *Gahnia raduala* and Small Grass-tree *Xanthorrhoea minor*, the grassy element is still present as are a range of ericoid shrubs. In this area both Kangaroo Grass *Themeda triandra* and Weeping Grass *Microlaena stipoides* are common. This vegetation once extended across the less dissected Silurian sedimentary terrain of the Blackburn-Mitcham and Box Hill north areas. North of this area where the soils are presumably younger, it is replaced by Grassy Dry Forest and Valley Grassy Forest. Valley Heathy Forest and Plains Grassy Woodland appear to have intergraded in the Box Hill-Balywyn area.

One small area of this vegetation occurs north of Mount Disappointment, and whilst a good floristic description is available, it may not be typical of Valley Heathy Forest elsewhere in the study area, as it may have affinities with Grassy Dry Forest and Box Ironbark Forest. It occurs on localised outwash from Silurian sandstone sedimentary ridges around Stony Creek. It is likely that the vegetation was once more widespread, however its past distribution is obscured by current land use practices.

The species present include: Red Stringybark *Eucalyptus macrorhynca*-Long-leaf Box *Eucalyptus goniocalyx* (grading into Valley Grassy Forest with Yellow Box *Eucalyptus melliodora* and Kangaroo Grass *Themeda triandra* on lower slopes). Other species readily observed included: Small Grass-tree *Xanthorrhoea minor*, Supple Spear-grass *Stipa mollis*, Weeping Grass *Microlaena stipoides*, Common Rapier-sedge *Lepidosperma filiforme*, Red-anther Wallaby-grass *Chionochloa pallida*, Grey Guinea-flower *Hibbertia obtusifolia*, Cat's Claw Grevillea *Grevillea alpina*, Tall Bluebell *Wahlenbergia stricta*, Honeypots *Acrotriche serrulata*, Shiny Everlasting *Bracteantha viscosa*, Rough Fireweed *Senecio hispidulus*, Common Rice-flower *Pimelea humilis*, Kneed Wallaby-grass *Danthonia geniculata*, Purplish Wallaby-grass *Danthonia tenuior*, Common Raspwort *Gonocarpus tetragynus*, Black-anther Flax-lily *Dianella revoluta*, Drooping Cassinia *Cassinia arcuata*, Yam Daisy *Microseris* aff. *lanceolata* (Foothills), Blue Pin-cushion *Brunonia australis*, Grass Trigger-plant *Stylidium graminifolium*, Thatch Saw-sedge *Gahnia radula*, Scaly Buttons *Leptorhynchos squamatus*, Black's Goodenia *Goodenia blackiana*, Grey Parrot-pea *Dillwynia cinarescens*, Matted Tussock Grass *Poa clelandii*, Stinking Pennywort *Hydrocotyl laxiflora*, Purplish Beard Orchid *Calochilus robertsonii*, Groundsel *Senecio* aff. *tenuiflorus*, Kangaroo Grass *Themeda triandra*, Heath Ti-tree *Leptospermum myrsinoides* and Thin-leaf Wattle *Acacia aculeatissima*.

Swampy Riparian Woodland*

Swampy Riparian Woodland was once widely scattered in the study area south of the Great Divide. This EVC occurred in broad drainage lines with slight gradients, on lower slopes near streams that were directly affected by riparian processes. Examples once occurred on the tributaries of the Yarra River between Healseville and Ringwood (for example Bushy and Olinda Creeks), and near Warragul on the lower reaches of the Bunyip River and Cannibal Creek. Soils are mostly of Quaternary age and are silt-rich river sands and gravels, although sites with heavier clay soils may also known.

As the name suggests, the overstorey of this vegetation type has a woodland structure which often forms mosaics with wetter tree-less areas dominated by sedges, rushes and many other plants associated with riparian environments. Swamp Gum *Eucalyptus ovata* and Manna Gum *Eucalyptus viminalis* are the dominant overstorey species. A wide range of other eucalypts can be present, mainly as adventive species from the surrounding drier forests..
The understorey shrubs consist of Blackwood *Acacia melanoxylon* (as it rarely reaches tree-form in this community), Swamp Paperbark *Melaleuca ericifolia*, Prickly Current-bush *Coprosma quadrifida*, Hemp Bush *Gynatrix pulchella*, Tree Violet *Hymenanthera dentata* and Hop Goodenia *Goodenia ovata*, Black Wattle *Acacia mearnsii* and Snowy Daisy Bush *Olearia lirata* especially on levees. The ground stratum is the most characteristic feature of this EVC and is normally dense with graminoids including Leafy Flat-sedge *Cyperus lucidus*, Tall Sedge *Carex appressa*, Common Reed *Phragmites australis* and Common Tussock Grasss *Poa labillardieri*. These species compete for space with ferns.

Grassy Forest

This EVC occurs from the western slopes of the Paul Range through to Coldstream, south to the Pakenham area on pale soils. Grassy Forest occupies an ecological position between box-stringybark woodlands Valley Grassy Forest, Lowland Forest and Herb-rich Foothill Forest. It occurs on pale soils which have poor drainage during the wettest periods of the year. It is characterised by a dominance of Messmate and *Eucalyptus obliqua* and Narrow-leaved Peppermint *Eucalyptus radiata* with associated species including Candlebark *Eucalyptus rubida*, *Eucalyptus goniocalyx*, Red Stringybark *Eucalyptus macrorhynca*, *Eucalyptus cephalocarpa* and Yellow Box *Eucalyptus melliodora* and Swamp Gum *Eucalyptus ovata* and Manna Gum *Eucalyptus viminalis* around gullies or seepage areas. Whilst the overstorey composition resembles that for Herb-rich Foothill Forest, tree stature is often reduced and the understorey has greater affinities with drier vegetation types.
Understorey species include a diverse array of graminoids such as Red-anther Wallaby-grass *Chionocloa pallida*, Wallaby Grasses *Danthonia* spp., Spear Grasses *Stipa* spp., especially Veined Spear-grass *Stipa rudis* and Tussock Grasses *Poa* spp., with Weeping Grass *Microlaena stipoides*, Soft Tussock-grass *Poa morrisii*, Grey Tussock-grass *Poa sieberiana*, Velvet Tussock-grass *Poa rodwayi*, Variable Sword-sedge *Lepidosperma laterale* and Kangaroo Grass *Themeda triandra* usually at lower levels of abundance if present. Black Sheoke *Allocasuarina littoralis*, Black Wattle *Acacia mearnsii* and Blackwood *Acacia melanoxylon* can be conspicuous, and Thatch Saw-sedge *Gahnia radula* is typically prevalent. Forbs and perennial geophytes are also common and can include species such as Creeping Bossiaea *Bossiaea prostrata*, Pale Grass-lily *Caesia spp.*, Golden Weather-glass *Hypoxis* spp., Early Nancy *Wurmbea* spp., Milkmaids *Burchardia umbellata*, Tall Bluebell *Wahlenbergia stricta*, Tufted Bluebell *Wahlenbergia communis*, Small Poranthera *Poranthera microphylla*, Stinking Pennywort *Hydrocotyl laxiflora*, Grass Trigger-plant *Stylidium graminifolium*, Blue Pin-cushion*Brunonia australis*, Vanilla Lilies *Arthropodium* spp., Shrubby Fireweed *Senecio minimus*, Annual Fireweed *Senecio glomeratus*, Cotton Fireweed *Senecio quadridentatus*, and Bent Goodenia *Goodenia geniculata*.

Wetland Formation

The Wetland Formation is rare in the study area and very few, small localised examples remain, largely due to the drainage of wetlands for agriculture. The formation described here, occurs in billabongs or other areas with standing water often in flood plains but may be more widespread. Nearly all of the environment where it could potentially occur has been dramatically altered and is invariably dominated by weed species. The species found in this vegetation include Common Reed *Phragmites australis* which is often abundant and various sedge species including Tall Spike-sedge *Eleocharis sphacelata* with Upright Millfoil *Myriophyllum crispatum* usually conspicuous.

Riverine Escarpment Scrub*

This EVC occurs along rocky cliffs and slopes associated rivers and major creeks and may extend onto alluvial terraces in some situations. It occurs along the Yarra River in the Warrandyte-Yering area. It is characterised by a medium to tall shrub layer which often limits the regeneration of overstorey trees to the natural gaps in the canopy and results in a sparse overstorey. The ground layer is often open due to heavy shading and bryophytes may be a conspicuous feature.
The shrub layer is dominated by Burgan *Kunzea ericoides*. Other species generally include a suite of *Pomaderris* species with restricted a distribution restricted to this vegetation and a range of shrubs such as Snowy Daisy Bush *Olearia lirata*, Sweet Bursaria *Bursaria spinosa*, *Correa glabra*, Victorian Christmas Bush *Prostanthera lasianthos*, Prickly Currant Bush *Coprosma quadrifida*, Tree Violet *Hymenanthera dentata*, Hop Goodenia *Goodenia ovata*, Swamp Paperbark *Melaleuca ericifolia* and Wattles *Acacia* spp. The conspicuous forbs include the genera Pennyworts *Hydrocotyl* spp., Small Poranthera *Poranthera microphylla*, Wood Sorrels *Oxalis* spp., Geraniums *Geranium* spp., Galiums *Galium* spp., Raspworts *Gonocarpus* spp., Bluebells *Wahlenbergia* spp., and Groundsels *Senecio* spp. Ferns include the Maidenhair Fern *Adiantum aethiopicum*, Necklace Fern *Asplenium flabellifolium* and the Rock Ferns *Chelianthes* spp. Graminoids are often conspicuous in this vegetation and include *Lepidosperma laterale*, *Lomandra longifolia*, and the genera *Microlaena*, *Danthonia* and *Stipa*. A range of riparian species will be present at localities nearer the river or creek.

Riverine Forest

Structurally this EVC was a tall forest dominated by River Red Gum *Eucalyptus camaldulensis*. The habitat is subject to annual flooding and takes upto three months to drain naturally. The exact composition of the vegetation is largely conjecture but it is considered likely that the structure of the understorey was primarily grassy and sedge-rich with many species shared with Plains Grassy Wetland. The most common species would have been Rush Sedge *Carex tereticaulis*, Brown-back Wallaby-grass *Danthonia duttoniana*, Swamp Wallaby-grasses *Amphibromus* spp., (Veined Swamp Wallaby-grass *A. nervosa* and River Swamp Wallaby-grass *A. fluitans*) Common Tussock Grass *Poa labillardieri* and Spike Rushes *Eleocharis* spp. There would also have been a large range of aquatic/wet site herbs also present.

EVCs of the Central Highlands and their map labels from the Biosis-Frood Pre-1750s mapping

Ecological Vegetation Class (Floristic Comm.)	*Map No.*
Lowland Forest	**16**
Riparian Scrub Complex	**17**, 706
Riparian Forest	**18**
Heathy Dry Forest	**20**
Grassy Dry Forest	**22**
Herb-rich Foothill Forest	**23**
Rocky Outcrop Scrub	**27**, 711
Damp Forest	**29**
Wet Forest	**30**
Cool Temperate Rainforest	**31**
Montane Dry Woodland	**36**
Montane Damp Forest	**38**
Montane Wet Forest	**39**
Montane Riparian Thicket	**41**

Sub-alpine Woodland	**43**
Treeless Sub-alpine Complex	**44**
Shrubby Foothill Forest	**45**, 707
Valley Grassy Forest	**47**, 719
Heathy Woodland	**48**
Wet/Swamp Heathland	**49**
Swamp Scrub	**53**
Box Woodland	**54**
Plains Grassy Woodland	**55**, 718, 703
Floodplain Riparian Woodland	**56**
Riparian Thicket	**59**
Box Ironbark Forest	**61**
Wetland Formation	**74**, 714

Ecological Vegetation Class (Floristic Comm.)	***Map No.***
Riverine Escarpment Scrub	**82**, 702, 717
Swampy Riparian Woodland	**83**, 712
Grassland	**120,** 718
Grey Clay Drainage Line Complex	700
Plains Grassy Wetland	701
Swampy Riparian Complex	704, 708, 709
Heathy Valley Forest	705, 710
Grassy Forest	713
Damp Sands Herb-rich Woodland	715
Riverine Forest	716
Rock	**993**, 720

APPENDIX E: Life history attributes of Threatened plant taxa

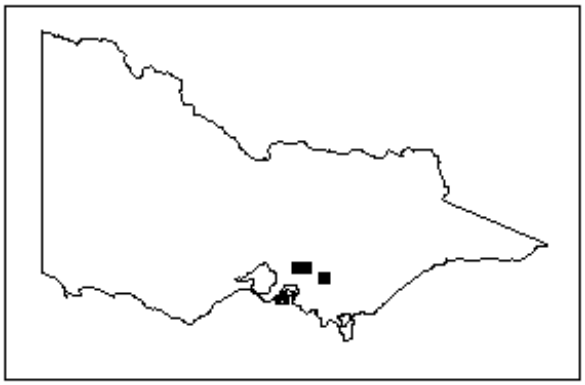
Notes on interpretation:

1. The following species summaries include information about the number of records within the Central Highlands region and Victoria for each taxon. This information is automatically derived from NRE databases, and may include historical records of populations which are now extinct or repeated records from the same populations. They do not therefore represent an accurate measure of the number of extant populations.
2. The distribution maps shown include only the distribution (based on 10 minute grids) within the Central Highlands region, and not beyond.
3. The tables which indicate the relative importance of potential threats to the each taxon include ratings as follows: 1 equates to relatively low importance and 3 equates to relatively high importance.

Tall Astelia *Astelia australiana*

Family: Liliaceae

Description: A tall tussock-forming graminoid: robust, perennial herb with strap-like leaves arising from distinct tussocks. Foliage to two meters tall. The ribbed leaves are long (60-230 cm) and quite broad (4-10cm) with a shining upper surface and densely felted undersurface (Turner & Sydes 1995). Green or reddish flowers are borne on many-flowered open panicles. Seeds are contained within orange berries.



Conservation Status:

- ROTAP: Vulnerable
- VROTS: Vulnerable
- ESP: Listed
- FFG: Is listed, with an Action Statement

no of records in Victoria	Victorian range (km)	no of records in region	regional range (km)	% of Aust Majority	Tenure of largest proportion of Central Highlands population	Tenure of next largest proportion of Central Highlands population
45	279	37	41	75-100	other public land	

Distribution: All but one of the twelve known colonies of Tall Astelia are within a relatively small area in the Powelltown-Beenak district of the Central Highlands. *Astelia australiana* is endemic to Victoria. The presumed habitat at European settlement was isolated and most is still present.

Habitat: The species occurs primarily in Cool Temperate Rainforest dominated by Myrtle Beech (*Nothofagus cunninghamii*), with two colonies in Riparian Scrub dominated by Scented Paperbark (*Melaleuca squarrosa*) and Woolly Tea-tree (*Leptospermum lanigerum*). It occurs in gullies on undulating, upland plateaus on soils that are generally moist.

Reproduction: Little is known of the reproductive biology of Tall Astelia: it flowers and sets seed infrequently. Plants predominantly flower from October to December. Pollination is by flies and it is likely that birds and mammals are the evolved dispersers of the seeds (Turner and Sydes 1995). The species is mainly reliant on vegetative reproduction via a horizontal stem. This habit of Tall Astelia leads to the formation of large swards or colonies that may be a single genetic individual (Turner & Sydes 1995).

Plants may re-establish following the dispersal of individuals downstream in flood conditions (Turner *et al* 1996). Plants are long-lived perennials, surviving for more than 50 years. The species is an obligate seed regenerator: all (or nearly all) plants are killed by fire, and regeneration is solely from seed, often only via invasion from unburnt sites. Tall Astelia is not thought to be dependent on disturbance for regeneration.

ISSUES & STATUS IN CENTRAL HIGHLANDS

Threatening processes: Tall Astelia has been much reduced by successive forest fires (Willis 1970). Wildfire represents the single most important threat to the survival of Cool Temperate Rainforest in Victoria (Howard 1981). Tall Astelia now occurs almost exclusively in drainage lines flanked by 1939 regrowth forest (Turner & Sydes 1995). The loss of the Cool Temperate Rainforest habitat through fire or other major disturbance is likely to lead to loss of colonies, furthermore, because ten of the twelve colonies are in a relatively small area around Dick Hill, south of Powelltown, the species is particularly vulnerable to local catastrophic events. Timber harvesting operations could alter sediment loads adversely affecting Tall Astelia and its habitat (Campbell & Doeg 1989). Regeneration burns extending beyond coupe boundaries could be detrimental to colonies and road construction has increased exposure, promoting other competing plants, in one case.

Threat	Rating	Threat	Rating
PLANT COLLECTION	1	WEED INVASION	2
RECREATIONAL DAMAGE	1	SMALL POPULATION SIZE	2
WILDFIRE	3	TIMBER HARVESTING	1
ALTERED HYDROLOGY	2	SOIL EROSION	1
DISEASE (Myrtle wilt)	1	LACK OF RECRUITMENT	1

Reservation: All colonies in the Central Highlands are within State Forest in which hardwood production is a major land use. Timber harvesting has been excluded from one subcatchment in each of the major watersheds in which Tall Astelia occurs. These areas are Bjorksten Creek (La Trobe watershed), Seven Acre Creek upstream from Bunyip Road (Bunyip watershed), and Tomahawk Creek tributary (Yarra watershed).

Management: The Action Statement for Tall Astelia includes a series of prescriptions designed to protect colonies and their habitat. Detailed monitoring has been undertaken and a study of genetic variability has been completed. Further research focusing on the reproductive biology and ecology of Tall Astelia is desirable.

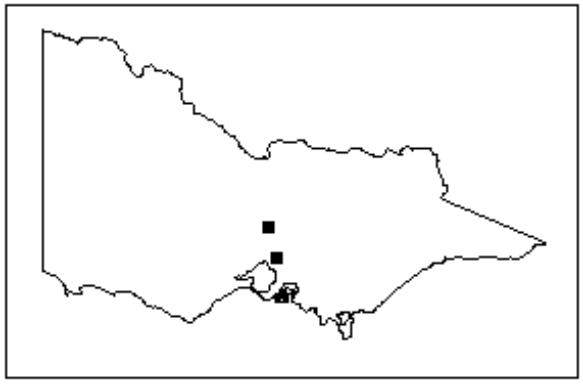
Crimson Spider Orchid *Caladenia concolor*

Family: Orchidaceae

Description: A perennial herb to 40cm high with a globose tuberoid, the underground stem and tuberoids are invested in a fibrous tunic. One or two flowers on a slender erect hairy stem.

Conservation Status:

- ROTAP: vulnerable
- VROTS: vulnerable
- ESP: Not listed
- FFG: Has been nominated



no of records in Victoria	Victorian range (km)	no of records in region	regional range (km)	% of Aust Majority	Tenure of largest proportion of Central Highlands population	Tenure of next largest proportion of Central Highlands population
11	447	3	40	0-25	private land	conservation reserve

Distribution: *Caladenia concolor* is currently known from the council-owned Tyaak Reserve approximately 10km east of Broadford, the Boomers Reserve near Eltham and private land in the Cottlesbridge area.

Habitat: Lowlands, Sandy Outwash Plains and Dunes on upper slopes. *Caladenia concolor* occurs in woodlands or open forest with a grassy or dry sclerophyll (shrubby) understorey on well-drained loamy, sandy or gravelly soils. Sites are broadly of the Box-Ironbark alliance.

Reproduction: *Caladenia concolor* is a long-lived summer-dormant perennial herb. The tuberoid ('tuber') is dormant between late spring or early summer-and autumn when the solitary leaf appears above ground(late April-May). During the winter to spring growing season the plant produces one leaf, and if sufficiently large, a flower stem develops from the center of the leaf. The 'mother' or 'current seasons' tuberoid that produces the leaf and flower renews itself over the growing season to produce a 'daughter' tuberoid by which the plant survives over the next summer. The 'mother' tuberoid dies at the end of the summer. In this way plants potentially have somatic immortality. Flowers open in September and October and remain open, if not pollinated for 4-6 weeks. Pollination is by male thynid wasps. Flowers close a day or so after pollination and seed ripens and is shed 3-4 weeks later. Seeds are minute and very numerous. The seed is assumed to be short lived in nature (not beyond a year) so that there is no carryover from one season to the next. Reproduction is exclusively by seed. Germination occurs in early winter and is dependant on an obligatory mycorrhizal relationship formed with a free-living fungus that provides sugars to the developing seedling. This mycorrhizal relationship continues throughout the life of the plant, the fungus apparently re-infecting the orchid tissue each autumn.

ISSUES & STATUS IN CENTRAL HIGHLANDS

Threatening processes: *Caladenia concolor* shows a familiar pattern of decline seen in many rare species, particularly orchids, in the Midland natural region. Features of this pattern include: wide distribution with no apparent shortage of habitat but with many of the records from last century or the early 1900s; only a few small or very small extant populations known; severe threats, particularly weed invasions; a vast area of potential or former habitat alienated for agriculture. It is probable that the end result of this process will be extinction. Given the small size of more recently examined populations and the serious weed invasion occurring in the sites, there can be no doubt that recruitment is not keeping pace with mortality in this species. The species is threatened across most of its range by gold exploration and mining operations. Unauthorised collection from the wild is a continuing problem (Backhouse and Jeanes 1995). Crimson Spider Orchid is palatable and readily eaten by stock, rabbits and other mammalian herbivores. Rabbits are likely to be present at all sites and could damage or destroy plants by grazing and digging. At the several locations reported (e.g. Chiltern Regional Park) weed invasions are

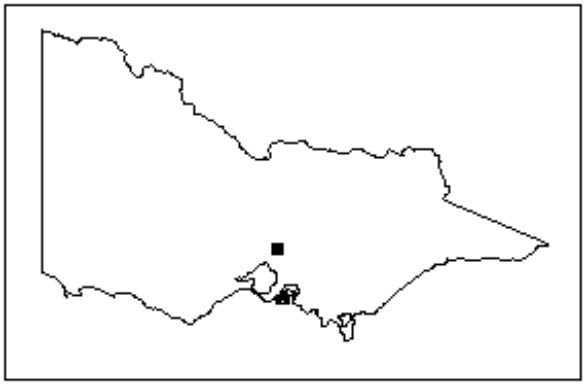
severe, the most seriously invasive species being Quaking Grass (*Briza maxima*) a Mediterranean annual. At Chiltern at least, this and other weed species will undoubtedly eliminate the orchid in a few years. Weeds directly compete with established plants causing their death by competition for light and water, and prevent seedling recruitment. All known populations of Crimson Spider-orchid are small with less than about 20 flowering plants seen at any one time (J.Jeanes pers. comm.; G. Carr pers. comm.).

Threat	Rating	Threat	Rating
GRAZING BY INTRODUCED HERBIVORES	1	SMALL POPULATION SIZE	2
4WD OR TRAILBIKE RIDING	1	POOR RECRUITMENT	2
WEED INVASION	3	MINING AND QUARRYING	2
PLANT COLLECTION	2		

Reservation: Statewide, the species is present in one state park and several small nature reserves but in such low numbers that its future survival prospects are poor (Backhouse & Jeanes 1995).

Management: A Draft Action statement is being prepared for the species.

Rosella Spider-orchid *Caladenia rosella*



Family: Orchidaceae

Description: A dwarf, non-tussock forming graminoid geophyte 10-15 cm tall. Single flower of 3-4 cm in diameter and a single, broad, hairy and upright basal leaf of grey-green colour. Distinguishing characters include the light to dark pink floral segments and broad, dark pink labellum containing 6 rows of calli (Carr 1988).

Conservation Status:

- ROTAP: endangered
- VROTS: endangered
- ESP: Listed
- FFG: Is listed, with a draft Action Statement

no of records in Victoria	Victorian range (km)	no of records in region	regional range (km)	% of Aust Majority	Tenure of largest proportion of Central Highlands population	Tenure of next largest proportion of Central Highlands population
7	291	3	2	25-50	private land	conservation reserve

Distribution: *Caladenia rosella* is confirned to occur at two sites, on private land at Cottlesbridge and in the One Tree Hill Flora and Fauna Reserve in Christmas Hills. Another small population occurred at Research on private land which was to be developed. Its current status is unknown.

Habitats: Box Ironbark Dry Foothills on soils that are generally dry.

Reproduction: Although very little is known of the biology of the orchid, it appears that reproductive maturity takes 3-5 years and a seedling leaf is produced in each of these years. On maturity, it apparently flowers for up to 5 consecutive years, beyond which time the "pseudo-bulb" is incapable of leaf initiation. There is no significant storage of seed. The majority of seedlings are dispersed within one metre of parent plants. Regeneration can be habitat dependent on particular rare and unpredictable (stochastic) events, e.g. fire, flood, unusual combination of seasonal conditions - between such events the plants may appear to be absent.

ISSUES & STATUS IN CENTRAL HIGHLANDS

Threatening processes: The primary colony at Cottlesbridge occurs within 50 meters of a dwelling and roadway and its location is well-known, increasing the likelihood of disturbance and interference. The long-term viability of this population is insecure: apart from three plants it is contained on private land. Between 35-45 flowering plants near the dwelling have been eliminated by earthworks, weed invasion, rubbish dumping, path development, off-road turning of vehicles, digging and trampling. Pressure from grazing by White-winged Choughs (*Corcorax melanorhampos*), European Rabbits (*Oryctolagus cuniculus*) and Common Brushtail Possums (*Trichosurus vulpecula*) and trampling by Eastern Grey Kangaroos (*Macropus giganteus*) at Cottlesbridge is a problem as the area sustains large populations of these species. Given the amount of searching undertaken and the extent of loss of suitable habitat, the species is considered as one of Victoria's most threatened and localised plant species. As the population has become fragmented and depleted, so too has the native pollinating agent. The rate of natural pollination in each colony of the Cottlesbridge population has declined and natural recruitment is inadequate to reverse the declining population size. Population maintenance is now dependent on hand pollination. Weed invasion poses another threat, especially the annual grass *Briza maxima* (Large Quaking-grass),

which smothers plants directly and reduces the area available for the recruitment of seedlings. Late autumn burns are detrimental because the species is early flowering, with leaf initiation occurring during April.

Threat	Rating	Threat	Rating
GRAZING BY INTRODUCED HERBIVORES	1	WEED INVASION	2
GRAZING BY NATIVE HERBIVORES	1	SMALL POPULATION SIZE	3
RECREATIONAL DAMAGE	2	URBAN DEVELOPMENT	2
POOR RECRUITMENT	3		

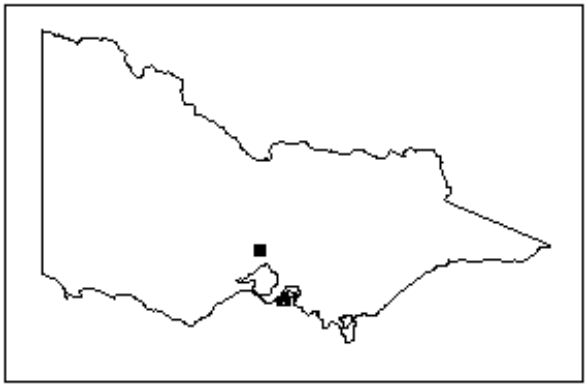
Reservation: The primary colony occurs on private land protected by conservation covenants. The other colony occurs in a conservation reserve.

Management: A Draft Action Statement has been prepared for the species that specifies a program of research, monitoring and propagation for re-establishment into the wild. Field surveys will be undertaken in appropriate habitat for the species. Fire management and appropriate grazing controls will be incorporated as a tool into land protection programs. Access to the colonies will be restricted. Liaison with landholders and raising public awareness of the orchid will be incorporated into prescribed management.

Curly Sedge *Carex tasmanica*

Family: Cyperaceae

Description: A short but wiry, clumped perennial sedge, to 50cm high. The narrow linear leaves end in distinctive curls. The minute greenish flowers appear in the warmer months of the year, in dense short spikes, at the end of long stems that extend beyond the foliage. The chaffy, stiff seed heads have rib-like margins and bold divergent teeth at the apex.



Conservation Status:

- ROTAP: vulnerable
- VROTS: vulnerable
- ESP: Not listed
- FFG: Is listed, but has no Action Statement

no of records in Victoria	Victorian range (km)	no of records in region	regional range (km)	% of Aust Majority	Tenure of largest proportion of Central Highlands population	Tenure of next largest proportion of Central Highlands population
20	371	11	11	0-25	private land	

Distribution: *Carex tasmanica* occurs along 1-2 kilometers of Merri Creek near Craigieburn and a few plants are present at a minor stream near Bald Hill (Frood 1992). Both sites are on private land.

Habitats: Seasonally moist to waterlogged ponds associated with drainage systems on sticky, heavy, grey to black clay soils developed on basalt plain. The mean annual rainfall is around 600 mm with a moderate to pronounced spring maximum. River Club-sedge (*Schoenoplectus validus*) is a conspicuous dominant, with Common Spike-sedge (*Eleocharis acuta*), Nodding Club-sedge (*Isolepis cernua*) and the introduced Strawberry Clover (*Trifolium fragiferum*) common. This zone is fringed by Common Tussock-grass (*Poa labillardieri*) dominated grassland (Frood 1992).

Reproduction: Curly Sedge relies on disturbance for its regeneration. Most of the Tasmanian populations are on seepage lines where soil disturbance occurs following heavy rainfall, particularly on steeper slopes, and those in grazed areas would be periodically disturbed by grazing animals seeking water. It is a species that resprouts after fire, and fire may stimulate seed germination. Regeneration is mainly achieved through division, and few germinates have been observed during demographic studies. Germination has only been achieved with fresh seed with approximately a 50% germination rate and it has not been possible to germinate seed more than 3 months old (Gilfedder 1991).

ISSUES & STATUS IN CENTRAL HIGHLANDS

Threatening processes: The major threats to the species are as a result of its rarity in terms of abundance and the fragmented nature of the populations. Nearly all of the former range of the species has been cleared for agriculture and Curly Sedge is now restricted to a few isolated sites surrounded by farmland. These sites are by no means secure. They are continually threatened by grazing, pasture development and even cropping at a few sites. The Fawthrop Lagoon population near Portland has been destroyed by dredging and subsequent overburden dumping onto the plants, by Portland municipal Council workers (Gullan *et al* 1990). Canopy closure and the rank growth of weedy grasses threaten the drier sites (Frood 1992). The proposed construction of the F2 extension of the Hume Highway threatens the Craigieburn population with changes in hydrology and sediment load and consequent invasion of

Nassella species (Frood pers.comm.). The Bald Hill population is threatened by proposed quarry development and intensive grazing by cattle and sheep(Frood pers.comm.).

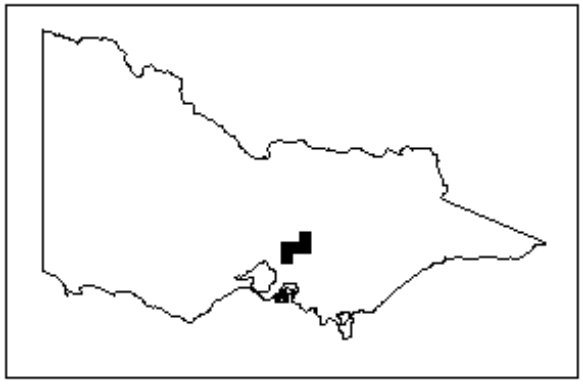
Threat	Rating	Threat	Rating
PLANT COMPETITION	2	LACK OF RECRUITMENT	1
ROAD OR RAILWORKS	2	GRAZING BY STOCK	1
MINING OR QUARRYING	1	WEED INVASION	1
SMALL POPULATION SIZE	1	URBAN DEVELOPMENT	1

Reservation: The only currently reserved population occurs at Lake Jollicum Wildlife Reserve south of Streatham in western Victoria. The Victorian Government is negotiating with the owners to acquire the private land at Craigieburn. The Bald Hill population will be protected through management agreements with the landholder (Craigie pers.comm.).

Management: A draft Action Statement is currently being prepared for the species. While current grazing levels are far heavier than desirable, strategic use of grazing may be an appropriate management tool in drier sites to prevent loss of herbland vegetation through rank growth of grass species (Frood 1992).

Buxton Gum *Eucalyptus crenulata*

Family: Myrtaceae



Description: A small tree, seldom taller than 8 meters, with a dense foliage of glaucous (whitish) leaves reaching almost to ground level. Buxton Gum is distinguished by its small, stem-clasping, heart-shaped, blue-green leaves with crinkly (crenulate) margins. The bark is slightly rough, thin and grey or grey-brown, longitudinally fissured on mature trunks but smooth on branches. During spring, the Buxton Gum has clusters of cream, honey-scented flowers.

Conservation status:

- ROTAP: endangered
- VROTS: endangered
- ESP: Listed
- FFG: Is listed, with an Action Statement

no of records in Victoria	Victorian range (km)	no of records in region	regional range (km)	% of Aust Majority	Tenure of largest proportion of Central Highlands population	Tenure of next largest proportion of Central Highlands population
34	250	33	108	75-100	conservation reserve	private land

Distribution: Eucalyptus crenulata has been recorded from 33 sites, over a 108 km range, between 65 meters and 270 meters altitude in the Central Highlands. It is currently known only from the Central Highlands and is highly localised. Both the known populations at Yering and Buxton are undergoing demonstrated ongoing decline.

Habitat: The species occurs in lowlands on flat terrain. Riparian Forest on soils that are inundated annually.

Reproduction: The species is adaptable to a range of environmental situations and is capable of regenerating from seed, lignotubers and epicormic buds. Plants are long-lived perennials, surviving for more than 50 years. Location of the seed store is in the soil. Regeneration is continuous, with seed germinating over an extended period. Regeneration may be habitat dependent on particular rare and unpredictable (stochastic) events, e.g. fire, flood, unusual combination of seasonal conditions - between such events the plants may appear to be absent. Most plants survive fire and resprout from dormant buds, either along the stems, at ground level or from underground; but also a significant re-establishment from seed germination.

ISSUES & STATUS IN CENTRAL HIGHLANDS

Threats: Introduced plants occur at both sites and threaten to invade the understorey and possibly inhibit seedling regrowth. Blackberry(Rubus fruticosa) grows at both sites and Japanese Honeysuckle(Lonicera japonica) grows at the Yering site. Buxton Silver Gum Reserve has not been burnt since the 1939 wildfire, or earlier. A dense ground cover is preventing seedling regeneration, and all mature Buxton Gums are in a poor state of health, possibly because of age, infestation by Coarse Dodder-laurel, and frequent water-logging of their habitat. At Yering, a dense growth of a native tussock grass, Poa labillardieri, inhibits seedling regeneration. Severe insect attacks on Buxton Gums have been noted at both localities. Hybrids of Buxton Gum and Swamp Gum(Eucalyptus ovata) have been recorded at both localities that

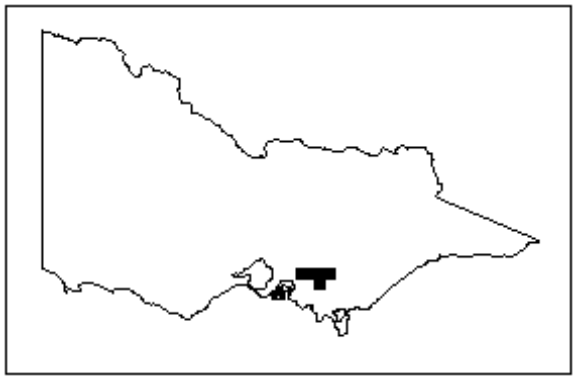
compete successfully with Buxton Gum, particularly in moist sites. There are probably no more than 500 plants left in the wild. Natural populations are small genetically isolated occurrences and are therefore susceptible to edge and 'island' effects. a natural disaster(severe flood, fire or winds) could destroy one or both populations. Changes in adjoining land use could have direct and indirect effects on the ecology of the reserves

Threat	Rating	Threat	Rating
GRAZING BY STOCK	1	SMALL POPULATION SIZE	2
INAPPROPRIATE BURNING REGIME	1	INSECT ATTACK	1
INAPPROPRIATE HYDROLOGY	1	ROAD OR RAILWORKS	1
WEED INVASION	2	PLANT COMPETITION	2

Reservation: One population, covering about 4 ha, is in the 16.9 ha Buxton Silver Gum Reserve, established in 1978 and managed by the Department of Natural Resources and Environment. Buxton Gums on Crown Land at Yering were incorporated within Spadonis Reserve, which is fenced off from grazing and managed by the Department of Natural Resources and Environment.

Management: The species has an Action Statement which specifies a program of enrichment planting of existing populations, public education and liasion with landholders and local authorities. Research of appropriate fire management and weed control and studies of species ecology are integrated into the statement. Control of introduced plants is given a high priority.

Strzelecki Gum *Eucalyptus strzeleckii*



Family: Myrtaceae

Description: A medium sized to tall forest tree to 30m with an open canopy. First branch at 8m or more above ground. Bark smooth throughout, whitish with red brown mottling, with old decorticated bark sometimes persisting about the base as loose, thin sheets or strips. Glossy dark green undulating adult leaves(broad-lanceolate to ovate) and small somewhat obconical fruits. Waxy growth tips occur in intermediate and coppice leaves, as well as on the mature canopy, and are particularly noticeable during spring growth spurts giving the foliage a bluish tinge(Rule 1992).

Conservation status:

- ROTAP: vulnerable
- VROTS: vulnerable
- ESP: Not listed
- FFG: Has not been nominated

no of records in Victoria	Victorian range (km)	no of records in region	regional range (km)	% of Aust Majority	Tenure of largest proportion of Central Highlands population	Tenure of next largest proportion of Central Highlands population
27	81	16	60	0-25	private land	unknown

Distribution: *Eucalyptus strzeleckii* has been recorded from 16 sites, over a 60 km range in Central Highlands and its current distribution is highly localised. Most of the populations occur across the western section of the Strzelecki Ranges, but populations extend to Neerim South north of Warragul (Rule 1992). Remnants of *Eucalyptus strzeleckii* still occupy farms, roadside verges and small segments of public land. Population size remains more or less constant within the CRA region.

Habitat: *Eucalyptus strzeleckii* favours a range of sites including ridges, slopes and along the banks of streams. Its preferred soils are grey, deep, fertile loams which are seasonally waterlogged. In a few cases it occurs on undulating or flat terrain close to creeks on the periphery of the ranges. *Eucalyptus strzeleckii* can be associated with a number of species but more often it grows in small but pure stands(Rule 1992).

Reproduction: *Eucalyptus strzeleckii* flowers in spring. Sexual reproduction, and subsequent establishment from seed is likely in most years and regeneration is continuous, with seed germinating over an extended period. Regeneration can be habitat dependent on particular rare and unpredictable (stochastic) events, e.g. fire, flood, unusual combination of seasonal conditions. Tolerates occasional major ('natural') disturbances and requires such disturbance for the rare opportunity to establish and spread. Plants are long-lived perennials, surviving for more than 50 years. Most plants survive fire and resprout from dormant buds, either along the stems, at ground level or from underground.

ISSUES & STATUS IN CENTRAL HIGHLANDS

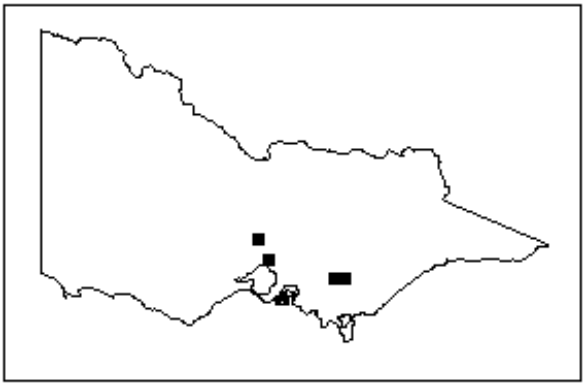
Threatening processes: At the turn of the century the Strzeleckii ranges were heavily timbered, but the demand for farming land bought about the destruction of substantial areas of forest (Rule 1992). Weeds are known to affect extant populations and species habitat. *Eucalyptus strzeleckii* is not palatable to mammalian species and is usually avoided but may be taken under adverse conditions.

Reservation: As yet, no substantial stands of *Eucalyptus strzeleckii* have been observed on either public or private land.

Management: Unknown.

Small Pepper-cress *Lepidium hyssopifolium*

Family: Brassicaceae



Description: Perennial herb to 1m tall, erect with short, fine acicular hairs and many thin branches. Each branch has numerous linear-lanceolate leaves that are pinnatisect, serrate or entire. At the end of each shoot an apical cluster of minute flowers produces a series of silicula(Cropper 1993).

Conservation status:

- ROTAP: endangered
- VROTS: endangered
- ESP: Listed
- FFG: Is listed, but has no Action Statement

no of records in Victoria	Victorian range (km)	no of records in region	regional range (km)	% of Aust Majority	Tenure of largest proportion of Central Highlands population	Tenure of next largest proportion of Central Highlands population
32	452	10	30	0-25	other public land	

Distribution: *Lepidium hyssopifolium* has been previously found scattered throughout south-east Australia. The species survives at only one locality (Beveridge) within the CRA region, and one other in Victoria at Bolwarrah. It also occurs at several localities in Tasmania (Cropper 1993). Population size often fluctuates significantly.

Habitat: *Lepidium hyssopifolium* occurs on flat terrain in Fertile Lowlands on soils that are generally dry. All populations are associated with introduced weedy species on land that tends to receive little maintenance such as derelict pasture. The species original habitat included eucalypt woodland with a grassy understorey, low open casuarina woodland with grassy ground cover and tussock grassland (Cropper 1993).

Reproduction: *Lepidium hyssopifolium* is an opportunist species that colonises disturbed soil. On average, plants live for four years and individuals readily produce thousands of viable seeds each year. Seeds are large and lack wings or plumes to aid in wind dispersal or hooks for attachment to animals. No animals have been seen feeding on seed and it is thought that seed dispersal is limited. Location of the seed store is in the soil where it remains viable for over two years. 'Natural' disturbances, such as fires, floods, or occasional browsing/grazing are tolerated. All (or nearly all) plants are killed by fire, and regeneration is solely from seed (or spores) stored in the soil pre-fire; fire-promoted germination or establishment. However if plants are slashed or mown, the species can quickly come back from buds that are near the soil surface.

ISSUES & STATUS IN CENTRAL HIGHLANDS

Threatening processes: Lepidium hyssopifolium has been 'reduced to great rarity by loss of habitat and heavy grazing' by cattle and sheep (Scarlett and Cropper 1987) however these processes no longer threaten the existing populations(Cropper 1993). The Beveridge stand is threatened by railway works, excessive disturbance through dumping of rubbish, mining and grazing (Scarlett and Cropper 1987). Consequent searches in 1990 were unable to locate any plants at this site and it is possible that all adult plants have been killed by herbicide spraying(Cropper 1993). The recruitment of the taxon to the reserved major stand is seriously declining. The Bolwarrah stands are threatened by excessive soil disturbance preventing seedling establishment and indiscriminate spraying of pest plants. The species similarity to the introduced Pepper-cress species(known to taint milk), the 'weedy nature' of the species and the degraded habitat in which the stands survive has made it difficult to convince land managers that *Lepidium hyssopifolium* is a native species. Small Pepper-cress often grows with a range of weeds along roadsides and railway lines increasing the chances of plants being destroyed through maintenance herbicide spraying. Plants at Mooramong have been damaged by the introduced Red-legged Earth Mite(*Halotydeus*

destructor)(Cropper 1993).

Threat	Rating	Threat	Rating
GRAZING BY STOCK	1	ROAD OR RAILWORKS	2
LACK OF KNOWLEDGE	1	URBAN DEVELOPMENT	1
PESTICIDES/HERBICIDES	2	POOR RECRUITMENT	1
MINING OR QUARRYING	1	INSECT ATTACK	1

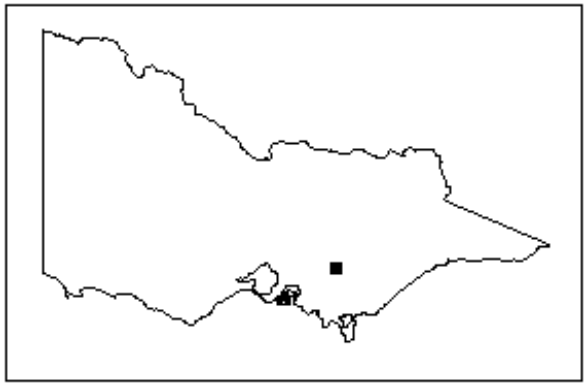
Reservation: The largest population on Public Land at Bolwarrah has been reserved to preserve the species. Populations have been established at Laverton North Grassland Reserve and Mooramong native grassland owned by the National Trust.

Management: Unknown.

Ridged Groundsel *Senecio laticostatus*

Family: Asteraceae

Description: An erect forb with mesic leaves: Broad-leaved herb (ie. no woody parts) arising from a "tussock" (ie. clump of foliage arising at much the same point), with or without stolons, with mesic leaves.



Conservation Status:

- ROTAP: vulnerable
- VROTS: vulnerable
- ESP: Listed
- FFG: Has not been nominated

no of records in Victoria	Victorian range (km)	no of records in region	regional range (km)	% of Aust Majority	Tenure of largest proportion of Central Highlands population	Tenure of next largest proportion of Central Highlands population
3	158	3	158	50-75	private land	

Distribution: In the Central Highlands Senecio laticostatus has been recorded from 3 sites, over a 158 km range. The species is highly localised and is now known from only one site along Beynon's Creek at Western Tyers in the Central Highlands.

Habitat: The extant site is on occasionally flooded flats at the junction of streams, with brown clay-loam soils formed on recent alluvium. The site has been severely disturbed and colonised by blackberry (*Rubus fruticosis)* but was formerly *Eucalyptus viminalis* open forest with a dense *Poa labillardieri* ground stratum (Scarlett 1985).

Reproduction: Senecio laticostatus is a post-fire pioneer of burnt blackberry infestations, occurring in dense patches after autumn burning. All (or nearly all) plants are killed by fire, and regeneration is solely from seed stored in the soil pre-fire. Stands originating from fire persist for two years. The species occasionally invades bare ground after blackberry has been removed by spraying. Seeds are widely dispersed by wind in late summer and autumn, but the species has never been observed in grassland resulting from past clearing or open forest areas fringing the creek flat (Scarlett 1985).

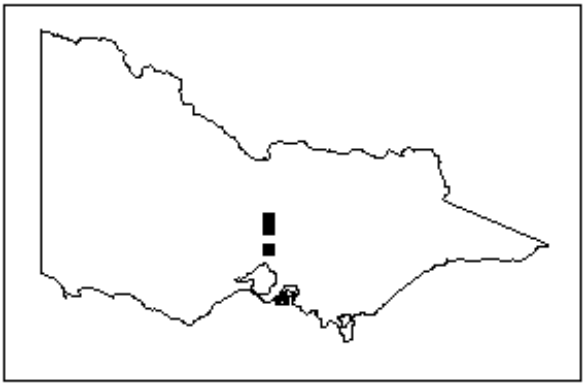
ISSUES & STATUS IN CENTRAL HIGHLANDS

Threatening processes: Burning in late spring destroys plants and prevents significant regeneration in that year. Colonies may be overtopped by vigorous blackberry growth. At Western Tyers, plants are grazed by wombats, wallabies and rabbits. The long term future of this population dependent on the landholder as conversion of the area to farmland would remove the species(Scarlett 1985).

Reservation: No populations are known to occur on public land.

Management: The population at Western Tyers will continue to receive appropriate fire management for the species unless there is a change in ownership of the property(Scarlett 1985).

Large-fruit Groundsel *Senecio macrocarpus*



Family: Asteraceae

Description: An erect forb growing to 40 cm high. It has narrow, woolly grey leaves that are alternate and linear, up to 10 cm long and 2 to 4 mm wide. The lower leaves are numerous and densely crowded, while the upper leaves are smaller and more expanded. The large flowerheads (18 mm long) are found at the end of ascending stalks that are up to 6 cm long. There are 50 to 100 yellow florets on each inflorescence, each floret being up to 15 mm long. The brown seed fruits are grow to 6 mm long and have very short dense hairs (Belcher 1983).

Conservation status:

- ROTAP: vulnerable
- VROTS: endangered
- ESP: Listed
- FFG: Is listed, with an Action Statement

no of records in Victoria	Victorian range (km)	no of records in region	regional range (km)	% of Aust Majority	Tenure of largest proportion of Central Highlands population	Tenure of next largest proportion of Central Highlands population
34	600	3	74	0-25	other public land	

Distribution: Senecio macrocarpus has been recorded from 3 sites, over a 74 km range in the Central Highlands, but it is now known only from the Yan Yean Catchment. The species was formerly widespread in western Victoria, but now only 13 populations at 11 locations throughout the state are known. There are old records for areas such as the Wimmera, Skipton, Colac and Casterton, as well as Tasmania, but the species has not been found recently in these areas, and in some cases is thought to no longer exist.

Habitat: In the Central Highlands the Large-fruit Groundsel occurs in grassy woodlands such as Grey Box Open Woodland (on Tertiary sediments) and Long-leaved Box (*Eucalyptus goniocalyx*) Open Woodland (Scarlett pers. comm.). Fertile Lowlands on flat terrain. Soils are generally dry and derived from Silurian sediments and Quaternary deposits.

Reproduction: Plants flower from September to November, but occasionally also flower in March and April (Scarlett *et al* 1993). Plants reach sexual maturity at 1 - 5 years. Location of the seed store is in the soil. Regeneration is continuous, with seed germinating over an extended period and can be habitat dependent on particular rare and unpredictable (stochastic) events, e.g. fire, flood, unusual combination of seasonal conditions - between such events the plants may appear to be absent. Most plants survive fire and resprout from dormant buds, either along the stems, at ground level or from underground; but also a significant re-establishment from seed germination.

ISSUES & STATUS IN CENTRAL HIGHLANDS

Threatening processes: High grazing pressure affects the survival rate of the Large-fruit Groundsel and rabbit grazing is considered a threat to all sites. When the Yan Yean site was surveyed in 1992 the population was thought to have declined rapidly (compared to surveys in 1987), and this is attributed to

the high density of kangaroos in the area (Tonkinson pers. comm.). The species can not compete efficiently with weeds and all sites are subject to weed invasion. Site disturbance (apart from fire) is a threat to all sites. It can directly remove vegetation, disturb the soil, introduce weed seeds and provide opportunities for weed growth. The Yan Yean population is close to a track, but no works on this track are planned (Curry pers. comm.). Burning during periods of growth or seed-set can threaten the plant's survival. Because the ecological requirements of the species are not fully understood, there is a risk of unintentional mismanagement.

Threat	Rating	Threat	Rating
GRAZING BY INTRODUCED HERBIVORES	2	WEED INVASION	2
INAPPROPRIATE BURNING REGIME	1	LACK OF KNOWLEDGE	1
INSECT ATTACK	1		

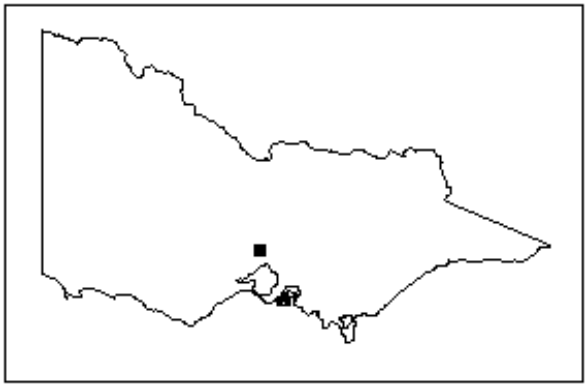
Reservation: The population in the Yan Yean Catchment is managed by Melbourne Water. All populations occur on Crown Land, with one population being located in a conservation reserve (the Deep Lead Flora and Fauna Reserve). The species also occurs in the Bannockburn Cemetery managed by the Bannockburn Cemetery Trust respectively. The remaining extant populations are in rail reserves under the management of the Public Transport Corporation (PTC) around the Melbourne, Geelong, Ballarat and Ararat areas.

Management: An Action Statement has been prepared which includes a program of fencing and signposting, appropriate fire management and re-establishment through propagation. Monitoring and research form integral parts of proposed management.

Swollen Swamp Wallaby-grass *Amphibromus pithogastrus*

Family: Poaceae

Description: Tufted perennial to one metre high. Leaves glabrous and smooth; blade flat or inrolled to 20cm long and 1.5mm to 5mm wide. Amphibromus pithogastrus is distinguished from other species of Amphibromus by the relatively short ligule, swollen lemma and relatively short palea.



Conservation Status:

- ROTAP: poorly known
- VROTS: endangered
- ESP: Not listed
- FFG: Is listed, but has no Action Statement

no of records in Victoria	Victorian range (km)	no of records in region	regional range (km)	% of Aust Majority	Tenure of largest proportion of Central Highlands population	Tenure of next largest proportion of Central Highlands population
12	273	6	9	?	private land	

Distribution: *Amphibromus pithogastrus* is currently known from one sites in the Central Highlands, on private land at Craigieburn (Frood 1992). Another site occurs on private land at Broadmeadows but is outside the study boundary.

Habitats: *Amphibromus pithogastrus* generally occurs in damp areas within treeless grassland or sedgeland, but a few of these sites were presumably lightly wooded at European settlement. Soils are basalt derived, ranging from heavy grey clay to black clays or duplex silty soils. The Craigieburn population is comprised of a few plants on a small seasonal soak at the base of a stony rise (Frood 1992).

Reproduction: Plants flower in November. 'Natural' disturbances, such as fires, floods, or occasional browsing/grazing are tolerated, but regeneration is not dependent on such disturbance.

ISSUES & STATUS IN CENTRAL HIGHLANDS

Threatening processes: While little is known of the original distribution of Swollen Swamp Wallaby-grass, the vast majority of its potential habitat has been effectively destroyed through residential and industrial development, intensive agriculture, fire prevention works and weed invasion. The total known Victorian population consists of less than twenty plants. *Amphibromus pithogastrus* is a species of marginal wetland habitat. Its dependence on these ephemeral wetland habitats is likely to be a factor in its extreme relative rarity, due to the vulnerability of these habitats to disturbance effects, including availability to grazing animals and weed invasions (anon 1992). A subsequent inspection of the Craigieburn population failed to relocate the species, and there is no guarantee that it has or will survive recent heavy grazing of the site. Plants are at risk from competition due to invasion by Yorkshire Fog (*Holcus lanatus*), Toowoomba Canary grass (*Phalaris aquatica*) and *Nassella* spp. The proposed construction of the F2 extension of the Hume Highway potentially threatens the site with changes in hydrology and sediment load and the consequent invasion of *Nassella* spp. (Frood pers.comm.).

Threat	Rating	Threat	Rating

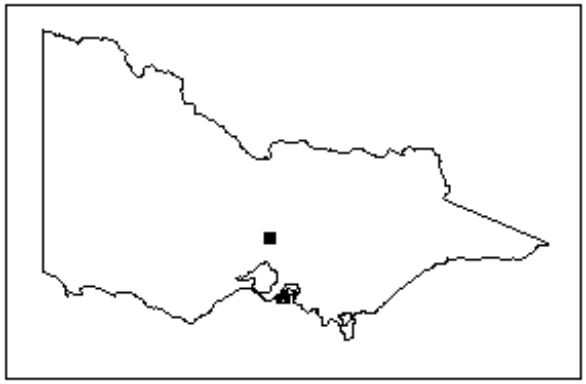
SMALL POPULATION SIZE	2	URBAN DEVELOPMENT	2
WEED INVASION	2	GRAZING BY STOCK	2
INAPPROPRIATE BURNING REGIME	1	PLANT COMPETITION	1
ROAD OR RAILWORKS	1	SMALL POPULATION SIZE	1

Reservation: In the Central Highlands the Victorian Government is negotiating with the owners to acquire the private land at Craigieburn (Craigie pers.comm.).

Management: A draft Action Statement is currently being prepared for the species.

Swamp Everlasting *Bracteantha* sp. aff. *subundulata*

Family: Asteraceae



Description: Swamp Everlasting is prostrate rhizomatous herb. The bright green lanceolate leaves have a prominent mid-vein. They form clusters at the base of flower stalks, and are scattered alternately along the stalks. Terminal golden-yellow flowers are produced in summer on stalks up to a meter tall. This taxon has not yet been formally described but it is quite distinct in its habitat preference from the Orange Everlasting (*Bracteantha subundulata*) which is found at high altitudes(Anon 1995).

Conservation Status:

- ROTAP: Not listed
- VROTS: vulnerable
- ESP: Not listed
- FFG: Is listed, but has no Action Statement

no of records in Victoria	Victorian range (km)	no of records in region	regional range (km)	% of Aust Majority	Tenure of largest proportion of Central Highlands population	Tenure of next largest proportion of Central Highlands population
11	440	1		?	other public land	

Distribution: In the Central Highlands, Swamp Everlasting is currently known from a single site at Hernes Swamp near Wallan. A second site at Bayswater North, an outlying suburb east of Melbourne, is just **outside** the study boundary. The Hernes Swamp population covers approximately one hectare along 1-2 km of rail reserve(Cook pers.comm.). The Bayswater North population may be only a single suckering individual occupying a small area, 10 meters in diameter, on the Proposed Healesville Freeway reserve (Lorimer pers.comm.).

Habitats: Lowland swamps. This taxon occurs in near-coastal sedge swamps with sandy soils and in grassy wetlands with heavy gray clay soils on fertile plains. The Hernes Swamp area is a swamp basin with heavy black clay soils developed on outlying Basalt plain. The species grows there in close proximity to Fine Twig-sedge (*Baumea arthrophylla*). The Bayswater North population is in a drainage line on alluvial soils developed on Silurian sedimentaries and granodiorite. The vegetation at the site is the Herb-rich Plains Grassy Wetland (West Gippsland), a community listed for protection under the Flora and Fauna Guarantee Act. Individuals grow in close proximity to Hooker Sedge(*Austrofestuca hookeriana*) and Paspalum (*Paspalum dilatatum*) while surrounding dominants include Common Reed (*Phragmites australis*), Soft Twig-sedge (*Baumea rubiginosa*) and both native and exotic *Juncus* and *Carex* species. The original vegetation is likely to have been swamp scrub with an overstorey of Prickly Tea-tree (*Leptospermum continentale*) and Swamp Paperbark (*Melaleuca ericifolia*) (Lorimer pers.comm.).

Reproduction: Plants are perennial. Sexual reproduction, and subsequent establishment from seeds is likely in most years. Asexual reproduction via suckering occurs commonly. Regeneration is not dependent on particular rare or unpredictable (stochastic) events, eg. fire, flood, unusual combination of seasonal conditions. Most plants survive fire and resprout from dormant buds, either along the stems, at ground level or from underground; but also a significant re-establishment from seed germination.

ISSUES & STATUS IN CENTRAL HIGHLANDS

Threatening processes: Swamp Everlasting has probably declined in abundance and distribution because of its sensitivity to grazing by introduced stock and loss of habitat caused by the draining of wetlands. The sewage treatment plant at Hernes Swamp threatens the site through overflow and consequent eutrophication. The construction of railway track or road maintenance work in the area could damage the population. The Bayswater North population occurs on land owned by Vic Roads and zoned for the construction of the proposed Healesville Freeway. The population is subject to frequent slashing, detrimental to the species, and Vic Roads is considering leasing the reserve area in the short term (Lorimer pers.comm.).

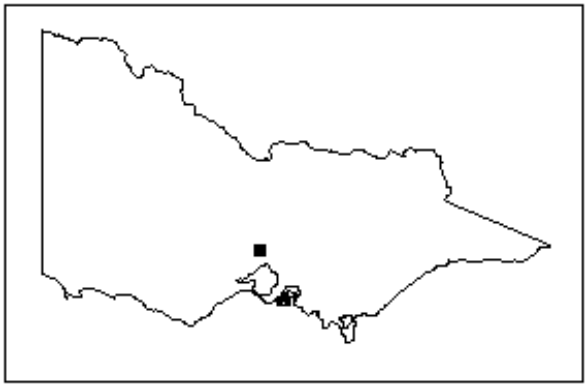
Threat	Rating	Threat	Rating
ROAD OR RAILWORKS	1	EUTROPHICATION	2
SLASHING	2		

Reservation: In the Central Highlands the population of Swamp Everlasting is located on railway reserve. The nearby Bayswater North population occurs on land owned by Vicroads zoned for the potential construction of the Healesville Freeway.

Management: Unknown.

Tough Scurf-pea *Cullen tenax*

(formerly *Psoralea tenax*)



Family: Fabaceae

Description: Trailing or ascending perennial herb; stems to circa 50cm long, glabrous or with sparse minute appressed hairs. Leaves palmate with five leaflets up to 2.5 cm long. Mauve or bluish flowers in groups of two or three(Walsh and Entwhistle 1996).

Conservation Status:

- ROTAP: Not listed
- VROTS: endangered
- ESP: Not listed
- FFG: Is listed, but has no Action Statement

no of records in Victoria	Victorian range (km)	no of records in region	regional range (km)	% of Aust Majority	Tenure of largest proportion of Central Highlands population	Tenure of next largest proportion of Central Highlands population
15	460	3	10	?	unknown	unknown

Distribution: *Cullen tenax* is currently known from a population of over 100 plants associated with a drainage system near Craigieburn and from a few individuals in a minor drainage line near Bald Hill (Frood 1992).

Habitats: Minor drainage lines on sticky dark soils. The mean annual rainfall is around 600 mm with a moderate to pronounced spring maximum. A degree of seasonal waterlogging would occur at most sites. Vegetation is basalt plains grassland with a sparse to moderate cover of Common Tussock Grass (*Poa labillardieri*). Chilean Needle-grass(**Nassella neesiana*) and other weed species are scattered throughout.

Reproduction: The species has been seen flowering throughout most of the year often in apparent response to rain. Plants usually die back to the rootstock each autumn, resprouting in late spring and flowering in midsummer. Plants may reach 1.5 meters in diameter each year (Tonkinson 1989). Sexual reproduction, with establishment from seed occurs only occasionally. It may be limited to a few seasons because of dormancy within the propagules, habitat requirements or because establishment needs the temporary removal of competitors. Regeneration is not dependent on particular rare or unpredictable (stochastic) events, eg. fire, flood, unusual combination of seasonal conditions. All (or nearly all) plants are killed by fire, and regeneration is solely from seed stored in the soil pre-fire.

ISSUES & STATUS IN CENTRAL HIGHLANDS

Threatening processes: Land clearance, cultivation and heavy grazing have eliminated the species over most of its former range. It has failed to survive in the usual refuges such as railway reserves and roadsides. Regular summer burning is likely to eliminate the species by preventing effective seed set. Many of the weeds present at the site are indicative of high grazing pressure from sheep. Chilean

Needle-grass(**Nassella neesiana*) is of scattered occurrence throughout the Craigieburn site and has the potential to become a major problem, particularly in the absence of grazing(Frood 1992). The proposed construction of the F2 extension of the Hume Highway threatens the site with changes in hydrology and sediment load and consequent invasion of introduced *Nassella* spp.(Frood pers.comm.). Heavy grazing by cattle and sheep and a proposed quarry development threaten the Bald Hill Population.

Threat	Rating	Threat	Rating
WEED INVASION	2	GRAZING BY STOCK	1
PLANT COMPETITION	2	ROAD OR RAILWORKS	1
INAPPROPRIATE BURNING REGIME	1		

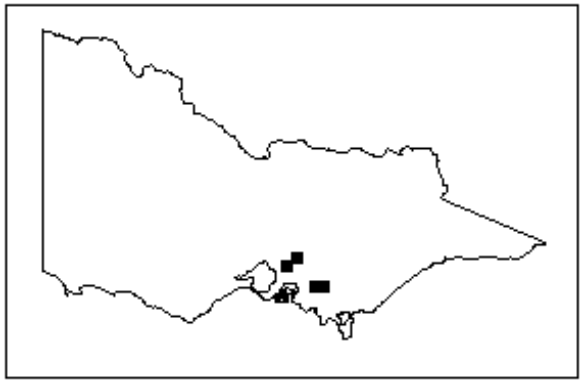
Reservation: The Victorian Government is negotiating to acquire the private land at Craigieburn and the Bald Hill population will be protected through management agreements with the landholder.

Management: A draft Action Statement is currently being prepared for the species. An intermittent grazing regime may be an appropriate short-term management option to maintain an open canopy at the Craigieburn site. In the absence of grazing, weed control and monitoring of a number of herbaceous species would be an essential part of sound management (Frood 1992).

Slender Tree-fern *Cyathea cunninghamii*

Family: Cyatheaceae

Description: Erect slender tree fern up to 20 m tall and 8-10 cm in diameter. The crown is generally small comprising dark green fronds 1.5-3m in length with the width of secondary primae decreasing abruptly near the tips. Stipe bases are black, crumbly and rough, and persist towards the base of the trunk. Scales of stipe bases are papery and fawn to brown.



Conservation status:

- ROTAP: rare
- VROTS: rare
- ESP: Not listed
- FFG: Is listed, with a draft Action Statement

no of records in Victoria	Victorian range (km)	no of records in region	regional range (km)	% of Aust Majority	Tenure of largest proportion of Central Highlands population	Tenure of next largest proportion of Central Highlands population
175	700	28	34	0-25(?)	other public land	

Distribution: *Cyathea cunninghamii* occurs at a single site in the Central Highlands, but occurs in other climatically suitable parts of Victora (the Otways, South Gippsland and East Gippsland). Populations are uncommon and typically very small, often comprising just a few individuals.

Habitat: Moist Foothills, Rainforests Confined to deep wet fern gullies and rainforest protected from fire and wind. Individuals are usually observed directly on creek banks with a constant moisture supply. However, the slender trunk can be damaged by flooding so populations tend to be confined to small catchments and headwaters (Lobert *et al* in prep.).

Reproduction: It has been reported that *Cyathea cunninghamii* does not become fertile before plants attain a height of about 7m, corresponding to an estimated age of approximately 80 years (Walsh and Entwistle 1994). Sexual reproduction, and subsequent establishment from seeds or spores, is likely in most years. Spores are available for three weeks in March. Although the release of tree-fern spores is prolific and distribution is extensive, little is known about the viability or longevity of the spores. Conditions for germination through to the development of the young tree-fern sporophyte are critical for the survival of tree-ferns on a site. Anecdotal evidence suggests that the species may be light tolerant (Gutowski 1995). All (or nearly all) plants are killed by fire; and colonies often re-establish only via invasion from unburnt sites. Slender Tree-Fern requires long periods without major disturbance for survival and establishment.

ISSUES & STATUS IN CENTRAL HIGHLANDS

Threatening processes: Slender Tree-fern usually occurs in populations of only one or two plants increasing its susceptibility to threatening processes. Plants may be killed or damaged directly from tree fall; deposited soil or vegetation; building and maintenance of logging roads and uncontrolled fuel reduction burns which unsuccessfully rely on moisture differentials to control their spread (Lobert *et al* 1991). Slender Tree-fern and its habitat may be affected by a number of factors associated with the establishment of adjacent logging or fire regrowth forests. Canopy disturbance opens up Slender Tree-fern habitat making plants more susceptible to windthrow, and promoting competition from other species. Timber harvesting and roading have the potential to increase the spread of Myrtle-wilt, a lethal fungal disease of Myrtle Beech. Epidemic levels of myrtle wilt have been recorded in the Otway Ranges (Cameron and Turner 1994). Although the impact of fire on Slender Tree-fern has not been studied it has been noted that Slender Tree-fern is uncommon and vanishing, presumably as a result of forest fires (Willis 1962). During the early years of forest regeneration there is an increase in fire risk due to the production and accumulation of large amounts of litter. A second fire during this time destroys the tree

seedlings at a stage when the availability of tree seed is at a minimum. This allows fire adapted weed species to gain a bigger hold in the habitat and a serious swing to a fire-prone type of vegetation occurs (Jackson 1968). Vegetation which buffers rainforest may be removed completely or replaced by more fire-prone species (Cameron 1992). The alteration of sediment loads in streams may affect Slender Tree-fern habitat. Roading operations including stream crossings and snig tracks have been shown to significantly increase sediment in streams. Fluctuations in stream flow yields in regrowth forest and corresponding decreases in soil moisture levels may adversely affect Slender Tree-fern and its habitat. Feeder streams in regrowth forest can dry up during severe droughts increasing fire hazards (Yugovic 1991). In the Dandenongs, Cape Ivy (*Delairea odorata*) and to a lesser extent Blackberry (*Rubus fruticosus* spp. agg.) exert a pressure on Slender Tree-fern habitat because their smothering infestations prevent germination. Other competing weeds in the Dandenongs include Holly (*Ilex aquifolium*), Sycamore Maple (*Acer pseudoplatanus*) and Cestrum (*Cestrum elegans*). Ivy(*Hedera helix*) has been seen growing on Slender Tree-fern plants. There is a high risk that individual populations of Slender Tree-fern may be wiped out by illegal tree-fern harvesting, especially in the Strzelecki Ranges and there is some risk of damage to colonies by visitors or collectors in the Dandenongs and at Tarra-Bulga National Park.

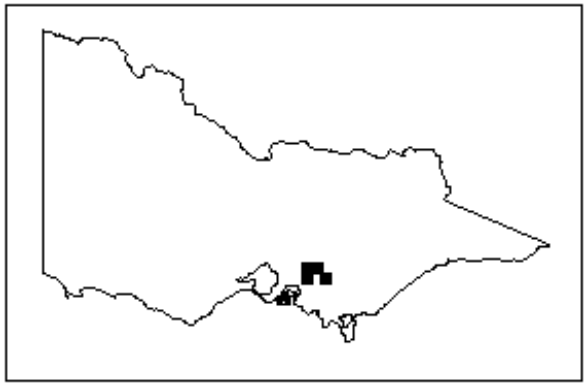
Threat	Rating	Threat	Rating
PLANT COLLECTION	1	RECREATIONAL DAMAGE	1
INAPPROPRIATE BURNING REGIME	2	INAPPROPRIATE HYDROLOGY	1
DISEASE	1	WEED INVASION	2
SMALL POPULATION SIZE	1	TIMBER HARVESTING	2
ROAD OR RAILWORKS	1		

Reservation: The largest population occurs in the Dandenong Ranges along Sassafras Creek, within public land currently managed by the Department of Natural Resources and the Environment. A single plant near the Corranderk Weir is on land managed by Melbourne Water. Substantial populations of Slender Tree-fern occur in the Tarra-Bulga National Park.

Management: A draft Action Statement has been prepared for the species specifying a program of monitoring and research and appropriate conservation measures will be determined in consultation with local Flora staff. Adherence to the Code of Forest Practices is critical to the protection of Slender Tree-fern. Properly constructed roads and snig tracks are to be located as far upstream as is practicable and roading works are not to be located in buffer zones. Adequacy of buffers both prescribed and imposed by topography will be assessed. Logging areas which are likely to contain Slender Tree-fern should be surveyed prior to approval of the Wood Utilisation Plan. Private land holders managing areas containing Slender Tree-fern will be encouraged to establish conservation covenants. All present and future locations of Slender Tree-fern on public land are to be protected by reservation or in special management zones (SMZ) within state forests. A buffer of 100 meters will be established around all sites from which logging will be excluded. The impact of myrtle wilt on Slender Tree-fern habitat will be determined. In areas where Slender Tree-fern occurs on land managed for timber production survey information will be provided to relevant managers for incorporation into coupe plans and an information kit for timber industry staff will be prepared. Forestry officers will be responsible for informing ground staff when operations are likely to take place near Slender Tree-fern habitat. Showing ground staff the plant in the environment is to be encouraged. Collection of Slender Tree-fern for sale should not be allowed to continue. An assessment will be made of the impact of visitors to locations of known populations and the most effective and environmentally acceptable means of removing and controlling weeds.

Gully Grevillea *Grevillea barklyana* ssp. *barklyana*

Family: Proteaceae



Description: Tall shrub or slender tree with a closed canopy, 3 to 10m high. The large flat leaves are green above and whitish-velvety beneath and are entire or appear 'oak like' by having sharp, pointed lobes (Willis 1972). Numerous silky, red flowers form a one-sided, brush-like inflorescence in late spring.

Conservation status:

- ROTAP: rare
- VROTS: rare
- ESP: Not listed
- FFG: Is listed, but has no Action Statement

no of records in Victoria	Victorian range (km)	no of records in region	regional range (km)	% of Aust Majority	Tenure of largest proportion of Central Highlands population	Tenure of next largest proportion of Central Highlands population
37	43	37	43	75-100	other public land	conservation reserve

Distribution: Gully Grevillea is confined in Victoria to 3 minor (10') grids north of Labertouche - an area of no more than 50 square kilometers surrounding the headwaters of the Bunyip and Tarago Rivers, in the catchment of Westernport Bay. The species is highly localised and populations are more or less continuous. Over a thousand plants are known to occur within the Central Highlands and population size rarely fluctuates significantly.

Habitat: Occurs on mountain forest gullies and damp gully slopes on gravelly clay/loam soils that are generally moist (Walsh & Entwisle 1996). Gully Grevillea is frequently a dominant component in the tall, shrubby understorey of Wet Sclerophyll Forest dominated by *Eucalyptus regnans*. The species spans a broad ecological range from Damp Forest to Cool Temperate Rainforest.

Reproduction: Plants are perennial, surviving for up to 50 years. Location of the seed store is in the soil. Regeneration is continuous, with seed germinating over an extended period. Plants tolerate occasional major ('natural') disturbances and require such disturbance for the rare opportunity to establish and spread. All (or nearly all) plants are killed by fire, and regeneration is solely from seed stored in the canopy or stored in the soil for only a short time pre-fire; fire-promoted germination or establishment.

ISSUES & STATUS IN CENTRAL HIGHLANDS

Threatening processes: It is unlikely that the species is threatened by wildfire, as many Victorian Proteaceae, including *Grevillea* are well adapted to wildfire. However, imposed fire regimes of high frequency and low intensity have the potential to locally eliminate populations. As a major proportion of the total population occurs in State Forest zoned for Hardwood production (e.g. Rysons Creek), timber removal and associated forestry activities (including road and track construction) have the potential to threaten this species.

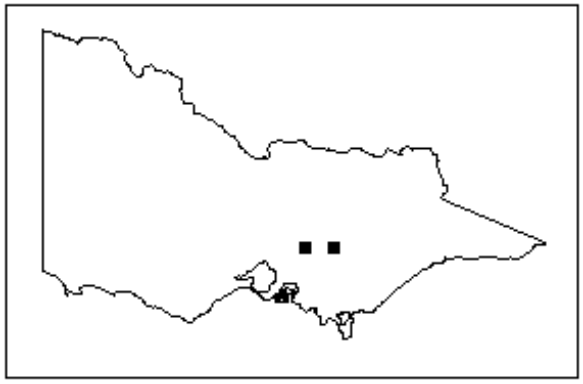
Threat	Rating	Threat	Rating
INAPPROPRIATE BURNING REGIME	1	TIMBER HARVESTING	2

Reservation: Populations occurring on Lawson Creek (in the Bunyip River Catchment) are within the boundaries of Bunyip State Park, a biological reserve.

Management: Draft Action Statement is being prepared. The Central Highlands Draft Forest Management Plan includes a commitment to protect mature individuals wherever possible and to investigate methods to enhance recruitment in order to maintain levels of abundance.

Shiny Phebalium *Phebalium wilsonii*

Family: Rutaceae



Description: Phebalium wilsonii occurs as a scattered tall shrub or small tree, 6-10m high. The leaves are narrowly elliptic to lanceolate, glossy on the upper surface and densely silvery lepidote on the lower surface. The flowers are axillary in position and have white, scaly petals 3.5mm-5.0mm long. The ovaries are also scaly and stamen filaments are of similar length to the petals. The fruit are obliquely ovoid cocci which can be glabrous at maturity.

Conservation Status:

- ROTAP: rare
- VROTS: vulnerable
- ESP: Not listed
- FFG: Is listed, but has no Action Statement

no of records in Victoria	Victorian range (km)	no of records in region	regional range (km)	% of Aust Majority	Tenure of largest proportion of Central Highlands population	Tenure of next largest proportion of Central Highlands population
12	47	12	47	75-100	conservation reserve	

Distribution: *Phebalium wilsonii* is currently known from a single site in the O'Shannessy Catchment within the Yarra Ranges National Parl, where approximately 500 plants were observed by Walsh and Albrecht (1988). Shiny Phebalium was previously collected from Woods Point, approximately 35 km east of the type locality, where it appears to have become locally extinct.

Habitat: *Eucalyptus regnans* (Mountain Ash) tall open forest merging to *Nothofagus cunninghamii* (Myrtle Beech) Cool Temperate Rainforest, on deep mountain loam soils of granitic origin. The location of *Phebalium wilsonii* along track margins at the type locality suggests it is an ecotonal species regenerating after disturbance.

Reproduction: Plants are perennial, surviving for up to 50 years. Sexual reproduction, with establishment from seed occurs only occasionally. It may be limited to a few seasons because of dormancy within the propagules, habitat requirements or because establishment needs the temporary removal of competitors. Pulse regeneration, with most seed germinating simultaneously. All (or nearly all) plants are killed by fire, and regeneration is solely from seed (or spores) stored in the canopy or stored in the soil for only a short time pre-fire; fire-promoted germination or establishment. 'Natural' disturbances, such as fires, floods, or occasional browsing/grazing are tolerated, but regeneration is not dependent on such disturbance.

ISSUES AND STATUS IN CENTRAL HIGHLANDS

Threatening processes: The Woods Point population has apparently become extinct since 1892, following wildfire, land development and gold prospecting. The extremely limited nature of the species distribution and the lack of knowledge on its biology possibly makes it susceptible to inappropriate management and natural disasters.

Threat	Rating	Threat	Rating

SMALL POPULATION SIZE	2	LACK OF KNOWLEDGE	1

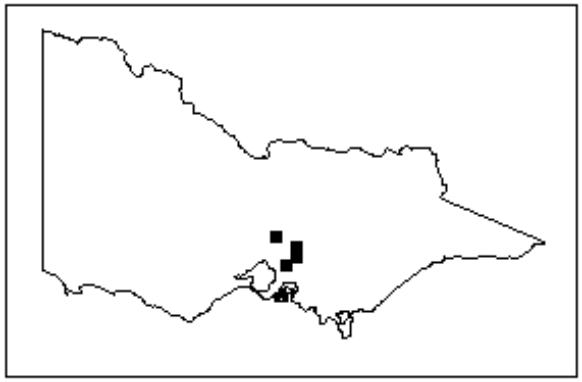
Reservation: The only known population is within the O'Shannessy Catchment, a proclaimed water catchment within the Yarra Ranges National Park. Part of the population extends into the Deep Creek Reference Area.

Management: *Phebalium wilsonii* is believed to be an ecotonal species, well adapted to coping with recurrent natural disturbance and management would need to take this into account (Walsh and Albrecht 1988). Nothing is known about the fire behaviour of the species or other features of its biology which may account for its extremely circumscribed natural distribution. To develop appropriate management it is necessary to determine the ecological requirements of the species.

Fairy Lanterns *Thismia rodwayi*

Family: Burmanniaceae

Description: Fairy Lanterns is a saprophytic herb 5-30mm high. The flower resembles a glowing amber-coloured lantern and is less than 2cm high. Scale leaves, 5-10mm long the largest ones just below the flower(Walsh N.G. & Entwisle, T.J. 1994).



Conservation Status:

- ROTAP: rare
- VROTS: vulnerable
- ESP: Not listed
- FFG: Has been nominated

no of records in Victoria	Victorian range (km)	no of records in region	regional range (km)	% of Aust Majority	Tenure of largest proportion of Central Highlands population	Tenure of next largest proportion of Central Highlands population
1	0	1	0	0-25	conservation reserve	

Distribution: *Thismia rodwayi* is currently known from only one site, within the Central Highlands, at Wallaby Creek near Kinglake, within the Kinglake National Park.. Although it is a very attractive plant, it is difficult to find since it is small and can be hidden within the litter layer. The species occurs in stable wet forests which have a wide distribution and have been reasonably well surveyed, indicating that Fairy Lanterns is extremely rare. Searches in the mid 1980's at sites of former collections at Sherbrooke Forest and Toorongo River have failed to find fairy lanterns.

Habitat: The species is currently known from occurrences in deeply shaded tall open-forest and closed forest and fern gullies on damp humus and leaf litter.

Reproduction: Plants are facultative annuals, biennials or short-lived perennials (1 - 3 years). Sexual reproduction and subsequent establishment is continuous with seed germinating over an extended period. All (or nearly all) plants are killed by fire, and regeneration is solely from seed, although no notable seed or canopy seed store is produced. Re-establishment is often only via invasion from unburnt sites. Fairy Lanterns requires long periods without major disturbance for survival and establishment (e.g. no fires, floods, clearing etc.). Plants grow in a symbiotic relationship with a fungus, which in turn is associated with the rhizosphere of certain forest trees: Blanket Leaf (*Bedfordia arborescens*), Mush Daisy-bush (*Olearia argophylla*) and Hazel Pomaderris (*Pomaderris aspera*). Detached pieces of rhizome can grow and develop to the flowering stage, however nothing is known about the conditions needed for regeneration from seed.

ISSUES & STATUS IN CENTRAL HIGHLANDS

Threatening processes: Fairy Lanterns is extant at only one of the six former sites in Victoria, at Wallaby Creek. The area was burnt by wildfires in 1926 and it is not known whether the species colonised the site from unburnt areas or survived these fires in situ. Scarlett and Ashton recorded approximately seven plants in 1986, and a recent survey by Forbes and Walsh identified only a few plants. There are no obvious threats to the species at this site, however the population has clearly declined.

Threat	Rating		Rating
SMALL POPULATION SIZE	2	LACK OF KNOWLEDGE	2

Reservation: The Wallaby Creek population is within the Kinglake National Park.

Management: Unknown.

APPENDIX F: List of taxa for inclusion in the review of threatened species and disturbance in the Central Highlands CRA

Species name	Common name	AROTS	VROTS
Acacia dealbata	Silver Wattle		
Acacia howittii	Sticky Wattle	R	r
Acacia melanoxylon	Blackwood		
Actinotus bellidioides	Tiny Flannel-flower		x
Adiantum diaphanum	Filmy Maidenhair		e
Allocasuarina littoralis	Black Sheoke		
Asplenium terrestre ssp. terrestre	Ground Spleenwort		r
Asplenium trichomanes	Common Spleenwort		r
Astelia australiana	Tall Astelia	V	v
Astrotricha parvifolia	Small-leaf Star-hair	R	r
Banksia spinulosa var. cunninghamii	Hairpin Banksia		
Bedfordia arborescens	Blanket-leaf		
Blechnum cartilagineum	Gristle Fern		
Blechnum wattsii	Hard Water-fern		
Brachyscome obovata	Baw Baw Daisy		r
Burnettia cuneata	Lizard Orchid	R	r
Caladenia concolor	Crimson Spider-orchid	V	v
Caladenia rosella	Rosella Spider-orchid	E	e
Carex alsophila	Forest Sedge		r
Cassinia trinerva	Three-nerved Cassinia		
Cassytha phaeolasia	Rusty Dodder-laurel		
Clematis aristata	Mountain Clematis		
Coprosma moorei	Turquoise Coprosma		r
Coprosma perpusilla ssp. perpusilla	Creeping Coprosma		r
Coprosma quadrifida	Prickly Currant-bush		
Cyathea australis	Rough Tree-fern		
Cymbonotus lawsonianus	Bear's-ears		r
Desmodium varians	Slender Tick-trefoil		r
Dicksonia antarctica	Soft Tree-fern		
Diuris X palachila	Broad-tip Diuris		r
Epacris coriacea	Tough Heath		r
Epacris glacialis	Reddish Bog Heath		r
Epilobium pallidiflorum	Showy Willow-herb		d
Erigeron pappocromus var. oblongatus	Violet Fleabane		v
Eucalyptus alligatrix	Silver-leaf Stringybark	R	r
Eucalyptus cinerea	Silver Stringybark		r
Eucalyptus crenulata	Buxton Gum	E	e
Eucalyptus neglecta	Omeo Gum	R	r
Eucalyptus obliqua	Messmate		
Eucalyptus pauciflora ssp. acerina	Snow Gum		r
Eucalyptus strzeleckii	Strzelecki Gum	V	v
Eucalyptus yarraensis	Yarra Gum	R	r
Euchiton umbricolus	Cliff Cudweed		r
Euphrasia scabra	Rough Eyebright	K	e
Gahnia grandis	Brickmakers' Saw-sedge		v
Gonocarpus mezianus	Hairy Raspwort		r
Grevillea barklyana ssp. barklyana	Gully Grevillea	R	r
Grevillea repens	Creeping Grevillea	R	r
Hakea sp. (ex H. sericea sensu Willis 1972)	Bushy Hakea		
Huperzia australiana	Fir Clubmoss		r
Huperzia varia	Long Clubmoss		v
Hymenophyllum cupressiforme	Common Filmy Fern		
Juncus antarcticus	Cushion Rush		v
Lastreopsis hispida	Bristly Shield-fern		r
Lepidium hyssopifolium	Small Pepper-cress	E	e
Leucopogon lanceolatus var. *lanceoloatus*	Lance Beard-heath		

Lindsaea microphylla	Lacy Wedge-fern		r
Lomandra longifolia ssp. exilis	Cluster-headed Mat-rush		r
Lycopodium scariosum	Spreading Clubmoss		r
Mitrasacme montana	Mountain Mitrewort		r
Monotoca oreophila	Mountain Broom-heath	R	r
Olearia argophylla	Musk Daisy-bush		
Oxalis magellanica	Snowdrop Wood-sorrel		r
Ozothamnus rogersianus	Nunniong Everlasting		r
Pandorea pandorana	Wonga Vine		
Persoonia arborea	Tree Geebung		r
Persoonia chamaepeuce X confertifolia	Heathy Geebung		r
Phebalium wilsonii	Shiny Phebalium	R	v
Poa crassicaudex (P. morrisii/P. sieb var. *hirtella)*	Thick-stem Tussock-grass		k
Poa halmaturina	Salt Tussock-grass	R	r
Poa labillardieri var. acris	Common Tussock-grass		k
Polyphlebium venosum	Veined Bristle-fern		
Polystichum proliferum	Mother Shield-fern		
Prostanthera sp. (Cultivation Ck)	Mint-bush		r
Psoralea parva	Small Psoralea	E	e
Pteridium esculentum	Austral Bracken		
Pteris comans	Netted brake		r
Pterostylis grandiflora	Cobra Greenhood		r
Pultenaea weindorferi	Swamp Bush-pea	R	r
Richea victoriana	Victorian Richea		r
Senecio laticostatus	Ridged Groundsel	V	v
Senecio macrocarpus	Large-fruit Groundsel	V	e
Spiranthes sinensis	Austral Ladies' Tresses		d
Taraxacum aristum	Austral Dandelion	R	r
Tetratheca stenocarpa	Long Pink-bells	R	r
Tmesipteris elongata ssp. elongata	Slender Fork-fern		v
Tmesipteris ovata	Oval Fork-fern		r
Wittsteinia vacciniacea	Baw Baw Berry		r

APPENDIX G: Life history parameters - priority fauna species

1. MAMMALS

Spot-tailed Quoll
Dasyurus maculatus

RARITY
a) Geographic Range
- Classification of range size: Medium
- Range size within region: (ha): 140 000
- Proportion of region occupied (%): 12
- Source: Atlas of Victorian Wildlife

b) Abundance
- Classification of abundance: Low
- Population Estimate: Unknown
- Density: Unknown
- Home Range (ha): 614 - 1067 females, 1287 - 1482 ha males
- Source: Mansergh (1984), Belcher (1995a)

c) Habitat Specificity
- Classification of habitat specificity: Wide
- Vegetation types used in the region: wet forest, dry forest
- Source: Mansergh (1984), S. Smith pers. comm.

DYNAMICS
Population Trend in Last Decade
- Increasing, stable or declined: Unknown, only six Atlas of Victorian Wildlife records in the past decade plus several unconfirmed sightings

Source: Atlas of Victorian Wildlife, S. Smith pers. comm

Population trend since discovery by Europeans
- Increasing, stable or declined: Declined
- Source: Mansergh (1984)

SPATIAL DYNAMICS
a) Population variability
- Classification of population variability: Low
- Source: Mansergh (1984), LCC (1991), Belcher (1995b)

b) Dispersal
- Classification of powers of dispersal: High
- Average distances dispersed: Unknown
- Maximum distance dispersed: 6km has been recorded for males with radio collars but the animals were often out of range indicating movements of > 6 km
- Source: Belcher (1995a)

LIFE HISTORY PARAMETERS
a) Reproductive output
- Classification of reproductive output: High
- Age of sexual maturity (yrs): 1
- Mean clutch/litter/brood size: 5
- Mean no of clutches/litters/broods per year: 1
- Time of year young born/hatch: June-August
- Source: Fleay (1940), Settle (1978), Edgar and Belcher in Strahan (1995)

b) Longevity
- Classification of lifespan: Unknown
- Average lifespan (yrs): Unknown
- Maximum lifespan (yrs): Unknown
- Source: C. Belcher pers. comm.

c) Morphology
Adult body size
- Weight (g): 4000-7000
- Length (mm): Snout-vent 350-450 females, 380-759 males
- Source: Edgar and Belcher in Strahan (1995)

d) Social organisation
- Colonial or non-colonial: non-colonial
- Territoriality: females and males territorial, several males may enter females territory during the breeding season
- Source: Belcher (1995a)

e) Other
- Nomadic, migratory, sedentary: Sedentary
- Mode of feeding: carnivore, scavenger, insectivore

Source: Green and Scarborough (1990), Belcher (1995c)

THREATS
1. Fire (planned): Ranking (1) Mansergh and Belcher (1992), C. Belcher pers. comm.
2. Fire (unplanned): Ranking (2) C. Belcher pers. comm.
3. Logging: Ranking (3) Mansergh (1984), Mansergh and Belcher (1992), C. Belcher pers. comm.
4. Introduced Species: Ranking (2) Mansergh (1984), Lumsden *et al* (1991), Mansergh and Belcher (1992), C. Belcher pers. comm.
5. Pest Control: Ranking (2) Mansergh and Belcher (1992), C. Belcher pers. comm.
6. Grazing: Ranking (-)
7. Disease: Ranking (0) Mansergh (1984)
8. Illegal harvesting: Ranking (0)
9. Non-forestry Clearing: Ranking (1) Mansergh (1984)
10. Mining/Quarrying: Ranking (-)
11. Roading: Ranking (1) C. Belcher pers. comm.
12 Recreation: Ranking (0)
13. Vandalism/Disturbance by Humans: Ranking (0)
14. Other: Ranking (0)

Current Management:

The Spot-tailed Quoll is listed under the Victorian *Flora and Fauna Guarantee Act* 1988 (CNR 1995a). An Action Statement has been prepared for this species (Mansergh and Belcher 1992) and the progress of management actions was reviewed in 1995. Intended management actions relevant to the Central Highlands include the implementation of predator control programs that minimise non-target mortality of Spot-tailed Quolls, the recording of all sightings on the Atlas of Victorian Wildlife, the protection of sites important for scientific research such as latrine or den sites by a minimum 200m interim buffer zone pending formal management prescriptions, and the input of relevant research findings to the Central Highlands Forest Management Plan. This document is currently being developed.

Comments: Spot-tailed Quolls are partly arboreal carnivorous marsupials which occupy large home ranges. Most prey consists of mammals of 0.5-5.0 kg. The species utilises caves, hollow logs and hollow trees for shelter and breeding (Mansergh 1984). Within the Central Highlands there are less than ten incidental records of the Spot-tailed Quoll, (Atlas of Victorian Wildlife) and its status is unknown. There have been no systematic surveys for the species and the limited information available on its ecology is from studies in other areas.

The most significant threats to the Spot-tailed Quoll within the Central Highlands include wildfire and logging, which can result in the loss of den sites and reduction in the availability of prey. Competition for prey items with cats and foxes may be a significant threat to the species as there appears to be some dietary overlap (Mansergh 1984, Lumsden *et al.* 1991, Mansergh and Belcher 1992). The

Spot-tailed Quoll is also susceptible to non-target poisoning from pest animal control methods which may result in the death of individuals or local populations (Mansergh and Belcher 1992, C. Belcher pers. comm.). Secondary poisoning through ingestion of baited rabbits may also threaten the Spot-tailed Quoll on a local scale (Mansergh and Belcher 1992). Disturbances which result in habitat fragmentation (logging, clearing, roading) represent a threat due to the species' large home range requirements (C. Belcher pers. comm.).

Brush-tailed Phascogale

Phascogale tapoatafa

RARITY

a) Geographic Range

- Classification of range size: Medium
- Range size within region: (ha): 300 000
- Proportion of region occupied (%): 25
- Source: Atlas of Victorian Wildlife

b) Abundance

- Classification of abundance: Low
- Population Estimate: 400 breeding females within Valley Forest and Grassy Dry Forest, the population within poorer habitat unknown
- Density: 0.025 females/ha maximum density in prime habitat
- Home Range (ha): 20-86
- Source: Traill and Coates (1993), Soderquist (1995), T. Soderquist pers. comm.

c) Habitat Specificity

- Classification of habitat specificity: Narrow
- Vegetation types used in the region: Valley Forest, Grassy Dry Forest, Shrubby Foothill Forest, Herb-rich Foothill Forest, Wet Forest
- Source: LCC (1973), Cuttle (1982), Brown *et al.* (1989), Menkhorst (1995), T. Soderquist pers. comm.

DYNAMICS

Population Trend in Last Decade

- Increasing, stable or declined: Declined
- Source: T. Soderquist pers. comm.

Population trend since discovery by Europeans

- Increasing, stable or declined: Declined
- Source: Mansergh in Menkhorst (1995)

SPATIAL DYNAMICS

a) Population variability

- Classification of population variability: High
- Source: Cuttle (1982)

b) Dispersal

- Classification of powers of dispersal: High
- Average distances dispersed: 2.8 km - from males released into the home ranges of established females
- Maximum distance dispersed: 6.5 km - many juvenile males moved out of radiotracking range, hence this may be an underestimate.
- Source: Soderquist and Lill (1995), Rhind (1996)

LIFE HISTORY PARAMETERS

a) Reproductive output

- Classification of reproductive output: High
- Age of sexual maturity (mths): 10-11
- Mean clutch/litter/brood size: 7-8
- Mean no of clutches/litters/broods per year: 1
- Time of year young born/hatch: July, August
- Source: Cuttle (1982), Soderquist (1993)

b) Longevity

- Classification of lifespan: Short-lived
- Average lifespan (yrs): 1
- Maximum lifespan (yrs): 2 females, 1 males
- Source: Cuttle (1982), Soderquist (1993)

c) Morphology

Adult body size

- Weight (g): 106-212 (156) females, 175-311(231) males
- Length (cm): 148-233 (181) females, 160-261 (199) males
- Source: Cuttle (1982)

d) Social organisation

- Colonial or non-colonial: Non-colonial, occasionally nest together
- Territoriality: Females territorial
- Source: Soderquist (1995), Soderquist and Ealy (1994)

e) Other

- Nomadic, migratory, sedentary: Sedentary
- Mode of feeding: Insectivore (invertebrates), Nectarivore
- Source: Traill and Coates (1993)

THREATS

1. Fire (planned): Ranking (1) T. Soderquist pers. comm.
2. Fire (unplanned): Ranking (2) Mansergh in Menkhorst (1995)
3. Logging: Ranking (1) Mansergh in Menkhorst (1995), Rhind (1996)
4. Introduced Species: Ranking (3) Soderquist (1993)
5. Pest Control: Ranking (1) T. Soderquist pers. comm.
6. Grazing: Ranking (1) Mansergh in Menkhorst (1995), T. Soderquist pers. comm.
7. Disease: Ranking (1) T. Soderquist pers. comm.
8. Illegal harvesting: Ranking (0)
9. Non-forestry Clearing: Ranking (3) Fleming *et al.* (1979), Mansergh in Menkhorst (1995), T. Soderquist pers. comm.
10. Mining/Quarrying: Ranking (1) Lumsden *et al.* (1991), Mansergh in Menkhorst (1995), T. Soderquist pers. comm.
11. Roading: Ranking (1) T. Soderquist pers. comm.
12 Recreation: Ranking (0)
13. Vandalism/Disturbance by Humans Ranking (0)
14. Other: Ranking (-)

Current Management:

The Brush-tailed Phascogale has been listed under the Victorian *Flora and Fauna Guarantee Act* 1988 and an Action Statement is being prepared. There are no current management prescriptions for the species in the Central Highlands.

Comments: The Brush-tailed Phascogale is a mainly arboreal insectivore which requires large areas of habitat to sustain populations. Females occupy large exclusive intrasexual home ranges (~ 40ha), hence the species occurs at very low population densities. The species is hollow- dependent, utilising tree hollows for breeding and shelter (Mansergh in Meankhorst 1995).

Within the Central Highlands Brush-tailed Phascogales have been recorded from Valley Forest and Grassy Dry Forest, Ecological Vegetation Communities not suitable for timber production (CNR and AHC 1994). The species has also been recorded from Wet Forest (Brown *et al.* 1989), although it is unknown how important this habitat is for Brush-tailed Phascogales and it is likely this record is from an area where dry forest is nearby (T. Soderquist pers. comm.). Records of the species from the south-east of the Central Highlands near Noojee and Moe are all pre 1970; recent surveys in this area have failed to locate the species and it is likely to be locally extinct (T. Soderquist pers. comm.).

Disturbances that result in the loss of tree hollows and habitat fragmentation are major threats to the Brush-tailed Phascogale (T. Soderquist pers. comm.). The species is known to occur in the mixed rural, urban and forested land north-east of Melbourne and clearing for urban development is a major threat. Predation by introduced

species is also a major threat (Soderquist 1993). Wildfire results in loss of critical habitat components and individuals and is a moderate threat (Mansergh in Menkhorst 1995). Logging also results in loss of critical habitat components but is only a minor threat as logging of the species preferred habitat in the Central Highlands is minimal (CNR and AHC 1994, G. Beech pers. comm.).

Dingo

Canis familiaris dingo

RARITY

a) Geographic Range

- Classification of range size: Unknown, given the difficulty in distinguishing dogs and dingoes
- Range size within region: (ha): Unknown
- Proportion of region occupied (%): Unknown
- Source: Atlas of Victorian Wildlife

b) Abundance

- Classification of abundance: Unknown probably low
- Population Estimate: Unknown
- Density: Unknown
- Home Range (ha): 2700, dependent on habitat and prey numbers
- Source: Harden (1985), E. Jones pers. comm.

c) Habitat Specificity

- Classification of habitat specificity: Wide
- Vegetation types used in the region: Unknown
- Source: Menkhorst (1995)

DYNAMICS

Population Trend in Last Decade

- Increasing, stable or declined: Unknown
- Source: Menkhorst (1995)

Population trend since discovery by Europeans

- Increasing, stable or declined: Increased
- Source: Corbett (1995)

SPATIAL DYNAMICS

a) Population variability

- Classification of population variability: Probably low
- Source: Harden (1985)

b) Dispersal

- Classification of powers of dispersal: High
- Average distances dispersed: Unknown
- Maximum distance dispersed: Unknown
- Source: Harden (1985)

LIFE HISTORY PARAMETERS

a) Reproductive output

- Classification of reproductive output: Low, given packs have only one breeding pair, hence a high proportion of non-breeding adults
- Age of sexual maturity (yrs): 1-4 females, 2-3 males
- Mean clutch/litter/brood size: 5.5
- Mean no of clutches/litters/broods per year: 1
- Time of year young born/hatch: March to September, peak between June and August
- Source: Jones and Stevens (1988)

b) Longevity

- Classification of lifespan: Long-lived
- Average lifespan (yrs): Unknown
- Maximum lifespan (yrs): 12 - may have been hybrids
- Source: Corbett (1995)

c) Morphology

Adult body size

- Weight (kg): 15.5 females, 18.6 males
- Length (mm): 1219 females, 1245 males
- Source: Jones (1990)

d) Social organisation

- Colonial or non-colonial: Colonial
- Territoriality: Territorial
- Source: Corbett (1995)

e) Other

- Nomadic, migratory, sedentary: Sedentary, animals living in packs
- Mode of feeding: Carnivore, medium to large mammals are the major prey item
- Source: Brown and Triggs (1990), Corbett (1995), Triggs *et al.* (1984)

THREATS

1. Fire (planned): Ranking (1) Catling (1991), Catling and Burt (1995)
2. Fire (unplanned): Ranking (1)
3. Logging: Ranking (1) Catling (1991), Catling and Burt (1995)
4. Introduced Species: Ranking (2) Brown and Triggs (1990)
5. Pest Control: Ranking (2) Corbett (1995), Menkhorst (1995)
6. Grazing: Ranking (1) Catling and Burt (1995)
7. Disease: Ranking (-)
8. Illegal Harvesting: Ranking (0)
9. Non-forestry Clearing: Ranking (0)
10. Mining/Quarrying: Ranking (0)
11. Roading: Ranking (0)
12 Recreation: Ranking (0)
13. Vandalism/Disturbance by Humans: Ranking (0)
14. Other, Genetic dilution, inbreeding with feral and domestic dogs : Ranking (1) Newsome and Corbett (1982), Newsome and Corbett (1985), Jones and Stevens (1988), Jones (1990), Corbett (1995)

Current Management:

Dingoes are classified as "insufficently known" in Victoria (CNR 1995a). This classification is partly due to the difficulties in distinguishing between Dingoes, feral dogs and their hybrids (Menkhorst 1995). There are no current management prescriptions for this species in the Central Highlands.

Comments: Dingoes are the largest terrestrial predator in Australia. They are a social animal living in packs of 3-12 animals consisting of one dominant breeding pair and other non-breeding animals. The size of the pack appears to be related to the availability of resources (Corbett 1995). Dingoes feed on medium to large mammals such as brushtail and ringtail possums, swamp wallabies and common wombats (Triggs *et al*. 1984, Brown and Triggs 1990).

Records of Dingoes on the Atlas of Victorian Wildlife are scarce, with only two records from within the Central Highlands. When Dingo and wild dog records are combined the number of records increases dramatically. It is not known what proportion of these records are of pure Dingoes and the status of the species within the Central Highlands is unknown.

Trapping, baiting and shooting for wild dogs occurs throughout the Central Highlands, and is thought to be a moderate threat to Dingoes (Corbett 1995, Menkhorst 1995). The effect on the Dingo population is unknown but can be intense, reducing local population numbers where control efforts are high (Corbett 1995). However, it may result in the fracture of the social group causing an increase in breeding females (Corbett 1995). Competition between foxes and Dingoes is also considered a moderate threat to the species due to the dietary ovelap in prey items (Brown and Triggs 1990).

Inbreeding with feral and domestic dogs, resulting in hybrids, is considered a minor threat to the genetic integrity of the Dingo. Jones (1990), after a detailed morphological study, concluded that little hybridisation has occured.

In a study of ground dwelling mammals in south eastern NSW, Catling and Burt (1995) found the Dingo to be positively correlated with high habitat complexity. Therefore, activities which simplify the vegetation structure such as control burning, grazing and logging, may be detrimental to populations of Dingo. Widespread severe wildfire may result in death of individuals and a reduction in available prey and cause population declines.

Swamp Antechinus
Antechinus minimus

RARITY
a) Geographic Range
- Classification of range size: Small
- Range size within region: (ha): < 270
- Proportion of region occupied (%): < 1
- Source: Atlas of Victorian Wildlife

b) Abundance
- Classification of abundance: Low
- Population Estimate: Unknown
- Density: Unknown
- Home Range (ha): Unknown, 1 individual tracked over 1 day moved within 0.53 ha.
- Source: Aberton *et al.* (1994)

c) Habitat Specificity
- Classification of habitat specificity: Narrow
- Vegetation types used in the region: Wet Heathland
- Source: LCC (1991)

DYNAMICS
Population Trend in Last Decade
- Increasing, stable or declined: Unknown
- Source: J. Seebeck pers. comm.

Population trend since discovery by Europeans
- Increasing, stable or declined: Probably declined (based on known habitat)
- Source: Lumsden *et al.* (1991)

SPATIAL DYNAMICS
a) Population variability
- Classification of population variability: High
- Source: Wilson and Bourne (1984)

b) Dispersal
- Classification of powers of dispersal: Low
- Average distances dispersed: Unknown
- Maximum distance dispersed: Unknown
- Source: B. Wilson pers. comm.

LIFE HISTORY PARAMETERS
a) Reproductive output
- Classification of reproductive output: High
- Age of sexual maturity (yrs): 1
- Mean clutch/litter/brood size: 6
- Mean no of clutches/litters/broods per year: 1
- Time of year young born/hatch: July - September
- Source: Wilson and Bourne (1984), Wilson (1986), Menkhorst (1995)

b) Longevity
- Classification of lifespan: Short-lived
- Average lifespan (yrs): 1, males and females
- Maximum lifespan (yrs): 1 males, 3 females
- Source: Wilson and Bourne (1984), Wilson (1986), Aberton *et al.* (1994)

c) Morphology
Adult body size
- Weight (g): 24-65 (42) females, 30-103 (65) males
- Length (mm): 98-117 (110) females, 103-140 (120) males
- Source: Wakefield and Warneke (1963)

d) Social organisation
- Colonial or non-colonial: Unknown
- Territoriality: Territorial
- Source: B. Wilson pers. comm.

e) Other
- Nomadic, migratory, sedentary: Sedentary
- Mode of feeding: Insectivore
- Source: Wainer and Wilson in Strahan (1995)

THREATS
1. Fire (planned): Ranking (1) D. Drangsholt pers. comm.
2. Fire (unplanned): Ranking (3) Aberton *et al.* (1994), Menkhorst (1995), B. Wilson pers. comm.
3. Logging: Ranking (0) D. Drangsholt pers. comm.
4. Introduced Species: Ranking (2) Menkhorst (1995), D. Drangsholt pers. comm., B. Wilson pers. comm.
5. Pest Control: Ranking (0)
6. Grazing: Ranking (1) D. Drangsholt pers. comm.
7. Disease: Ranking (-)
8. Illegal Harvesting: Ranking (0)
9. Non-forestry Clearing: Ranking (0) Andrew *et al.* (1984), D. Drangsholt pers. comm.
10. Mining/Quarrying: Ranking (0)
11. Roading: Ranking (0)
12 Recreation: Ranking (2) D. Drangsholt pers. comm.
13. Vandalism/Disturbance by Humans: Ranking (0)
14. Other: Ranking (0)

Current Management:
The Swamp Antechinus is classified as "rare" in Victoria (CNR 1995a). There are no current management prescriptions for the species in the Central Highlands.

Comments: The Swamp Antechinus is a terrestrial species that uses its long foreclaws to forage in the leaf litter and soil for insects and other invertebrates (Wainer and Wilson in Strahan 1995). Most records of the species are from coastal areas. There are three records of Swamp Antechinus from the Central Highlands, all east of Gembrook within the Bunyip State Park (Atlas of Victorian Wildlife). These animals were located in wet heathland in 1981 and 1983, but have not been recorded since. The current status of this population is unknown (D. Drangsholt and B. Wilson pers. comm.).

Due to the small, isolated nature of the population, serious threats to the the Central Highlands population of the Swamp Antechinus include wildfire and predation (Menkhorst 1995). One population is known to have declined, possibly to extinction, as a result of wildfire (B. Wilson pers. comm.) and wildfire is considered a major threat. Cats and foxes are known to be present in Bunyip State Park (D. Drangsholt pers. comm.) and predation is considered a moderate threat to the species. Recreational 4-wheel driving and trail bikes are popular in the park and may cause habitat degradation; this is thought to be a moderate threat to the Swamp Antechinus (D. Drangsholt pers. comm.).

Broad-toothed Rat
Mastacomys fuscus

RARITY
a) Geographic Range
- Classification of range size: Medium
- Range size within region: (ha): 240 000-330 000, likely to be over estimate as this species is found along drainage lines
- Proportion of region occupied (%): 20-28
- Source: Atlas of Victorian Wildlife, CNR and AHC (1994)

b) Abundance
- Classification of abundance: Low
- Population Estimate: Unknown
- Density: Unknown, dependent on habitat

- Home Range (km^2): 4.9 females, 10.7 males
- Source: Bubela *et al.* (1991), R. Wallis pers. comm.

c) Habitat Specificity
- Classification of habitat specificity: Narrow
- Vegetation types used in the region: Wet Forest, Damp Forest, Montane Riparian Thicket, Riparian Forest, Sub-alpine Woodland, also has been located in *Pinus radiata* forest with suitable ground cover
- Source: Seebeck (1971), Wallis *et al.* (1982), Lumsden *et al*. (1991)

DYNAMICS

Population Trend in Last Decade
- Increasing, stable or declined: Unknown
- Source: R. Wallis pers. comm.

Population trend since discovery by Europeans
- Increasing, stable or declined: Possibly declined (based on known habitat)
- Source: Lumsden *et al.* (1991)

SPATIAL DYNAMICS

a) Population variability
- Classification of population variability: Probably low
- Source: Carron (1985), Happold (1989)

b) Dispersal
- Classification of powers of dispersal: Low
- Average distances dispersed: Unknown
- Maximum distance dispersed: Unknown
- Source: R. Wallis pers. comm.

LIFE HISTORY PARAMETERS

a) Reproductive output
- Classification of reproductive output: Low
- Age of sexual maturity (mths): 10-12
- Mean clutch/litter/brood size: 1-3
- Mean no of clutches/litters/broods per year: 2
- Time of year young born/hatch: October-March
- Source: Calaby and Wimbush (1964), Wallis *et al.* (1982), Happold (1989), Bubela *et al.* (1991)

b) Longevity
- Classification of lifespan: Unknown, possibly long-lived
- Average lifespan (yrs): Unknown
- Maximum lifespan (yrs): Unknown
- Source: Carron (1985), Happold (1989)

c) Morphology

Adult body size
- Weight (g): 110-130(118) females, 122-144(131) males
- Length (mm): 154 females, 172 males
- Source: Wallis *et al.* (1982)

d) Social organisation
- Colonial or non-colonial: Colonial during winter in subalpine region
- Territoriality: Females territorial
- Source: Wallis *et al.* (1982), Happold (1989)

e) Other
- Nomadic, migratory, sedentary: Sedentary
- Mode of feeding: Herbivore (monocotyledons)
- Source: Calamby and Wimbush (1964)

THREATS

1. Fire (planned): Ranking (1) R. Wallis pers. comm.
2. Fire (unplanned): Ranking (1) R. Wallis pers. comm.
3. Logging: Ranking (1) R. Wallis pers. comm.
4. Introduced Species: Ranking (3) Seebeck (1971), Brunner and Bertuch (1976), Brunner *et al.* (1977), Green and Osborne (1981), Wallis and Brunner (1987) May and Norton (1996)
5. Pest Control: Ranking (2) H. Brunner pers. comm.
6. Grazing: Ranking (2) Menkhorst (1995)
7. Disease: Ranking (0)
8. Illegal Harvesting: Ranking (0)
9. Non-forestry Clearing: Ranking (1) Seebeck (1971)
10. Mining/Quarrying: Ranking (0)
11. Roading: Ranking (0)
12 Recreation: Ranking (0)
13. Vandalism/Disturbance by Humans: Ranking (0)
14. Other: Ranking (0)

Current Management:

The Broad-toothed Rat is classified as "rare" in Victoria (CNR 1995a). There are no current management prescriptions for this species in the Central Highlands.

Comments: The Broad-toothed Rat is a specialist herbivore which feeds on grasses and sedges. Due to its specialised habitat requirements, populations are localised and patchily distributed (Menkhorst 1995). While this species does occur in forests, this habitat appears suboptimal. Preferred habitat includes treeless areas with few shrubs and a dense cover of sedges and grasses. Sites are usually near permanent flowing water and are often on slight slopes (Menkhorst 1995, H. Brunner pers. comm.).

A population of the Broad-toothed Rat, occuring at comparatively high densities, has recently been located at Labertouche in a slashed area beneath high tension powerlines. The use of chemicals to control wattles and eucalypts at this site is considered a moderate threat to this population (H. Brunner pers. comm.).

Predation by foxes and cats are a major threat to the Broad-toothed Rat in the Central Highlands, particularly as populations are highly localised and disjunct (Menkhorst 1995). Grazing by cattle and trampling of sedgeland, particularly in alpine areas, results in loss of food and cover and is also a major threat to the species (Menkhorst 1995).

Smoky Mouse

Pseudomys fumeus

RARITY

a) Geographic Range
- Classification of range size: Medium
- Range size within region: (ha): 110 000 - 220 000
- Proportion of region occupied (%): 9-18
- Source: Atlas of Victorian Wildlife, CNR and AHC (1994)

b) Abundance
- Classification of abundance: Low
- Population Estimate: Unknown
- Density: Unknown
- Home Range (ha): Unknown
- Source: Menkhorst and Seebeck (1981), J. Seebeck pers. comm.

c) Habitat Specificity
- Classification of habitat specificity: Narrow
- Vegetation types used in the region: Subalpine Woodland, Montane Dry Woodland, Foothill Forest Complex, Heathy Dry Forest
- Source: Fleming *et al*. (1979), Menkhorst and Seebeck (1981), Lumsden *et al.* (1991)

DYNAMICS

Population Trend in Last Decade
- Increasing, stable or declined: Unknown
- Source: J. Seebeck pers. comm.

Population trend since discovery by Europeans
- Increasing, stable or declined: Declined
- Source: Menkhorst and Seebeck (1981)

SPATIAL DYNAMICS

a) Population variability
- Classification of population variability: High
- Source: Cockburn (1981b)

b) Dispersal
- Classification of powers of dispersal: Probably low
- Average distances dispersed: Unknown
- Maximum distance dispersed: Unknown

- Source: Cockburn (1981b)

LIFE HISTORY PARAMETERS
a) Reproductive output
- Classification of reproductive output: High
- Age of sexual maturity (yrs): 1
- Mean clutch/litter/brood size: 3
- Mean no of clutches/litters/broods per year: 2
- Time of year young born/hatch: October-January; based on enlarged nipples
- Source: Cockburn (1981b)

b) Longevity
- Classification of lifespan: Short-lived
- Average lifespan (yrs): 1
- Maximum lifespan (yrs): 2
- Source: Cockburn (1981b)

c) Morphology
Adult body size
- Weight (g): 45-90 (70)
- Length (mm): 85-100 (90)
- Source: Cockburn in Strahan (1995)

d) Social organisation
- Colonial or non-colonial: Unknown
- Territoriality: Territorial
- Source: Cockburn (1981b)

e) Other
- Nomadic, migratory, sedentary: Sedentary
- Mode of feeding: Omnivore; fungi, seed, insects, flowers
- Source: Cockburn (1981a), Cockburn (1981b)

THREATS
1. Fire (planned): Ranking (2) Fleming *et al.* (1979), Menkhorst and Seebeck (1981), Menkhorst (1995), J. Seebeck pers. comm.
2. Fire (unplanned): Ranking (2) Fleming *et al.* (1979), Menkhorst and Seebeck (1981), Menkhorst (1995), J. Seebeck pers. comm.
3. Logging: Ranking (1) Fleming *et al.* (1979), J. Seebeck pers. comm.
4. Introduced Species: Ranking (1) Cockburn (1981b), J. Seebeck pers. comm.
5. Pest Control: Ranking (0) J. Seebeck pers. comm.
6. Grazing: Ranking (0) J. Seebeck pers. comm.
7. Disease: Ranking (-) J. Seebeck pers. comm.
8. Illegal Harvesting: Ranking (0) J. Seebeck pers. comm.
9. Non-forestry Clearing: Ranking (1) Fleming *et al.* (1979), Menkhorst (1995), J. Seebeck pers. comm.
10. Mining/Quarrying: Ranking (-) J. Seebeck pers. comm.
11. Roading: Ranking (1) J. Seebeck pers. comm.
12 Recreation: Ranking (1) J. Seebeck pers. comm.
13. Vandalism/Disturbance by Humans:Ranking (0) J. Seebeck pers. comm.
14. Other: Ranking (0)

Current Management:
The Smoky Mouse is classified as "vulnerable" in Victoria (CNR 1995a) and has been recommended for listing under the Victorian *Flora and Fauna Guarantee Act* 1988. There are no current management prescriptions for this species in the Central Highlands. The LCC (1993) recommend protection of the Smoky Mouse within the Central Forest Management Area.

Comments: The Smoky Mouse is an omnivorous heath specialist. Studies in the Grampians found fungus and winter flowering plants (eg. *Correa* spp. *Leucopogon* spp. and plants from the Fabaceae family) were major food items. Invertebrates are also eaten (Cockburn 1981a). Records of the Smoky Mouse within the Central Highlands are in the north-east, Upper Yarra, Upper Thompson and Big River areas. The current status of these populations is unknown.

The Smoky Mouse appears reliant on understorey vegetation components strongly influenced by fire frequency and intensity (Menkhorst 1995). As a result, inappropriate fire regimes, eg. too frequent burning or absence of fire, may lead to the development of unsuitable successional stages and is a moderate threat to the species in the Central Highlands. There is a lack of information on the species' ecological requirements, particularly in relation to fire (Lee 1995). Planned fire may be beneficial for this species.

The preferred habitat of the Smoky Mouse often occurs along ridges, and the construction of roads along ridge tracks may represent a threat to the species. Roading removes and disturbs habitat and also makes areas accessible to recreation vehicles. This may damage vegetation and cause soil compaction (J. Seebeck pers. comm.).

Common Dunnart
Sminthopsis murina

RARITY
a) Geographic Range
- Classification of range size: Small
- Range size within region: (ha): 45 000- 120 000
- Proportion of region occupied (%): 4-10
- Source: Atlas of Victorian Wildlife, CNR and AHC (1994)

b) Abundance
- Classification of abundance: Low
- Population Estimate: Unknown
- Density: Unknown
- Home Range (ha): Unknown
- Source: Menkhorst (1995), J. Seebeck pers. comm.

c) Habitat Specificity
- Classification of habitat specificity: Narrow
- Vegetation types used in the region: Valley Forest, Grassy Dry Forest
- Source: Morton *et al.* (1980), Lumsden *et al.* (1991)

DYNAMICS
Population Trend in Last Decade
- Increasing, stable or declined: Unknown
- Source: J. Seebeck pers. comm.

Population trend since discovery by Europeans
- Increasing, stable or declined: Probably declined (based on known habitat)
- Source: Lumsden *et al.* (1991)

SPATIAL DYNAMICS
a) Population variability
- Classification of population variability: High
- Source: Fox and Whitford (1982)

b) Dispersal
- Classification of powers of dispersal: Low
- Average distances dispersed: Unknown
- Maximum distance dispersed: Unknown
- Source: J. Seebeck pers. comm.

LIFE HISTORY PARAMETERS
a) Reproductive output
- Classification of reproductive output: High
- Age of sexual maturity (mths): 8-11
- Mean clutch/litter/brood size: 8 (4-10)
- Mean no of clutches/litters/broods per year: 2
- Time of year young born/hatch: September, December
- Source: Fox and Whitford (1982), Lee *et al.* (1982), Menkhorst (1995)

b) Longevity
- Classification of lifespan: Short-lived
- Average lifespan (yrs): 1
- Maximum lifespan (yrs): 2 females
- Source: Fox (1982)

c) Morphology
Adult body size
- Weight (g): 10-22 (14) females, 16-28 (20) males
- Length (mm): 64-92 (76) females, 76-101 (81) males
- Source: Fox in Stahan (1995)

d) Social organisation
- Colonial or non-colonial: Unknown
- Territoriality: Unknown; males probably during breeding season
- Source: Fox and Whitford (1982)

e) Other
- Nomadic, migratory, sedentary: Sedentary
- Mode of feeding: Insectivore, possibly an opportunistic predator, closely related White-footed Dunnart which has been recorded eating frogs
- Source: Fox and Archer (1984), Hutchings (1996)

THREATS
1. **Fire (planned): Ranking (1)** J. Seebeck pers. comm.
2. Fire (unplanned): Ranking (2) Coventry and Dixon (1984), Fox and McKay (1981), Fox (1982), J. Seebeck pers. comm.
3. Logging: Ranking (0)
4. Introduced Species: Ranking (1) Brunner *et al.* (1976), J. Seebeck pers. comm.
5. Pest Control: Ranking (1) J. Seebeck pers. comm.
6. Grazing: Ranking (2) J. Seebeck pers. comm.
7. Disease: Ranking (-) J. Seebeck pers. comm.
8. Illegal Harvesting: Ranking (0) J. Seebeck pers. comm.
9. Non-forestry Clearing: Ranking (2) J. Seebeck pers. comm.
10. Mining/Quarrying: Ranking (0) J. Seebeck pers. comm.
11. Roading: Ranking (1) J. Seebeck pers. comm.
12 Recreation: Ranking (1) J. Seebeck pers. comm.
13. Vandalism/Disturbance by Humans: Ranking (0) J. Seebeck pers. comm.
14. Other: Ranking (0)

Current Management:

The Common Dunnart is classified as "rare" in Victoria (CNR 1995a). There are no current managment prescriptions for the species in the Central Highlands.

Comments: The distribution of the Common Dunnart is related to habitat structure rather than floristics; midstorey complexity and ground layer cover appear determining factors (Fox 1982). In Victoria, the Common Dunnart inhabits dry forest and woodland with an open midstorey, sparse ground cover and often dense leaf and bark litter (Menkhorst 1995). Within the Central Highlands records of the species are concentrated in the south-west around Christmas Hills, Kangaroo Ground and Strathewen (Atlas of Victorian Wildlife). The current status of the Common Dunnart in the Central Highlands is unknown.

Clearing for urban development, and the associated habitat modification, is a moderate threat to the Common Dunnart in the Central Highlands. Grazing on private property which contains suitable habitat also causes considerable and possibly irreversable habitat modification (J. Seebeck pers. comm.) and is a moderate threat to the species. Severe widespread wildfire can devastate small populations and is also considered a moderate threat (J. Seebeck pers. comm.).

Squirrel Glider

Petaurus norfolcensis

RARITY
a) Geographic Range
- Classification of range size: Small
- Range size within region: (km^2): 20
- Proportion of region occupied (%): < 1
- Source: Atlas of Victorian Wildlife

b) Abundance
- Classification of abundance: Low
- Population Estimate: Unknown, very small
- Density: 0.4 /ha
- Home Range (ha): 13
- Source: Traill and Coates (1993)

c) Habitat Specificity
- Classification of habitat specificity: Narrow
- Vegetation types used in the region: Roadside remnants, Floodplain Riparian Woodland
- Source: Menkhorst *et al.* (1988)

DYNAMICS
Population Trend in Last Decade
- Increasing, stable or declined: Probably declined
- Source: J. Alexander pers. comm.

Population trend since discovery by Europeans
- Increasing, stable or declined Declined:
- Source: Menkhorst *et al.* (1988)

SPATIAL DYNAMICS
a) Population variability
- Classification of population variability: Unknown
- Source: J. Alexander pers. comm.

b) Dispersal
- Classification of powers of dispersal: High, provided continuous tree cover is present
- Average distances dispersed: Unknown
- Maximum distance dispersed: Unknown
- Source: J. Alexander pers. comm.

LIFE HISTORY PARAMETERS
a) Reproductive output
- Classification of reproductive output: Low
- Age of sexual maturity (yrs): Unknown
- Mean clutch/litter/brood size: 1-2
- Mean no of clutches/litters/broods per year:
- Time of year young born/hatch: Throughout year
- Source: Smith (1979), Quin (1995)

b) Longevity
- Classification of lifespan: Long-lived
- Average lifespan (yrs): Unknown
- Maximum lifespan (yrs): at least 5-6
- Source: Quin (1995)

c) Morphology
Adult body size
- Weight (g): 190-300 (230)
- Length (mm): 180-230 (210)
- Source: Suckling in Strahan (1995)

d) Social organisation
- Colonial or non-colonial: Colonial
- Territoriality: No
- Source: Quin (1995)

e) Other
- Nomadic, migratory, sedentary: Sedentary
- Mode of feeding: Exudivore, Insectivore (arboreal invertebrates)
- Source: Menkhorst and Collier (1987)

THREATS
1. Fire (planned): Ranking (2) J. Alexander pers. comm.
2. Fire (unplanned): Ranking (1) J. Alexander pers. comm.
3. Logging: Ranking (0) Meredith (1984), J. Alexander pers. comm.
4. Introduced Species: Ranking (2) Alexander 1981, J. Alexander pers. comm.
5. Pest Control: Ranking (0) J. Alexander pers. comm.
6. Grazing: Ranking (2) Alexander (1981), Alexander (1989), J. Alexander pers. comm.
7. Disease: Ranking (-) J. Alexander pers. comm.

8. Illegal Harvesting: Ranking (0) J. Alexander pers. comm.
9. Non-forestry Clearing: Ranking (2) Meredith (1984), Menkhorst *et al.* (1988), Alexander (1989), J. Alexander pers. comm.
10. Mining/Quarrying: Ranking (0) J. Alexander pers. comm.
11. Roading: Ranking (2) Alexander (1981), Alexander (1989), J. Alexander pers. comm.
12 Recreation: Ranking (0)
13. Vandalism/Disturbance by Humans: Ranking (0)
14. Other: Ranking (-)

Current Management:

The Squirrel Glider is listed under the Victorian *Flora and Fauna Guarantee Act* 1988. An Action Statement is currently being prepared for this species. There are no current management prescriptions for the species in the Central Highlands.

Comments: The Squirrel Glider feeds on plant exudates and arboreal invertebrates, and requires tree hollows for breeding and shelter (Menkhorst 1995). Within Victoria it is found predominantly in the north-east and west. The Central Highlands is the southerly extension of its known range and there are very few records of the species from the area (Atlas of Victorian Wildlife). Squirrel Gliders have been recorded close to the Goulburn River just south of Seymour. It is not known if this area has a resident population or is visited intermittently. A population of Squirrel Gliders exists just east of the study area along Wales Road (Alexander 1989).

Due to extensive clearing in the past, much of the habitat of the Squirrel Glider is confined to narrow strips along roads or streams (Menkhorst 1995). Road maintenance and widening, fire prevention activities and grazing can result in further loss and degradation of isolated remnants of suitable habitat and are threats to the species (Menkhorst *et al.* 1988, Alexander 1989, J. Alexander pers. comm.). Squirrel Gliders require continuous tree cover for movement; gaps can prevent access to adjoining habitat and Gliders attempting to cross open space on the ground are highly vulnerable to predation (Alexander 1981, J. Alexander pers. comm.).

Leadbeater's Possum

Gymnobelideus leadbeateri

RARITY

a) Geographic Range
- Classification of range size: Medium
- Range size within region: (ha): 170 000 - 235 000
- Proportion of region occupied (%): 14 - 20
- Source: Macfarlane and Seebeck (1991)

b) Abundance
- Classification of abundance: Medium - this is dependent on the quality of the habitat
- Population Estimate: 7500 ± 2300, estimated for the population in 1980
- Density: 1.6-2.9 possums/ha
- Home Range (ha): 1.3-1.9
- Source: Smith (1984a), Smith *et al.* in Smith and Lindenmayer (1992)

c) Habitat Specificity
- Classification of habitat specificity: Narrow - mainly confined to wet and damp forests
- Vegetation types used in the region: Montane Damp Forest, Montane Wet Forest, Wet Forest, Riparian Forest, Subalpine Woodland
- Source: Smales (1994), Jelinek *et al.* (1995), Macfarlane *et al.* (1995)

DYNAMICS

Population Trend in Last Decade
- Increasing, stable or declined: Probably declined, due a decline in nest tree availability and the progression of current favorable habitat to a structurally less-suitable successional stage
- Source: Smith *et al.* in Macfarlane *et al.* (1995), Smith and Lindenmayer (1988), Lindenmayer (1990)

Population trend since discovery by Europeans
- Increasing, stable or declined: Declined
- Source: Lumsden *et al.* (1991)

SPATIAL DYNAMICS

a) Population variability
- Classification of population variability: Low
- Source: Smith (1984a)

b) Dispersal
- Classification of powers of dispersal: High, juvenile females disperse further
- Average distances dispersed: Unknown, juvenile females typically beyond natal home range
- Maximum distance dispersed: Unknown
- Source: Smith (1984a)

LIFE HISTORY PARAMETERS

a) Reproductive output
- Classification of reproductive output: Low
- Age of sexual maturity (yrs): 1.5
- Mean clutch/litter/brood size: 1.4
- Mean no of clutches/litters/broods per year: 2
- Time of year young born/hatch: April-June, October-December (majority of births)
- Source: Smith (1984a)

b) Longevity
- Classification of lifespan: Short-lived
- Average lifespan (yrs): Unknown, high mortality in juvenile females
- Maximum lifespan (yrs): 4 females, >7 males
- Source: Smith (1984a)

c) Morphology

Adult body size
- Weight (g): 100-135(122) Spring, 110-166(133) Autumn
- Length (mm): 150-170(160)
- Source: Smith in Strahan (1995)

d) Social organisation
- Colonial or non-colonial: Colonial
- Territoriality: Females territorial, transient females unsuccessful breeding
- Source: Smith (1984a)

e) Other
- Nomadic, migratory, sedentary: Sedentary
- Mode of feeding: Insectivore (arthropods), Exudivore
- Source: Smith (1984b)

THREATS

1. **Fire (planned): Ranking (2)** Macfarlane and Seebeck (1991), Lindenmayer (1990), Milledge *et al.* (1991)
2. Fire (unplanned): Ranking (3) Lindenmayer and Possingham (1994), Macfarlane *et al.* (1995)
3. Logging: Ranking (3) Andrew *et al.* (1984), Fleming *et al.* (1979), Smith and Lindenmayer (1988), Macfarlane and Seebeck (1991), Lumsden *et al.* (1991), LCC (1991), Smith and Lindenmayer (1992), Lindenmayer (1995)
4. Introduced Species: Ranking (1)
5. Pest Control: Ranking (0)
6. Grazing: Ranking (0)
7. Disease: Ranking (0)
8. Illegal Harvesting: Ranking (0)
9. Non-forestry Clearing: Ranking (0)
10. Mining/Quarrying: Ranking (0)
11. Roading: Ranking (1) Macfarlane and Seebeck (1991)
12 Recreation: Ranking (0)
13. Vandalism/Disturbance by Humans: Ranking (0)

14. Other: Enhanced Greenhouse Effect Ranking (2))
Lindenmayer (1990) Bennett *et al.* (1991), Macfarlane and Seebeck (1991)

Current management:

Leadbeater's Possum is listed under the Victorian *Flora and Fauna Guarantee Act* 1988 and the Commonwealth *Endangered Species Protection Act* 1992. An Action Statement (Macfarlane *et al*. 1995), a Draft Management Strategy (Macfarlane and Seebeck 1991) and Management Guidelines which are applicable only to timber production forests, are currently being implemented. Management actions include: the establishment of a zoning system with specific prescriptions relating to the assessment of habitat, size and shape of coupes, buffer establishment and the protection of all hollow-bearing trees regardless of zoning classification. All known colonies are to be protected and other management activities including roading and reforestation are to be addressed. Intended management actions outlined in the Action Statement include: establishment of 21 Leadbeater's Possum Management Units, resource assessment surveys to determine the extent and distribution of current optimum and potentially optimum habitat, a revision of the current zoning system to reflect habitat changes over time, logging coupe assessment, retention of buffer strips, protection of hollow trees, salvage logging plans, operational trials of retained overwood silvicultural systems, reserve establishment, continuation of research to assist and improve long-term conservation, captive management planning, social and economic planning and continuation of community education (Macfarlane *et al.* 1995).

Comments: The distribution of Leadbeater's Possum is centered on the montane ash forests (*Eucalyptus regnans*, *E. delegatensis* and *E. nitens*) of the Central Highlands (Macfarlane *et al*. 1995). There is a single colony in a lowland swamp forest (*E. camphora* and *E. ovata*) within Yellingbo State Nature Reserve (Smales 1994) and a few records from Lake Mountain within snow gum woodland (*E. pauciflora*) (Jelinek 1995).

The habitat of Leadbeater's Possum includes large old trees for breeding and shelter, a vegetation structure that facilitates movement, and available food (Macfarlane *et al.* 1995). In ash forests Leadbeater's Possum forages for arboreal arthropods beneath the decorticating bark of the eucalypts and the sap of Acacia species (*Acacia dealbata*, *A. melanoxylon* and *A. frigescens*). A dense layer of Acacias also provides a suitable structure for movement (Smith 1984a). The montane ash forests of the Central Highlands are a valued timber resource and loss of hollow trees as a consequence of logging is a major threat to Leadbeater's Possum (Smith and Lindenmayer 1992, Lindenmayer 1995). Harvesting prescriptions stipulate that all live hollow trees are to be left standing and protected on logging coupes. However, these trees are often killed during the hot regeneration burns used for seed bed preparation in these forests, and are highly vulnerable to windthrow and collapse. The longevity of these habitat trees post logging requires research (Lindenmayer *et al.* 1990, Rhind 1996)

Although wildfire has been important in the development of suitable habitat for Leadbeater's Possum, widespread, severe wildfire was predicted to have a major negative impact on the persistence of the species. This impact is particularly evident in areas with little old-growth forest (Lindenmayer and Possingham 1994) and is a major threat to the species (Macfarlane *et al*. 1995). A contraction in the range of Leadbeater's Possum as well as *E. regnans* and *E. delegatensis* was predicted by models of the likely influence of the Enhanced Greenhouse Effect (Lindenmayer 1990), and is a moderate threat to the species.

Common Bent-wing Bat

Miniopteris schreibersii blepotis

RARITY

a) Geographic Range

- Classification of range size: Medium
- Range size within region: (ha): 182 000 - 325 000
- Proportion of region occupied (%): 15 -27
- Source: Atlas of Victorian Wildlife, Lumsden *et al*. (1991), CNR and AHC (1994)

b) Abundance

- Classification of abundance: Medium
- Population Estimate: 5 000 - 10 000
- Density: Unknown
- Home Range (ha): Unknown
- Source: L. Lumsden pers. comm.

c) Habitat Specificity

- Classification of habitat specificity: Narrow, given the roosting requirements (dependence on mineshafts) of this species
- Vegetation types used in the region: Damp Forest, Riparian Forest, Foothill Forest Complex, Grassy Dry Forest, Floodplain Riparian Woodland
- Source: Lumsden *et al.* (1991)

DYNAMICS

Population Trend in Last Decade

- Increasing, stable or declined: Declined, due to destruction, closing and natural collapse of mineshafts within the region
- Source: L. Lumsden pers. comm.

Population trend since discovery by Europeans

- Increasing, stable or declined: Increased, the construction of mineshafts has resulted in an increase in suitable roost sites.
- Source: Lumsden *et al.* (1991)

SPATIAL DYNAMICS

a) Population variability

- Classification of population variability: Low
- Source: Lumsden pers. comm.

b) Dispersal

- Classification of powers of dispersal: High
- Average distances dispersed: 200km, juveniles dispersal from Nargun's Cave, East Gippsland to the region
- Maximum distance dispersed: 240 km
- Source: Lumsden *et al.* (1991)

LIFE HISTORY PARAMETERS

a) Reproductive output

- Classification of reproductive output: Low
- Age of sexual maturity (yrs): 2 females, 1 males
- Mean clutch/litter/brood size: 1
- Mean no of clutches/litters/broods per year: 1
- Time of year young born/hatch: December
- Source: Dwyer (1963)

b) Longevity

- Classification of lifespan: Long-lived
- Average lifespan (yrs): Unknown
- Maximum lifespan (yrs): 20
- Source: Purchase (1982)

c) Morphology

Adult body size

- Weight (g): 13-17
- Length (mm): 52-58
- Source: Dwyer in Strahan (1995)

d) Social organisation

- Colonial or non-colonial: Colonial
- Territoriality: Unknown
- Source: Dwyer (1966a)

e) Other

- Nomadic, migratory, sedentary: Adult females are migratory, seasonally to Nargun's maternity cave, East Gippsland, Males and first year females are sedentary
- Mode of feeding: Insectivore (flying insects)
- Source: Dwyer and Hamilton-Smith (1965), Vestjens and Hall (1977), L. Lumsden pers. comm.

THREATS
1. Fire (planned): Ranking (-) L. Lumsden pers. comm.
2. Fire (unplanned): Ranking (-) L. Lumsden pers. comm.
3. Logging: Ranking (-) Law (1996), L. Lumsden pers. comm.
4. Introduced Species: Ranking (2) Dwyer (1964), Dwyer (1966b), Hall (1982), L. Lumsden pers. comm.
5. Pest Control: Ranking (2) Dunsmore *et al.* (1974), Menkhorst and Lumsden in Menkhorst (1995), L. Lumsden pers. comm.
6. Grazing: Ranking (0) L. Lumsden pers. comm.
7. Disease: Ranking (0) L. Lumsden pers. comm.
8. Illegal Harvesting: Ranking (0) L. Lumsden pers. comm.
9. Non-forestry Clearing: Ranking (1) L. Lumsden pers. comm.
10. Mining/Quarrying: Ranking (2) Lumsden *et al.* (1991), L. Lumsden pers. comm.
11. Roading: Ranking (0) L. Lumsden pers. comm.
12. Recreation: Ranking (0) L. Lumsden pers. comm.
13. Vandalism/Disturbance by Humans: Ranking (3) Seebeck and Hamilton-Smith (1967), Hall (1982), Lumsden *et al.* (1991), Menkhorst and Lumsden in Menkhorst (1995), L. Lumsden pers. comm.
14. Other: Collapse of mineshafts and overgrown entrances: Ranking (3) L. Lumsden pers. comm.

Current Management:.

The Common Bent-wing Bat is listed under the Victorian *Flora and Fauna Guarantee Act* 1988, and an Action Statement is being prepared. During determination of National Estate Values of the Central Highlands, old mines used by colonial or roosting bats were identified as key fauna habitat (CNR and AHC 1994). The conservation principal is the maintainence of key fauna habitats within the Central Highlands project area.

Comments: The Common Bent-wing Bat is a fast flying, highly mobile aerial insectivore. Most available information is related to roosting; very little is known about other habitat requirements and ecology. The species is relatively widespread but is considered threatened due to its dependence on a small number of maternity caves (two known in the State) and overwintering sites (L. Lumsden pers. comm.)

Within the Central Highlands there are no maternity sites of the Common Bent-wing Bat, but there are important roost sites (Lumsden *et al*. 1991). Males and first year females use these sites all year round while adult females travel to maternity sites (Nargun's Cave) from December to March then return to overwinter in the Central Highlands.

Common Bent-wing Bats go into torpor during winter. Colonial overwintering sites have had as many as 2000 individuals recorded (Seebeck and Hamilton-Smith 1967). During this time the species is particularly vulnerable to human disturbance, including the deliberate closure of mineshaft entrances for safety reasons near areas of human habitation, which can result in mortality and is a major threat. Collapse of mineshafts and blockage of entrances by vegetation which inhibits bat access, are also major threats to the species (Lumsden pers. comm.).

Moderate threats to the Common Bent-wing Bat in the Central Highlands include the reworking of mines (L. Lumsden pers. comm.), predation by introduced species, bats have been recorded being taken by feral cats as they leave roosts, and poisoning through cumulation of pesticides (Menkhorst and Lumsden in Menkhorst 1995). The effects of forestry practices on this species are unknown (L. Lumsden pers. comm.).

Eastern Horseshoe Bat
Rhinolophus megaphyllus

RARITY
a) Geographic Range
- Classification of range size: Small
- Range size within region: (ha): 60 000
- Proportion of region occupied (%): 5
- Source: Atlas of Victorian Wildlife, CNR and AHC (1994)

b) Abundance
- Classification of abundance: Low
- Population Estimate: < 500
- Density: Unknown
- Home Range (ha): Unknown
- Source: L. Lumsden pers. comm.

c) Habitat Specificity
- Classification of habitat specificity: Narrow given roosting requirements (dependence on mineshafts)
- Vegetation types used in the region: Grassy Dry Forest
- Source: Lumsden *et al.* (1991)

DYNAMICS
Population Trend in Last Decade
- Increasing, stable or declined: Declined, due to natural collapse of mineshafts within the region
- Source: L. Lumsden pers. comm.

Population trend since discovery by Europeans
- Increasing, stable or declined: Increased, due to the construction of mineshafts
- Source: Kerle (1979), Lumsden *et al.* (1991)

SPATIAL DYNAMICS
a) Population variability
- Classification of population variability: Low
- Source: L. Lumsden pers. comm.

b) Dispersal
- Classification of powers of dispersal: Low, individuals rarely move far from their roosts however the species is thought to be capable of long distance movements.
- Average distances dispersed: Unknown
- Maximum distance dispersed: Unknown
- Source: Dwyer (1966c), Lumsden and Menkhorst in Menkhorst (1995)

LIFE HISTORY PARAMETERS
a) Reproductive output
- Classification of reproductive output: Low
- Age of sexual maturity (yrs): 2-3 females, 2 males
- Mean clutch/litter/brood size: 1
- Mean no of clutches/litters/broods per year: 1
- Time of year young born/hatch: November, December
- Source: Purchase and Hiscox (1960), Dwyer (1966c), Young (1975)

b) Longevity
- Classification of lifespan: Long-lived
- Average lifespan (yrs): Unknown
- Maximum lifespan (yrs): Unknown, closely related European species of the same genus (different species) can live up to 30 years.
- Source: L. Lumsden pers. comm.

c) Morphology
Adult body size
- Weight (g): 7-14
- Length (mm): 42-58
- Source: Pavey and Young in Strahan (1995)

d) Social organisation
- Colonial or non-colonial: Colonial
- Territoriality: Unknown, but unlikely
- Source: Dwyer (1966c), L. Lumsden pers. comm.

e) Other
- Nomadic, migratory, sedentary: Probably sedentary
- Mode of feeding: Insectivore
- Source: Vestjens and Hall (1977), L. Lumsden pers. comm.

THREATS
1. Fire (planned): Ranking (-) L. Lumsden pers. comm.
2. Fire (unplanned): Ranking (-) L. Lumsden pers. comm.
3. Logging: Ranking (-) Law (1996), L. Lumsden pers. comm.
4. Introduced Species: Ranking (2) L. Lumsden pers. comm.
5. Pest Control: Ranking (2) Dunsmore *et al.* (1974), L. Lumsden pers. comm.
6. Grazing: Ranking (0) L. Lumsden pers. comm.
7. Disease: Ranking (0) L. Lumsden per. comm.
8. Illegal Harvesting: Ranking (0) L. Lumsden pers. comm.
9. Non-forestry Clearing: Ranking (0) L. Lumsden pers. comm.
10. Mining/Quarrying: Ranking (2) Lumsden *et al.* (1991), L. Lumsden pers. comm.
11. Roading: Ranking (0) L. Lumsden pers. comm.
12. Recreation: Ranking (0) L. Lumsden pers. comm.
13. Vandalism/Disturbance by Humans: Ranking (3) Lumsden *et al.* (1991), Lumsden and Menkhorst in Menkhorst (1995), L. Lumsden pers. comm.
14. Other: Mineshaft collapse and entrance overgrown Ranking (3) L. Lumsden pers. comm.

Current Management:

The Eastern Horseshoe Bat is classified as a "Restricted Colonial or Roosting Species" (CNR 1995a). During determination of National Estate Values of the Central Highlands, old mines used by colonial or roosting bats were identified as key fauna habitat (CNR and AHC 1994). The conservation principal is the maintainence of such habitats within the Central Highlands project area.

Comments: Like the Common Bent-wing Bat, the Eastern Horseshoe Bat is dependent on caves and mineshafts for roosting and breeding. Within the Central Highlands the species is at the western most limit of its range within Victoria. With the construction of mines it appears that the range of the species has expanded into the region since European settlement (L. Lumsden pers. comm.).

The Eastern Horseshoe Bat is a slow flying species which does not make long journeys between roost sites. Heavily pregnant females have been trapped in the Eildon area 200km from the nearest known maternity colony (Lumsden *et al.* 1991). Given the known flight pattern and movements of this species it is thought that there may be a maternity site within the Central Highlands. If a maternity colony is found within the Central Highlands this site will be very important for the conservation of the species within the region (Lumsden *et al.* 1991).

Major threats to the Eastern Horseshoe Bat within the Central Highlands relate to the species' roosting requirements and include disturbance at the roost by humans, loss of habitat through mineshaft collapse and overgrown entrances, and loss of habitat through reworking of old mines (Lumsden *et al.* 1991, L. Lumsden pers. comm.) Predation by feral animals (particularly cats) and poisoning through cumulation of pesticides (Dunsmore *et al.* 1974) are moderate threats to the species and L. Lumsden pers. comm.).

Large-footed Myotis

Myotis macropus

RARITY

a) Geographic Range
- Classification of range size: Medium
- Range size within region: (ha): 40 000 - 130 000
- Proportion of region occupied (%): 3 - 11
- Source: Atlas of Victorian Wildlife, Lumsden *et al.* (1991), CNR and AHC (1994)

b) Abundance
- Classification of abundance: Low
- Population Estimate: Unknown
- Density: Unknown
- Home Range (ha): Unknown
- Source: L. Lumsden pers. comm.

c) Habitat Specificity
- Classification of habitat specificity: Narrow
- Vegetation types used in the region: Riparian Forest Complex, Floodplain Riparian Woodland
- Source: Lumsden *et al.* (1991)

DYNAMICS

Population Trend in Last Decade
- Increasing, stable or declined: Unknown
- Source: L. Lumsden pers. comm.

Population trend since discovery by Europeans
- Increasing, stable or declined: Unknown
- Source: Lumsden *et al.* (1991)

SPATIAL DYNAMICS

a) Population variability
- Classification of population variability: Low
- Source: L. Lumsden pers. comm.

b) Dispersal
- Classification of powers of dispersal: Unknown, but no recorded long-distance movements
- Average distances dispersed: Unknown
- Maximum distance dispersed: Unknown
- Source: L. Lumsden pers. comm.

LIFE HISTORY PARAMETERS

a) Reproductive output
- Classification of reproductive output: Low
- Age of sexual maturity (yrs): 1 or 2
- Mean clutch/litter/brood size: Probably 1
- Mean no of clutches/litters/broods per year: 1 or 2
- Time of year young born/hatch: Heavily pregnant females have been recorded October and lactating females have been recorded in March
- Source: Lumsden and Menkhorst in Menkhorst (1995), L. Lumsden pers. comm.

b) Longevity
- Classification of lifespan: Long-lived
- Average lifespan (yrs): Unknown
- Maximum lifespan (yrs): Unknown
- Source: L. Lumsden pers. comm.

c) Morphology

Adult body size
- Weight (g): 10-14
- Length (mm): 52-56 (54)
- Source: Richards in Strahan (1995), L. Lumsden pers. comm.

d) Social organisation
- Colonial or non-colonial: Colonial
- Territoriality: Unknown, closely related to a Queensland species, male territorial
- Source: Seebeck and Hamilton-Smith (1967), Dwyer (1970)

e) Other
- Nomadic, migratory, sedentary: Sedentary
- Mode of feeding: Insectivore, Piscivore

- Source: Vestjens and Hall (1977), Robson (1984), Jansen (1987)

THREATS
1. **Fire (planned): Ranking (1)** L. Lumsden pers. comm.
2. Fire (unplanned): Ranking (1) L. Lumsden pers. comm.
3. Logging: Ranking (2) L. Lumsden pers. comm.
4. Introduced Species: Ranking (1) L. Lumsden pers. comm.
5. Pest Control: Ranking (2) L. Lumsden pers. comm.
6. Grazing: Ranking (0) L. Lumsden pers. comm.
7. Disease: Ranking (-) L. Lumsden pers. comm.
8. Illegal Harvesting: Ranking (0) L. Lumsden pers. comm.
9. Non-forestry Clearing: Ranking (1) L. Lumsden pers. comm.
10. Mining/Quarrying: Ranking (2) L. Lumsden pers. comm.
11. Roading: Ranking (2) L. Lumsden pers. comm.
12. Recreation: Ranking (1) L. Lumsden pers. comm.
13. Vandalism/Disturbance by Humans: Ranking (1) Seebeck and Hamilton-Smith (1967), L. Lumsden pers. comm.
14. Other: Ranking (0)

Current Management:

The Large-footed Myotis is classified as "rare" (FFG Act). Under the Code of Forest Practices for Timber Production (CNR 1996a) the water quality and riparian vegetation of permanent streams are protected by a buffer on either side of the stream of a minimum width of 20m. Trees must not be felled within or into buffer strips and machinery must not enter other than for construction and use of approved stream crossings. Such prescriptions afford some protection to the habitat and food resource of the Large-footed Myotis. The LCC (1993) recommend protection of the species within the Central Forest Management Area.

Comments: The Large-footed Myotis *Myotis macropus*, formerly known *as Myotis adversus macropus*, is a newly recognised species (Kitchener *et al.* 1995). The species is always associated with permanent, usually slow flowing water bodies, and is found in a wide range of vegetation communities associated with water. The Large-footed Myotis feeds on aquatic and flying insects and fish.

Targeted surveys have been conducted for the Large-footed Myotis in the Central Highlands but the species was caught at a only a few sites (5 of 42 trap sites) (Lumsden *et al.* 1991). It has been recorded on the Goulburn, O'Shannassy, Taponga, Tyers and Yarra Rivers as well as along smaller creeks including Badger Creek at Healseville and Walsh Creek in the Upper Yarra Catchment (Lumsden *et al.* 1991).

Within the Central Highlands the Large-footed Myotis has been recorded roosting in tunnels with Common Bent-wing Bats (Seebeck and Hamilton-Smith 1967) and in tree hollows near Healesville (N. Schedvin pers. comm. in Lumsden and Menkhorst 1995). Some roost trees were overhanging the Yarra River while others were up to 400m from the water. It is thought that tree hollows are likely to be the more common roosting site for this species (L. Lumsden pers. comm.). However, research is required to determine roosting requirements particularly the relative dependence on caves versus tree hollows (Lumsden and Menkhorst in Menkhorst 1995)

Pest control, mining/quarrying and roading were identified as moderate threats to the Large-footed Myotis in the Central Highlands (L. Lumsden pers. comm.). These processes could potentially affect water quality and hence may secondarily impact on the species which depends on instream fauna; chemicals used for pest control and mining may drain into the waterways, and siltation of streams as a result of poor road construction and maintenance, may all affect the species' prey.

Grey-headed Flying-fox

Pteropus poliocephalus

RARITY
a) Geographic Range
- Classification of range size: Small
- Range size within region: (ha): 20 000
- Proportion of region occupied (%): < 2
- Source: Atlas of Victorian Wildlife

b) Abundance
- Classification of abundance: Low
- Population Estimate: Unknown, a small number intermittently recorded from the Central Highlands
- Density: Unknown
- Home Range: overnight foraging area 15-50 km from camp
- Source: Tidemann in Strahan (1995), L. Lumsden pers. comm.

c) Habitat Specificity
- Classification of habitat specificity: Narrow
- Vegetation types used in the region: Planted fruit trees, Box/Ironbark forest
- Source: Menkhorst and Dixon (1985), Craig (1996)

DYNAMICS
Population Trend in Last Decade
- Increasing, stable or declined: Increased
- Source: Aston (1987), Peake and Carr (1995)

Population trend since discovery by Europeans
- Increasing, stable or declined: Increased
- Source: Menkhorst and Dixon (1985)

SPATIAL DYNAMICS
a) Population variability
- Classification of population variability: High
- Source: L. Lumsden pers. comm.

b) Dispersal
- Classification of powers of dispersal: High
- Average distances dispersed: Unknown
- Maximum distance dispersed: Unknown
- Source: Menkhorst (1995), L. Lumsden pers. comm.

LIFE HISTORY PARAMETERS
a) Reproductive output
- Classification of reproductive output: Low
- Age of sexual maturity (yrs): 1-2 females, 2.5 males
- Mean clutch/litter/brood size: 1
- Mean no of clutches/litters/broods per year: 1
- Time of year young born/hatch: September-October
- Source: Nelson (1965), Martin *et al.* (1987), Tidemann in Strahan (1995)

b) Longevity
- Classification of lifespan: Long-lived
- Average lifespan (yrs): 7-8
- Maximum lifespan (yrs): 20 (in captivity)
- Source: Martin *et al.* (1987)

c) Morphology
Adult body size
- Weight (g): 600-1000 (700)
- Length (mm): 230-289 (255)
- Source: Tidemann in Strahan (1995)

d) Social organisation
- Colonial or non-colonial: Colonial
- Territoriality: Territorial, within roost
- Source: Nelson (1965)

e) Other
- Nomadic, migratory, sedentary: Nomadic, Migratory and Sedentary, individuals differ, also dependent on food supply
- Mode of feeding: Nectivorous, Frugivorous

- Source: Nelson (1965), Tidemann in Strahan (1995)

THREATS

1. Fire (planned): Ranking (0) L. Lumsden pers. comm.
2. Fire (unplanned): Ranking (0) L. Lumsden pers comm.
3. Logging: Ranking (0) L. Lumsden pers. comm.
4. Introduced Species: Ranking (0) L. Lumsden pers. comm.

5. Pest Control: Ranking (1) L. Lumsden pers. comm.

6. Grazing: Ranking (0) L. Lumsden pers. comm.
7. Disease: Ranking (-) Suton and Hariono (1987), L. Lumsden pers. comm.
8. Illegal Harvesting: Ranking (0) L. Lumsden pers. comm.

9. Non-forestry Clearing: Ranking (1) L. Lumsden pers. comm.

10. Mining/Quarrying: Ranking (0) L. Lumsden pers. comm.
11. Roading: Ranking (0) L. Lumsden pers. comm.
12. Recreation: Ranking (0) L. Lumsden pers. comm.
13. Vandalism/Disturbance by Humans: Ranking (0) L. Lumsden pers. comm.
14. Weather: Ranking (-)L. Lumsden pers. comm.

15 Other: Powerlines / Electrocution: Ranking (1) Luckhoff (1987), Aston (1987)

Current Management:

The Grey-headed Flying-fox is classified in Victoria as a "Restricted Colonial Breeding or Roosting Species" (CNR 1995a). There are no current management prescriptions for this species in the Central Highlands.

Comments: There are five records from three localities of the Grey-headed Flying-fox within the Central Highlands (The Atlas of Victorian Wildlife). Two records were from Warburton and the other from Christmas Hills. Although there are likely to be more occurences of the species within the area, it is unlikely that it is dependent on forest habitat and instead appears largely dependent on cultivated fruit trees (Menkhorst and Dixon 1985, Aston 1987, Peake 1996). Within the Central Highlands the Grey-headed Flying-fox is at the southerly most extension of its range. It is not in prime habitat or climate and the area is not important for the species' survival (L. Lumsden pers. comm.).

The Grey-headed Flying-fox has been recorded feeding in flowering Ironbarks within the Central Highlands, and non-forestry clearing for urban development of Box/Ironbark forests in north-east Melbourne is identified as a moderate threat. Disease is an unknown threat; dead bats have recently been found to be carrying the Lyssavirus. It is unknown if Grey-headed Flying-foxes are long-term carriers of the virus and it has only recently been discovered by humans (L. Lumsden per. comm.), or if it is a new virus. If it is a new virus it may have a major impact on the species. The Grey-headed Flying-fox is at the limit of its climatic tolerance within the Central Highlands however, the impact of weather events are unknown.

2. BIRDS

Helmeted Honeyeater

Lichenostomus melanops cassidix

RARITY

a) Geographic Range

- Classification of range size: Small
- Range size within region: (ha): 20-25
- Proportion of region occupied (%): <1
- Source: B. Quin pers. comm.

b) Abundance

- Classification of abundance: Low
- Population Estimate: 100-110 birds
- Density: 6-8birds/ha
- Home Range (ha): 0.3-0.5 male territories
- Source: B. Quin pers. comm., Menkhorst and Middleton (1991).

c) Habitat Specificity

- Classification of habitat specificity: Narrow
- Vegetation types used in the region: Mountain Swamp Gum *Eucalyptus camphora* swampland and Manna Gum *E. viminalis*-dominated riparian forest
- Source: Pearce, Burgman and Franklin (1994)

DYNAMICS

Population Trend in Last Decade

- Increasing, stable or declined: Increasing. 1987 32-36 adults within Yellingbo, 1994 100-110 adults within Yellingbo, numbers have remained relatively stable since 1994.
- Source: Menkhorst and Middleton (1991), B. Quin pers. comm.

Population trend since discovery by Europeans

- Increasing, stable or declined: Declined
- Source: Menkhorst and Middleton (1991), B. Quin pers. comm.

SPATIAL DYNAMICS

a) Population variability

- Classification of population variability: Low
- Source: B. Quin pers. comm.

b) Dispersal

- Classification of powers of dispersal: Low
- Average distances dispersed: Local movements during non-breeding, although basically sedentary species.
- Maximum distance dispersed: Unpaired birds and breeding females may move several kilometres over winter.
- Source: Menkhorst and Middleton (1991), Runciman, Franklin and Menkhorst (1995), B. Quin pers. comm.

LIFE HISTORY PARAMETERS

a) Reproductive output

- Classification of reproductive output: High
- Age of sexual maturity (yrs): 20% breed one year after hatching
- Mean clutch/litter/brood size: 2
- Mean no of clutches/litters/broods per year: 3
- Time of year young born/hatch: August-January
- Source: Smales (1995), Quin (1996), Franklin *et al.* (1995)

b) Longevity

- Classification of lifespan: Long-lived
- Average lifespan (yrs): 4
- Maximum lifespan (yrs): 10
- Source: Smales (1995), Menkhorst (1992)

c) Morphology

Adult body size

- Weight (g): 32
- Length (cm): 200
- Source: Menkhorst (1992)

d) Social organisation

- Colonial or non-colonial: Colonial
- Territoriality: Males defend territory year round
- Source: Menkhorst and Middleton (1991), B. Quin pers. comm.

e) Other
- Nomadic, migratory, sedentary: Sedentary
- Mode of feeding: Insectivore, nectarivore
- Source: Menkhorst and Middleton (1991)

THREATS
1. Fire (planned): Ranking (0)
2. Fire (unplanned): Ranking (3) Menkhorst and Middleton (1991), Menkhorst (1992), McCarthy (1996).
3. Logging: Ranking (1) B. Quin pers. comm.
4. Introduced Species: Ranking (1) B. Quin pers. comm.
5. Pest Control: Ranking (0)
6. Grazing: Ranking (1) B. Quin pers. comm.
7. Disease: Ranking (2) B. Quin pers. comm.
8. Illegal harvesting: Ranking (0)
9. Non-forestry Clearing: Ranking (1) B. Quin pers. comm.
10. Mining/Quarrying: Ranking (0)
11. Roading: Ranking (0)
12 Recreation: Ranking (1) B. Quin pers. comm.
13. Vandalism/Disturbance by Humans: Ranking (1) B. Quin pers. comm.
14. Other: Interspecific competition: Ranking (3) Pearce *et al*. (1995), B. Quin pers. comm. **Enhanced Greenhouse Effect: Ranking (2)** Bennett *et al.* (1991), B. Quin pers. comm.

Current Management:
The Helmeted Honeyeater and the Sedge-rich *Eucalyptus camphora* Swamp Community are listed under the Victorian *Flora and Fauna Guarantee Act* 1988. The Helmeted Honeyeater is also listed under the Commonwealth *Endangered Species Protection Act* 1992. A Recovery Plan for the Helmeted Honeyeater is in operation (Menkhorst and Middleton 1991). Actions include intensive monitoring of breeding biology, protection of nests, control of Bell Miners, captive breeding and reintroductions, revegetation of habitat and research into the natural hydrological patterns of the species' habitat.

Comments: The Helmeted Honeyeater has suffered a steady decline in population and distribution throughout the 20th century. It is currently restricted to one population which inhabits Mountain Swamp Gum swampland and Manna Gum dominated riparian forest along the Cockatoo and Macclesfield Creeks (Menkhorst and Middleton 1991). The majority of the population is now contained within the Yellingbo State Nature Reserve where numbers appear to have stabilised mainly due to an intensive recovery program (B. Quin pers. comm.).

Helmeted Honeyeaters are colonial, sedentary and feed on insects and nectar. Wildfire is known to have caused extinction of local populations and is a major threat due to the restricted distribution of the species (Menkhorst and Middleton 1991, Menkhorst 1992, McCarthy 1996). Other major threats include interspecific aggression from Bell Miners which exclude Helmeted Honeyeaters from areas of suitable habitat (Pearce *et al.* 1995), and non-forestry clearing and agricultural activities in the surrounding land which may lead to altered hydrological regimes and increased nutrient levels within the swampland, possible causes of eucalypt dieback and habitat deterioration (Menkhorst and Middleton 1991). The species is also susceptible to logging upstream within the catchment which may cause habitat deterioration due to altered hydrological regimes and increased siltation (B. Quin pers. comm.). Due to the small, restricted nature of the population threats such as disease (although there is no evidence of disease at present) and impacts associated with the Enhanced Greenhouse Effect which could further restrict suitable habitat, are considered moderate threats to the species (B. Quin pers. comm.).

Regent Honeyeater
Xanthomyza phrygia

RARITY
a) Geographic Range
- Classification of range size: Unknown, potentially large due to mobility
- Range size within region: (ha): Unknown, likely <150 000
- Proportion of region occupied (%): Unknown, likely <10
- Source: Atlas of Victorian Wildlife, CNR and AHC (1994), N. Schedvin pers. comm.

b) Abundance
- Classification of abundance: Low
- Population Estimate: Unknown
- Density: Unknown, National population estimate 500-1500 birds
- Home Range (ha): Unknown
- Source: Menkhorst (in prep)

c) Habitat Specificity
- Classification of habitat specificity: Wide
- Vegetation types used in the region: Inhabits eucalypt woodlands and open forest, as well as treed farmland and urban areas. EVCs containing key eucalypt species (Red Ironbark *Eucalyptus sideroxylon*, White Box *E. albens*, Yellow Box *E. melliodora*, Yellow Gum *E. leucoxylon* and Blakey's Red Gum *E. blakelyi*) include Valley Forest, Grassy Dry Forest and Box Woodland
- Source: CNR and AHC (1994), Franklin *et al.* (1989)

DYNAMICS
Population Trend in Last Decade
- Increasing, stable or declined: Declined
- Source: Webster and Menkhorst (1992), Menkhorst in prep.

Population trend since discovery by Europeans
- Increasing, stable or declined: Declined
- Source: Webster and Menkhorst (1992), Menkhorst (in prep)

SPATIAL DYNAMICS
a) Population variability
- Classification of population variability: High
- Source: Menkhorst (1993)

b) Dispersal
- Classification of powers of dispersal: High, nomadic
- Average distances dispersed: Unknown one bird was recorded travelling 85km
- Maximum distance dispersed: Unknown, possibly 100s of kms
  Seasonal patterns of abundance and breeding linked to regional patterns of flowering of key eucalypt species.
- Source: Menkhorst (in prep), N. Schedvin pers. comm.

LIFE HISTORY PARAMETERS
a) Reproductive output
- Classification of reproductive output: Low
- Age of sexual maturity (yrs): 1
- Mean clutch/litter/brood size: 2-3
- Mean no of clutches/litters/broods per year: 1, occasionally more
- Time of year young born/hatch: July-February (mainly November-January)
- Source: Menkhorst (1993), Menkhorst (in prep), N. Schedvin pers. comm.

b) Longevity
- Classification of lifespan: Unknown
- Average lifespan (yrs): Unknown
- Maximum lifespan (yrs): 7 years

- Source: N. Schedvin pers. comm.

c) Morphology

Adult body size

- Weight (g): 43
- Length (mm): 225
- Source: Longmore (1991)

d) Social organisation

- Colonial or non-colonial: Nest in pairs, non- breeding may form loose flocks
- Territoriality: Yes, nest tree and feeding site defence
- Source: Webster and Menkhorst (1992), Franklin and Robinson (1989)

e) Other

- Nomadic, migratory, sedentary: Nomadic/Migratory. Movement poorly understood. May be linked to food availability and could include semi-migratory longer distances between regions and local wanderings.
- Mode of feeding: Nectivore, insectivore
  Source: Franklin *et al.* (1989)

THREATS

1. Fire (planned): Ranking (-)
2. Fire (unplanned): Ranking (1) (particularly in breeding areas) N. Schedvin pers. comm.
3. Logging: Ranking (1) N. Schedvin pers. comm.
4. Introduced Species: Ranking (-)
5. Pest Control: Ranking (-)
6. Grazing: Ranking (1) N. Schedvin pers. comm.
7. Disease: Ranking (-)
8. Illegal harvesting: Ranking (0) N. Schedvin pers. comm.
9. Non-forestry Clearing: Ranking (2) N. Schedvin pers. comm.
10. Mining/Quarrying: Ranking (-) N. Schedvin pers. comm.
11. Roading: Ranking (1) N. Schedvin pers. comm.
12 Recreation: Ranking (-)
13. Vandalism/Disturbance by Humans: Ranking (-)
14.Other: Interspecific competition: Ranking (2) Menkhorst (1993), N. Schedvin pers. comm., **Firewood collection: Ranking (2)** N. Schedvin pers. comm.

Current Management:

The Regent Honeyeater is listed under the Victorian *Flora and Fauna Guarantee Act* 1988 and the Commonwealth *Endangered Species Protection Act* 1992. An Action Statement (Menkhorst 1993) and draft Recovery Plan have been prepared for this species (Menkhorst, in prep). Exclusion of timber harvesting, mining and grazing is recommended for regularly used sites. Exclusion areas include a 100m wide disturbance-free zone surrounding the site, and a further 150m wide zone within which at least 10 habitat trees per hectare should be retained. Actions specified within the draft Recovery Plan relate to habitat mangement, population monitoring, ecological research, extension and captive management.

Comments: The Regent Honeyeater is most frequently found in box-ironbark habitat, containing key eucalypt species such as Red Ironbark *E. sideroxylon*, White Box *E. albens*, Yellow Box *E. melliodora*, Yellow Gum *E. leucoxylon* and Blakey's Red Gum *E. blakelyi*. Regularly used sites are areas where the birds appear most years and may also breed. Birds are often recorded in small remnants which have not experienced intensive silviculture (including loss of large trees). Larger trees appear to be selected for nectar feeding (Webster and Menkhorst 1992). It appears to occur more frequently in blocks rather than strips or isolates. The loss of high quality sites and habitat fragmentation creates the potential for competition for nectar with other honeyeater species and from apiarists (Menkhorst 1993).

Over 80% of records for the species occur in 3 localities in northern Victoria (Menhorst, in prep). In the Central Highlands, the majority of records are in the vicinity of Melbourne. Suitable habitat occurs primarily in foothill country to the north and east of Melbourne, and the lower slopes and upper terraces of the Goulburn River. The Plenty Gorge Park contains known breeding habitat, and Lake Eildon National Park has potentially suitable habitat (N. Schedvin pers. comm.). Due to the scarcity of suitable habitat within the Central Highlands there are no major threats to the Regent Honeyeater. Threats relate to further loss and degradation of existing habitat which may be caused by clearing and firewood collection (N. Schedvin pers. comm.). Habitat fragmentation as a result of clearing has lead to greater competition for limited resources from more aggressive species which may exclude Regent Honeyeaters (Menkhorst 1993).

Painted Honeyeater

Grantiella picta

RARITY

a) Geographic Range

- Classification of range size: Small
- Range size within region: (ha): Unknown
- Proportion of region occupied (%): Unknown, possibly <5
  There are only 7 post-1980 records for the species on the Atlas of Victorian Wildlife within the Central Highlands area
- Source: Atlas of Victorian Wildlife

b) Abundance

- Classification of abundance: Low
- Population Estimate: Unknown
- Density: Unknown, usually occurs at low densities
- Home Range (ha): Unknown
- Source: Eddy (1961)

c) Habitat Specificity

- Classification of habitat specificity: Narrow
- Vegetation types used in the region: Dry sclerophyll forest and woodland. EVCs containing key eucalypt species which are parasited by preferred mistletoe species include Valley Forest, Grassy Dry Forest, Box Woodland and Heathy Dry Forest
- Source: CNR and AHC (1994)

DYNAMICS

Population Trend in Last Decade

- Increasing, stable or declined: Unknown
- Source: D. Robinson pers. comm.

Population trend since discovery by Europeans

- Increasing, stable or declined: Unknown, probably declined
- Source: Lumsden *et al.* (1991)

SPATIAL DYNAMICS

a) Population variability

- Classification of population variability: High
- Source: D. Robinson pers. comm.

b) Dispersal

- Classification of powers of dispersal: High
- Average distances dispersed: Unknown
- Maximum distance dispersed: Unknown
- Source: D. Robinson pers. comm.

LIFE HISTORY PARAMETERS

a) Reproductive output

- Classification of reproductive output: High
- Age of sexual maturity (yrs): Unknown
- Mean clutch/litter/brood size: 2
- Mean no of clutches/litters/broods per year: 2
- Time of year young born/hatch: October-March
- Source: Longmore (1991)

b) Longevity

- Classification of lifespan: Unknown
- Average lifespan (yrs): Unknown

- Maximum lifespan (yrs): Unknown
- Source: D. Robinson pers. comm.

c) Morphology
Adult body size
- Weight (g): 23
- Length (mm): 160
- Source: Longmore (1991)

d) Social organisation
- Colonial or non-colonial: Sometimes occurs in small flocks or nesting groups
- Territoriality: Males defend nesting territories
- Source: Longmore (1991), Robinson (1994)

e) Other
- Nomadic, migratory, sedentary: Migratory
- Mode of feeding: Primarily a frugivore, although also insectivore and nectivore
- Source: Longmore (1991)

THREATS
1. Fire (planned): Ranking (-)
2. Fire (unplanned): Ranking (-)
3. Logging: Ranking (1) D. Robinson pers. comm.
4. Introduced Species: Ranking (-)
5. Pest Control: Ranking (-)
6. Grazing: Ranking (1) D. Robinson pers. comm.
7. Disease: Ranking (-)
8. Illegal harvesting: Ranking (-)
9. Non-forestry Clearing: Ranking (1) Garnett (1992), D. Robinson pers. comm.
10. Mining/Quarrying: Ranking (-)
11. Roading: Ranking (-)
12. Recreation: Ranking (-)
13. Vandalism/Disturbance by Humans: Ranking (-)
14. Other: Pasture Improvement: Ranking (1) D. Robinson pers. comm. **Interspecific competition: Ranking (1)** D. Robinson pers. comm.

Current Management:

The Painted Honeyeater is listed under the Victorian *Flora and Fauna Guarantee Act* 1988. There are no current management prescriptions for the species in the Central Highlands.

Comments: There is very little known about the biology, ecology, popultion dynamics and movements of the Painted Honeyeater. A specialist feeder of mistletoe fruit (Longmore 1991), the Painted Honeyeater is a summer migrant to Victoria and occurs primarily in dry forests and woodlands on the inland slopes and adjacent plains of the Great Dividing Range. There are only seven post 1980 records of the species within the Central Highlands (Atlas of Victorian Wildlife).

The Painted Honeyeater generally inhabits open stands of old eucalypts infested with mistletoes and loss of mature trees as a result of logging could represent a threat (D. Robinson pers. comm.). Clearing of habitat for agriculture and lack of habitat regeneration as a result of grazing could accelerate any long-term decline (Garnett 1992). Tree decline may be exacerbated by pasture improvement activities which contribute to habitat degradation and loss (Landsberg *et al.* 1990). Other possible reasons for the species' apparent decline (which require research) include displacement by the generalist Mistletoebird *Dicaeum hirundinaceum* and exclusion by Noisy Miners *Manorina melanocephala* (Robinson 1994).

Swift Parrot

Lathamus discolor

RARITY
a) Geographic Range
- Classification of range size: Small
- Range size within region: (ha): Unknown, possibly 150 000
- Proportion of region occupied (%): Unknown, possibly 10-20
- Source: Atlas of Victorian Wildlife, CNR and AHC (1994)

b) Abundance
- Classification of abundance: Low
- Population Estimate: Unknown
- Density: Unknown
- Home Range (ha): Unknown
- Source: C. Tzaros pers. comm.

c) Habitat Specificity
- Classification of habitat specificity: Narrow
- Vegetation types used in the region: Box Woodland. Eucalypt forests and woodlands primarily with 5 key winter flowering species. The species may also occur in dry forests, dry woodlands, wooded farmlands and suburban parks. Rarely seen in treeless areas, rainforests and wet forests.
- Source: Emison *et al.* (1987)

DYNAMICS
Population Trend in Last Decade
- Increasing, stable or declined: Declined Australia wide population census 1320 pairs (1989), 940 pairs (1995)
- Source: Brereton (1996)

Population trend since discovery by Europeans
- Increasing, stable or declined: Declined
- Source: Lumsden *et al.* (1991)

SPATIAL DYNAMICS
a) Population variability
- Classification of population variability: High Presence linked to flowering patterns of eucalypts
- Source: Tzaros and Davidson (1996)

b) Dispersal
- Classification of powers of dispersal: High
- Average distances dispersed: Birds migrate from Tasmania to south eastern Australia each winter
- Maximum distance dispersed: 100s km
- Source: Brereton (1996)

LIFE HISTORY PARAMETERS
a) Reproductive output
- Classification of reproductive output: High, Breeding success varies; dependent on Blue Gum flowering
- Age of sexual maturity (yrs): Possibly 2 years
- Mean clutch/litter/brood size: 4-5 eggs
- Mean no of clutches/litters/broods per year: 1
- Time of year young born/hatch: October-December
- Source: Foreshaw and Cooper (1981), Brereton (1996), R. Loyn pers. comm.

b) Longevity
- Classification of lifespan: Unknown, possibly long-lived
- Average lifespan (yrs): Possibly 5-6 years
- Maximum lifespan (yrs): Unknown
- Source: C. Tzaros pers. comm.

c) Morphology
Adult body size
- Weight (g): 77
- Length (mm): 236
- Source: Brereton (1996)

d) Social organisation
- Colonial or non-colonial: Nesting pairs, also gregarious
- Territoriality: No
- Source: Brereton (1996)

e) Other
- Nomadic, migratory, sedentary: Non breeding winter migrant to Victoria
- Mode of feeding: Primarily nectivore, also eats psyllids and lerps

- Source: Brereton (1996), Tzaros and Davidson (1996)

THREATS
1. Fire (planned): Ranking (-)
2. Fire (unplanned): Ranking (-)
3. Logging: Ranking (1) Brereton (1996)
4. Introduced Species: Ranking (-)
5. Pest Control: Ranking (-)
6. Grazing: Ranking (-)
7. Disease: Ranking (-)
8. Illegal harvesting: Ranking (0)
9. Non-forestry Clearing: Ranking (1) C. Tzaros pers. comm.
10. Mining/Quarrying: Ranking (-)
11. Roading: Ranking (-)
12 Recreation: Ranking (0)
13. Vandalism/Disturbance by Humans: Ranking (-)
14. Other: Firewood collection: Ranking (1) Brereton (1996)

Current Management:

The Swift Parrot is listed under the Victorian *Flora and Fauna Guarantee Act* 1988 and an Action Statement is currently being prepared. The species is also listed under the Commonwealth *Endandered Species Protection Act* 1992 and an Australia wide Recovery Plan has been published (Brereton 1996). In Victoria, overwinter surveys commenced in 1995 and will run for at least 3 more years (Tzaros and Davidson 1996). The majority of the Central Highlands is not included within the survey area.

Comments: The Swift Parrot is a gregarious arboreal nectivore which breeds in Tasmania and overwinters on the mainland. The over wintering population of Swift Parrots is generally recorded in Victoria from March to October (Tzaros and Davidson 1996). Birds primarily visit box-ironbark vegetation in north east and central Victoria, particularly where winter flowering eucalypts occur (Tzaros and Davidson 1996). Suitable vegetation is restricted within the Central Highlands and the majority of records from this area may be of birds moving through the area. However, there are records of large flocks feeding in flowering Manna Gums at Yellingbo in 1990 (Franklin pers. comm. in Lumsden *et al.* 1991) and in Plenty Gorge in Yellow Gum woodland. In addition birds may feed on non-indigenous eucalypt species around Melbourne before dispersing (C. Tzaros pers. comm.).

There has been a substantial loss of breeding and overwintering habitat in Australia (Brereton 1996). Although only minor threats in the Central Highlands, logging, firewood collection and clearing for agriculture and development result in habitat loss, particularly of large old trees which produce high nectar yields in winter and are a significant food resource in Victoria (Brereton 1996). A significant number of Swift Parrots are lost through collisions with vehicles and illegal harvesting in Tasmania (Brereton 1996). The importance of these threats in Victoria are unknown and not likely to be significant in the Central Highlands.

Bush Stone-curlew
Burhinus grallarius

RARITY
a) Geographic Range
- Classification of range size: Small
- Range size within region: (ha): Minimal
- Proportion of region occupied (%): Minimal
  There is a one recent record from St Andrews (possibly a dispersing bird)
- Source: Atlas of Victorian Wildlife, D. Robinson pers. comm.

b) Abundance
- Classification of abundance: Low
- Population Estimate: Marginal to area. Victorian estimate 500-1000 breeding pairs
- Density: Not applicable
- Home Range (ha): 250-600
- Source: Robinson (in prep)

c) Habitat Specificity
- Classification of habitat specificity: Narrow
- Vegetation types used in the region: Lowland grassy woodland and open forest. EVCs - Valley Forest, Grassy Dry Forest, Box Woodland, Plains Grassy Woodland
- Source: CNR and AHC (1994), D. Robinson pers. comm.

DYNAMICS
Population Trend in Last Decade
- Increasing, stable or declined: Declined
- Source: Johnson and Baker-Gabb (1994)

Population trend since discovery by Europeans
- Increasing, stable or declined: Declined
- Source: Johnson and Baker-Gabb (1994)

SPATIAL DYNAMICS
a) Population variability
- Classification of population variability: Low
- Source: D. Robinson pers. comm.

b) Dispersal
- Classification of powers of dispersal: Unknown
- Average distances dispersed: Unknown
- Maximum distance dispersed: Unknown
- Source: D. Robinson pers. comm.

LIFE HISTORY PARAMETERS
a) Reproductive output
- Classification of reproductive output: Low
- Age of sexual maturity (yrs):
- Mean clutch/litter/brood size: 2
- Mean no of clutches/litters/broods per year: 1
- Time of year young born/hatch: August-March (primarily November-January)
- Source: Webster and Baker-Gabb (1994), Johnson and Baker-Gabb (1994)

b) Longevity
- Classification of lifespan: Long-lived
- Average lifespan (yrs): 10-30
- Maximum lifespan (yrs): At least 25 years
- Source: Robinson (in prep), D. Robinson pers. comm.

c) Morphology
Adult body size
- Weight (g): males 672, females 625 (tropical Australia)
- Length (mm): 540-600
- Source: Marchant and Higgins (1993), D. Robinson (in prep)

d) Social organisation
- Colonial or non-colonial: Usually pairs, occasionally unpaired birds
- Territoriality: Territories defended during breeding season
  After breeding may form loose flocks
- Source: Johnson and Baker-Gabb (1994)

e) Other
- Nomadic, migratory, sedentary: Sedentary
- Mode of feeding: Primarily insectivore
- Source: Johnson and Baker-Gabb (1994)

THREATS
1. Fire (planned): Ranking (-)
2. Fire (unplanned): Ranking (-)
3. Logging: Ranking (1) D. Robinson pers. comm.

4. Introduced Species: Ranking (1) D. Robinson pers. comm.
5. Pest Control: Ranking (1) D. Robinson pers. comm.
6. Grazing: Ranking (1) D. Robinson pers. comm.
7. Disease: Ranking (-)
8. Illegal harvesting: Ranking (1) D. Robinson pers. comm.
9. Non-forestry Clearing: Ranking (1) D. Robinson pers. comm.
10. Mining/Quarrying: Ranking (-)
11. Roading: Ranking (-)
12 Recreation: Ranking (-)
13. Vandalism/Disturbance by Humans: Ranking (1) D. Robinson pers. comm.
14.Other: Firewood collection: Ranking (1) D. Robinson pers. comm.

Current Management:

The Bush Stone-curlew is listed under the Victorian *Flora and Fauna Guarantee Act* 1988 and an Action Statement is currently being prepared. There are no current management prescriptions for the species in the Central Highlands.

Comments: The Bush Stone-curlew occurs primarily in lowland grassy woodland and open forest remnants in northern and western Victoria. There is only one current record and very few historical records for the Central Highlands (Atlas of Victorian Wildlife).

Bush Stone-curlews are dependent on woodland remnants with sparse grass cover and abundant fallen timber and tree litter for daytime roosts and feeding habitat (Johnson and Baker-Gabb 1994). Statewide the species has undergone a significant decline as a result of habitat clearance and fragmentation. Existing threats include predation by foxes and cats, weed invasion, clearing for agriculture and associated activities including pasture improvement, cultivation, irrigation, chemical use, grazing and lack of tree regeneration, and removal of trees and fallen timber (Robinson in prep). Egg collecting and shooting may be minor threats across the species' range but are unlikely to be significant in the Central Highlands (Robinson pers. comm.).

Grey-crowned Babbler

Pomatostomus temporalis

RARITY

a) Geographic Range
- Classification of range size: Small
- Range size within region: (ha): Minimal
- Proportion of region occupied (%): Minimal
  Most recent records from Churchill National Park (1983)
- Source: Atlas of Victorian Wildlife, D. Robinson pers. comm.

b) Abundance
- Classification of abundance: Low
- Population Estimate: Marginal to area-viable populations may no longer occur
- Density: Not applicable
- Home Range (ha): 2-53
- Source: D. Robinson pers. comm., Blakers *et al.* (1984)

c) Habitat Specificity
- Classification of habitat specificity: Narrow
- Vegetation types used in the region: Open forest and woodlands. Rarely recorded in regrowth forests, large forest/woodland patches, forest with dense understorey or sparsely-treed woodland.
- Source: Robinson (1994)

DYNAMICS

Population Trend in Last Decade
- Increasing, stable or declined: Declined
- Source: Robinson (1992)

Population trend since discovery by Europeans
- Increasing, stable or declined: Declined
- Source: Robinson (1992)

SPATIAL DYNAMICS

a) Population variability
- Classification of population variability: Low
- Source: D. Robinson pers. comm.

b) Dispersal
- Classification of powers of dispersal: Low
- Average distances dispersed: < 2 km
- Maximum distance dispersed: 15 km
- Source: D. Robinson pers. comm.

LIFE HISTORY PARAMETERS

a) Reproductive output
- Classification of reproductive output: High
- Age of sexual maturity (yrs): 2-3
- Mean clutch/litter/brood size: 2-3
- Mean no of clutches/litters/broods per year: usually 1
- Time of year young born/hatch: June-February
- Source: Robinson (1994), D. Robinson pers. comm.

b) Longevity
- Classification of lifespan: Long-lived
- Average lifespan (yrs): 4
- Maximum lifespan (yrs): Unknown
- Source: Brown in Robinson (1992), D. Robinson pers. comm.

c) Morphology

Adult body size
- Weight (g): 45
- Length (mm): 230-290
- Source: Robinson (1992), D. Robinson pers. comm.

d) Social organisation
- Colonial or non-colonial: Colonial
- Territoriality: Yes
  Breeding groups consist of a breeding pair and helpers
- Source: Robinson (1994), D. Robinson pers. comm.

e) Other
- Nomadic, migratory, sedentary: Sedentary
- Mode of feeding: Primarily insectivore
- Source: Robinson (1994)

THREATS

1. Fire (planned): Ranking (1) D. Robinson pers. comm., Davidson and Robinson (1992), Adam and Robinson (1996)
2. Fire (unplanned): Ranking (1) D. Robinson pers. comm.
3. Logging: Ranking (1) D. Robinson pers. comm.
4. Introduced Species: Ranking (1) D. Robinson pers. comm.
5. Pest Control: Ranking (-)
6. Grazing: Ranking (1) D. Robinson pers. comm.
7. Disease: Ranking (-)
8. Illegal harvesting: Ranking (-)
9. Non-forestry Clearing: Ranking (1) D. Robinson pers. comm., Davidson and Robinson (1992)
10. Mining/Quarrying: Ranking (-)
11. Roading: Ranking (1) D. Robinson pers. comm.
12 Recreation: Ranking (-)
13. Vandalism/Disturbance by Humans: Ranking (1) D. Robinson pers. comm.
14. Weather: Ranking (-)
15. Other: Tree dieback: Ranking (1) D. Robinson pers. comm**. Firewood collection: Ranking (1)** D. Robinson pers. comm.

Current Management:

The Grey-crowned Babbler is listed under the Victorian *Flora and Fauna Guarantee Act* 1988 and an Action

Statement has been published (Davidson and Robinson 1992). Intended management actions include: research into aspects of the species' ecology, a monitoring program to assess current status of all populations with more than five family groups, production of extension material, determination of critical habitat, provision of funds to private land holders to fence off habitat, investigation of existing management of firewood resources and current fire protection practices and the development of site-specific management to maintain and enhance habitat where possible. A Management Plan for the species is currently being prepared .

Comments: The Grey-crowned Babbler occurs primarily in open forests and woodlands, apparently prefering a mixture of open grassy habitat and stands of trees (Robinson 1994). It is most abundant in strips of mature remnant woodland vegetation where an open ground layer is provided in adjoining paddocks. The species has undergone a decline, with extant populations now largely in northern Victoria (Robinson 1992). In the Central Highlands, a population from Churchill National Park was last recorded in 1983 and may no longer occur there. Existing threats include the fragmentation and degradation of suitable habitat by grazing, removal of fallen timber, tree dieback, predation by foxes and cats, fire protection works (ploughing, burning) along roadsides, weed invasion and mortalities by vehicles (Robinson, pers. comm.).

Square-tailed Kite

Lophoictinia isura

RARITY

a) Geographic Range

- Classification of range size: Large
- Range size within region: (ha): Approximately 400 000 -500 000
- Proportion of region occupied (%): Approximately 50
  There are 12 records for the species on the Atlas of Victorian Wildlife within the Central Highlands
- Source: CNRandAHC (1994), Atlas of Victorian Wildlife

b) Abundance

- Classification of abundance: Low
- Population Estimate: A few pairs.
- Density: Approximately 1 pair/1200km^2, Estimated 20-50 pairs in Victoria
- Home Range (ha): Unknown
- Source: C. Silveria pers. comm., Debus and Silveira (1989), Baker-Gabb in Garnett (1992)

c) Habitat Specificity

- Classification of habitat specificy: Wide
- Vegetation types used in the region: Most forest and woodland EVCs, especially riparian forest. Not recorded from extensively cleared and naturally open areas, alpine areas, mountain ash forest and small forest remnants.
- Source: Debus and Silveira (1989), R. Loyn pers. comm.

DYNAMICS

Population Trend in Last Decade

- Increasing, stable or declined: Unknown
- Source: C. Silveira pers. comm.

Population trend since discovery by Europeans

- Increasing, stable or declined: Possibly declined
- Source: Lumsden *et al.* (1991), C. Silveira pers. comm.

SPATIAL DYNAMICS

a) Population variability

- Classification of population variability: Unknown
- Source: R. Loyn pers. comm.

b) Dispersal

- Classification of powers of dispersal: High
- Average distances dispersed: Capable of moving 100s km
- Maximum distance dispersed: Unknown
- Source: Debus and Silveira (1989)

LIFE HISTORY PARAMETERS

a) Reproductive output

- Classification of reproductive output: Low
- Age of sexual maturity (yrs): 2-3 years
- Mean clutch/litter/brood size: 2-3 eggs
- Mean no of clutches/litters/broods per year: 1
- Time of year young born/hatch: Spring
- Source: Debus and Czechura (1989), Marchant and Higgins (1993)

b) Longevity

- Classification of lifespan: Long-lived
- Average lifespan (yrs): Unknown
- Maximum lifespan (yrs): >15 years
- Source: Marchant and Higgins (1993)

c) Morphology

Adult body size

- Weight (g): Female 590-680, male 501
- Length (mm): Female 550-560, male 500-510
- Source: Olsen *et al.* (1993)

d) Social organisation

- Colonial or non-colonial: Usually seen singly
- Territoriality: Nesting territories
- Source: Debus and Czechura (1989)

e) Other

- Nomadic, migratory, sedentary: Migratory
- Mode of feeding: Mainly carnivore (including young birds from nests)
- Source: Debus and Czechura (1989)

THREATS

1. Fire (planned): Ranking (1) R. Loyn pers. comm.
2. Fire (unplanned): Ranking (2) R. Loyn pers. comm.
3. Logging: Ranking (1) R. Loyn, pers. comm., Debus and Czechura (1989)
4. Introduced Species: Ranking (0)
5. Pest Control: Ranking (0)
6. Grazing: Ranking (1) R. Loyn pers. comm.
7. Disease: Ranking (-)
8. Illegal harvesting: Ranking (1) R. Loyn pers. comm., Jolly (1989)
9. Non-forestry Clearing: Ranking (1) R. Loyn pers. comm., Debus and Czechura (1989)
10. Mining/Quarrying: Ranking (-) R. Loyn pers. comm.
11. Roading: Ranking (1) R. Loyn pers. comm.
12 Recreation: Ranking (0)
13. Vandalism/Disturbance by Humans: Ranking (1) R. Loyn pers. comm., Jolly (1989)
14. Other: Ranking (-)

Current Management:

The Square-tailed Kite is classified as "vulnerable" in Victoria (CNR 1995a). There are no current management prescriptions for the species in the Central Highlands.

Comments: The Square-tailed Kite is a spring-summer visitor to Victoria, and occurs naturally in low densities (Debus and Silveria 1989, C. Silveria pers. comm.). Only a few pairs may occur within the Central Highlands. Its migration is likely to be linked to food availability; the species' main prey is nestling passerines. The Square-tailed Kite is known to use traditional nest sites, and nests in mature living Eucalypts. It relies on an adequate supply of prey and tall trees for nesting, and threats to the species relate to loss or disturbance of these critical resources (Debus and Czechura 1989). In the Central Highlands the highest ranked threat is wildfire which results in loss of habitat and prey. Illegal shooting and egg collection have

been recorded (Jolly 1989) and are minor threats to the species.

Grey Goshawk
Accipiter novaehollandiae

RARITY

a) Geographic Range
- Classification of range size: Medium
- Range size within region: (ha): Unknown, possibly 250 000-600 000
- Proportion of region occupied (%): Unknown, possibly 20-50
- Source: CNRandAHC (1994), Atlas of Victorian Wildlife, R. Loyn pers. comm.

b) Abundance
- Classification of abundance: Low
- Population Estimate: Possibly a few pairs
- Density: Densities of 2-3 pairs/100km^2 in optimum habitat with little disturbance recorded in Tasmania.
- Home Range (ha): Unknown, possibly core areas of about 10km^2
- Source: Mooney and Holdsworth (1988), C. Silveira pers. comm.

c) Habitat Specificity
- Classification of habitat specificity: Wide
- Vegetation types used in the region: Wet forests and gullies (including those containing Mountain Grey Gum), riparian forest, occasionally woodlands, dry forest, suburban parks and wooded farmlands.
- Source: Emison *et al.* (1987), R. Loyn pers. comm.

DYNAMICS

Population Trend in Last Decade
- Increasing, stable or declined: Unknown
- Source: R. Loyn pers. comm.

Population trend since discovery by Europeans
- Increasing, stable or declined: Possibly declined
- Source: Lumsden *et al.* (1991), C. Silveira pers. comm.

SPATIAL DYNAMICS

a) Population variability
- Classification of population variability: Unknown
- Source: R. Loyn pers. comm.

b) Dispersal
- Classification of powers of dispersal: High
- Average distances dispersed: Unknown
- Maximum distance dispersed: Unknown
- Source: R. Loyn pers. comm.

LIFE HISTORY PARAMETERS

a) Reproductive output
- Classification of reproductive output: Low
- Age of sexual maturity (yrs): 2-3 years
- Mean clutch/litter/brood size: 2-4
- Mean no of clutches/litters/broods per year: 1
- Time of year young born/hatch: September-December Mooney and Holdsworth (1988) suggest one third of adults may not breed in any one year
- Source: Burton *et al.* (1994), Marchant and Higgins (1993)

b) Longevity
- Classification of lifespan: Unknown
- Average lifespan (yrs): Unknown
- Maximum lifespan (yrs): Unknown
- Source: R. Loyn pers. comm.

c) Morphology

Adult body size
- Weight (g): Female 530-859, male 283-450
- Length (mm): Female 500-550, male 380-420
- Source: Olsen *et al.* (1993)

d) Social organisation
- Colonial or non-colonial: Monogamous pairs
- Territoriality: Territorial when breeding
- Source: Marchant and Higgins (1993)

e) Other
- Nomadic, migratory, sedentary: Established pairs sedentary
- Mode of feeding: Carnivore, occasional scavenger and insectivore
- Source: Marchant and Higgins (1993)

THREATS

1. Fire (planned): Ranking (1) R. Loyn pers. comm.
2. Fire (unplanned): Ranking (1) R. Loyn pers. comm.
3. Logging: Ranking (2) R. Loyn pers. comm. 4. Introduced Species: Ranking (0)
5. Pest Control: Ranking (2) R. Loyn pers. comm.
6. Grazing: Ranking (-)
7. Disease: Ranking (-)
8. Illegal harvesting: Ranking (-)
9. Non-forestry Clearing: Ranking (1) R. Loyn pers. comm.
10. Mining/Quarrying: Ranking (-)
11. Roading: Ranking (1) R. Loyn, pers. comm.
12 Recreation: Ranking (1) R. Loyn pers. comm.
13. Vandalism/Disturbance by Humans: Ranking (1) R. Loyn pers. comm.
14. Other: Ranking (-)

Current Management:

The Grey Goshawk is classified as "rare" in Victoria (CNR 1995a). There are no current management prescriptions for the species in the Central Highlands.

Comments: The Grey Goshawk is rarely recorded in the Central Highlands and the population possibly consists of only a few pairs. In Tasmania, adult Grey Goshawks are known to primarily use old growth wet forests for hunting and nesting. Some birds may also nest in mixed-age or young regrowth forest if old growth trees are present (Mooney and Holdsworth 1988, Brereton and Mooney 1994). Suitable sheltered perches for hunting may also be important. The loss and modification of such habitat by logging and clearing for agriculture and development is likely to be detrimental to the species (Brereton and Mooney 1994). While the species may tolerate some level of disturbance near nest sites (eg. selective logging, limited road building), nests are deserted following intense/direct disturbance (Mooney and Holdsworth 1988).

In the Central Highlands loss of habitat as a result of logging is a moderate threat to the Grey Goshawk (R. Loyn pers. comm.). In Victoria the species is known to take rabbits in farmland near forest edges, and reduction of rabbit numbers through pest control measures may have an adverse affect on the population (R. Loyn pers comm). Illegal shooting of birds is considered a significant threat in Tasmania (Brereton and Mooney 1994) but is not likely to be significant in the Central Highlands. Other minor threats including secondary poisoning through consumption of baited prey and contamination by pesticides (Mooney 1988, Mooney and Holdsworth 1988).

White-bellied Sea-Eagle
Haliaeetus leucogaster

RARITY

a) Geographic Range
- Classification of range size: Unknown, possibly large
- Range size within region: (ha): Unknown
- Proportion of region occupied (%): Unknown
  There are less than 30 records of the species within the Central Highlands. While the species can range widely and occur in a wide range of habitats, its use of the Central Highlands is largely unknown.

- Source: Atlas of Victorian Wildlife, P. Clunie pers. comm.

b) Abundance
- Classification of abundance: Low
- Population Estimate: Unknown
  Only one known breeding pair currently known within Central Highlands.
  Possibly 100 breeding pairs or less in Victoria
- Density: Unknown. Estimates for other areas of Victoria vary greatly
- Home Range (ha): Unknown in Victoria.
- Source: R. Bilney pers. comm., Clunie (1994), Atlas of Victorian Wildlife

c) Habitat Specificity
- Classification of habitat specificity: Wide
- Vegetation types used in the region: Usually nests near water, in tall live or dead trees (including River Red Gum *Eucalyptus camaldulensis*, Forest Red Gum *E. tereticornis* and Southern Mahogany *E. botryoides*). Usually tall open forest and woodland, may occur in open areas (grassland, heath) and urban areas, rarely within dense vegetation.
- Source: Emison and Bilney (1982), Marchant and Higgins (1993)

DYNAMICS

Population Trend in Last Decade
- Increasing, stable or declined: Unknown
- Source: P. Clunie pers. comm.

Population trend since discovery by Europeans
- Increasing, stable or declined: Declined
  Decline over coastal range could be presumed due to clearing
- Source: Lumsden *et al.* (1991), Clunie (1994)

SPATIAL DYNAMICS

a) Population variability
- Classification of population variability: Low
- Source: P. Clunie pers. comm.

b) Dispersal
- Classification of powers of dispersal: High
  Immature birds may disperse widely
- Average distances dispersed: Unknown
- Maximum distance dispersed: Unknown
- Source: Emison *et al.* (1987)

LIFE HISTORY PARAMETERS

a) Reproductive output
- Classification of reproductive output: Low
- Age of sexual maturity (yrs): 4-5 years
- Mean clutch/litter/brood size: 1-2 eggs
- Mean no of clutches/litters/broods per year: 1
- Time of year young born/hatch: July-October (in Gippsland Lakes area)
- Source: Bilney and Emison (1983), Mooney (1986)

b) Longevity
- Classification of lifespan: Long-lived
- Average lifespan (yrs): Unknown
- Maximum lifespan (yrs): Unknown, possibly 17 years
- Source: Mooney (1986)

c) Morphology

Adult body size
- Weight (g): Female 3100-3900g, male 2000-2420g
- Length (mm): Female 800-850mm, male 750-770mm
- Source: Olsen *et al.* (1993)

d) Social organisation
- Colonial or non-colonial: Generally alone or in pairs
- Territoriality: Defend small territory around nest during breeding season
- Source: Marchant and Higgins (1993)

e) Other
- Nomadic, migratory, sedentary: Sedentary, established pairs
- Mode of feeding: Carnivore, opportunistic
- Source: Marchant and Higgins (1993)

THREATS

1. Fire (planned): Ranking (-) P. Clunie pers. comm.
2. Fire (unplanned): Ranking (-)
3. Logging: Ranking (1) P. Clunie, pers. comm.
4. Introduced Species: Ranking (0)
5. Pest Control: Ranking (1) P. Clunie pers. comm.
6. Grazing: Ranking (-)
7. Disease: Ranking (-)
8. Illegal harvesting: Ranking (0)
9. Non-forestry Clearing: Ranking (1) P. Clunie, pers. comm.
10. Mining/Quarrying: Ranking (-) P. Clunie, pers. comm.
11. Roading: Ranking (-) P. Clunie, pers. comm.
12 Recreation: Ranking (1) P. Clunie, pers. comm.
13. Vandalism/Disturbance by Humans: Ranking (2) P. Clunie pers. comm.
14. Other: Interspecific competition Ranking (1) Wiersma (1996).

Current Management:

The White-bellied Sea-Eagle is listed under the *Flora and Fauna Guarantee Act* 1988 and an Action Statement has been prepared (Clunie 1994). Intended management actions include: annual surveys of known beeding sites to determine breeding success over time, identify population trends, determine critical habitat, encourage research particularly in relation to heavy metal levels in the species and the effect of food chain contamination on survival and reproduction, undertake a population viability analysis once more information is known about dispersal activity, and the protection of known nest sites including buffer zones which will be incorporated into Forest Management Plans and encourage protection of breeding sites on private land through extension programs or conservation covenants.

Comments: White-bellied Sea-Eagles occur in low densities over much of Victoria. They are most common along the coast from Gabo Island to Wilsons Promontory, with birds also occuring along the Murray and Goulburn Rivers and sometimes over inland areas with impoundments. The species is found in a range of habitat types, and usually nests near water in tall live or dead trees. There are few records of the species from the Central Highlands, only one breeding pair is currently known.

White-bellied Sea-Eagles are sensitive to disturbance, particularly during the breeding season when disturbance can lead to reduced breeding success (Dennis and Lashmar 1996). As a result activities including recreation, mining, logging and agriculture which disturb or encroach into its habitat represent a threat. Loss of habitat components such as nest trees also represent a threat (Mooney 1986). Birds may nest in suboptimal habitat but under these conditions breeding success can be reduced (Bilney and Emison 1983). Eggshell thinning has been recorded due to past DDT use; while this may not have caused significant population declines (Olsen *et al.* 1993a), it is an issue to be considered. Deliberate shooting has been recorded (Mooney 1986) although is unlikely to be a significant threat within the Central Highlands. The significance of poisoning (direct or secondary), and food chain contamination by heavy metals is also unknown. Competition with Wedge-tailed Eagles for nest sites and food has been recorded (Wiersma 1996), although its significance is unclear.

Barking Owl

Ninox connivens

RARITY

a) Geographic Range

- Classification of range size: Medium
- Range size within region: (ha): Unknown, possibly 200 000-500 000
- Proportion of region occupied (%): Unknown, possibly < 10
  There are approximately 50 records post 1980 within the Central Highlands, although very few breeding records. Misidentification is a significant issue.
  Source: Atlas of Victorian Wildlife, CNR and AHC (1994), R. Loyn pers. comm.

b) Abundance
- Classification of abundance: Low
- Population Estimate: Unknown, probably < 10 pairs
  Population estimate of < 100 pairs in Victoria
- Density: Unknown
- Home Range (ha): Approximately 100ha
- Source: P. Peake pers. comm. in Robinson (1994), R. Loyn pers. comm.

c) Habitat Specificity
- Classification of habitat specificity: Narrow
- Vegetation types used in the region: Dry forest and woodlands, open forest and wooded farmlands. Particularly near riverine and swampy areas. Rarely wet forest and then usually only near clearings.
- Source: Emison *et al.* (1987), Schodde and Mason (1980), Kavanagh *et al.* (1995)

DYNAMICS

Population Trend in Last Decade
- Increasing, stable or declined: Unknown
- Source: R. Loyn pers. comm.

Population trend since discovery by Europeans
- Increasing, stable or declined: Possible decline
  Clearing and degradation of habitat for agriculture
- Source: Lumsden *et al.* (1991), Robinson (1991)

SPATIAL DYNAMICS

a) Population variability
- Classification of population variability: Low
- Source: R. Loyn pers. comm.

b) Dispersal
- Classification of powers of dispersal: Probably high
- Average distances dispersed: Unknown
- Maximum distance dispersed: Unknown
  Some may be dispersive, linked to fluctuations in food
- Source: Robinson (1994), R. Loyn pers. comm.

LIFE HISTORY PARAMETERS

a) Reproductive output
- Classification of reproductive output: Low
- Age of sexual maturity (yrs): > 2 years
- Mean clutch/litter/brood size: 1-3 eggs
- Mean no of clutches/litters/broods per year: 1
- Time of year young born/hatch: July-November
- Source: Schodde and Mason (1980), Robinson (1994)

b) Longevity
- Classification of lifespan: Possibly long-lived
- Average lifespan (yrs): Unknown
- Maximum lifespan (yrs): Unknown
- Source: R. Loyn pers. comm.

c) Morphology

Adult body size
- Weight (g): 425-485 females, 425-510 males
- Length (mm): 370-440 females, 350-450 males
- Source: Schodde and Mason (1980)

d) Social organisation
- Colonial or non-colonial: Breeding pairs
- Territoriality: Yes
- Source: Schodde and Mason (1980)

e) Other
- Nomadic, migratory, sedentary: Sedentary
- Mode of feeding: Carnivore, insectivore
- Source: Schodde and Mason (1980)

THREATS

1. Fire (planned): Ranking (-)
2. Fire (unplanned): Ranking (-)
3. **Logging: Ranking (-)** R. Loyn pers. comm.
4. Introduced Species: Ranking (0) R. Loyn pers. comm.
5. **Pest Control: Ranking (1)** R. Loyn pers. comm.
6. **Grazing: Ranking (2)** R. Loyn pers. comm.
7. Disease: Ranking (-)
8. Illegal Harvesting: Ranking (0) R. Loyn pers. comm.
9. **Non-forestry Clearing: Ranking (2)** R. Loyn pers. comm., Robinson (1994).
10. Mining/Quarrying: Ranking (-)
11. Roading: Ranking (-)
12 Recreation: Ranking (-)
13. Vandalism/Disturbance by Humans: Ranking (-)
14. Other: Ranking (-)

Current Management:

The Barking Owl has received a final recommendation for listing under the Victorian *Flora and Fauna Guarantee Act* 1988.

Comments: There are approximately 50 post-1980 records and four breeding records of Barking Owls within the Central Highlands. However, misidentification of the species is a significant issue (R. Loyn, pers. comm.) and this is likely to be an overestimate. Recent surveys within the Central Highlands covering all forest types, failed to record this species (R. Loyn pers. comm.). Barking Owls are conspicuous birds which range widely, and densities are likely to be low (R. Loyn pers. comm.).

The Barking Owl is mainly recorded in dry, open forest and woodlands and wooded farmlands; frequently in habitat with moderate tree cover including wooded farmland near forests or along ecotones of large forest blocks (Emison *et al.* 1987, P. Peake pers. comm. in Robinson 1994). The species appears to have a preference for hunting in open habitat (Robinson 1994) but may roost among dense vegetation. Birds primarily nest in large, hollow-bearing trees (Schodde and Mason 1980).

Loss and fragmentation of habitat through clearing is a moderate threat to Barking Owls in the Central Highlands. The species is known to utilise broad strips of riverine forest along major creeks however, isolated, narrow strips of linear habitat do not appear to be used (Robinson 1994). Kavanagh *et al*. (1995) suggest the Barking Owl may be tolerant to intermediate levels of disturbance.

Reduced availability of large hollow-bearing trees as a result of logging and lack of habitat regeneration due to grazing which will limit future habitat availability are minor threats to the Barking Owl. Rabbits can be an important food source (P. Peake, pers. comm. in Robinson 1994), and the implications of pest control are unknown. However, Kavangh *et al.* (1995) suggest the species has a wide dietary flexibility.

Powerful Owl

Ninox strenua

RARITY

a) Geographic Range
- Classification of range size: Large
- Range size within region (ha): 520 000
- Proportion of region occupied (%): 40
- Source: Atlas of Victorian Wildlife

b) Abundance
- Classification of abundance: Low
- Population Estimate: 40-120 pairs
- Density: Unknown
- Home Range (ha): 300 - >1000, dependent on habitat and availability of prey

- Source: McNabb (1996), Seebeck (1976)

c) Habitat Specificity
- Classification of habitat specificity: Wide
- Vegetation types used in the region: Damp Forest, Riparian Forest, Heathy Dry Forest, Floodplain Riparian Woodland, recent survey will add to this information
- Source: Lumsden *et al.* (1991)

DYNAMICS

Population Trend in Last Decade
- Increasing, stable or declined: Stable
- Source: R. Loyn per. comm.

Population trend since discovery by Europeans
- Increasing, stable or declined: Declined
- Source: Lumsden *et al.* (1991)

SPATIAL DYNAMICS

a) Population variability
- Classification of population variability: Low
- Source: R. Loyn pers. comm.

b) Dispersal
- Classification of powers of dispersal: High
- Average distances dispersed: Unknown
- Maximum distance dispersed: Unknown
- Source: Schodde and Mason (1980)

LIFE HISTORY PARAMETERS

a) Reproductive output
- Classification of reproductive output: Low
- Age of sexual maturity (yrs): 2, in captivity, in the wild age at first breeding may be later due to the hunting skills required by the male to provide for the female and offspring.
- Mean clutch/litter/brood size: 1.4
- Mean no of clutches/litters/broods per year: 1
- Time of year young born/hatch: June, July
- Source: Fleay (1968), Schodde and Mason (1980), Debus and Chafer (1994), McNabb (1996)

b) Longevity
- Classification of lifespan: Long-lived
- Average lifespan (yrs): Unknown
- Maximum lifespan (yrs): > 20
- Source: Brouwer and Garnett (1990)

c) Morphology

Adult body size
- Weight (g): 1050-1600 females, 1130-1700 males
- Length (mm): 450-540 females, 480-650 males
- Source: Schodde and Mason (1980)

d) Social organisation
- Colonial or non-colonial: Non-colonial
- Territoriality: Territorial
- Source: Schodde and Mason (1980)

e) Other
- Nomadic, migratory, sedentary: Sedentary
- Mode of feeding: Carnivore (predominantly arboreal mammals)
- Source: Tilley (1982), Lavazanian *et al.* (1994)

THREATS

1. Fire (planned): Ranking (1) Debus and Chafer (1994), R. Loyn pers. comm.

2. Fire (unplanned): Ranking (2) Debus and Chafer (1994), R. Loyn pers. comm.

3. Logging: Ranking (3) Garnett (1992), Davey (1993), Collar *et al.* (1994), Debus and Chafer (1994), Kavanagh and Bamkin (1995), R. Loyn pers. comm.

4. Introduced Species: Ranking (1) R. Loyn pers. comm.

5. Pest Control: Ranking (0) R. Loyn pers. comm.

6. Grazing: Ranking (1) R. Loyn pers. comm.

7**. Disease: Ranking (1)** R. Loyn pers. comm.

8.Illegal Harvesting: Ranking (0) R. Loyn pers. comm.

9. Non-forestry Clearing: Ranking (3) Collar *et al.* (1994), R. Loyn pers. comm.

10. Mining/Quarrying: Ranking (1)R. Loyn pers. comm.

11. Roading: Ranking (-) R. Loyn pers comm.

12 Recreation: Ranking (0) R. Loyn pers. comm.

13. Vandalism/Disturbance by Humans: Ranking (1) Quinn (1993), R. Loyn pers. comm.

14. Other : Ranking (0)

Current Management:.

The Powerful Owl is listed under the Victorian *Flora and Fauna Guarantee Act* 1988. There are no current management prescriptions for this species in the Central Highlands. The LCC (1993) recommends protection of the species within the Central Forest Management Area

Comments: The Powerful Owl is Australia's largest owl species. It is an opportunistic predators, arboreal mammals composing the bulk of the diet (Tilley 1982, Lavazanian *et al.* 1994). During the day the Powerful Owl roosts in the tree canopy. It requires large tree hollows for breeding. Breeding pairs of Powerful Owls occupy large permanent territories (300-1000ha) that contain a number of roost sites and nest trees (McNabb 1996).

Recent playback surveys by the Department of Natural Resources and Environment within the Central Highlands (between Gembrook and Eildon) located the Powerful Owl at 25 sites. The total number of sites surveyed was 273 (R. Loyn pers. comm.).

Threats to this species include any disturbance that reduces the availability of nest sites or the number of prey. Logging is considered a major threat in the Central Highlands. Widespread wildfire can result in loss of habitat and reduce prey availability (Debus and Chafer 1994) and is considered a moderate threat (R. Loyn pers. comm.). Human disturbance of nest sites during the breeding season and competition for nest hollows by Starlings and Mynas in areas close to human habitation, are minor threats to the species (R. Loyn pers. comm.).

Masked Owl

Tyto novaehollandiae

RARITY

a) Geographic Range
- Classification of range size: Small
- Range size within region: (ha): 90 000
- Proportion of region occupied (%): 8
- Source: Atlas of Victorian Wildlife

b) Abundance
- Classification of abundance: Low
- Population Estimate: 15-20 pairs
- Density: Unknown
- Home Range (ha): 1017-1178, from radiotracking one female
- Source: Kavanagh and Murray (1996), R. Loyn pers. comm.

c) Habitat Specificity
- Classification of habitat specificity: Unknown
- Vegetation types used in the region: Generally found in lowland forests, most records from ecotones
- Source: Peake *et al.* (1993)

DYNAMICS

Population Trend in Last Decade
- Increasing, stable or declined: Unknown
- Source: R. Loyn pers. comm.

Population trend since discovery by Europeans
- Increasing, stable or declined: Unknown
- Source: R. Loyn pers. comm.

SPATIAL DYNAMICS

a) Population variability
- Classification of population variability: Unknown
- Source: R. Loyn pers. comm.

b) Dispersal
- Classification of powers of dispersal: High

- Average distances dispersed: Unknown
- Maximum distance dispersed: Unknown
- Source: Schodde and Mason (1980)

LIFE HISTORY PARAMETERS

a) Reproductive output

- Classification of reproductive output: Low
- Age of sexual maturity (yrs): Unknown
- Mean clutch/litter/brood size: 1-3 typically survive to fledge (2-4 eggs laid)
- Mean no of clutches/litters/broods per year: < 1
- Time of year young born/hatch: April - November
- Source: Schodde and Mason (1980), Hollands (1991), Debus (1993), Olsen and Marples (1993), Peake *et al.* (1993), Kavanagh (1996).

b) Longevity

- Classification of lifespan: Long-lived
- Average lifespan (yrs): Unknown
- Maximum lifespan (yrs): Unknown
- Source: R. Loyn per. comm.

c) Morphology

Adult body size

- Weight (g): 545-800 females, 420-670 males
- Length (mm): 380-460 females, 330-410 males
- Source: Schodde and Mason (1980)

d) Social organisation

- Colonial or non-colonial: Non-colonial
- Territoriality: Territorial
- Source: Schodde and Mason (1980)

e) Other

- Nomadic, migratory, sedentary: Sedentary
- Mode of feeding: Carnivore (terrestrial prey dominant)
- Source: Schodde and Mason (1980), Kavanagh and Murray (1996)

THREATS

1. Fire (planned): Ranking (1) R. Loyn pers. comm.
2. Fire (unplanned): Ranking (1) Garnett 1992, R. Loyn pers. comm.
3. Logging: Ranking (2) Debus and Rose 1992, Garnett 1992, R. Loyn pers. comm.
4. Introduced Species: Ranking (3) R. Loyn pers. comm.
5. Pest Control: Ranking (2) Peake *et al.* (1993), Czechura pers. comm. in Garnett (1992), R. Loyn pers. comm.
6. Grazing: Ranking (1) R. Loyn pers. comm.
7. Disease: Ranking (-) R. Loyn pers. comm.
8. Illegal Harvesting: Ranking (0) R. Loyn pers. comm.
9. Non-forestry Clearing: Ranking (3) Debus (1993), Garnett (1992), R. Loyn pers. comm.
10. Mining/Quarrying: Ranking (1) R. Loyn pers. comm.
11. Roading: Ranking (-) R. Loyn pers. comm.
12 Recreation: Ranking (0) R. Loyn pers. comm.
13. Vandalism/Disturbance by Humans: Ranking (1) R. Loyn pers. comm.
14. Other : Ranking (0)

Current Management:.

The Masked Owl is listed under the Victorian *Flora and Fauna Guarantee Act* 1988. There are currently no management prescriptions for the species in the Central Highlands.

Comments: The Masked Owl is a rarely recorded species which requires trees with large hollows for daytime roosting and breeding. Caves may also be used if present. Terrestrial mammals form the greater part of the Masked Owls diet but arboreal mammals are also eaten. Breeding pairs occupy large permanent territories (>1000ha) (Kavanagh and Murray 1996).

Recent surveys by the Department of Natural Resources and Environment within the Central Highlands (between Eildon and Gembrook) recorded Masked Owl at only 2 of 273 sites. These sites were within Bunyip State Park and Lake Eildon National Park (R. Loyn pers. comm.). Although Masked Owls are cryptic and do not readily respond to playback (Debus 1995), the survey indicates the species is rare in the Central Highlands.

Introduced species, particularly foxes, may be competing for prey with the Masked Owl and may be a major threat to the species (R. Loyn pers. comm.). Logging and mining are considered moderate threats to the species in the Central Highlands as they result in loss of habitat including important roost and nest trees. Pest control is considered a moderate threat as it results in a reduction in the availability of prey, particularly rabbits, and the risk of secondary poisoning following rabbit control programs and rat baiting (Peak *et al.* 1993, R. Loyn pers. comm.). The possible effects of loss of prey due to rabbit calicivirus are unknown.

Sooty Owl

Tyto tenebricosa

RARITY

a) Geographic Range

- Classification of range size: Large
- Range size within region: (ha): 520 000
- Proportion of region occupied (%): 40
- Source: Atlas of Victorian Wildlife

b) Abundance

- Classification of abundance: Low
- Population Estimate: 70-200
- Density: Unknown
- Home Range (ha): 200-800
- Source: Schodde and Mason (1980), R. Loyn pers. comm.

c) Habitat Specificity

- Classification of habitat specificity: Narrow
- Vegetation types used in the region: Montane Wet Forest, Montane Damp Forest, Wet Forest, Riparian Forest
- Source: Lumsden *et al.* (1991)

DYNAMICS

Population Trend in Last Decade

- Increasing, stable or declined: Unknown
- Source: R. Loyn pers. comm.

Population trend since discovery by Europeans

- Increasing, stable or declined: Possibly declined (based on known habitat)
- Source: Lumsden *et al.* (1991), Debus (1993)

SPATIAL DYNAMICS

a) Population variability

- Classification of population variability: Low
- Source: R. Loyn pers. comm.

b) Dispersal

- Classification of powers of dispersal: High
- Average distances dispersed: Unknown
- Maximum distance dispersed: Unknown
- Source: Schodde and Mason (1980)

LIFE HISTORY PARAMETERS

a) Reproductive output

- Classification of reproductive output: Low
- Age of sexual maturity (yrs): Probably 2
- Mean clutch/litter/brood size: 2
- Mean no of clutches/litters/broods per year: 1
- Time of year young born/hatch: all year round
- Source: Schodde and Mason (1980), R. Loyn and E. McNabb pers. comm.

b) Longevity

- Classification of lifespan: Long-lived
- Average lifespan (yrs): Unknown

- Maximum lifespan (yrs): Unknown
- Source: R. Loyn pers. comm.

c) Morphology

Adult body size

- Weight (g): 750-1000 females, 500-700 males
- Length (mm): 440-510 females, 370-430 males
- Source: Shodde and Mason (1980)

d) Social organisation

- Colonial or non-colonial: Non-colonial
- Territoriality: Territorial
- Source: Schodde and Mason (1980)

e) Other

- Nomadic, migratory, sedentary: Sedentary
- Mode of feeding: Carnivore (terrestrial and arboreal mammals)
- Source: Schodde and Mason (1980), Lundie-Jenkins (1992)

THREATS

1. Fire (planned): Ranking (1) R. Loyn pers. comm.
2. Fire (unplanned): Ranking (2) R. Loyn pers. comm.
3. Logging: Ranking (3) Milledge *et al.* (1991), Garnett (1992), Davey (1993), Debus (1994), R. Loyn pers. comm.
4. Introduced Species: Ranking (0) R. Loyn pers. comm.
5. Pest Control: Ranking (1) R. Loyn pers. comm.
6. Grazing: Ranking (0) R. Loyn pers. comm.
7. Disease: Ranking (-) R. Loyn pers. comm.
8. Illegal Harvesting: Ranking (0) R. Loyn pers. comm.
9. Non-forestry Clearing: Ranking (1) R. Loyn pers. comm.
10. Mining/Quarrying: Ranking (1) R. Loyn pers. comm.
11. Roading: Ranking (1) R. Loyn pers. comm.
12 Recreation: Ranking (0) R. Loyn pers. comm.
13. Vandalism/Disturbance by Humans: Ranking (1) R. Loyn pers. comm.
14. Other : Enhanced Greenhouse Effect Ranking (2) Bennett *et al.* 1991, R. Loyn pers. comm.

Current Management:.

The Sooty Owl is listed under the Victorian *Flora and Fauna Guarantee Act* 1988. There are no current management actions for the species in the Central highlands.

Comments: The Sooty Owl is a specialist inhabitant of nutrient rich, wet forests (Lumsden *et al*. 1991, Milledge *et al*. 1991). Large trees with hollows are required for roosting and breeding; caves may also be used if available. Sooty Owls feed on both arboreal and terrestrial mammals (Schodde and Mason 1980).

The Central Highlands and East Gippsland appear to be the Victorian stronghold of the Sooty Owl. Within the Central Highlands much of the species' preferred habitat appears to be Mountain Ash forest. In these forests large areas of old growth provide optimal habitat with numerous suitable tree hollows and abundant prey (Milledge *et al.* 1991). During recent surveys by the Department of Natural Resources and Environment (within the Central Highlands (between Eildon and Gembrook) the Sooty Owl was recorded at 37 of 273 surveyed sites. These birds were located mainly in Wet Forest, but records were not confined to gullies (R. Loyn pers. comm.).

The Wet Forests of the Central Highlands are a valued timber resource and loss of habitat as a consequence of logging is a major threat to the Sooty Owl. Logging results in a reduction in the availability of tree hollows and consequently the abundance of prey (Milledge *et al.* 1991, Garnett 1992, Davey 1993, Debus 1994, R. Loyn pers. comm.). Extensive wildfire also reduces hollow availability and prey abundance and is a moderate threat to the species (R. Loyn pers. comm.). Habitat alteration as a consequence of the Enhanced Greenhouse Effect is a moderate threat to the species (Bennet *et al.* 1991, R. Loyn pers. comm.).

3. REPTILES

Glossy Grass Skink

Pseudemoia rawlinsoni

RARITY

a) Geographic Range

- Classification of range size: Small
- Range size within region: (ha): Unknown
- Proportion of region occupied (%): Possibly < 1
- Source: Atlas of Victorian Wildlife, P. Robertson pers. comm.

b) Abundance

- Classification of abundance: Low
- Population Estimate: Unknown
- Density: Unknown
- Home Range (ha): Unknown
- Source: P. Robertson pers. comm.

c) Habitat Specificity

- Classification of habitat specificity: Narrow
- Vegetation types used in the region: Wetland Complex, Wet Heathland, Swamp Heathland
- Source: CNR and AHC (1994), P. Robertson pers. comm.

DYNAMICS

Population Trend in Last Decade

- Increasing, stable or declined: Unknown, possibly stable
- Source: P. Robertson pers. comm.

Population trend since discovery by Europeans

- Increasing, stable or declined: Declined Declined due to reduction in habitat as a result of clearing for agricultural development
- Source: P. Robertson pers. comm.

SPATIAL DYNAMICS

a) Population variability

- Classification of population variability: Low
- Source: P. Robertson pers. comm.

b) Dispersal

- Classification of powers of dispersal: Low
- Average distances dispersed: Unknown
- Maximum distance dispersed: Unknown
- Source: P. Robertson pers. comm.

LIFE HISTORY PARAMETERS

a) Reproductive output

- Classification of reproductive output: Low
- Age of sexual maturity (yrs): 1-3 years
- Mean clutch/litter/brood size: 4-8 young
- Mean no of clutches/litters/broods per year: 1
- Time of year young born/hatch: December-February
- Source: Hutchinson and Donnellan (1988), P. Robertson pers. comm.

b) Longevity

- Classification of lifespan: Unknown
- Average lifespan (yrs): Unknown
- Maximum lifespan (yrs): Unknown
- Source: P. Robertson pers. comm.

c) Morphology

Adult body size

- Weight (g): Unknown
- Length (mm): 40-61 females, 37-63 males
- Source: Hutchinson and Donnellan (1988)

d) Social organisation

- Colonial or non-colonial: Non-colonial
- Territoriality: None observed, unlikely
- Source: P. Robertson pers. comm.

e) Other

- Nomadic, migratory, sedentary: Sedentary
- Mode of feeding: Insectivore
- Source: P. Robertson pers. comm.

THREATS

1. Fire (planned): Ranking (1) P. Robertson pers. comm.
2. Fire (unplanned): Ranking (1) P. Robertson pers. comm.
3. Logging: Ranking (1) P. Robertson pers. comm.
4. Introduced Species: Ranking (1) P. Robertson pers. comm.
5. Pest Control: Ranking (0)
6. Grazing: Ranking (2) P. Robertson pers. comm.
7. Disease: Ranking (-)
8. Illegal harvesting: Ranking (0)
9. Non-forestry Clearing: Ranking (2) P. Robertson pers. comm.
10. Mining/Quarrying: Ranking (-)
11. Roading: Ranking (1) P. Robertson pers. comm.
12 Recreation: Ranking (0)
13. Vandalism/Disturbance by Humans: Ranking (0)
14. Other: Impoundments: Ranking (1) (P. Robertson pers. comm.

Current Management:

The Glossy Grass Skink is classified as "insufficiently known" in Victoria (CNR 1995a). There are no current management prescriptions for the species in the Central Highlands.

Comments: The Glossy Grass Skink is known from areas with humid microenvironments (Hutchinson and Donnellan 1988) and occurs in swampland and heathland vegetation in the Central Highlands. Areas where the species has been recorded include Yan Yean, Whittlesea, Gembrook and Burleigh (Atlas of Victorian Wildlife, P. Robertson pers. comm.).

The habitat of the Glossy Grass Skink is characterised by dense vegetation within which animals bask and forage (Hutchinson and Donnellan 1988). Habitat alteration resulting from inappropriate fire regimes and wildfire are potential threats (P. Robertson pers. comm.) although only minor within the Central Highlands. Other threats include habitat loss through grazing, clearing and drainage of suitable habitat and changes to hydrological regimes within drainage lines and swamps as a result of logging and associated roading activities (P. Robertson pers. comm.).

Swamp Skink

Egernia coventryi

RARITY

a) Geographic Range

- Classification of range size: Small
- Range size within region: (ha): < 10 000
- Proportion of region occupied (%): < 1
- Source: Atlas of Victorian Wildlife, P. Robertson pers. comm.

b) Abundance

- Classification of abundance: Low
- Population Estimate: Unknown
- Density: 50 animals per ha
- Home Range (ha): possibly 10m, estimate for mark-recapture $5m^2$
- Source: P. Robertson pers. comm.

c) Habitat Specificity

- Classification of habitat specificity: Narrow
- Vegetation types used in the region: Riparian Thicket, Wet Heathland, Swamp Heathland, Wetland Complex
- Source: CNR and AHC (1994), P. Robertson pers. comm.

DYNAMICS

Population Trend in Last Decade

- Increasing, stable or declined: Probably stable
- Source: P. Robertson pers. comm.

Population trend since discovery by Europeans

- Increasing, stable or declined: Declined
  Declined due to habitat clearance
- Source: P. Robertson pers. comm.

SPATIAL DYNAMICS

a) Population variability

- Classification of population variability: Low
- Source: P. Robertson pers. comm.

b) Dispersal

- Classification of powers of dispersal: Low
- Average distances dispersed: <5m
- Maximum distance dispersed: Unknown
- Source: P. Robertson pers. comm.

LIFE HISTORY PARAMETERS

a) Reproductive output

- Classification of reproductive output: Low
- Age of sexual maturity (yrs): 2-3 years
- Mean clutch/litter/brood size: 2-6 young, usually 3
- Mean no of clutches/litters/broods per year: 1
- Time of year young born/hatch: January-February
- Source: Roberston (1980), P. Robertson pers. comm.

b) Longevity

- Classification of lifespan: Probably long-lived
- Average lifespan (yrs): Approximately 10 years
- Maximum lifespan (yrs): Unknown
- Source: P. Robertson pers. comm.

c) Morphology

Adult body size

- Weight (g): 25-28g
- Length (mm): 100mm (snout-vent)
- Source: Cogger (1995), P. Robertson pers. comm.

d) Social organisation

- Colonial or non-colonial: Non-colonial
- Territoriality: Yes, aggressive to conspecifics, especially males
- Source: P. Robertson pers. comm.

e) Other

- Nomadic, migratory, sedentary: Sedentary
- Mode of feeding: Primarily insectivore, up to 20-50% plant material
- Source: Douch (1994)

THREATS

1. Fire (planned): Ranking (1) P. Robertson pers. comm., Gillespie *et al.* (1992)
2. Fire (unplanned): Ranking (1) P. Robertson pers. comm., Gillespie *et al.* (1992)
3. Logging: Ranking (1) P. Robertson pers. comm.
4. Introduced Species: Ranking (1) P. Robertson pers. comm.
5. Pest Control: Ranking (0)
6. Grazing: Ranking (1) P. Robertson pers. comm.
7. Disease: Ranking (-)
8. Illegal harvesting: Ranking (0)
9. Non-forestry Clearing: Ranking (1) including drainage of swamps P. Robertson pers. comm., Lumsden *et al.* (1991)
10. Mining/Quarrying: Ranking (-)
11. Roading: Ranking (1) P. Robertson pers. comm., Gillespie *et al.* (1992)
12 Recreation: Ranking (0)
13. Vandalism/Disturbance by Humans: Ranking (0)
14. Other: Ranking (-)

Current Management:

The Swamp Skink is classified as "rare" in Victoria (CNR 1995a). There are no current management prescriptions for the species in the Central Highlands.

Comments: The Swamp Skink occurs in swampland and heathland vegetation in the Central Highlands. Areas where the species has been recorded include Yellingbo, Olinda State Park and near Mt Tanjil (Atlas of Victorian Wildlife, P. Robertson pers. comm.). The species shelters in burrows (Robertson 1980), and exposed logs may be used as basking sites and for shelter (Smales 1981). Gillespie *et al.* (1992) note that in East Gippsland the species appears to be dependent on late successional stages of riparian scrub and coastal heathland. They suggest inappropriate fire regimes and wildfires represent a threat, as does road construction which could affect hydrological regimes. Alienation or drainage of swamps could also threaten the species (Lumsden *et al.* 1991). In the Central Highlands the identified threats are relatively minor.

Alpine Bog Skink

Pseudemoia cryodroma

RARITY

a) Geographic Range

- Classification of range size: Small
- Range size within region: (ha): <10 000
- Proportion of region occupied (%): < 1
- Source: Atlas of Victorian Wildlife, P. Robertson pers. comm.

b) Abundance

- Classification of abundance: Low
- Population Estimate: Unknown
- Density: Unknown
- Home Range (ha): Unknown
- Source: P. Robertson pers. comm.

c) Habitat Specificity

- Classification of habitat specificity: Narrow
- Vegetation types used in the region: Wet Subalpine Heathland
- Source: CNR and AHC(1994)

DYNAMICS

Population Trend in Last Decade

- Increasing, stable or declined: Possibly declined
  Appears to have declined at one site due to resort development
- Source: P. Robertson pers. comm.

Population trend since discovery by Europeans

- Increasing, stable or declined: Unknown
- Source: P. Robertson pers. comm.

SPATIAL DYNAMICS

a) Population variability

- Classification of population variability: Low
- Source: P. Robertson pers. comm.

b) Dispersal

- Classification of powers of dispersal: Low
- Average distances dispersed: Unknown
- Maximum distance dispersed: Unknown
- Source: P. Robertson pers. comm.

LIFE HISTORY PARAMETERS

a) Reproductive output

- Classification of reproductive output: Low
- Age of sexual maturity (yrs): 2-3 years
- Mean clutch/litter/brood size: 3
- Mean no of clutches/litters/broods per year: 1
- Time of year young born/hatch: February
- Source: Hutchinson and Donnellan (1992), P. Robertson pers. comm.

b) Longevity

- Classification of lifespan: Unknown
- Average lifespan (yrs): Unknown
- Maximum lifespan (yrs): Unknown
- Source: P. Robertson pers. comm.

c) Morphology

Adult body size

- Weight (g): Unknown
- Length (mm): 44-60mm females, 40-55mm males
- Source: Hutchinson and Donnellan (1992), P. Robertson pers. comm.

d) Social organisation

- Colonial or non-colonial: Non-colonial
- Territoriality: None observed
- Source: P. Robertson, pers. comm.

e) Other
- Nomadic, migratory, sedentary: Sedentary
- Mode of feeding: Insectivore
- Source: P. Robertson pers. comm.

THREATS
1. Fire (planned): Ranking (2) P. Robertson, pers. comm.
2. Fire (unplanned): Ranking (3) P. Robertson pers. comm.
3. Logging: Ranking (0)
4. Introduced Species: Ranking (1) P. Robertson pers. comm.
5. Pest Control: Ranking (0)
6. Grazing/Trampling: Ranking (3) P. Robertson pers. comm.
7. Disease: Ranking (-)
8. Illegal harvesting: Ranking (0)
9. Non-forestry Clearing: Ranking (2) P. Robertson pers. comm.
10. Mining/Quarrying: Ranking (0)
11. Roading: Ranking (3) P. Robertson pers. comm.
12 Recreation: Ranking (3) (P. Robertson, pers. comm.)
13. Vandalism/Disturbance by Humans: Ranking (0)
14. Other: Enhanced Greenhouse Effect: Ranking (3) P. Robertson, pers. comm **Sphagnum harvesting: Ranking (1)** P. Robertson pers. comm.

Current Management:

The Alpine Bog Skink has received a final recommendation for listing under the *Flora and Fauna Guarantee Act* 1988. Management prescriptions relating to the Baw Baw Frog may benefit this species where they occur together.

Comments: The Alpine Bog Skink is restricted to mountain plateaux in north eastern Victoria, being found in subalpine to alpine heathlands. Within the Central Highlands one area where the species is recorded is within a conservation reserve; other areas occur within state forest (P. Robertson pers. comm.).

The vegetation characteristic of the habitat of the Alpine Bog Skink, is particularly sensitive to damage; processes such as grazing, fire and earthworks can contribute to erosion, and revegetation is difficult to achieve because of the short growing season (LCC 1982). Major threats include habitat modification and degradation as a result of resort development, the Enhanced Greenhouse Effect, damage to the species' sensitive habitat as a result of recreational uses including cross-country skiing, hiking, four-wheel driving and horse riding, and grazing and trampling by cattle. The species is also susceptible to habitat alteration as a result of inappropriate fire regimes and wildfire (P. Robertson pers. comm.).

4. AMPHIBIANS

Baw Baw Frog

Philoria frosti

RARITY
a) Geographic Range
- Classification of range size: Narrow
- Range size within region: (km^2): 100
- Proportion of region occupied (%): < 1
- Source: Malone (1985), Atlas of Victorian Wildlife, G. Gillespie pers. comm.

b) Abundance
- Classification of abundance: Low
- Population Estimate: 200-300 males
- Density: Unknown
- Home Range (ha): Unknown
- Source: Hollis (1995)

c) Habitat Specificity
- Classification of habitat specificity: Narrow, given it only occurs on Mt Baw Baw
- Vegetation types used in the region: Subalpine Woodland, Wet Subalpine Heathland, Montane Riparian Thicket, Montane Wet Forest
- Source: Malone (1985), Hollis (1995), G. Gillespie pers. comm.

DYNAMICS
Population Trend in Last Decade
- Increasing, stable or declined: Declined, 1985 estimate 10 000-15000 males, recent estimate 200-300 males
- Source: Malone (1985), Hollis (1995)

Population trend since discovery by Europeans
- Increasing, stable or declined: Declined
- Source: Hollis (1995)

SPATIAL DYNAMICS
a) Population variability
- Classification of population variability: Unknown, possibly high. Considerable variation in breeding success has been noted in successive years.
- Source: James and Morey (1993)

b) Dispersal
- Classification of powers of dispersal: Unknown
- Average distances dispersed: Unknown
- Maximum distance dispersed: Unknown
- Source: G. Gillespie pers. comm.

LIFE HISTORY PARAMETERS
a) Reproductive output
- Classification of reproductive output: Low
- Age of sexual maturity (yrs): Probably several years
- Mean clutch/litter/brood size: 90
- Mean no of clutches/litters/broods per year: Unknown, possibly < 1
- Time of year young born/hatch: Aquatic phase November -February
- Source: Malone (1985), G. Gillespie pers. comm.

b) Longevity
- Classification of lifespan: Long-lived
- Average lifespan (yrs): Unknown
- Maximum lifespan (yrs): > 7
- Source: G. Gillespie pers. comm.

c) Morphology
Adult body size
- Weight (g): No information
- Length (cm): 48-51 (49) females, 42-46 (44) males
- Source: Littlejohn (1963)

d) Social organisation
- Colonial or non-colonial: Unknown
- Territoriality: Males known to be territorial during the breeding season
- Source: G. Gillespie pers. comm.

e) Other
- Nomadic, migratory, sedentary: Nomadic
- Mode of feeding: Opportunistic predator

- Source: G. Gillespie pers. comm.

THREATS
1. Fire (planned): Ranking (0)
2. Fire (unplanned): Ranking (3) James and Morey (1993), G. Gillespie pers. comm.
3. Logging: Ranking (3) G. Gillespie pers. comm.
4. Introduced Species: Ranking (1) Hollis (1995), G. Gillespie pers. comm.
5. Pest Control: Ranking (0)
6. Grazing: Ranking (2) Malone (1985), Hollis (1995), G. Gillespie pers. comm.
7. Disease: Ranking (1)
8. Illegal harvesting: Ranking (0)
9. Non-forestry Clearing: Ranking (2) Malone (1985), LCC (1991), Gillespie *et al.* (1995), Hollis (1995), G. Gillespie per. comm.
10. Mining/Quarrying: Ranking (0)
11. Roading: Ranking (1) G. Gillespie pers. comm.
12. Recreation: Ranking (2) James and Morey (1993), G. Gillespie pers. comm.
13. Vandalism/Disturbance by Humans: Ranking (0)
14 Other: Enhanced Greenhouse Effect Ranking (3) Bennett *et al.* (1991), James and Morey (1993), G. Gillespie pers. comm

Current Management:

The Baw Baw Frog is listed under the Victorian *Flora and Fauna Guarantee Act* 1988 and an Action Statement has been prepared (James and Morey 1993). The species is also listed under the Commonwealth *Endangered Species Protection Act* 1992. A Recovery Plan is currently being prepared for this species. Intended management actions outlined in the Action Statement include: development and implementation of an annual survey to monitor population fluctuations, the initiation of long-term research to identify crucial breeding areas, determination of critical habitat, removal of feral cattle from the Baw Baw plateau, monitor and control of environmental weeds, and monitor and manage the effects of recreation on the species and its habitat. Other actions include input from NRE into any proposed development or improvement within the Mount Baw Baw Alpine Resort that may affect habitat and the control of recreation which is likely to cause habitat degradation. The Baw Baw National Park Management Plan recommended high priority be given to the protection of Wet Alpine Heathland and the conduction of surveys to confirm the distribution of the frog and investigate its distribution over the range of habitat on the plateau.

Comments: The Baw Baw Frog is endemic to the Central Highlands. Its distribution is highly restricted; until recently the population was believed to be confined to the Baw Baw Plateau, within an area of 80 km^2 (Malone 1985). The majority of this area is contained within the Baw Baw National Park although approximately 3km^2 near Mount Baw Baw is part of the Mount Baw Baw Alpine Resort. Recent surveys have located the Baw Baw Frog in adjoining Montane Wet Forest (*Eucalyptus delegatensis* and *E. nitens*) (G. Gillespie pers. comm.).

Due to the cryptic nature of the Baw Baw Frog very little is known of the species outside the breeding season. The population has declined markedly over the last decade although reasons for this decline remain unclear (James and Morey 1993, Gillespie *et al*. 1995).

Major threats to the Baw Baw Frog include habitat loss from logging of Montane Wet Forest (G. Gillespie pers. comm.), loss of habitat and individuals due to wildfire, and impacts associated with the Enhanced Greenhouse Effect which may be causing the decline of frog populations found at high altitudes Australia wide (James and Morey 1993, Gillespie *et al.* 1995). Moderate threats include damage to the subalpine heath and sphagnum bog communities due to recreation activities and grazing, and clearance of native vegetation in and around the Mount Baw Baw Alpine Resort and associated snow-sports infrastructure (James and Morey 1993)

Giant Burrowing Frog
Heleioporus australiacus

RARITY
a) Geographic Range
- Classification of range size: Unknown
- Range size within region: (ha): Unknown
- Proportion of region occupied (%): Unknown
- Source: G. Gillespie pers. comm.

b) Abundance
- Classification of abundance: Low
- Population Estimate: Unknown
- Density: Unknown
- Home Range (ha): Unknown
- Source: G. Gillespie pers. comm.

c) Habitat Specificity
- Classification of habitat specificity: Unknown but probably wide
- Vegetation types used in the region: Not described within the Central Highlands but known to use Montane Riparian Forest, Montane Sclerophyll Woodland, Riparian Forest, Wet Forest, Dry Forest, Damp Forest in other areas.
- Source: Gillespie (1990)

DYNAMICS
Population Trend in Last Decade
- Increasing, stable or declined: Unknown in the Central Highlands but have not been recorded in other areas where they were known from historically.
- Source: Gillespie (1990), Mazzer (1994).

Population trend since discovery by Europeans
- Increasing, stable or declined: Unknown
- Source: G. Gillespie pers. comm

SPATIAL DYNAMICS
a) Population variability
- Classification of population variability: Unknown
- Source: G. Gillespie pers. comm.

b) Dispersal
- Classification of powers of dispersal: High, several individuals have been recorded long distances from water bodies
- Average distances dispersed: Unknown
- Maximum distance dispersed: Unknown
- Source: Mazzer (1994)

LIFE HISTORY PARAMETERS
a) Reproductive output
- Classification of reproductive output: High
- Age of sexual maturity (yrs): Unknown
- Mean clutch/litter/brood size: 775-1239
- Mean no of clutches/broods per year: 1
- Time of year young born/hatch: Unknown, between November and May, egg masses were found in February within the Central Highlands
- Source: Littlejohn and Martin (1967), Watson and Martin (1973), G. Gillespie pers. comm.

b) Longevity
- Classification of lifespan: Unknown
- Average lifespan (yrs): Unknown
- Maximum lifespan (yrs): Unknown
- Source: G. Gillespie pers. comm.

c) Morphology
Adult body size
- Weight (g): No information
- Length (mm): snout-vent 80-90
- Source: Littlejohn and Martin (1967)

d) Social organisation
- Colonial or non-colonial: Unknown

- Territoriality: Males during breeding season
- Source: G. Gillespie pers. comm.

e) Other
- Nomadic, migratory, sedentary: Unknown
- Mode of feeding: Generalist predator (arthropods)
- Source: Littlejohn and Martin (1967), Webb (1983), Webb (1987)

THREATS
1. Fire (planned): Ranking (2) Gillespie (1990), Mazzer (1994), G. Gillespie pers. comm.
2. Fire (unplanned): Ranking (2) G. Gillespie pers. comm.
3. Logging Ranking: (2) Bury and Corn (1988), Campbell and Doeg (1989), Mazzer (1994), deMaynadier and Hunter (1995), G. Gillespie pers. comm.
4. Introduced Species: Ranking (1) Mazzer (1994)**,** G. Gillespie pers. comm.
5. Pest Control: Ranking (1) Mazzer (1994), G. Gillespie pers. comm.
6. Grazing: Ranking (0)
7. Disease: Ranking (0)
8. Illegal harvesting: Ranking (0) G. Gillespie pers. comm.
9. Non-forestry Clearing: Ranking (-) G. Gillespie pers. comm.
10. Mining/Quarrying: Ranking (-) G. Gillespie pers. comm.
11. Roading: Ranking (1) Campbell and Doeg (1989), G. Gillespie pers. comm.
12. Recreation: Ranking (1) G. Gillespie pers. comm.
13. Vandalism/Disturbance by Humans: Ranking (0)
14. Other: Ranking (0)

Current Management:

The Giant Burrowing Frog is listed under the Victorian *Flora and Fauna Guarantee Act 1988* and an Action Statement has been prepared (Mazzer 1994). Intended management actions include prescriptions for timber harvesting and fuel reduction burning at sites where the species is located, the conduction of research into aspects of the species' ecology and the monitoring of sites where the species has been recorded in recent years.

Comments: Within the Central Highlands the Giant Burrowing Frog was located with egg masses in 1966, approximately 11 km south of Walhalla (Littlejohn and Martin 1967). This is one of only a few breeding records within the State. The species has not been recorded since and its current status within the Central Highlands is unknown.

There is very little information on the basic biology and ecology of the Giant Burrowing Frog (Gillespie 1990, Mazzer 1994). The species is known to use small flowing streams as breeding sites. Outside of the breeding season it has been located within forests away from water, indicating it utilises or at least disperses through forested areas (Gillespie 1990). Timber harvesting is possibly a moderate threat to the Giant Burrowing Frog in the Central Highlands due to the concommitant reduction in litter and ground cover layers that harbour invertebrate food (Mazzer 1994). The effect of forest fragmentation on the species is unknown but may be significant. Changes to stream flow and perenniality within catchments carrying large areas of regrowth forest as a consequence of logging or wildfire are also threats. Herbicide spraying following weed invasion is also a potential threat to the species (Mazzer 1994, G. Gillespie pers. comm.).

Spotted Tree Frog
Litoria spenceri

RARITY

a) Geographic Range
- Classification of range size: Small
- Range size within region: (km): 30
- Proportion of region occupied (%): < 1
- Source: G. Gillespie pers. comm.

b) Abundance
- Classification of abundance: Low
- Population Estimate: 2 populations, one <1000 (Goulburn River) and the second <1500 adults (Taponga River)
- Density: Unknown
- Home Range (m): <200m
- Source: G. Gillespie pers. comm.

c) Habitat Specificity
- Classification of habitat specificity: Narrow
- Vegetation types used in the region: Montane Riparian Thicket, Riparian Thicket, Riparian Forest, Shrubby Dry Forest, Heathy Dry Forest, Grassy Dry Forest, Damp Forest
- Source: Gillespie and Hollis (1996)

DYNAMICS
Population Trend in Last Decade
- Increasing, stable or declined: Declined
- Source: Gillespie and Hollis (1996)

Population trend since discovery by Europeans
- Increasing, stable or declined: Declined
- Source: Gillespie and Hollis (1996)

SPATIAL DYNAMICS
a) Population variability
- Classification of population variability: High
- Source: G. Gillespie pers. comm.

b) Dispersal
- Classification of powers of dispersal: Low
- Average distances dispersed: No dispersal
- Maximum distance dispersed: No dispersal
- Source: G. Gillespie pers. comm.

LIFE HISTORY PARAMETERS
a) Reproductive output
- Classification of reproductive output: Low
- Age of sexual maturity (yrs): > 2.5 females, >1.5 males,
- Mean clutch/litter/brood size: 630 eggs
- Mean no of clutches/broods per year: 1
- Time of year young born/hatch: December (eggs laid)
- Source: Gillespie *et al.* (1995), G. Gillespie pers. comm.

b) Longevity
- Classification of lifespan: Long
- Average lifespan (yrs): Unknown
- Maximum lifespan (yrs): 6 females, 5 males
- Source: G. Gillespie pers. comm.

c) Morphology
Adult body size
- Weight (g): 12 females, 4.5 males (maximum)
- Length (mm): 37-53 females, 24-38 males
- Source: G. Gillespie pers. comm.

d) Social organisation
- Colonial or non-colonial: Non-colonial
- Territoriality: Males during breeding season
- Source: Gillespie (1993), G. Gillespie pers. comm.

e) Other
- Nomadic, migratory, sedentary: Sedentary
- Mode of feeding: Insectivore
- Source: Ehmann *et al.* (1992),G. Gillespie pers. comm.

THREATS
1. Fire (planned): Ranking (2) Watson *et al.* (1991), G. Gillespie pers. comm., Robertson in prep.
2. Fire (unplanned): Ranking (2) G. Gillespie pers. comm., Robertson in prep.
3. Logging: Ranking (3) Bruce and Cormn (1988), Campbell and Doeg (1989), Watson *et al.* (1991),

deMaynadier and Hunter (1995), Gillespie and Hollis (1996), Robertson in prep., G. Gillespie pers. comm.
4. Introduced Species: Ranking (3) Watson *et al.* (1991), G. Gillespie per. comm.
5. Pest Control: Ranking (2) G. Gillespie pers. comm., Robertson in prep.
6. Grazing: Ranking (1) Watson *et al.* (1991), Gillespie and Hollis (1996), Robertson in prep., G. Gillespie pers. comm. ,
7. Disease: Ranking (-) G. Gillespie per. comm.
8. Illegal harvesting: Ranking (0)
9. Non-forestry Clearing: Ranking (0) G. Gillespie pers. comm.
10. Mining/Quarrying: Ranking (2) Hall (1988), Watson *et al.* (1991), Gillespie and Hollis (1996), Robertson in prep., G. Gillespie pers. comm.
11. Roading: Ranking (3) Campbell and Doeg (1989), Watson *et al*. (1991), Gillespie and Hollis (1996), Robertson in prep., G. Gillespie pers. comm.
12. Recreation: Ranking (2) Watson *et al.* (1991), Gillespie and Hollis (1996), Robertson in prep., G. Gillespie pers. comm
13. Vandalism/Disturbance by Humans: Ranking (1) Watson *et al*. (1991), Gillespie and Hollis (1996), Robertson in prep., Gillespie pers. comm
14. Other: Dams Ranking (3) Watson *et al*. (1991), Robertson in prep., G. Gillespie pers. comm., **Enhanced Greenhouse Effect: Ranking (3)** Bennett *et al.* (1991), G. Gillespie pers. comm.

Current Management:

The Spotted Tree Frog is listed under the Victorian *Flora and Fauna Guarantee Act* 1988. An action statement is currently being prepared. The species is also listed under the Commonwealth *Endangered Species Protection Act* 1992. Under the Code of Forest Practices for Timber Production (CNR 1996a) the water quality and riparian vegetation of permanent streams are protected by a buffer on either side of the stream of a minimum width of 20m. Trees must not be felled within or into buffer strips and machinery must not enter other than for construction and use of approved stream crossings.

Comments: The Spotted Tree Frog inhabits rocky, swift-flowing upland streams in dissected mountainous country. The distribution of individuals along the stream is patchy and is generally associated with substrates of loose rock, rocky banks and rapids. Adjacent stream-side vegetation is used for shelter and basking. Extensive searches of every major stream within the broad distribution of the Spotted Tree Frog have found only 11 extant populations. The distribution of the species is fragmented and there has been a significant decline during the last 20 years (Watson *et al.* 1991, Gillespie and Hollis 1996, G. Gillespie pers. comm, Robertson in prep.). Surveys are conducted during the breeding season and are confined to rivers; use of adjoining forest in the non-breeding season is unknown (G. Gillespie pers. comm., Robertson in prep).

Within the Central Highlands the Spotted Tree Frog is found in Big River, Taponga River, Still Creek, Black River and Goulburn River. The species is locally common in these rivers with the exception of the Big River where numbers have decreased markedly and the species is now extremely rare (G. Gillespie pers. comm.). Spotted Tree Frogs appear to have disappeared from the Woods Point area; number have declined in the Goulburn River (Gillespie 1993). Recent surveys have failed to locate Spotted Tree Frogs in the Thompson River where it was formerly known (Gillespie and Hollis 1996).

In most cases the intensity, extent and timing of different disturbances are unknown (Gillespie 1993). Disturbances in and adjacent to streams and in stream catchments which effect water quality and flow and cause altered streambed conditions (eg sedimentation), and changes to stream-side vegetation are likely causes of population declines (Gillespie and Hollis 1996). Such threats include logging within catchments, roading, wildfire, inappropriate fire regimes, eductor dredging, dam construction, herbicide use, and recreation activities (Robertson in prep., G. Gillespie pers. comm.) Anthropogenic disturbances including recreation/human access to catchments, off road vehicles, and clearance of bank vegetation for bush camping, have been negatively correlated with the relative abundance of the Spotted Tree Frog. Eductor dredging, roads near streams and post-1972 logging in catchments were also negatively correlated with abundance (Gillespie and Hollis 1996). Predation of eggs and larvae by trout is also a threat to the species (Watson *et al.* 1991, G. Gillespie pers. comm.). Habitat alteration as a consequence of the Enhanced Greenhouse Effect is a major threat to the Spotted Tree Frog (Bennett *et al.* 1991, G. Gillespie pers. comm.).

Alpine Tree Frog

Litoria verreauxii alpina

RARITY

a) Geographic Range
- Classification of range size: Small
- Range size within region: (ha): 60 000 - 98 000
- Proportion of region occupied (%): 3 - 8
- Source: Atlas of Victorian Wildlife, CNR and AHC (1994)

b) Abundance
- Classification of abundance: Low
- Population Estimate: Unknown
- Density: Unknown
- Home Range (ha): Unknown
- Source: G. Gillespie pers. comm.

c) Habitat Specificity
- Classification of habitat specificity: Narrow
- Vegetation types used in the region: Dry Subalpine Shrubland, Damp Subalpine Heathland, Wet Subalpine Heathland, Subalpine Woodland, Montane Dry Woodland, Montane Forest
- Source: Gillespie *et al.* (1995), G. Gillespie pers. comm.

DYNAMICS

Population Trend in Last Decade
- Increasing, stable or declined: Declined
- Source: Gillespie *et al.* (1995)

Population trend since discovery by Europeans
- Increasing, stable or declined: Declined
- Source: Gillespie *et al.* (1995)

SPATIAL DYNAMICS

a) Population variability
- Classification of population variability: Unknown
- Source: G. Gillespie pers. comm.

b) Dispersal
- Classification of powers of dispersal: Low
- Average distances dispersed: Unknown
- Maximum distance dispersed: Unknown
- Source: G. Gillespie pers. comm.

LIFE HISTORY PARAMETERS

a) Reproductive output
- Classification of reproductive output: Low
- Age of sexual maturity (yrs): Unknown
- Mean clutch/litter/brood size: Unknown
- Mean no of clutches/litters/broods per year: 1
- Time of year young born/hatch: December
- Source: G. Gillespie pers. comm.

b) Longevity
- Classification of lifespan: Unknown
- Average lifespan (yrs): Unknown
- Maximum lifespan (yrs): Unknown

- Source: G. Gillespie pers. comm.

c) Morphology

Adult body size

- Weight (g): Unknown
- Length (mm): 30 snout-vent
- Source: Cogger (1995)

d) Social organisation

- Colonial or non-colonial: Colonial (breeding)
- Territoriality: Unknown
- Source: G. Gillespie pers. comm.

e) Other

- Nomadic, migratory, sedentary: Sedentary
- Mode of feeding: Opportunistic predator
- Source: G. Gillespie pers. comm.

THREATS

1. Fire (planned): Ranking (-)
2. Fire (unplanned): Ranking (-)
3. Logging: Ranking (-)
4. Introduced Species: Ranking (-)
5. Pest Control: Ranking (0)

6. Grazing: Ranking (2) Gillespie *et al.* (1995), G. Gillespie pers. comm.

7. Disease: Ranking (0)
8. Illegal harvesting: Ranking (0)

9. Non-forestry Clearing: Ranking (2) Gillespie *et al.* (1995)

10. Mining/Quarrying: Ranking (0)
11. Roading: Ranking (-)

12 Recreation: Ranking (2) G. Gillespie pers. comm.

13. Vandalism/Disturbance by Humans: Ranking (0)

14. Other, Hydroelectric facilities: Ranking (1) Gillespie *et al.* (1995) **Enhanced Greenhouse Effect: Ranking (3)** Bennett *et al.* (1991), Gillespie *et al*. (1995), G. Gillespie pers. comm**. Ozone depletion: Ranking (3)** (G. Gillespie pers. comm.).

Current Management:

The species is classified as "insufficently known" in Victoria (CNR 1995A). There are no current management actions in operation to ameliorate potential threats to this species.

Comments: The Alpine Tree Frog is a high-altitude subspecies of the Whistling Tree Frog. This largely terrestrial species is found at altitudes above 1200m in southern N.S.W. and eastern Victoria. Within the Central Highlands, Alpine Tree Frogs have been recorded at Mt Baw Baw and Lake Mountain. Many records are pre 1980. Since this time there have been fewer records and a large decrease in numbers on the Baw Baw Plateau, (G. Hollis pers. comm. in Gillespie *et al.* 1995) and it is likely the population is declining. The current status of the species in other alpine regions within the Central Highlands is unknown (Gillespie *et al*. 1995).

Large breeding populations of the Alpine Tree Frog occur on plains or open valleys where there are stream side pools, fens and bogs. The subspecies also breeds around the margins of artificial lakes (Gillespie *et al.* 1995). The ecology of the species is virtually unknown however, major threats most likely relate to disturbances which impact on the breeding sites and include clearing associated with development, human recreation activities and trampling by grazing cattle. The Enhanced Greenhouse Effect may result in altered breeding conditions and is a major threat to alpine frog species including the Alpine Tree Frog (Gillespie *et al.* 1995). An increase in UV radiation is known to cause the death of the eggs and larvae of this species and is also a major threat as a consequence of ozone depletion (G. Gillespie pers. comm.).

APPENDIX H: Records from the ANIC Database of insect species found in a 70km radius of Marysville*

Family	Genus	Species	Subspecies
Aeshnidae	Austroaeschna	multipunctata	
Aeshnidae	Austroaeschna	parvistigma	
Aeshnidae	Austroaeschna	subapicalis	
Aeshnidae	Austroaeschna	unicornis	unicornis
Aeshnidae	Spinaeschna	tripunctata	
Aeshnidae	Telephlebia	brevicauda	
Coenagrionidae	Austrocnemis	splendida	
Coenagrionidae	Caliagrion	billinghursti	
Gomphidae	Austrogomphus	ochraceus	
Hemiphlebiidae	Hemiphlebia	mirabilis	
Lestidae	Austrolestes	analis	
Lestidae	Austrolestes	leda	
Lestidae	Austrolestes	psyche	
Megapodagrionidae	Austroargiolestes	calcaris	
Megapodagrionidae	Austroargiolestes	icteromelas	icteromelas
Synlestidae	Synlestes	weyersii	tillyardi
Synlestidae	Synlestes	weyersii	weyersii
Austroperlidae	Acruroperla	atra	
Austroperlidae	Austroheptura	illiesi	
Eustheniidae	Eusthenia	venosa	venosa
Gripopterygidae	Eunotoperla	kershawi	
Gripopterygidae	Illiesoperla	mayi	
Gripopterygidae	Leptoperla	kimminsi	
Gripopterygidae	Neboissoperla	alpina	
Gripopterygidae	Riekoperla	angusta	
Gripopterygidae	Riekoperla	cornuta	
Gripopterygidae	Riekoperla	williamsi	
Gripopterygidae	Riekoperla	zwicki	
Notonemouridae	Austrocercella	tillyardi	
Notonemouridae	Notonemoura	maculata	
Kalotermitidae	Bifiditermes	improbus	
Kalotermitidae	Glyptotermes	neotuberculatus	
Kalotermitidae	Kalotermes	convexus	
Kalotermitidae	Kalotermes	rufinotum	
Rhinotermitidae	Coptotermes	frenchi	
Rhinotermitidae	Coptotermes	lacteus	
Termitidae	Amitermes	xylophagus	
Termitidae	Nasutitermes	dixoni	
Termitidae	Nasutitermes	fumigatus	
Termopsidae	Porotermes	adamsoni	
Termopsidae	Stolotermes	victoriensis	
Eumastacidae	Vandiemenella	viatica	
Cerambycidae	Phoracantha	alternata	
Cerambycidae	Phoracantha	semipunctata	
Cerambycidae	Phoracantha	synonyma	
Chrysomelidae	Augomela	hypochalcea	
Chrysomelidae	Calomela	bartoni	
Chrysomelidae	Calomela	curtisi	
Chrysomelidae	Calomela	ioptera	
Chrysomelidae	Calomela	juncta	

Family	Genus	Species	Subspecies
Chrysomelidae	Calomela	maculicollis	
Chrysomelidae	Calomela	parilis	
Chrysomelidae	Calomela	vittata	
Chrysomelidae	Chalcolampra	constricta	
Chrysomelidae	Chalcolampra	pustulata	
Chrysomelidae	Cheiloxena	insignis	
Chrysomelidae	Cheiloxena	westwoodii	
Chrysomelidae	Eurispa	howitti	
Chrysomelidae	Eurispa	vittata	
Chrysomelidae	Hispellinus	fimbriatus	
Chrysomelidae	Hispellinus	multispinosus	
Chrysomelidae	Microdonacia	grevilleae	
Chrysomelidae	Microdonacia	terricola	
Chrysomelidae	Platycolaspis	australis	
Chrysomelidae	Platycolaspis	pubescens	
Dytiscidae	Allodessus	bistrigatus	
Dytiscidae	Antiporus	blakei	
Dytiscidae	Australphilus	saltus	
Dytiscidae	Chostonectes	gigas	
Dytiscidae	Copelatus	australiae	
Dytiscidae	Lancetes	lanceolatus	
Dytiscidae	Necterosoma	penicillatum	
Dytiscidae	Platynectes	darlingtoni	
Dytiscidae	Platynectes	decempunctatus	
Dytiscidae	Spencerhydrus	latecinctus	
Dytiscidae	Sternopriscus	mundanus	
Elmidae	Austrolimnius	anytus	
Elmidae	Austrolimnius	cheops	
Elmidae	Austrolimnius	dayi	
Elmidae	Austrolimnius	hebrus	
Elmidae	Austrolimnius	luridus	
Elmidae	Austrolimnius	maro	
Elmidae	Austrolimnius	sulmo	
Elmidae	Austrolimnius	victoriensis	
Hydrophilidae	Dactylosternum	abdominale	
Scarabaeidae	Anoplognathus	hirsutus	
Scarabaeidae	Anoplognathus	montanus	
Scarabaeidae	Anoplognathus	olivieri	
Scarabaeidae	Anoplognathus	suturalis	
Scarabaeidae	Anoplognathus	velutinus	
Scarabaeidae	Anoplognathus	viriditarsis	
Scarabaeidae	Onthophagus	auritus	
Scarabaeidae	Onthophagus	australis	
Scarabaeidae	Onthophagus	dunningi	
Scarabaeidae	Onthophagus	fuliginosus	
Scarabaeidae	Onthophagus	granulatus	
Scarabaeidae	Onthophagus	hoplocerus	
Scarabaeidae	Onthophagus	longipes	
Scarabaeidae	Thyregis	kershawi	
Chironomidae	Cricotopus	conicornis	
Chironomidae	Cricotopus	parbicinctus	
Chironomidae	Eukiefferiella	insolida	
Castniidae	Synemon	plana	
Geometridae	Mnesampela	privata	
Noctuidae	Uraba		lugens
Formicidae	Adlerzia		froggatti

Family	Genus	Species	Subspecies
Formicidae	Amblyopone		
Formicidae	Amblyopone	australis	
Formicidae	Anonychomyrma		
Formicidae	Aphaenogaster	longiceps	
Formicidae	Bothriomyrmex		
Formicidae	Brachyponera		
Formicidae	Camponotus		
Formicidae	Camponotus	agilis	
Formicidae	Camponotus	bendigensis	
Formicidae	Camponotus	consobrinus	
Formicidae	Camponotus	nigriceps	
Formicidae	Camponotus	piliventris	
Formicidae	Cerapachys		
Formicidae	Colobostruma		
Formicidae	Cryptopone		
Formicidae	Discothyrea		
Formicidae	Doleromyrma		
Formicidae	Dolichoderus		
Formicidae	Dolichoderus	australis	
Formicidae	Dolichoderus	scabridus	
Formicidae	Epopostruma		
Formicidae	Froggattella	kirbii	
Formicidae	Hypoponera		
Formicidae	Iridomyrmex	purpureus	
Formicidae	Leptomyrmex	erythrocephalus	
Formicidae	Linepithema humile		
Formicidae	Mayriella overbecki		
Formicidae	Monomorium		
Formicidae	Myopias		
Formicidae	Myrmecia	forficata	
Formicidae	Myrmecorhynchus		
Formicidae	Notoncus		
Formicidae	Ochetellus		
Formicidae	Orectognathus		
Formicidae	Pachycondyla		
Formicidae	Papyrius		
Formicidae	Paratrechina		
Formicidae	Pheidole		
Formicidae	Plagiolepis		
Formicidae	Platythyrea		
Formicidae	Podomyrma		
Formicidae	Ponera		
Formicidae	Prolasius		
Formicidae	Pseudonotoncus	hirsutus	
Formicidae	Rhytidoponera	aspera	
Formicidae	Rhytidoponera	confusa	
Formicidae	Rhytidoponera	victoriae	
Formicidae	Solenopsis		
Formicidae	Sphinctomyrmex		
Formicidae	Stigmacros		
Formicidae	Strumigenys		
Formicidae	Tapinoma		
Formicidae	Technomyrmex		
Tetramorium			

* = coordinates 37° 31'S 145° 45'E