Biodiversity Assessment

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Foreword

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

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1.1 Background

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

- establishment of a dedicated forest reserve system on public land based on the principles of comprehensiveness, adequacy and representativeness;
- complementary management of public native forests outside conservation reserves which assists biodiversity conservation; and
- promotion of the management of private forests in sympathy with nature conservation goals (Commonwealth of Australia 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 national criteria has been developed to guide the establishment of a Comprehensive, Adequate and Representative (CAR) forest reserve system (JANIS 1997). The criteria relating specifically to biodiversity are outlined in Box 1.

Box 1 Summary of the JANIS biodiversity criteria

1. As a general criterion, 15% of the pre-1750 distribution of each forest ecosystem should be protected in the CAR reserve system with flexibility considerations applied according to regional circumstances, and recognising that as far as possible and practicable, the proportion of dedicated reserves should be maximised.
2. Where forest ecosystems are recognised as vulnerable, (eg. approaching a reduction in areal extent of 70% within a bioregional context or subject to continuing and significant threatening processes), then at least 60% of their remaining extent should be reserved. (Vulnerable ecosystems include those where threatening processes have caused significant changes in species composition, loss or significant decline in species that play a major role within the ecosystem, or significant alteration to ecosystem processes.)
3. All remaining occurrences of rare and endangered forest ecosystems should be reserved or protected by other means as far as is practicable.
4. Reserved areas should be replicated across the geographic range of the forest ecosystem to decrease the likelihood that chance events such as wildfire or disease will cause the forest ecosystem to decline.
5. The reserve system should seek to maximise the area of high quality habitat for all known elements of biodiversity wherever practicable, but with particular reference to:
   - the special needs of rare, vulnerable or endangered species;
   - special groups of organisms, for example species with complex habitat requirements, or migratory or mobile species;
   - areas of high species diversity, natural refugia for flora and fauna, and centres of endemism; and
   - those species whose distributions and habitat requirements are not well correlated with any particular forest ecosystem.
6. Reserves should be large enough to sustain the viability, quality and integrity of populations.
7. To ensure representativeness, the reserve system should, as far as possible, sample the full range of biological variation within each forest ecosystem, by sampling the range of environmental variation typical of its geographic range and sampling its range of successional stages.
8. In fragmented landscapes, remnants that contribute to sampling the full range of biodiversity are vital parts of a forest reserve system. The areas should be identified and protected as part of the development of integrated regional conservation strategies.

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

The results of this assessment are to be used in identifying a comprehensive, adequate and representative (CAR) reserve system that protects forest biodiversity in accordance with nationally agreed criteria. The strategy for conserving biodiversity relies not just on a CAR reserve system, but also on the application of ecologically sustainable forest management practices in off-reserve areas. The assessment provides a benchmark for monitoring the efficacy of these practices.

1.2 Elements of biodiversity

Biological diversity is usually considered at three levels:

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

1.2.1 Genetic diversity

Empirical data on genetic variation within and between species is sparse and generally restricted to a small number of species, primarily vertebrates and vascular plants. The time and cost of analyses to incorporate a full consideration of genetic variation is beyond the scope of the 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 North East forests for the CRA required a review of the conservation status of threatened taxa, their susceptibility to decline and extinction and an evaluation of the effects of disturbance on each of these taxa. Existing or proposed management actions are also addressed.

1.2.3 Ecosystem diversity

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

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

1.3 Conservation of biodiversity

1.3.1 National and State obligations and actions

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

The Convention on Biological Diversity

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

The Convention on Biological Diversity, ratified by Australia on 18 June 1993, deals at a global level with the full range of the conservation of biological diversity, its sustainable use, and the fair and equitable sharing of the benefits arising from this use. The National Strategy for the Conservation of Australia's Biological Diversity, signed by the Commonwealth and all State and Territory governments, provides the framework for giving effect to Australia's international obligations (Commonwealth of Australia 1996). Under the Strategy, governments in Australia have undertaken to identify the terrestrial, marine and other aquatic components of biodiversity that are important for biodiversity conservation and ecologically sustainable use.

Commonwealth Endangered Species Protection Act

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

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

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

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

Victorian Flora and Fauna Guarantee Act

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

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

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

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

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

Victoria's Biodiversity Strategy

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

Victorian National Parks Act

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

Forest Management

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

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

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

A forest management plan for the North East Region is in preparation.

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

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

A list and description of key Commonwealth and State legislation relating to RFAs in Victoria is provided in Appendix 1 of the North East CRA Report (VicRFASC 1998) and in the statewide assessment of Ecologically Sustainable Forest Management (VicRFASC 1997).

1.4 Biodiversity assessment methods

1.4.1 Methodological approaches: an overview

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

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

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

Analysis of data involves the following:

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

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

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

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

1.4.2 Limits to reliability of information

The utility of all scientific information is constrained by the reliability inherent in the method of its collection. The limitations imposed by incompleteness and/or a lack of replication of biological data sets are largely unavoidable, but their impact can be minimised if deficiencies are acknowledged and well circumscribed. The Chapter on data audit deals with a

number of these issues. The following are other important factors relating to the reliability of assessment of biodiversity in the North East CRA. Many are generally applicable to forested regions of Australia as a whole:

For species assessments,

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

For Ecological Vegetation Class (EVC) mapping,

- The digital coverages were produced at a scale of 1:100 000. The minimum polygon size defined is approximately 25 hectares.
- Vegetation associations tend to merge along a continuum, so that a line on the vegetation map often represents an ecotone rather than a discrete boundary. Discrete boundaries do, however, occur in some situations; for example, the boundary between closed forest and sedgelands.
- Most of the vegetation boundaries can be clearly derived from aerial photo interpretation based on canopy height and cover. Dominant floristics are attributed to each polygon on the basis of the site data present, expert knowledge, aerial photo-interpretation of forest types, and extensive field validation.
- The pre-1750 vegetation reconstruction was conducted using the best available environmental modelling, remnant site data, reference to historical information, and expert knowledge. This component of the assessment was, however, impossible to validate in the field in most places.

2. AUDIT OF EXISTING BIOLOGICAL DATA

2.1 Introduction

Biodiversity assessment relies on having adequate information about the distribution of species. It is important to know whether or not surveys undertaken for species or groups of species have been adequately distributed across the range of environments represented within the region. As part of this assessment, analyses were undertaken to determine where surveys for flora and fauna had been carried out in the North East region, which species were targeted, and whether survey sites are reasonably distributed to detect most species in most geographic or environmental components. From analyses, gaps were identified early in the RFA assessment process for the North East and revealed the need for further fauna survey work. This work was subsequently completed and formed the basis for the North East Region fauna assessment. It covered over 200 sites and has resulted in more complete distributional information for vertebrate fauna in the North East region. The survey, which is reported on in Chapter 5, also collected an amount of invertebrate fauna information.

Site selection for the fauna survey was developed using a statewide environmental stratification as a guide and using EVCs as an additional stratification to assist in site selection. A separate regional stratification was developed to verify the site selection for fauna survey and assess the adequacy of flora survey. The data review process involved systematically evaluating databases to identify 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 is to stratify the region. This enables an assessment of the environmental and geographic representation by sites from accredited data sets. A regional environmental stratification should be based on variables which 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. 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 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).

2.1.1 Methods

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

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

The tool kit is designed to perform the following tasks:

- develop a regional environmental stratification;
- create ARC/INFO point coverages from site text files and add species attributes;
- intersect sites with a regional environmental stratification and calculate statistics;
- generate cumulative species curves and predicted species richness statistics;

- create a histogram showing the proportion of total land area and the proportion of total sites of each stratum;
- produce maps of the regional environmental stratification and survey intensity; and view and print graphs and maps.

Process of developing the stratification

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

Climate

Methods have been developed to estimate climate at any point in a landscape, given the availability of topographic and meteorological data. 'Climate surfaces' fitted to a Digital Elevation Model provide spatially reliable estimates of mean monthly climate attributes derived from long-term meteorological station records for any given longitude, latitude and elevation (Hutchinson and Bischof, 1983; Hutchinson *et al*., 1984; Hutchinson, 1989, 1991a, 1991b). Currently, the estimated standard errors are 0.5^{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 Victoria have been calculated for each cell in the nine second elevation grid using the software package ANUCLIM (McMahon *et al*., 1995). Of the climatic variables available for the North East region, mean annual precipitation (with a range of 499 to 2519 mm), mean maximum temperature of the warmest month (16 to 31^{o}C) and mean minimum temperature of the coldest month (- 5.8 to + 3.7C) were selected for use in the stratification of the region. These variables were used to develop the stratification in the Central Highlands RFA region and were considered the most appropriate group of environmental variables for the North East stratification. Each of these climatic variables was then divided into intervals which most accurately reflect the bioclimatic variation within the North East region.(Table 0.1).

Lithology

Lithology (rock type) influences soil fertility, drainage and landform which in turn influence vegetation distribution. Lithology has been mapped for Victoria at 1:250,000 scale and was considered to be the most suitable surrogate for these variables in the stratification process. Of the 26 lithological types described in the Land Systems coverage of Victoria at a 1:250,000 scale, 10 are represented in the North East (see Table 0.1). It was not considered necessary to aggregate any of these lithological types for the purpose of deriving an environmental stratification.

Deriving the regional stratification

The environmental stratification was based on the three climatic attributes and lithology as described above, and estimated for each 250 x 250 metre grid cell. A total of 704 individual units or strata are possible when the four classes of annual precipitation, four classes of minimum temperature of the coldest month, four classes of maximum temperature of the warmest month and 11 classes of lithology are combined. Of the potential strata, only 133 occurred in the North East, ranging in area from 3.4 to more than 220,000 hectares. Very small strata were assigned to larger strata which were spatially and environmentally similar, resulting in the total number of strata being reduced to 97. However, 14 of the remaining strata are less than 500 ha in size (comprising only 0.2 % of the forest cover), and for the purpose of this analysis, were not evaluated. The spatial arrangement of strata across the Region is shown in Map 1. This environmental stratification was subsequently used for the analyses of flora and fauna databases presented here.

Of the 97 strata represented in the area under forest cover (1,353,809 ha) the 34 largest strata (>10,000 ha) occupied 89% of the forested land area. Almost 60% of strata (56) were smaller than 5000 hectares. These small strata represented only 8% of the forested land and were generally scattered throughout the fragmented landscape of the private land/public land interface.

Table 0.1 Attributes and classes used in the North East environmental stratification

Variable	Classes
mean annual precipitation	Low =499 - 800mm
North East range =499 to 2519 mm	Moderate =801 - 1100mm
	High = 1101 - 1500mm
	Very high = 1501 - 2519mm

mean minimum temperature of coldest month North East range = minus 5.8 to 3.7°C	Low = minus 5.8 - minus 1°C Moderate = minus 1.1 - 1.0°C High = 1.1 - 2.5°C Very High = 2.6 - 3.7°C
mean maximum temperature of warmest month North East range = 16 to 31°C	Low = 16 - 20°C Moderate = 20.1 - 26.°C High = 26.1 - 29°C Very High = 29.1 - 31°C
lithology	**a** finely textured unconsolidated deposits - highest fertility **b** finely textured unconsolidated deposits/coarsely textured unconsolidated deposits - moderate fertility **c** granites and gneisses - moderate to low fertility **d** granites and gneisses, /sedimentary - moderate fertility **e** sedimentary rock - low fertility (except where rainfall is high) **f** sedimentary/ granites and gneisses - low fertility **g** sedimentary/ volcanic rock - low/moderate fertility **h** volcanic rock (acid volcanics) - low fertility **I** volcanic rock/ granites and gneisses - low fertility **j** volcanic/ sedimentary rock - high fertility **?** undescribed

2.2 Flora survey data review

2.2.1 Methods

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

1730 sites (quadrats) have been sampled for vascular plants in the North East. Of these sites, 1365 are on forested land and 365 are non forest sites, the following analysis is based only on sites in forested areas. The sites sampled have been collected in a consistent manner as part of a range of studies including: region-wide studies; intensive sampling of experimental areas and other studies based on targeted sampling of particular habitats, such as alpine areas. The quadrat sampling has been largely undertaken by NRE for the purpose of classifying and describing native vegetation in the North East.

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

Of the 97 strata making up the stratification, the 14 strata which occupy less than 500 hectares have not been evaluated. The remaining 83 strata were classified on the basis of flora survey intensity (none, low, moderate, high - see Map 4). The geographic locations referred to in the discussion below relate primarily to the Geographic Representation Units (GRUs) identified in the Region (See Map 1 of the Comprehensive Regional Assessment Report).

2.2.2 Results and discussion

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

Three strata in the North East fell into this category. These strata, 20, 76 and 77 occupy 48,529 hectares or 4% of the total forested land area and are predominantly located in the Bogong Mountains and Pinnabar Mountains GRUs.

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

Strata with moderate site densities comprise 219,872 hectares or 16% of the total forested land area. Six of the 20 strata in this group, 10, 30, 61, 68, 70 and 73, are large and comprise 176,694 hectares. These strata are located in a range of GRUs

including Bogong Mountains, Pinnabar Mountains, Dartmouth Mountains, Buffalo Mountains and Big River Mountains along the Great Dividing Range as well as the Highlands Foothills, Strathbogie Foothills and Mt Pilot Foothills.

Strata under forest cover with low flora survey site density (>0-10 sites per 10,000 hectares)

Strata with low site densities comprise the majority of the forested land area totalling 1,040,668 hectares or 77% of the forested area. The majority of the largest strata are in this category. The largest of these strata is 50 which covers almost 220,000 hectares of the northern slopes of the Great Dividing Range. Land tenure within this stratum is a mixture of areas set aside for conservation and State forest.

Strata without flora survey sites

The strata without flora survey sites comprise 42,088 hectares or 3% of the total forested land area. These strata are generally small and scattered, the majority are between 1,100 and 3,300 hectares, occurring either in the drier, more remote parts of the region, or in the fragmented landscape of the private land/public land interface.

Survey density in largest strata (by area)

Of the 34 strata occupying more than 10,000 hectares each, all but eight fell within the low density category. Those with a moderate survey density are 10, 30, 61, 68, 70, 73. Two large strata, 76 and 77, mostly located in the Bogong Mountains and Pinnabar Mountains GRUs, have a high survey density.

Cumulative species curves

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

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

Probability that next species is new (%)	Percentage of Area included (%)	Number of strata included
sample too small to calculate	22%	33
< 10	47%	10
10 - 20	17%	10

The results obtained in the cumulative species curve analysis suggest more adequate survey effort than reflected in the survey intensity analysis, with 47% of the forested area of the region (10 strata) having probabilities of <10% that the next species is new. If this threshold is raised to 20%, then 64% of the region (20 strata) is included.

Summary

The flora survey coverage of the North East is not as comprehensive as that of the East Gippsland and Central Highlands RFA regions. The majority of the region (77% of forested area) has a low flora survey intensity. However, when a cumulative species curve analysis is carried out, a greater percentage of the region is determined to have been adequately surveyed, with 65% of the region with a probability of ≤ 20% that the next species recorded will be new.

This situation is partly explained by the historical pattern of flora survey. Some parts of the Region, particularly the alpine and subalpine areas, have been intensively surveyed in the past. In preparation for the Ecological Vegetation Class mapping project for this assessment, 348 new sites were surveyed for flora and while this significantly improved the spread of flora survey sites across the Region, parts of the North East remain more intensively sampled than others (see Map 4).

2.3 Fauna survey data review

2.3.1 Methods

In Victoria, much of the existing site data for fauna has come from individual records from a range of sources supplemented by information from systematic surveys. A lack of species records in certain strata does not necessarily mean that the strata have not been sampled; but that the information might not have been appropriate for use in this analysis. All biological records over an area as large and diverse as the North East are to some extent artefacts of differential collecting effort and subject to the sampling bias arising from the relative ease with which the occurrence of

certain groups (such as birds) can be scored. A lack of systematic survey for specific faunal groups weakens the power of the audit tool to expose under-sampled environmental strata for those groups, but it is not without value.

To ensure an adequate database of systematic survey records for terrestrial fauna, a general survey covering over 200 sites was undertaken in the North East region as part of the RFA assessment process. The records from this survey were entered onto the Atlas of Victorian Wildlife to supplement the existing data sets.

The site-based biological data sets used in the fauna assessment were drawn from the Atlas of Victorian Wildlife and the Victorian Freshwater and Estuarine Fish Database. A description of these data sets is given in a separate metadata report.

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

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

The data audit only includes data from formal surveys, incidental records were excluded from the analysis. The fauna data audit only includes strata under forest cover.

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

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

As was done for flora information, the distribution and density of survey site records were used to evaluate the adequacy of sampling of the environmental variation in the region. Strata and large polygons with low densities of sites were identified. The probability of the next species recorded for a particular stratum being new (ie. not previously recorded in surveys for that fauna group in that stratum) was used as an indication of the adequacy of sampling effort. The analysis was mostly confined to the 34 most extensive strata (>10,000 ha.), totalling 89 % of the forested area.

2.3.2 Results and discussion

The results of the survey site analysis for each fauna group are shown in Table 0.2, Maps 5-13 and in Appendix B. Incidental records were not included in the analysis but are shown separately on the maps referred to above.

Arboreal Mammals

A total of 871 sites in 64 strata have been surveyed for arboreal mammals. Of the 34 most extensive strata, all have been surveyed, with 11 of these strata having a low (≤5%) probability of a new species being detected. The majority of these large strata have either a low survey intensity (1-5 sites per 10,000 ha; 14 strata) or a medium survey intensity (5-10 sites per 10,000 ha; 14 strata). Six strata 10, 12, 30, 61, 63 and 71 have high survey intensities (10-20 sites per 10,000 ha). All six have low probabilities (≤5%) that the next species detected is new. Five strata, 4, 54, 66, 76, and 77 had insufficient data for calculation of a probability statistic. Together these five strata encompass most of the region north-east from the Big Ben Foothills GRU and the mountainous GRUs in the south along the Great Dividing Range.

Large Mammals

A total of 2,173 sites in 66 strata have been surveyed for large mammals in the North East. Of the 34 most extensive strata, all have been surveyed with 11 having a low (≤5%) probability of a new species being detected. For the majority (25) of large strata survey intensity was either high (10-20 sites per 10,000 ha; 13 strata) or very high (>20 sites per 10,000 ha; 12 strata). The most intensely surveyed large stratum is 28 (29,717 ha) located in the Tallangatta Foothills and Pinnabar Mountains GRUs. This stratum has 42 sites per 10,000 ha and a 9% probability of the next species detected being new.

Small Ground Mammals

A total of 2,640 sites in 57 strata have been surveyed for small ground mammals in the North East. All of the 34 largest strata have been surveyed. Survey intensity is very high (>20 sites per 10, 000 ha) for 12 of the largest strata, and high (10-20 sites per 10,000 ha) for 13 of the largest strata. Eighteen percent of the largest strata have a low probability (≤ 5%) of the next species detected being new. Strata 38, 54, and 66 have a low survey intensity (1-5 sites per 10,000 ha) and stratum 115 has a very low survey intensity (0-1 sites per 10,000 ha). The probability that a new species will be detected is 100% for stratum 38, while strata 54, 66 and 115 had too few survey sites to calculate a probability. These four poorly surveyed strata constitute 77,483 ha or 6% of the total forested area in the region.

Table 0.2 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 83 strata with survey sites	64	66	57	49	62	60	61	48	48
Number of the 34 largest strata with survey sites	34	34	34	31	34	33	34	34	34
Number of the largest strata with low probability (≤5%) of new species in next survey	11	11	18	24	14	13	4	5	4

Bats

A total of 1,324 sites have been surveyed for bats. Of the 83 strata in the North East, 49 (59%) have been surveyed. Of the 34 large strata, 31 have been surveyed. The three large unsurveyed strata, 38, 66 and 115, comprise 66,373 ha or 5% of the forested land in the region and are located in a range of GRUs including the Mitta Foothills, Big Ben Foothills, King River Floodplain, Buffalo Mountains, Delatite Valley and Big River Mountains. Survey intensity of the largest strata varies, 7 strata have a low survey intensity (1-5 sites per 10,000 ha), 9 strata have a moderate survey intensity (5-10 sites per 10,000 ha), 8 strata have a high survey intensity (10-20 sites per 10,000 ha) and 7 strata have a very high survey intensity (>20 sites per 10,000 ha). Twenty-four of the 34 large strata surveyed have low probabilities (≤ 5%) of the next species detected being new, while a further 5 strata have probabilities ≤13% of the next species detected being new.

Diurnal Birds

A total of 1,158 sites in 62 strata have been surveyed for diurnal birds. All 34 of the largest strata have been surveyed although the majority (25) have either a low survey intensity (1-5 sites per 10, 000 ha; 10 strata) or a moderate survey intensity (5-10 sites per 10,000 ha; 15 strata). However, for all large strata the probability of detecting a new species is ≤ 25%. Fourteen have a low probability (≤ 5%) of detecting a new species and a further 7 have a probability of < 10% of detecting a new species.

Nocturnal Birds

Nocturnal birds have been surveyed at 586 sites in 60 strata in the North East. The majority (21) of large strata have either a very low (0-1 sites per 10,000 ha; 4 strata) or low survey intensity (1-5 sites per 10,00 ha; 17 strata); stratum 66 has not been surveyed. Of the large strata, 14 have a low probability (≤ 5%) of detecting a new species. The 21 poorly surveyed strata comprise 184,231 ha or 63% of forested land in the North East. These strata are spread over the region, from the Corryong Foothills GRU in the north-east to the Delatite Valley and Big River Mountain GRUs in the south.

Large Forest Owls

A total of 947 sites in 61 strata have been surveyed for large forest owls. All of the 34 largest strata have been surveyed for this faunal group. Survey intensity is variable, 9 of the largest strata have a low survey intensity (1-5 sites per 10,00 ha), 15 have a moderate survey intensity (5-10 sites per 10,00 ha) and 8 have a high survey intensity (10-20 sites per 10,000 ha). Four strata, 30, 52, 61, and 70 have a low probability (≤ 5%) of the next species recorded being new. These strata are incorporated in a number of GRUs in the south-east of the region, in the south along the Great Dividing Range and in the Big Ben and Mitta Foothills geographic units in the central area of the region. Fifteen of the largest strata have a 100% chance of the next species detected being new.

Reptiles

A total of 797 sites in 48 strata have been surveyed for reptiles in the forested area of the region. All large strata have been surveyed, the majority (28) have either a low (0-5 sites per 10,000 ha; 17 strata) or moderate (5-10 sites per 10,000 ha; 11 strata) survey intensity. Five of the largest strata have been surveyed sufficiently to reduce the probability of detecting a new species to 5% or less. One of these is stratum 50, the largest stratum in the region covering 219,771 ha, or 16% of the forested area. The majority of the area of this stratum falls in the Dartmouth Mountains, Bogong Mountains, Buffalo Mountains, Barry Mountains and Big River Mountain GRUs. Of the remaining 34 large strata, 12 strata (representing 26% of the forested area) have a probability of ≥20% of detecting a new species.

Amphibians

A total of 804 sites have been surveyed in 48 strata. All 34 of the large strata have been surveyed although survey intensity is generally low (0-5 sites per 10, 000 ha; 18 strata) or moderate (5-10 sites per 10,000 ha; 11 strata). Four of these strata have been surveyed intensively enough to reduce the probability of detecting a new species to zero. These strata are 23, 30, 70 and 76 covering 118,347 ha, or 9% of the forested area of the region located mostly in the Tallangatta

Foothills, Pinnabar Mountains, Dartmouth Mountains, Bogong Mountains, Upper King Mountains, Highlands Foothills, and Strathbogie Foothills GRUs. Eight strata have a 100% probability that the next species detected is new, and a further eight strata were not surveyed sufficiently to allow calculation of a probability.

2.3.3 Summary

Of the 34 largest strata generated by the stratification of the North East region, the majority have been surveyed for each of the fauna groups considered. Bats, diurnal birds, and small ground mammals are the groups most comprehensively surveyed across the region, given that most large strata have low probabilities of new species of these groups being detected. Arboreal mammals, large mammals and nocturnal birds have been moderately well surveyed. The analysis indicates that for the majority of the largest strata, future surveys for reptiles are most likely to detect species not previously recorded in formal surveys. While a similar conclusion could be drawn from the data for amphibians and large forest owls, these groups are comprised of very few species and the reported probabilities are less reliable since the analysis was designed for larger data sets.

3. FOREST ECOSYSTEM ASSESSMENT

3.1 Introduction

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

To meet these objectives the following assessment outputs are required:

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

3.1.1 Ecological Vegetation Classes

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

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

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

Descriptions of EVCs occurring in the North East is given in Appendix C. On the adjacent foot slopes of the Great Dividing Range 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 also described in Appendix C under a separate heading.

Reference details for descriptions of EVCs severely depleted or at the edge of their range on public land within the study area are also provided as follows:

- Plains Grassy Woodland is described by Foreman (in prep.). However, the one remnant mapped in the study area was not sampled.
- Alluvial Terraces Herb-rich Woodland only occurs within the study area at Reef Hills Regional Park. Because the environment is at the margins of the defined ecological boundaries of the study area, it was not sampled during this study. However, the sites within the study area were sampled during the Box Ironbark Study by Muir *et. al* (1995) and were described in that report.
- Creekline Grassy Woodland was recognised along ephemeral drainage lines in the Mt Pilot Multi-Purpose Park. This vegetation type was not well sampled in the study area, as most occurrences in this locality are too small to map.
- A series of wetland sites which occur in floodplain environments were identified during the study. These comprise several wetland environment EVCs. However, as this environment is at the margins of the defined ecological boundaries on public land on the study area, and as most sites are degraded few sites were sampled. As a consequence these wetland environments are described and mapped as a 'formation'.
- At the foot slopes of granite hills in the Mt Pilot Multi-Purpose Park, Spring Soak Herbland (Cameron and Moorrees unpubl.) was mapped where it occurs on public land. Only the larger examples of this EVC were mapped as it generally occurs as areas of less than one hectare which could not adequately be represented at a scale of 1:100 000.
- Clay Heathland is well known south of the Great Dividing Range on the foothills and coastal plains in East Gippsland, central and south Gippsland and in the Central Highlands. It was first described in Woodgate *et al*. (1994). Several small areas are located north of the Great Dividing Range in Mt Lawson State Park.
- Grassy Woodland was characterised by Forbes *et al*. (1981) as Rainshadow Woodland where it occurs in the upper Snowy River valley and the lower valleys of the Deddick and Suggan Buggan Rivers. In the study area it has largely been cleared, with a few remnants in the Bethanga district and between Talgarno and Walwa.
- Riparian Shrubland generally occurs on streams with rocky and sandy stream beds. This EVC was first described in East Gippsland by Woodgate *et al*. (1994), where it occurs primarily on the Snowy, Cann and Genoa Rivers. In the study area it occurs on smaller streams such as Reedy Creek and Eurobin Creek.

3.2 Pre-1750 extent of Ecological Vegetation Classes

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

EVCs which were not recorded in the public land vegetation mapping of the study area (Appendix C) occur either on fertile lowland, riverine plains or rolling hills which have been largely cleared for agriculture, or occur on less fertile areas that have been cleared for urban development on the fringes of the larger towns.

3.2.1 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 0.1 shows the attributes used for those EVCs that occur on private land in the region, listed in their order of importance for each EVC. Further EVC attributes are presented in Appendix C.

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

Table 0.1 Physical attributes used to model and map the pre-1750 extent of EVCs

Ecological Vegetation Class	Attributes
Plains Grassy Woodland	Soil, topography, rainfall
Floodplain Riparian Woodland	Topography, floodplain morphology, inundation regime
Creekline Grassy Woodland	Stream order, gradient, topography
Grassy Woodland	Geology, rainfall, aspect, slope, soils, topography
Wetland Formation	Hydrology, soil, topography
Alluvial Terraces Herb-rich Woodland	Topography, hydrology, soils, rainfall
Box Ironbark Forest	Geology, rainfall, topography
Valley Heathy Forest	Soil, rainfall
Valley Grassy Forest	Geology, landsystems, rainfall
Heathy Dry Forest	Geology, aspect, elevation, slope, rainfall
Grassy Dry Forest	Geology, aspect, elevation, slope, rainfall
Shrubby Dry Forest	Geology, aspect, elevation, rainfall
Granitic Hills Woodland	Geology, aspect, slope, elevation, rainfall
Spring Soak Herbland	Geology, topography, hydrology
Clay Heathland	Geology, soil profile, hydrology
Perched Boggy Shrubland	Geology, soil, hydrology
Rocky-outcrop Shrubland / Herbland Mosaic	Geology, topography
Swampy Riparian Woodland	Topography, hydrology
Riparian Forest	Topography, hydrology
Riparian Shrubland	Geology, topography, soils
Riverine Escarpment Scrub	Topography (slope)
Herb-rich Foothill Forest	Aspect, rainfall, elevation
Damp Forest	Aspect, rainfall, elevation
Wet Forest	Aspect, rainfall, elevation
Montane Dry Woodland	Aspect, elevation, geology
Montane Damp Forest	Aspect, elevation
Montane Riparian Thicket	Elevation, topography, hydrology

Ecological Vegetation Class	Attributes
Sub-alpine Woodland	Elevation, topography, geology
Treeless Sub-alpine Mosaic	Elevation, topography

The inherent reliability of mapping produced at 1:100 000 scale using current technology is adequate for the assessment. The certainty of this mapping is related to the quality of the underlying data sets used to define the vegetation boundaries. Reliability was determined for the study area as a whole and for each 1:100,000 mapsheet. For each mapsheet both EVC labelling and EVC boundary reliability was determined. For a particular rating criterion not all components were required to be satisfied. However, for a "High" to be relevant at least the "EVC descriptions" criterion with either "Remnants" and "Ground-truthing" **or** "Attributes for modelling" criteria were required to be rated as "High".

Table 0.2 outlines the map reliability rating criteria for three categories and Table 0.3 outlines the regional reliability of mapping of the modelled pre-1750 vegetation in North East against these categories.

Table 0.2 Pre-1750 EVC map reliability rating criteria

COMPONENT	RELIABILITY LEVEL		
	HIGH	MODERATE	LOW
Ground-truthing	Large number of sites visited	Limited number of sites visited	Few sites visited
Remnants	Relatively intact remnants existing	High level of disturbance of remnants thus EVC difficult to determine	Few or no remnants exist
EVC descriptions	Accurate descriptions with specific parameters	Inadequate to cover environmental parameters or floristic community in area	Inadequate or non-existent
Attributes for modelling	EVC linked to a specific attribute (eg. geology) of which better than 1:100,000 scale map data was available	EVC linked to a number of attributes of which 1:100,000 scale map data was available for at least one.	EVC/complex/mosaic linked to several attributes which varied depending on geographic area and 1:250,000 scale map data available only **or** EVC/complex/mosaic linked to attributes but parameters not distinct.

Table 0.3 Mapping reliability of modelling Pre-1750 EVCs

High	Moderate	Low
Areas adjacent to public land mapping where remnant vegetation exists.	Mapping on Strathbogie Range plateau. Little remnant vegetation but some parameters distinct. Extent of Swampy Riparian Woodland and Perched Boggy Shrubland may be under-represented	Some of the large valleys with no remnant vegetation remaining eg. around Corryong, Tallangatta, Mansfield, Euroa
Areas with accessible remnant vegetation. eg. private land and road reserve remnants	Nagambie, Euroa, Yea, Mansfield mapsheets in general. Largely cleared but relatively more time spent on these mapsheets.	Areas now inundated - Hume Dam, Dartmouth Dam, Lake Buffalo, Lake Nillahcootie, Eildon Weir
	Pine plantations - with surrounding vegetation on public land	Pine plantations - surrounded by private land, particularly where no remnants exist
	Albury mapsheet around Mt Pilot Multi-purpose Park - although some remnant vegetation in this area is very complex and public land mapping is less reliable.	Extent and labels of EVCs around Walwa and Jingellic through to Talgarno.
	Mosaics - labels accurate but boundary less so.	Complexes between two or more EVCs.
	Power line easements with adjacent public land were all modelled based on previous EVC mapping.	

3.2.2 Results

The results of the Pre-1750 EVC analysis are presented in Table 0.4. 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 conservation reserves and other land tenures is shown in Table 3.4.

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

Table 0.4 Representative conservation (percentage reservation status) of EVCs in the North East study area based on Pre-1750s vegetation mapping

Ecological Vegetation Class	Area (ha)		Percent remaining	Percent of EVC (pre-1750 extent) in each land category					
				Conservation	State Forest		Other Parks & Reserve	Other Public Land	Private land
	Pre 1750	Current			*Code	Non-code			
Clay Heathland	65	35	54.2	25.4	0.7	3.6	-	-	24.4
Riparian Forest	16,080	11,270	70.1	19.0	15.2	26.8	0.8	1.3	6.9
Riparian Shrubland	1,440	910	63.0	56.5	-	-	-	-	6.5
Heathy Dry Forest	99,280	83,090	83.7	29.9	2.0	39.5	0.4	0.9	11.0
Shrubby Dry Forest	291,100	276,930	95.1	28.1	2.6	59.8	0.6	0.4	3.5
Grassy Dry Forest	296,420	146,500	49.4	7.7	1.1	19.0	1.1	0.8	19.6
Herb-rich Foothill Forest	555,490	402,600	72.5	17.0	4.9	39.1	0.4	0.7	10.5
Damp Forest	48,310	46,690	96.6	24.9	11.4	57.8	0.9	0.8	0.8
Wet Forest	6,690	6,250	93.5	39.2	15.1	38.0	-	1.1	-
Montane Dry Woodland	138,150	136,330	98.7	41.9	2.4	50.7	2.1	1.6	-
Montane Damp Forest	40,360	38,330	95.0	35.2	4.8	51.3	2.5	1.3	-
Montane Riparian Thicket	1,200	1,090	90.8	22.3	18.7	45.6	0.6	3.0	-
Sub-alpine Woodland	35,480	35,340	99.6	78.9	0.3	10.6	1.4	8.4	-
Treeless Sub-alpine Mosaic	21,020	20,490	97.5	89.6	-	0.0	-	7.7	-
Valley Grassy Forest	250,250	18,810	7.5	0.8	0.1	0.8	0.5	0.1	5.3
Heathy Woodland	35	35	100.0	-	1.7	98.3	-	-	-
Plains Grassy Woodland	210,800	1,930	0.9	0.0	0.0	0.0	-	0.0	0.9
Floodplain Riparian Woodland	46,750	4,310	9.2	1.9	0.0	0.0	-	0.2	6.4
Swampy Riparian Woodland/Perched Boggy Shrubland Mosaic	500	120	23.5	-	-	-	-	-	23.5
Box Ironbark Forest	20,310	3,800	18.7	15.0	-	-	-	0.3	3.4

Ecological Vegetation Class	Area (ha)		Percent remaining	Percent of EVC (pre-1750 extent) in each land category					
				Conservation	State Forest		Other Parks & Reserve	Other Public Land	Private land
Alluvial Terraces Herb-rich Woodland	210	10	5.6	3.8	-	-	-	-	1.8
Creekline Grassy Woodland	9,980	440	4.4	0.3	0.0	0.0	-	0.0	4.1
Granitic Hills Woodland	31,080	21,150	68.0	50.0	0.0	1.1	0.9	0.1	15.9
Rocky Outcrop Shrubland/Herbland Mosaic	3,480	3,230	92.9	67.4	0.1	15.0	3.5	1.2	5.8
Wetland Formation	3,670	250	6.8	-	-	-	-	-	6.8
Gilgai Plain Woodland/Wetland/ Heathy Dry Forest Mosaic	760	530	69.8	66.9	-	-	-	-	2.9
Spring Soak Herbland	55	15	24.4	0.3	-	-	-	1.1	23.0
Alluvial Terraces Herb-rich Woodland/Creekline Grassy Woodland Mosaic	340	35	10.3	-	-	-	-	0.0	10.3
Riverine Escarpment Scrub	680	520	76.2	22.4	6.1	32.8	-	4.1	10.7
Swampy Riparian Woodland	5,210	2,010	38.5	8.4	5.5	12.5	2.1	0.5	9.5
Riparian Mosaic - North East	6,730	2,600	38.6	6.0	8.9	15.3	0.1	3.8	4.4
Valley Heathy Forest	1,750	95	5.4	0.7	-	-	-	-	4.7
Alluvial Terraces Herb-rich Woodland/Plains Grassy Woodland Complex	1,090	20	1.7	1.6	-	-	-	-	0.1
Alluvial Terraces Herb-rich Woodland/Valley Grassy Forest Complex	920	20	2.3	0.2	-	-	-	-	2.1
Grassy Dry Forest/Rocky Outcrop Shrubland/Herbland Mosaic	950	190	19.8	-	-	-	-	4.1	15.7
Grassy Woodland	86,740	4,470	5.2	0.2	0.0	0.5	0.2	0.1	4.2
Perched Boggy Shrubland	1,730	300	17.2	-	0.1	0.8	-	0.0	16.2

Ecological Vegetation Class	Area (ha)		Percent remaining	Percent of EVC (pre-1750 extent) in each land category					
				Conservation	State Forest		Other Parks & Reserve	Other Public Land	Private land
Plains Grassy Woodland/Floodplain Riparian Woodland Complex	7,880	270	3.5	-	0.0	0.0	-	0.0	3.4
Plains Grassy Woodland/Rainshadow Grassy Woodland Complex	2,730	20	0.8	-	-	-	-	-	0.8
Plains Grassy Woodland/Valley Grassy Forest Complex	1,940	20	1.1	-	-	-	-	-	1.1
Plains Grassy Woodland/Valley Grassy Forest/Rainshadow Grassy Woodland Complex	2,400	110	4.5	-	-	-	-	-	4.5
Valley Grassy Forest/Box Ironbark Forest Complex	1,640	130	8.0	-	-	-	-	-	8.0
Gilgai Plain Woodland/Wetland Mosaic	9,900	480	4.9	2.8	-	-	-	-	2.0
Riparian Forest/Swampy Riparian Woodland Mosaic	4,640	390	8.4	0.2	0.2	0.5	0.0	0.1	7.4
Plains Grassy Woodland/Creekline Grassy Woodland/Floodplain Riparian Woodland Mosaic	3,880	55	1.4	-	-	-	-	-	1.4
Plains Grassy Woodland/Creekline Grassy Woodland/Wetland Mosaic	8,310	350	4.2	-	-	-	-	-	4.2
Valley Grassy Forest/Plains Grassy Woodland Mosaic	580	-	0.4	-	-	-	-	-	0.4
Grassy Dry Forest/Shrubby Granitic-outwash Grassy Woodland Mosaic	190	-	1.2	-	-	-	-	-	1.2
Granitic Hills Woodland/Rocky Outcrop Shrubland/Herbland Mosaic	3,980	3,020	75.7	58.7	0.2	2.8	-	1.4	12.7
Granitic Hills Woodland/Heathy Dry Forest Mosaic	10	-	-	-	-	-	-	-	-

Ecological Vegetation Class	Area (ha)		Percent remaining	Percent of EVC (pre-1750 extent) in each land category					
				Conservation	State Forest		Other Parks & Reserve	Other Public Land	Private land
Box Ironbark Forest/Spring Soak Herbland Mosaic	210	5	3.4	-	-	-	-	-	3.4
Grassy Dry Forest/Spring Soak Herbland Mosaic	390	65	16.4	-	-	-	-	-	16.4
Floodplain Riparian Woodland/Plains Grassy Woodland Mosaic	3,100	75	2.4	0.1	-	-	-	0.0	2.2
Rainshadow Grassy Woodland/Valley Grassy Forest Mosaic	3,620	50	1.4	-	-	-	-	-	1.4
Shrubby Granitic-outwash Grassy Woodland/Valley Grassy Forest Mosaic	170	20	10.2	-	-	-	-	6.3	3.9
Riverine Grassy Woodland/Riverine Sedgy Forest Mosaic	26,790	3,950	14.7	0.7	0.1	0.9	-	0.0	12.9
Sand Ridge Woodland	25	-	7.2	-	-	-	-	-	7.2
Valley Grassy Forest/Grassy Dry Forest Mosaic	250	100	39.2	-	-	-	-	-	39.2
Conifer Plantation	-	59,310	-	-	-	-	-	-	-
Cleared/Severely Disturbed	-	71,520	-	-	-	-	-	-	-
Rock/Bare Ground	-	25	-	-	-	-	-	-	-
Non-Treed Area	-	881,910	-	-	-	-	-	-	-
Water Body	-	25,490	-	-	-	-	-	-	-
Unknown/Unclassified	-	20	-	-	-	-	-	-	-
Grand Total	2,318,130	2,318,120							

Riparian Mosaic - North East is Riparian Forest/Swampy Riparian Woodland/Riparian Shrubland/Riverine Escarpment Scrub

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

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

*Areas protected under the Code of Forest Practices for Timber Production (NRE,1996)

3.3 Reservation status of Ecological Vegetation Classes

Information on the current reservation status of EVCs for the North East is provided in Table 0.4. The reservation level of each EVC can be assessed against the national reserve criteria. For those EVCs that are not endangered, vulnerable or rare, the criteria establish a reservation target of 15 per cent of the pre-1750 extent. If an EVC is vulnerable, then 60 per cent of its remaining extent should be reserved. All remaining occurrences of rare and endangered EVCs should be protected.

There are 58 EVCs occurring in the North East. Half of these (29) are vegetation mosaics or complexes which are usually comprised of small areas of two or more vegetation types interspersed with each other and are too small to be mapped individually at a scale of 1:100,000.

The occurrence of 31 of the EVCs is predominantly on private land and 27 EVCs occur predominantly on public land. For those EVCs that are not endangered, vulnerable or rare, the national reserve criteria reservation target of 15 per cent of the pre-1750 extent has been met for all EVCs except Grassy Dry Forest.

For many of the EVCs which are endangered, vulnerable or rare as a result of depletion (Table 3.4), the only occurrence outside conservation reserves is on private land. This reflects the historic demarcation between public land and the selection of arable lands for farming associated with private land.

3.3.1 Sub-regional reservation of Ecological Vegetation Classes

Nineteen Geographic Representation Units (GRUs) have been identified across the North East which reflect the landscape scale variation across the region (See Map 1 of the Comprehensive Regional Assessment Report). These are based on similar land form, geology, vegetation and climate. Table 0.5 lists the GRUs and the attributes that characterise them. The overall reservation status of each EVC was undertaken by overlaying the reserve system with the EVC coverage using a Geographic Information System (GIS).

Table 0.5 Geographic Representation Units of the North East and their attributes

Geographic Representation Unit (GRU)	Attributes
Barry Mountains	Montane to sub-alpine steep sided dissected ranges dissected by broad, fertile river valleys. River valleys of Quaternary alluviums. Ranges dominated by Ordovician marine sediments with Devonian granites and other volcanics, Devonian sediments and Carboniferous sediments. Rainfall high to very high.
Big Ben Foothills	Dissected foothills and steep-sided low mountains. Devonian and Silurian granites and Silurian metamorphics with smaller areas of Ordovician sediments. Rainfall low to very high.
Big River Mountains	Steeply dissected mountain ranges dissected by broad, fertile valleys of major rivers. River valleys with Quaternary alluviums. Ranges dominated by Devonian and Ordovician sediments with Carboniferous sediments, Devonian granites and granodiorites, Devonian metamorphics and Tertiary basalts. Rainfall high to very high.
Bogong Mountains	Steeply dissected ranges and alpine/sub-alpine plateaux with complex faulting. Ordovician metamorphics with smaller areas of Silurian/Ordovician granite/granodiorite and plateaux outcrops of Tertiary basalt. Rainfall high to very high.
Buffalo Mountains	Steep sedimentary hills (Mt Buffalo granite massif the most dominant feature) and narrow river valleys with restricted flats. Ordovician sediments with Devonian granites. Rainfall low to very high.
Corryong Foothills	Three distinct mountain ranges of Devonian granite and Devonian acid volcanics interspersed by broad valleys of Quaternary sediments and older alluvial terraces no longer subject to flooding. Rainfall low to high.
Dartmouth Mountains	Steeply dissected ranges and sub-alpine areas. Dominated by Ordovician and Silurian sediments with substantial areas of Silurian acid volcanics and a small area of Ordovician granodiorite. Rainfall high to very high.

Geographic Representation Unit (GRU)	Attributes
Delatite Valley	Undulating foothills and fertile plains and river flats to dissected mountain ranges in the east. Foothills and ranges predominantly Carboniferous sediments with Devonian sediments, Devonian metamorphics and Devonian volcanics. Broad river valleys of Quaternary alluviums. Rainfall moderate to high.
Granya Foothills	Low rolling hills of Silurian and Devonian granites to the east of the unit with Ordovician metamorphics west of Bullioh. Rainfall low to high.
Highlands Foothills	Kobyboyn and Callen Ranges, gently rolling hills of Devonian Granite with minor Devonian and Silurian sediments. Rainfall generally moderate.
King River Floodplain	Plain of recent Quaternary sediments (mostly alluvial) and low hills of Ordovician sediments. Rainfall low to high.
Matlock Mountains	Steeply dissected ranges. Devonian and Silurian sediments. Rainfall low to moderate.
Mitta Foothills	Dissected hills. Equally dominated by Ordovician metamorphics and sediments with smaller areas of Silurian granite and granodiorite and Quaternary sediments along major streams. Rainfall high to very high.
Mt Pilot Foothills	Low, gentle foothills of Devonian granite and narrow plains of Quaternary alluvial sediments with substantial colluvial sediments on the footslopes above plains. Contains substantial areas of alluvial plains through which rise low Ordovician sedimentary hills (Chiltern area). Rainfall low to high.
Pinnibar Mountains	Steeply dissected ranges. Ordovician sediments and substantial Ordovician/Silurian granodiorites and smaller areas of Ordovician metamorphics. Rainfall generally very high.
Strathbogie Foothills	Steep hills rising from plains and broad granite plateaux. Devonian acid volcanics and granites. Rainfall moderate to high on the granite plateau of Strathbogie Ranges, with the decline running northwards.
Tallangatta Foothills	Moderately steep hills dominated by Silurian granite, granodiorites. Rainfall high to very high.
Toombullup Foothills	Low, rolling hills and steep-sided foothill plateaux and Quaternary alluvial plains. Geology/lithology is complex and includes Devonian granites, acid volcanics, Ordovician sediments, Carboniferous sediments, Tertiary volcanics and Cambrian greenstones. Rainfall low to high, declining northwards.
Upper King Mountains	Steeply dissected ranges and broad, fertile river valleys. Ranges predominantly Devonian volcanics and Ordovician sediments with Devonian metamorphics, Tertiary basalt volcanics, and Carboniferous sediments. River valleys quaternary alluviums. Rainfall high.

Note: Rainfall is classified as low (<700mm), moderate (700-1000mm), high (1000-1200m) or very high (>1200mm).

The results of the analysis of representation of EVCs by Geographic Representation Unit are presented in Table 0.6.

Table 0.6 Representative conservation (percentage reservation status) of EVCs in the North East region by Geographic Representation Unit

Ecological Vegetation Classes	Pre 1750 Area (ha)	Barry Mountains		Big Ben Foothills		Big River Mountain		Bogong Mountains		Buffalo Mountains		Corryong Foothills	
		Area (ha)	Prot %	Area (ha)	Prot%	Area (ha)	Prot %	Area (ha)	Prot%	Area (ha)	Prot %	Area (ha)	Prot %
7. Clay Heathland	65	-		5	-	-		-		-		-	
18. Riparian Forest	16,080	1,760	48	80	38	2,910	19	1,500	53	900	3	20	100
19. Riparian Shrubland	1,440	-		-		-		-		570	96	-	
20. Heathy Dry Forest	99,280	7,400	39	3,330	1	3,150	15	1,290	38	10,640	16	5,130	73
21.Shrubby Dry Forest	291,100	19,880	55	19,270	4	17,620	34	8,620	37	42,890	35	2,620	60
22. Grassy Dry Forest	296,420	-		51,710	7	3,110	8	710	27	20,310	9	22,140	12
23. Herb-rich Foothill Forest	555,490	28,160	51	43,680	6	25,540	23	13,260	29	50,300	24	8,610	43
29. Damp Forest	48,310	3,490	50	860	-	7,070	26	3,030	52	2,050	29	-	
30. Wet Forest	6,690	1,380	58	40	-	790	40	1,390	63	45	100	-	
36. Montane Dry Woodland	138,150	23,330	59	1,750	7	15,200	42	20,750	74	12,850	58	1,930	99
38. Montane Damp Forest	40,360	4,300	49	170	-	5,590	37	7,930	71	3,280	66	40	100
41. Montane Riparian Thicket	1,200	75	77	-		30	83	140	78	-		-	
43. Sub-alpine Woodland	35,480	2,670	96	-		4,320	69	16,810	88	4,270	94	-	
44. Treeless Sub-alpine Mosaic	21,020	300	100	-		680	72	18,490	90	900	99	-	
47. Valley Grassy Forest	250,250	-		31,050	-	1,600	2	410	-	4,760	-	31,480	3
48. Heathy Woodland	35	-		-		35	-	-		-		-	
55. Plains Grassy Woodland	210,800	-		3,550	-	5	-	-		2,960	-	2,420	-
56.Floodplain Riparian Woodland	46,750	-		3,760	-	-		-		3,360	-	9,520	2
212 Swampy Riparian Woodland/Perched Boggy Shrubland Mosaic	500	-		-		-		-		-		-	
61. Box Ironbark Forest	20,310	-		-		-		-		-	-	-	
67. Alluvial Terraces Herb-rich Woodland	210	-		-		-		-		-		-	
68. Creekline Grassy Woodland	9,980	-		720	1	-		-		130	-	210	-
72.Granitic Hills Woodland	31,080	-		-		-		-		-		11,620	64
73. Rocky Outcrop Shrubland/Herbland Mosaic	3,480	150	100	180	18	-		15	27	610	97	730	100
74. Wetland Formation	3,670	-		-		-		-		-		-	
79. Gilgai Plain Woodland/Wetland/Heathy Dry Forest Mosaic	760	-		-		-		-		-		-	
80. Spring Soak Herbland	55	-		-	-	-		-		-		-	
81. Alluvial Terraces Herb-rich Woodland/Creekline Grassy Woodland Mosaic	340	-		-		-		-		-		-	
82. Riverine Escarpment Scrub	680	-		-		-		-		75	96	5	-
83. Swampy Riparian Woodland	5,210	400	53	55	1	45	21	320	1	220	9	35	52
84. Riparian Mosaic - North East	6,730	160	-	390	-	240	71	-		1,190	16	-	-
127. Valley Heathy Forest	1,750	-		-		-		-		-		-	
152. Alluvial Terraces Herb-rich Woodland/Plains Grassy Woodland Complex	1,090	-		-		-		-		-		-	
153. Alluvial Terraces Herb-rich Woodland/Valley Grassy Forest Complex	920	-		-		-		-		-		-	
174. Grassy Dry Forest/Rocky Outcrop Shrubland/Herbland Mosaic	950	-		-		-		-		-		-	
175. Grassy Woodland	86,740	-		330	-	330	-	-		40	-	1,150	2
185. Perched Boggy Shrubland	1,730	-		-		-		-		-		-	
186. Plains Grassy Woodland/Floodplain Riparian Woodland Complex	7,880	-		-		-		-		-		-	
187. Plains Grassy Woodland/Rainshadow Grassy Woodland Complex	2,730	-		-		-		-		-		-	
188. Plains Grassy Woodland/Valley Grassy Forest Complex	1,940	-		95	-	-		-		-		-	
190. Plains Grassy Woodland/Valley Grassy Forest/Rainshadow Grassy Woodland Complex	2,400	-		2,320	1	-		-		-		-	
213. Valley Grassy Forest/Box Ironbark Forest Complex	1,640	-		-		-		-		-		-	
235. Gilgai Plain Woodland/Wetland Mosaic	9,900	-		-		-		-		-		-	
237. Riparian Forest/Swampy Riparian Woodland Mosaic	4,640	-		1,600	2	-		560	4	440	-	250	4
238. Plains Grassy Woodland/Creekline Grassy Woodland/Floodplain Riparian Woodland Mosaic	3,880	-		740	-	-		-		3,140	-	-	
240. Plains Grassy Woodland/Creekline Grassy Woodland/Wetland Mosaic	8,310	-		-		-		-		-		-	
241. Valley Grassy Forest/Plains Grassy Woodland Mosaic	580	-		-		-		-		-		-	
243. Grassy Dry Forest/Shrubby Granitic-outwash Grassy Woodland Mosaic	190	-		-		-		-		-		-	
244. Granitic Hills Woodland/Rocky Outcrop Shrubland/Herbland Mosaic	3,980	-		180	-	-		-		-		-	
245. Granitic Hills Woodland/Heathy Dry Forest Mosaic	10	-		-		-		-		-		-	
247. Box Ironbark Forest/Spring Soak Herbland Mosaic	210	-		-		-		-		-		-	
248. Grassy Dry Forest/Spring Soak Herbland Mosaic	390	-		-		-		-		-		-	
250. Floodplain Riparian Woodland/Plains Grassy Woodland Mosaic	3,100	-		-		-		-		-		2,390	1
251. Rainshadow Grassy Woodland/Valley Grassy Forest Mosaic	3,620	-		830	-	-		-		-		-	
254. Shrubby Granitic-outwash Grassy Woodland/Valley Grassy Forest Mosaic	170	-		-		-		-		-		-	
255. Riverine Grassy Woodland/Riverine Sedgy Forest Mosaic	26,790	-		1,300	-	-		-		210	-	-	
264. Sand Ridge Woodland	25	-		-		-		-		-		-	
265. Valley Grassy Forest/Grassy Dry Forest Mosaic	250	-		-		-		-		-		-	
Grand Total	2,318,130												

Ecological Vegetation Classes	Pre 1750 Area (ha)	Dartmouth Mountains		Delatite Valley		Granya Foothills		Highlands Foothills		King River Floodplain		Matlock Mountains	
		Area (ha)	Prot %	Area (ha)	Prot %	Area (ha)	Prot %	Area (ha)	Prot %	Area (ha)	Prot %	Area (ha)	Prot %
7. Clay Heathland	65	-		-		15	100	20	-	-		-	
18. Riparian Forest	16,080	1,220	9	810	17	-		840	27	55	-	200	-
19. Riparian Shrubland	1,440	-		-		110	3	410	92	-		-	
20. Heathy Dry Forest	99,280	4,760	90	1,160	27	7,320	55	2,050	1	3,610	2	1,240	-
21.Shrubby Dry Forest	291,100	29,780	53	7,600	4	7,460	66	1,090	-	450	-	3,710	-
22. Grassy Dry Forest	296,420	3,210	33	16,930	28	16,140	17	28,160	4	19,710	1	160	-
23. Herb-rich Foothill Forest	555,490	29,090	47	21,270	8	10,260	31	53,020	3	3,860	1	3,920	0
29. Damp Forest	48,310	6,880	27	2,110	8	-		200	51	15	-	3,760	-
30. Wet Forest	6,690	340	18	75	15	-		-		-	-	-	
36. Montane Dry Woodland	138,150	15,530	30	3,730	5	-		-		10	-	3,410	7
38. Montane Damp Forest	40,360	7,020	15	680	3	-		-		-	-	1,340	5
41. Montane Riparian Thicket	1,200	30	-	60	11	-		-		-	-	-	
43. Sub-alpine Woodland	35,480	1,160	60	1,180	1	-		-		-	-	690	93
44. Treeless Sub-alpine Mosaic	21,020	380	100	130	-	-		-		-	-	55	100
47. Valley Grassy Forest	250,250	1,250	1	25,950	-	10,290	5	30,220	1	12,270	-	-	
48. Heathy Woodland	35	-		-		-		-		-	-	-	
55. Plains Grassy Woodland	210,800	-		25,000	-	4,070	1	15,370	-	45,950	-	-	
56.Floodplain Riparian Woodland	46,750	-		2,990	-	2,500	-	6,680	17	4,670	-	-	
212 Swampy Riparian Woodland/Perched Boggy Shrubland Mosaic	500	-		-		-		500	-	-	-	-	
61. Box Ironbark Forest	20,310	-		-		-		5,720	-	250	-	-	
67. Alluvial Terraces Herb-rich Woodland	210	-		-		-		-		-	-	-	
68. Creekline Grassy Woodland	9,980	-		330	-	880	1	1,190	-	860	-	-	
72.Granitic Hills Woodland	31,080	-		-		6,900	90	3,350	10	30	-	-	
73. Rocky Outcrop Shrubland/Herbland Mosaic	3,480	-		-		160	71	380	40	-	-	-	
74. Wetland Formation	3,670	-		300	-	-		95	-	1,200	-	-	
79. Gilgai Plain Woodland/Wetland/Heathy Dry Forest Mosaic	760	-		-		-		-		-	-	-	
80. Spring Soak Herbland	55	-		-		-		5	-	-	-	-	
81. Alluvial Terraces Herb-rich Woodland/Creekline Grassy Woodland Mosaic	340	-		-		-		-		-	-	-	
82. Riverine Escarpment Scrub	680	5	-	5	-	5	-	25	25	-	-	-	
83. Swampy Riparian Woodland	5,210	35	-	10	-	430	2	1,560	8	40	-	35	-
84. Riparian Mosaic - North East	6,730	1,600	8	190	-	-		520	57	55	-	-	
127. Valley Heathy Forest	1,750	-		-		-		710	-	-	-	-	
152. Alluvial Terraces Herb-rich Woodland/Plains Grassy Woodland Complex	1,090	-		-		-		-		-	-	-	
153. Alluvial Terraces Herb-rich Woodland/Valley Grassy Forest Complex	920	-		-		-		-		-	-	-	
174. Grassy Dry Forest/Rocky Outcrop Shrubland/Herbland Mosaic	950	-		-		-		950	-	-	-	-	
175. Grassy Woodland	86,740	-		6,940	1	15,400	1	21,470	0	4,400	-	-	
185. Perched Boggy Shrubland	1,730	-		-		-		490	2	-	-	-	
186. Plains Grassy Woodland/Floodplain Riparian Woodland Complex	7,880	-		-		-		-		-	-	-	
187. Plains Grassy Woodland/Rainshadow Grassy Woodland Complex	2,730	-		-		-		-		-	-	-	
188. Plains Grassy Woodland/Valley Grassy Forest Complex	1,940	-		-		-		-		1,200	-	-	
190. Plains Grassy Woodland/Valley Grassy Forest/Rainshadow Grassy Woodland Complex	2,400	-		-		-		-		-	-	-	
213. Valley Grassy Forest/Box Ironbark Forest Complex	1,640	-		-		-		-		-	-	-	
235. Gilgai Plain Woodland/Wetland Mosaic	9,900	-		-		-		-		-	-	-	
237. Riparian Forest/Swampy Riparian Woodland Mosaic	4,640	60	-	-		-		-		-	-	-	
238. Plains Grassy Woodland/Creekline Grassy Woodland/Floodplain Riparian Woodland Mosaic	3,880	-		-		-		-		-	-	-	
240. Plains Grassy Woodland/Creekline Grassy Woodland/Wetland Mosaic	8,310	-		-		-		-		8,310	-	-	
241. Valley Grassy Forest/Plains Grassy Woodland Mosaic	580	-		-		-		130	-	-	-	-	
243. Grassy Dry Forest/Shrubby Granitic-outwash Grassy Woodland Mosaic	190	-		-		-		190	-	-	-	-	
244. Granitic Hills Woodland/Rocky Outcrop Shrubland/Herbland Mosaic	3,980	-		-		-		170	-	-	-	-	
245. Granitic Hills Woodland/Heathy Dry Forest Mosaic	10	-		-		-		10	-	-	-	-	
247. Box Ironbark Forest/Spring Soak Herbland Mosaic	210	-		-		-		210	-	-	-	-	
248. Grassy Dry Forest/Spring Soak Herbland Mosaic	390	-		-		-		390	-	-	-	-	
250. Floodplain Riparian Woodland/Plains Grassy Woodland Mosaic	3,100	-		-		-		710	1	-	-	-	
251. Rainshadow Grassy Woodland/Valley Grassy Forest Mosaic	3,620	-		-		-		-		260	-	-	
254. Shrubby Granitic-outwash Grassy Woodland/Valley Grassy Forest Mosaic	170	-		-		-		150	-	-	-	-	
255. Riverine Grassy Woodland/Riverine Sedgy Forest Mosaic	26,790	-		-		1,290	-	-		6,770	-	-	
264. Sand Ridge Woodland	25	-		-		-		-		-	-	-	
265. Valley Grassy Forest/Grassy Dry Forest Mosaic	250	-		-		-		-		250	-	-	
Grand Total	2,318,130												

Ecological Vegetation Classes	Pre 1750 Area (ha)	Mitta Foothills		Mt Pilot Foothills		Pinnibar Mountains		Strathbogie Foothills		Tallangatta Foothills		Toombullup Foothills		Upper King Mountains	
		Area (ha)	Prot %	Area (ha)	Prot %	Area (ha)	Prot %	Area (ha)	Prot %	Area (ha)	Prot %	Area (ha)	Prot %	Area (ha)	Prot %
7. Clay Heathland	65	-		-		-		-		-		-		18	-
18. Riparian Forest	16,080	550	-	-		1,450	18	410	-	500	-	980	-	1,890	37
19. Riparian Shrubland	1,440	45	-	250	70	-		-		50	-	-		-	
20. Heathy Dry Forest	99,280	2,290	-	6,360	43	2,430	4	5,600	11	5,100	10	15,660	14	10,770	56
21.Shrubby Dry Forest	291,100	31,370	2	-		33,760	29	490	40	29,370	14	2,100	2	33,030	28
22. Grassy Dry Forest	296,420	21,270	0	22,200	15	7,220	5	17,200	1	19,210	2	22,590	10	4,460	11
23. Herb-rich Foothill Forest	555,490	45,320	1	550	11	47,320	25	43,590	2	50,090	9	29,210	13	48,440	27
29. Damp Forest	48,310	3,830	1	-		6,100	36	1,250	1	3,680	35	1,620	15	2,370	23
30. Wet Forest	6,690	-		-		2,490	21	-		-		-		140	46
36. Montane Dry Woodland	138,150	2,870	-	-		22,800	18	-		5,130	31	-		8,870	28
38. Montane Damp Forest	40,360	1,070	-	-		5,950	13	-		1,670	31	-		1,310	15
41. Montane Riparian Thicket	1,200	-		-		270	-	-		350	18	230	-	15	84
43. Sub-alpine Woodland	35,480	-		-		3,500	59	-		110	100	-		780	11
44. Treeless Sub-alpine Mosaic	21,020	-		-		40	100	-		-		-		40	90
47. Valley Grassy Forest	250,250	13,740	-	32,430	4	3,950	2	19,920	0	12,080	-	18,220	1	650	-
48. Heathy Woodland	35	-		-		-		-		-		-		-	
55. Plains Grassy Woodland	210,800	3,640	3	72,690	0	230	-	17,130	0	170	-	16,740	-	870	-
56.Floodplain Riparian Woodland	46,750	4,950	-	720	-	920	-	1,770	-	690	-	3,710	-	490	-
212 Swampy Riparian Woodland/Perched Boggy Shrubland Mosaic	500	-		-		-		-		-		-		-	
61. Box Ironbark Forest	20,310	-		7,880	32	-		1,540	44	-		4,920	-	-	
67. Alluvial Terraces Herb-rich Woodland	210	-		65	12	-		150	-	-		-		-	
68. Creekline Grassy Woodland	9,980	250	-	2,910	3	-		1,680	-	120	-	730	-	-	
72.Granitic Hills Woodland	31,080	150	-	7,980	29	-		80	5	460	-	510	-	-	
73. Rocky Outcrop Shrubland/Herbland Mosaic	3,480	-		500	64	30	23	220	6	-		55	69	430	47
74. Wetland Formation	3,670	-		1,960	6	-		15	-	-		100	-	-	
79. Gilgai Plain Woodland/Wetland/Heathy Dry Forest Mosaic	760	-		-		-		760	68	-		-		-	
80. Spring Soak Herbland	55	-		45	-	-		-		-		-	-	-	
81. Alluvial Terraces Herb-rich Woodland/Creekline Grassy Woodland Mosaic	340	-		340	-	-		-		-		-		-	
82. Riverine Escarpment Scrub	680	100	-	-		170	43	-		160	-	-	-	130	7
83. Swampy Riparian Woodland	5,210	310	-	160	5	290	16	510	16	400	2	130	11	230	44
84. Riparian Mosaic - North East	6,730	520	-	-		540	38	85	-	640	4	250	3	350	-
127. Valley Heathy Forest	1,750	-		-		-		-		-		850	-	180	7
152. Alluvial Terraces Herb-rich Woodland/Plains Grassy Woodland Complex	1,090	-		1,090	2	-		-		-		-		-	
153. Alluvial Terraces Herb-rich Woodland/Valley Grassy Forest Complex	920	-		920	1	-		-		-		-		-	
174. Grassy Dry Forest/Rocky Outcrop Shrubland/Herbland Mosaic	950	-		-		-		5	-	-		-		-	
175. Grassy Woodland	86,740	4,610	1	18,890	3	-		12,560	0	130	-	490	-	-	
185. Perched Boggy Shrubland	1,730	-		-		-		1,230	6	-		-		-	
186. Plains Grassy Woodland/Floodplain Riparian Woodland Complex	7,880	7,200	-	-		-		-		680	-	-		-	
187. Plains Grassy Woodland/Rainshadow Grassy Woodland Complex	2,730	-		2,730	-	-		-		-		-		-	
188. Plains Grassy Woodland/Valley Grassy Forest Complex	1,940	170	-	470	-	-		-		-		-		-	
190. Plains Grassy Woodland/Valley Grassy Forest/Rainshadow Grassy Woodland Complex	2,400	-		75	-	-		-		-		-		-	
213. Valley Grassy Forest/Box Ironbark Forest Complex	1,640	-		920	-	-		85	-	-		630	-	-	
235. Gilgai Plain Woodland/Wetland Mosaic	9,900	-		2,040	2	-		4,440	6	-		3,430	-	-	
237. Riparian Forest/Swampy Riparian Woodland Mosaic	4,640	420	-	-		25	-	210	-	760	-	-		320	1
238. Plains Grassy Woodland/Creekline Grassy Woodland/Floodplain Riparian Woodland Mosaic	3,880	-		-		-		-		-		-		-	
240. Plains Grassy Woodland/Creekline Grassy Woodland/Wetland Mosaic	8,310	-		-		-		-		-		-		-	
241. Valley Grassy Forest/Plains Grassy Woodland Mosaic	580	-		-		-		450	-	-		-		-	
243. Grassy Dry Forest/Shrubby Granitic-outwash Grassy Woodland Mosaic	190	-		-		-		-		-		-		-	
244. Granitic Hills Woodland/Rocky Outcrop Shrubland/Herbland Mosaic	3,980	-		3,630	66	-		-		-		-		-	
245. Granitic Hills Woodland/Heathy Dry Forest Mosaic	10	-		-		-		-		-		-		-	
247. Box Ironbark Forest/Spring Soak Herbland Mosaic	210	-		-		-		-		-		-		-	
248. Grassy Dry Forest/Spring Soak Herbland Mosaic	390	-		-		-		-		-		-		-	
250. Floodplain Riparian Woodland/Plains Grassy Woodland Mosaic	3,100	-		-		-		-		-		-		-	
251. Rainshadow Grassy Woodland/Valley Grassy Forest Mosaic	3,620	580	-	490	-	-		-		-		1,470	-	-	
254. Shrubby Granitic-outwash Grassy Woodland/Valley Grassy Forest Mosaic	170	-		-		-		-		-		23	-	-	
255. Riverine Grassy Woodland/Riverine Sedgy Forest Mosaic	26,790	7,370	2	9,840	17	-		-		-		-		-	
264. Sand Ridge Woodland	25	-		25	-	-		-		-		-		-	
265. Valley Grassy Forest/Grassy Dry Forest Mosaic	250	-		-		-		-		-		-		-	
Grand Total	2,318,130														

3.3.2

Representation within reserves of floristic variation across EVCs

Floristic communities are the basic unit for assessing flora biodiversity in local management planning. They are described at a finer scale than EVCs which are a regional-scale management tool, i.e. an EVC may consist of one or more floristic communities.

An assessment of the representation of floristic variation (represented by floristic communities) 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 using the PATN method of floristic computer analysis (Belbin, 1987) 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 there are 28 EVCs, 29 mosaics and complexes and one formation (see Appendix C). Of these thirteen of the EVCs were comprised of more than one floristic community. These are Sub-alpine Woodland (6 floristic communities), Montane Riparian Thicket (2 floristic communities), Montane Damp Forest (5 floristic communities), Montane Dry Woodland (3 floristic communities), Wet Forest (2 floristic communities), Damp Forest (2 floristic communities), Herb-rich Foothill Forest (5 floristic communities), Heathy Dry Forest (2 floristic communities), Grassy Dry Forest (2 floristic communities), Box Ironbark Forest (2 floristic communities), Riparian Forest (2 floristic communities), Valley Grassy Forest (2 floristic communities) and Grassy Woodland (4 floristic communities). The remaining EVCs consist of only a single floristic community within the study area. Based on current information, those floristic communities which are not represented in reserves are Foothill Grassy Woodland 1 which occurs along the Gibbo River Valley between the confluences of King and Donnovan Creeks with the Gibbo River; Perched Boggy Shrubland which occurs on public land near Koetong Creek, south east of Mt Lawson; and Riverine Escarpment Scrub which occurs on the Buffalo River upstream of Abbeyard.

Three EVCs, Riparian Shrubland, Heathy Woodland and Creekline Grassy Woodland, were not represented by quadrat samples on public land, thus their reservation status could not be assessed by this method. However, the following occurrences have been located on public land:

- Riparian Shrubland - Mt Pilot Multi-purpose Park (Reedy Creek)
- Heathy Woodland - Jamieson Gap, north east of Jamieson
- Creekline Grassy Woodland - Mt Pilot Multi-purpose Park

3.3.3 Reservation status of Ecological Vegetation Class growth stages

In addition to the representation of EVCs and old growth forest in reserves, representation of the range of different forest growth stages in each EVC has been assessed. 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.

The following forest disturbance class growth stages are based on Woodgate *et al*. (1994) and used for this assessment.

1. Old-growth Forest - see the Study of Old Growth Forest in Victoria's North East report or the North East CRA Report;
2. No Recorded Disturbance - forests which are not old growth where no records of disturbance are found. Mature forests with no recorded disturbance can be categorised as Negligibly Disturbed Forest, and Regrowth Forest with no recorded disturbance as Significantly Disturbed Forest.
3. 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;
4. 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 (ie. wildfire), and forests which have been subjected to un-natural disturbances thought to have had a significant effect on their naturalness;
5. Temporary Significant Unnatural Disturbance - associated with the number of years since the last fire event, typically 1-10 years. Forests which are not old-growth and have been subject to temporary significant unnatural disturbance can be categorised as Negligibly Disturbed Forest (Mature Forest) or Significantly Disturbed Forest (Regrowth Forest).
6. Other Forest - non-forest EVCs.

The data used in the assessment derive from the North East public land mapping EVC coverage, the North East old growth forest study, and land tenure data layers held by the Department of Natural Resources and Environment.

The area by EVC of old-growth forest, negligibly and significantly disturbed forest and other forest is presented in Table 0.7. The area figures in Table 0.7 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.

Some refinements to the EVC layers (both current and pre-1750 layers) have been made during the pre-1750 mapping exercise. 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 this data. Consequently, there are minor differences in the total EVC areas on public land shown in this table and in Table 0.4.

Table 0.7 Extent and level of protection for different forest growth stages and disturbance categories in the North East region.

Ecological Vegetation Classes	Old-growth Forest		No recorded disturbance		Negligibly Disturbed		Significantly Disturbed		Temporary Significant Unnatural Disturbance		Other Forest	
	Area (ha)	% Prot	Area (ha)	% Prot	Area (ha)	% Prot	Area (ha)	% Prot	Area (ha)	% Prot	Area (ha)	% Prot
Clay Heathland	-	-	5	100	10	100	-		-	-	-	-
Riparian Forest	520	26	590	39	2,620	30	5,850	30	190	46	430	24
Riparian Shrubland	-	-	550	100	110	100	40	100	-	100	10	100
Heathy Dry Forest	22,110	46	4,740	34	17,020	37	21,760	42	7,260	33	700	33
Shrubby Dry Forest	93,800	32	9,330	18	77,390	35	59,140	30	16,970	29	2,260	26
Grassy Dry Forest	16,750	26	12,420	18	16,550	27	44,230	24	4,120	20	2,050	19
Herb-rich Foothill Forest	60,250	27	19,840	20	118,530	31	137,440	26	2,070	35	5,650	20
Grassy Woodland	-	-	210	0	65	100	210	99	-	-	-	5
Damp Forest	6,320	26	1,020	23	26,750	26	9,890	24	1,600	37	740	42
Wet Forest	1,460	41	110	17	2,380	42	1,890	46	140	74	75	68
Montane Dry Woodland	31,790	44	2,610	37	33,070	43	64,730	43	2,080	29	2,130	29
Montane Damp Forest	6,790	36	640	36	8,820	37	20,930	38	380	13	770	19
Montane Riparian Thicket	120	30	20	1	470	23	470	26	-	-	-	0
Sub-alpine Woodland	14,870	82	710	86	4,540	83	13,380	77	550	66	1,240	52
Treeless Sub-alpine Mosaic	-	-	620	70	6,300	88	12,930	95	550	100	60	78
Valley Grassy Forest	15	64	480	27	140	45	4,130	33	270	19	90	45
Plains Grassy Woodland	-	-	15	4	-	-	40	95	-	-	5	49
Floodplain Riparian Woodland	-	-	1,070	92	-	-	40	90	-	-	5	100
Box Ironbark Forest	-	-	15	98	-	100	3,080	99	-	-	46	97
Alluvial Terraces Herb-rich Woodland	-	-	-	-	-	-	230	100	-	-	4	100
Creekline Grassy Woodland	-	-	15	-	-	-	10	90	-	-	0	100
Granitic Hills Woodland	4,260	99	2,000	97	2,630	97	5,480	93	500	92	1,200	100
Rocky Outcrop Shrubland/Herbland Mosaic	-	-	3,570	84	720	93	340	69	930	79	60	78

Ecological Vegetation Classes	Old-growth Forest		No recorded disturbance		Negligibly Disturbed		Significantly Disturbed		Temporary Significant Unnatural Disturbance		Other Forest	
	Area (ha)	% Prot	Area (ha)	% Prot	Area (ha)	% Prot	Area (ha)	% Prot	Area (ha)	% Prot	Area (ha)	% Prot
Wetland Formation	-	-	20	100	-	-	5	81	10	-	5	46
Gilgai Plain Woodland/Wetland/Heathy Dry Forest Mosaic	-	-	-	100	-	-	500	100	-	-	5	100
Spring Soak Herbland	-	-	-	-	-	-	40	-	-	-	-	-
Riverine Escarpment Scrub	-	-	160	8	100	67	25	37	140	43	-	23
Swampy Riparian Woodland	250	39	55	24	100	19	1,050	26	5	8	15	31
Riparian Mosaic - North East	160	35	250	6	250	16	1,430	17	25	69	120	26
Total (ha)	259,980	37	60,570	30	318,560	36	409,300	34	37,780	33	17,670	11

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.

(c) Forests which are not old-growth and have been subject to temporary significant unnatural disturbance (disturbance associated with the number of years since the last fire event, typically 1 - 10 years) can be categorised as Negligibly Disturbed Forest (Mature Forest) or Significantly Disturbed Forest (Regrowth Forest).

(d) Forests with no recorded disturbance can be categorised as Negligibly Disturbed Forest (Mature Forest) or Significantly Disturbed Forest (Regrowth Forest).

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

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

1.1.1

3.3.4 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 are presented in Table 0.9. This assessment is relevant to Criteria 2 and 3 which specify reservation targets for EVCs classified as endangered, vulnerable or rare. As outlined previously, all remaining occurrences of rare and endangered EVCs should be reserved or protected by other means as far as is practicable, and at least 60 percent of the remaining extent of vulnerable EVCs should be reserved.

Table 0.8 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, or **R2**. Total area generally less than 1 000 ha, or **R3**. Patch sizes generally less than 100 ha.
Vulnerable	**V1**. Approaching greater than 70% lost (depletion), or **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, or **V3**. Subject to continuing threatening processes.
Endangered	**E1**. Distribution has contracted to less than 10% of original range, or **E2**. Less than 10% of original area remaining, or **E3**. 90% of area is in small patches subjected to threatening processes.

Most of the EVCs listed in Table 0.9 are largely confined to private land in the region (see also Section 3.2).

Table 0.9 Endangered, Vulnerable and Rare Ecological Vegetation Classes in the North East

			Current Management		
EVC	**Criteria**	**Threatening Processes[1]**	**Management Mechanism**	**% Reservation in Conservation Parks and Reserves**	**Research**
Clay Heathland	R1, R2, R3	-		25.4	
Riparian Forest	R3, V2, V3	weed invasion, grazing, recreation, mining	Native Vegetation Retention Controls (NVR) Weed control Exclusion from timber harvesting through buffers	19.0	Weed control
Riparian Shrubland	R3	-		56.5	
Heathy Dry Forest	V2, V3	inappropriate fire regimes (frequency, season of burn and intensity)	NVR Code of Practice for Fire Management on Public Land	29.9	
Valley Grassy Forest	V1, V2, V3	weed invasion, grazing, firewood and post and pole production	NVR *Land for Wildlife*	0.8	
Heathy Woodland	R1, R2	-		-	
Plains Grassy Woodland	V2, V3, E2, E3	habitat loss, clearing, agriculture, fragmentation, grazing, weed invasion, road construction and maintenance	NVR *Land for Wildlife*	0.0	
Floodplain Riparian Woodland	V2, V3, E2, E3	habitat loss, clearing, agriculture, fragmentation, alteration of flooding regimes, grazing	NVR *Land for Wildlife*	1.9	
Swampy Riparian Woodland/Perched Boggy Shrubland Mosaic	R1, R2, R3, V1, V2, V3, E3	clearing for agriculture, grazing, weed invasion	NVR *Land for Wildlife*	-	
Box Ironbark Forest	V1, V2, V3	timber harvesting, firewood and post and pole production, grazing, mining, habitat loss, fragmentation, weed invasion	NVR *Land for Wildlife*	15.0	Monitoring of habitat conditions
Alluvial Terraces Herb-rich Woodland	R1, R2, V2, V3, E2, E3	firewood and post and pole production, grazing, clearing, habitat loss, fragmentation,	NVR	3.8	Monitoring of habitat conditions

			Current Management		
EVC	**Criteria**	**Threatening Processes[1]**	**Management Mechanism**	**% Reservation in Conservation Parks and Reserves**	**Research**
		weed invasion	*Land for Wildlife*		
Creekline Grassy Woodland	R3, V2, V3, E2, E3	firewood and post and pole production, grazing, clearing, habitat loss, fragmentation, weed invasion	NVR *Land for Wildlife*	0.3	Monitoring of habitat conditions
Rocky Outcrop Shrubland/Herbland Mosaic	R3	-		67.4	
Wetland Formation	V2, V3, E2, E3	altered water /drainage regimes, grazing, weed invasion, habitat loss, salination	NVR Fencing *Land for Wildlife*	-	
Alluvial Terraces Herb-rich Woodland/Wetland/Heathy Dry Forest Mosaic	R1, R2	-		66.9	
Spring Soak Herbland	R1, R2, R3, V1, V2, V3, E3	grazing, timber harvesting, altered water regimes, weed invasion, agriculture	NVR *Land for Wildlife*	0.3	
Alluvial Terraces Herb-rich Woodland/Creekline Grassy Woodland Mosaic	R1, R2, R3, V2, V3, E2, E3	weed invasion, grazing, timber harvesting, agriculture, fragmentation, habitat loss	NVR *Land for Wildlife*	-	Monitoring of habitat conditions
Riverine Escarpment Scrub	R1, R2	-		22.4	
Swampy Riparian Woodland	V2, V3	weed invasion, grazing, mining	Fencing Weed control *Land for Wildlife*	8.4	Weed control
Riparian Mosaic - North East	R3, V2, V3	weed invasion, grazing, recreation, mining		6.0	

			Current Management		
EVC	**Criteria**	**Threatening Processes[1]**	**Management Mechanism**	**% Reservation in Conservation Parks and Reserves**	**Research**
Valley Heathy Forest	R3, V2, V3, E2, E3	clearing, agriculture, habitat loss, weed invasion	NVR *Land for Wildlife*	0.7	
Alluvial Terraces Herb-rich Woodland/Plains Grassy Woodland Complex	R1, R2, V2, V3, E2, E3	habitat loss, clearing, agriculture, fragmentation, grazing, weed invasion, road construction and maintenance, firewood collection and post and pole production	NVR *Land for Wildlife*	1.6	
Alluvial Terraces Herb-rich Woodland/Valley Grassy Forest Complex	R1, R2, V2, V3, E2, E3	firewood collection and post and pole production, grazing, clearing, habitat loss, fragmentation, weed invasion	NVR *Land for Wildlife*	0.2	
Grassy Dry Forest/Rocky Outcrop Shrubland/Herbland Mosaic	R1, R2, V1, V2, V3	weed invasion, grazing, agriculture, clearing	NVR *Land for Wildlife*	-	
Grassy Woodland	V2, V3, E2, E3	grazing, weed invasion, habitat loss, fragmentation, clearing, agriculture, lack of fire	NVR *Land for Wildlife*	0.2	Fire regimes
Perched Boggy Shrubland	V1, V2, V3, E3	clearing for agriculture and conifer plantations, altered water regimes, weed invasion, fragmentation, habitat loss, grazing	NVR *Land for Wildlife*	-	
Plains Grassy Woodland/Floodplain Riparian Woodland Complex	V2, V3, E2, E3	habitat loss, clearing, agriculture, fragmentation, grazing, weed invasion, road construction and maintenance, alteration of flooding regimes	NVR *Land for Wildlife*	-	
Plains Grassy Woodland/Rainshadow Grassy Woodland Complex	R1, V2, V3, E2, E3	habitat loss, clearing, agriculture, fragmentation, grazing, weed invasion, road construction and maintenance, clearing, lack of fire	NVR *Land for Wildlife*	-	Fire regimes
Plains Grassy Woodland/Valley Grassy Forest	V2, V3, E2, E3	habitat loss, clearing, agriculture, fragmentation, grazing, weed invasion, road construction and maintenance, firewood collection and post and	NVR *Land for Wildlife*	-	

			Current Management		
EVC	**Criteria**	**Threatening Processes[1]**	**Management Mechanism**	**% Reservation in Conservation Parks and Reserves**	**Research**
Complex		pole production	Habitat tree prescriptions		
Plains Grassy Woodland/Valley Grassy Forest/Rainshadow Grassy Woodland Complex	R1, V2, V3, E2, E3	habitat loss, clearing, agriculture, fragmentation, grazing, weed invasion, road construction and maintenance, firewood collection and post and pole production, habitat loss, fragmentation, clearing, agriculture, lack of fire	NVR *Land for Wildlife*	-	Fire regimes
Valley Grassy Forest/Box Ironbark Forest Complex	R3, V2, V3, E2	weed invasion, grazing, firewood collection and post and pole production, mining, fragmentation, habitat loss	NVR *Land for Wildlife*	-	
Gilgai Plain Woodland/Wetland Mosaic	R2, V2, V3, E2	altered flooding regime, weed invasion, clearing for agriculture, grazing, timber harvesting	NVR *Land for Wildlife*	2.8	
Riparian Forest/Swampy Riparian Woodland Mosaic	V2, V3, E2	weed invasion, grazing, recreation, mining	*Land for Wildlife*	0.2	Weed control
Plains Grassy Woodland/Creekline Grassy Woodland/Floodplain Riparian Woodland Mosaic	R1, R3, V2, V3, E2, E3	habitat loss, clearing, agriculture, fragmentation, grazing, weed invasion, road construction and maintenance, firewood collection and post and pole production, alteration of flooding regimes	NVR *Land for Wildlife*	-	
Plains Grassy Woodland/Creekline Grassy Woodland/Wetland Mosaic	V2, V3, E2, E3	habitat loss, clearing, agriculture, fragmentation, grazing, weed invasion, road construction and maintenance, firewood collection and post and pole production, altered water /drainage regimes, salination	NVR *Land for Wildlife*	-	
Valley Grassy Forest/Plains Grassy Woodland Mosaic	R2, V2, V3, E2, E3	weed invasion, grazing, firewood collection and post and pole production, habitat loss, clearing, agriculture, fragmentation, road construction and maintenance	NVR *Land for Wildlife*	-	
Grassy Dry Forest/Shrubby	R1, R2, R3, V2, V3, E2,	grazing, weed invasion, habitat loss, fragmentation, clearing, agriculture, lack of fire	NVR	-	

			Current Management		
EVC	**Criteria**	**Threatening Processes[1]**	**Management Mechanism**	**% Reservation in Conservation Parks and Reserves**	**Research**
Granitic-outwash Grassy Woodland Mosaic	E3		*Land for Wildlife*		
Granitic Hills Woodland/Heathy Dry Forest Mosaic	R1, R2, R3	-		-	Fire regimes
Box Ironbark Forest/Spring Soak Herbland Mosaic	R1, R2, V2, V3, E2, E3	grazing, timber harvesting, altered water regimes, weed invasion, agriculture, firewood collection and post and pole production, mining, habitat loss, fragmentation, clearing	NVR *Land for Wildlife*	-	
Grassy Dry Forest/Spring Soak Herbland Mosaic	R1, R2, R3, V1, V2, V3, , E3	grazing, altered water regimes, weed invasion, agriculture, clearing	NVR *Land for Wildlife*	-	
Floodplain Riparian Woodland/Plains Grassy Woodland Mosaic	R1, V2, V3, E2, E3	habitat loss, clearing, agriculture, fragmentation, grazing, weed invasion, road construction and maintenance, alteration of flooding regimes	NVR *Land for Wildlife*	0.1	
Rainshadow Grassy Woodland/Valley Grassy Forest Mosaic	R1, R2, V2, V3, E2, E3	weed invasion, grazing, firewood collection and post and pole production, habitat loss, fragmentation, clearing, agriculture, lack of fire	NVR *Land for Wildlife*	-	Fire regimes
Shrubby Granitic-outwash Grassy Woodland/Valley Grassy Forest Mosaic	R2, V1, V2, V3, E3	weed invasion, grazing, firewood collection and post and pole production, habitat loss, fragmentation, clearing, agriculture, lack of fire	NVR *Land for Wildlife*	-	Fire regimes
Riverine Grassy Woodland/Riverine Sedgy Forest Mosaic	V1, V2, V3, E3	clearing, agriculture, grazing, fragmentation, altered water regimes, weed invasion	NVR *Land for Wildlife*	0.7	
Sand Ridge Woodland	R1, R2, R3, V2, V3, E2, E3	grazing, weed invasion, clearing, timber harvesting, habitat loss	NVR *Land for Wildlife*	-	
Valley Grassy Forest/Grassy Dry Forest Mosaic	R1, R2, R3, V2, V3	weed invasion, grazing, firewood collection and post and pole production	NVR *Land for Wildlife*	-	

Notes: [1] Threatening processes are those which have occurred in the past, and may or may not be current threatening processes for these EVCs. The references to firewood collection and post and pole production relate to private land. Further information on disturbances and management actions is provided in chapter 6.

Some areas containing these EVCs may already be protected under *Land for Wildlife*. The program could also be applied to other areas in the future to protect these values and address threatening processes.

4. VASCULAR FLORA SPECIES ASSESSMENT

4.1 Introduction

Assessment of the North East 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 North East region, including 166 species of conservation significance and approximately 400 exotic species.

4.1.1 Priority flora species

The focus of assessment of flora species in the North East 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 exhibit a range of life histories, life-forms, reproductive strategies and distribution patterns. Included among the plants considered rare or threatened in the North East 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, grassy woodland, riverine and sub-alpine species etc.;
- 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 North East region addresses:

- plants listed as threatened under the Victorian *Flora and Fauna Guarantee Act* 1988 (FFG Act),
- plants listed as endangered or vulnerable under the Commonwealth *Endangered Species Protection Act* 1992 (ESP Act),
- 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 North East could not be confirmed in terms of accurate identification or location, or where they are hybrids. The full list of 166 priority species and 95 indicator species is at Appendix F

4.2 Life history and population parameters for priority flora species

4.2.1 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;
- what are the regenerative and dispersal capabilities of the plant; and
- how does the plant respond to various forms of disturbance or common environmental conditions found in different land-use categories or management regimes.

NRE databases, expert opinion and available scientific literature were used to compile the following information for each species:

- conservation status;
- the approximate proportion each species' total Australian range that occurs within the North East Region;
- the number of Victorian and North East records held within NRE databases;
- the number of populations and individuals known to occur in the North East Region;
- any trends which may be apparent in the demography of the plant;
- the geographic range of the plant within the North East Region; and
- the reservation status of known populations within the North East Region.

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

Some of these data are presented in Table 0.1. More details for plants listed under the *Flora and Fauna Guarantee Act* 1988 or *Endangered Species Protection Act* 1992 can be found in Appendix E.

4.2.2 Patterns of abundance, distribution and habitat

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

Plants of restricted, highly localised and naturally rare habitat types

Plants of alpine and sub-alpine habitats

In Australia alpine and sub-alpine environments are relictual, their distribution having contracted over time due to climate change since the end of the last ice age. These habitats, therefore, represent very small areas of a unique environment within the Australian context (NRE 1997) and act as refugia for species confined to the narrow range of environmental variables typical of such environments. Due to the restricted nature of their habitat, and their usually low population numbers a significant number of these species are considered rare or threatened both within Victoria and nationally. Twenty-five per cent of all the rare or threatened plants found within the North east region occur in alpine and sub-alpine habitats.

In the North East, alpine and sub-alpine habitats are restricted to areas in and around the Alpine National Park (eg. Mt Bogong) and, to a lesser extent, on Mt Buffalo and Mt Buller. Two distinct EVCs dominate these regions of the North East: Sub-alpine Woodland (dominated in by Snowgum *Eucalyptus pauciflora* over varied shrub and field layers) and Treeless Sub-alpine Mosaic (existing as a complex range of floristic communities including wet heathlands, grasslands, shrublands, bogs and frost hollows). Both EVCs are restricted to altitudes between 1200 to 1830 metres above sea level.

Plants of riparian environments

Although widespread, riparian environments have a narrow range of habitat requirements and as such are restricted in extent. With the exception of alpine environments (see previous section) riparian environments include the EVCs Riparian Forest, Riparian Shrubland, Riverine Escarpment Scrub, Spring Soak Herbland, Swampy Riparian Woodland, Creekline Grassy Woodland, Floodplain Riparian Woodland, Wetland Formation Wet Forest and Montane Riparian Thicket. These EVCs occur in a variety of habitats and altitudes. Rare or threatened species in this category include Catkin Wattle *Acacia dallachiana*, Native Wintercress *Barbarea grayi*, Silky Daisy *Celmisia sericophylla*, Yellow Flat-sedge *Cyperus flavidus*, Showy willow-herb *Epilobium pallidiflorum*, Omeo Gum *Eucalyptus neglecta*, Cliff Cudweed *Euchiton umbricolus* and Hypsela *Hypsela tridens*.

Plants of habitat types which are marginal to the North East

Plants of plains environments

Habitats such as grasslands, grassy woodlands and riverine plains occur within the North East Region, but are marginal to it, being more widespread beyond the region. Rare or threatened species occurring in these environments include Deane's Wattle *Acacia deanei* ssp. *deanei*, Buloke *Allocasuarina luehmannii*, Dark Wire-grass *Aristida calycina* var. *calycina*, Spurred spear-grass *Austrostipa gibbosa*, Bluish Bulbine-lily *Bulbine glauca*, Broom Bitter-pea *Daviesia genistifolia*, Wedge Diuris *Diuris dendrobioides*, Hydrilla *Hydrilla verticillata*, Northern Plains Leek-orchid *Prasophyllum campestre*, Glandular Early Nancy *Wurmbea biglandulosa*, and Mugga E*ucalyptus sideroxylon* s.s..

Plants of the foothills west of Burrowa-Pine Mountain National Park

This area on the lower foothills to the north of the Great Dividing Range in the north-eastern Victoria is comprised of granitic, metamorphic and sedimentary rocks (NRE 1997) and represents the only expression of the New South Wales South Western Slopes IBRA (Interim Biogeographic Regionalisation Zones for Australia) Zone in the Region. It includes the foothills of Burrowa-Pine Mountain National Park west to Mt Lawson and the Warby Range and south-west to the hills in the Beechworth area. This area supports a significant number of rare or threatened plants. The main EVCs

supporting these species include Valley Grassy Forest, Grassy Dry Forest, Herb-rich Foothill Forest, Rocky Outcrop Mosaic, Granitic Hills Woodland and Box-Ironbark Forest.

Rare or threatened species found in these areas include *Dampiera purpurea,* Hairy Hop-bush *Dodonaea boroniifolia*, *Dodonaea rhombifolia* and Warby Swamp Gum *Eucalyptus cadens, Acacia triptera*, Buloke *Allocasuarina luehmannii*, Crimson spider-orchid *Caladenia concolor,* White Cypress-pine *Callitris glaucophylla,* Naked Beard-orchid *Calochilus imberbis,* Yellow Hyacinth-orchid *Dipodium hamiltonianum* and Grey Rice-flower *Pimelea treyvaudii.*

Plants of habitats which have been depleted in the North East

Since European settlement, a range of woodland Ecological Vegetation Classes (EVCs) have been substantially cleared, or significantly disturbed in the North East Region. These include Box Ironbark Forest, Valley Grassy Forest, Grassy Dry Forest and Shrubby Granitic-outwash Grassy Woodland. Rare or threatened species from these EVCs known or suspected to have declined due to the loss of habitat include Deane's Wattle *Acacia deanei* ssp. *deanei*, Broom Bitter-pea *Daviesia genistifolia*, Purple Diuris *Diuris punctata* var. *punctata*, Mugga *Eucalyptus sideroxylon* s.s., Purple Eyebright *Euphrasia collina* ssp. *muelleri*, Warby Swamp Gum *Eucalyptus cadens*, and Euroa Guinea Flower *Hibbertia humifusa* ssp. *erigens.*

Within Victoria and the North East RFA region, plants which are endemic, at the limit of their biogeographic range or disjunct poulations.

Endemic species are those whose distribution is restricted to a specific area. Limit of biogeographic range incorporates those places where species occur at the edge of their natural biogeographic range. Disjunct populations are those which have become physically separated such that there is no gene flow between populations (Commonwealth of Australia, in press.).

These criteria are covered in detail for all vascular flora species in the National Estate Assessment (VICRFASC, in prep.)

Table 0.1 Conservation Status and Distribution of Rare or Threatened Plants in the North East Regional Forest Agreement region

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

Species Name	Common Name	Conservation Status				% of Aust range	Tenure of North East populations		
		ESP	ROTAP	FFG	VROTS		biological conservation reserve (%)	other public land (%)	private land (%)
Acacia deanei ssp. *deanei*	Deane's wattle	no	-	yes	e	75 - 100	90	10	-
Acacia phasmoides	Phantom Wattle	V	V	no	v	50 - 75	100	-	-
Allocasuarina luehmannii	Buloke	no	-	yes	d	0 - 25	20	-	80
Almaleea capitata	Slender Parrot-pea	no	R	yes	r	0 - 25	50	50	-
Baeckea crenatifolia	Fern-leaf Baeckea	V	V	no	v	75 - 100	100	-	-
Brachyscome gracilis ssp. *gracilis*	Dookie Daisy	no	-	final rec.	v	50 - 75	20	30	50
Brachyscome tenuiscapa	Mountain Daisy	no	-	yes	v	25 - 50	60	40	-
Caladenia concolor	Crimson Spider-orchid	V	V	yes	v	0 - 25	50	-	50
Carex cephalotes	Wire-head Sedge	no	R	yes	v	50 - 75	100	-	-
Carex paupera	Dwarf Sedge	no	R	yes	v	25 - 50	100	-	-
Celmisia sericophylla	Silky Daisy	no	R	yes	r	75 - 100	80	20	-
Dipodium hamiltonianum	Yellow Hyacinth-orchid	no	-	yes	e	0 - 25	50	50	-
Diuris dendrobioides	Wedge Diuris	no	-	yes	e	0 - 25	-	100	-
Diuris punctata var. punctata	Purple Diuris	no	-	yes	v	0 - 25	-	20	80
Eucalyptus alligatrix ssp. *limaensis*	Lima Stringybark	V	V	no	r	0 - 25	-	100	-
Eucalyptus cadens	Warby Swamp Gum	V	V	yes	v	75 - 100	-	80	20
Euchiton nitidulus	Shining Cudweed	V	V	no	v	50 - 75	90	10	-
Euphrasia collina ssp. *muelleri*	Purple Eyebright	E	E	final rec	e	25 - 50	-	100	-
Euphrasia eichleri	Bogong Eyebright	V	V	no	v	75 - 100	100	-	-

Species Name	Common Name	Conservation Status				% of Aust range	Tenure of North East populations		
		ESP	ROTAP	FFG	VROTS		biological conservation reserve (%)	other public land (%)	private land (%)
Euphrasia scabra	Rough Eyebright	no	K	yes	e	25 - 50	100	-	-
Glycine latrobeana	Clover Glycine	V	V	yes	v	0 - 25	-	100	-
Goodenia macbarronii	Narrow Goodenia	V	V	yes	v	0 - 25	10	10	80
Kelleria laxa	Kelleria	V	V	yes	v	75 - 100	100	-	-
Poa saxicola	Rock Poa	no	-	yes	v	25 - 50	100	-	-
Pomaderris subplicata	Concave Pomaderris	V	V	yes	v	75 - 100	-	-	100
Pterostylis cucullata	Leafy Greenhood	V	V	yes	v	0 - 25	-	50	50
Santalum lanceolatum	Northern Sandalwood	no	-	yes	e	0 - 25	-	-	100
Swainsona galegifolia	Smooth Darling Pea	no	-	yes	v	0 - 25	-	50	50
Thelypteris confluens	Swamp Fern	no	K	yes	e	50 - 75	-	-	100

(b) Other Victorian Rare Or Threatened Species

Species Name	Common Name	Conservation Status				% of Aust range	Tenure of North East populations		
		ESP	ROTAP	FFG	VROTS		biological conservation reserve (%)	other public land (%)	private land (%)
Abrotanella nivigena	Snow-wort	no	R	no	v	25 - 50	100	-	-
Acacia ausfeldii	Ausfeld's Wattle	no	R	reject	v	0 - 25	50	-	50
Acacia dallachiana	Catkin Wattle	no	R	no	r	75 - 100	50	50	-
Acacia dawsonii	Poverty Wattle	no	-	no	v	0 - 25	-	30	70
Acacia decora	Western Silver Wattle	no	-	no	v	0 - 25	-	-	100
Acacia penninervis	Hickory Wattle	no	-	no	r	0 - 25	20	20	60
Acacia phlebophylla	Buffalo Sallow Wattle	no	R	no	r	75 - 100	100	-	-
Acacia triptera	Spur-wing Wattle	no	-	no	v	0 - 25	50	50	-

Species Name	Common Name	Conservation Status				% of Aust range	Tenure of North East populations		
		ESP	ROTAP	FFG	VROTS		biological conservation reserve (%)	other public land (%)	private land (%)
Agrostis meionectes	Alpine Bent	no	R	no	k	50 - 75	90	-	10
Aristida calycina var. *calycina*	Dark Wire-grass	no	-	no	r	0 - 25	30	-	70
Asplenium trichomanes ssp. *trichomanes*	Common Spleenwort	no	-	no	r	0 - 25	70	30	-
Astrotricha linearis	Narrow-leaf Star-hair	no	-	no	r	25 - 50	60	40	-
Austrodanthonia richardsonii	Straw Wallaby-grass	no	-	no	v	0 - 25	-	100	-
Austrostipa gibbosa	Spurred Spear-grass	no	-	no	r	0 - 25	-	40	60
Austrostipa setacea	Corkscrew Spear-grass	no	-	no	r	0 - 25	-	-	100
Barbarea grayi	Native Wintercress	no	-	no	v	0 - 25	100	-	-
Bossiaea riparia	River Bossiaea	no	-	no	r	25 - 50	unknown	unknown	unknown
Brachyscome chrysoglossa	Yellow-tongue Daisy	no	-	prelim. listing	v	0 - 25	-	-	100
Brachyscome obovata	Baw Baw Daisy	no	-	no	r	0 - 25	100	-	-
Brachyscome ptychocarpa	Tiny Daisy	no	-	no	r	0 - 25	40	60	-
Brachyscome tadgellii	Tadgell's Daisy	no	-	no	r	25 - 50	100	-	-
Bulbine glauca	Bluish Bulbine-lily	no	-	no	r	0 - 25	80	20	-
Caladenia flavovirens	Summer Spider-orchid	no	-	no	r	0 - 25	unknown	unknown	unknown
Callitris glaucophylla	White Cypress-pine	no	-	no	d	0 - 25	30	40	30
Calochilus imberbis	Naked Beard-orchid	no	-	no	r	0 - 25	100	-	-
Carex archeri	Archer's Sedge	no	-	no	v	50 - 75	100	-	-
Carex capillacea	Hair Sedge	no	R	reject	r	0 - 25	100	-	-
Carex echinata	Star Sedge	no	-	no	v	25 - 50	100	-	-
Carex raleighii	Raleigh Sedge	no	R	reject	r	0 - 25	50	50	-
Colobanthus affinis	Alpine Colobanth	no	-	no	r	25 - 50	90	10	-
Coprosma moorei	Turquoise Coprosma	no	-	no	r	50 - 75	100	-	-

Species Name	Common Name	Conservation Status				% of Aust range	Tenure of North East populations		
		ESP	ROTAP	FFG	VROTS		biological conservation reserve (%)	other public land (%)	private land (%)
Coprosma nivalis	Snow Coprosma	no	-	no	r	25 - 50	70	30	-
Corybas hispidus	Bristly Helmet-orchid	no	-	no	r	0 - 25	-	100	-
Craspedia alba	White Billy-buttons	no	R	no	-	50 - 75	100	-	-
*Craspedia sp. (*Mt Stirling)	Mt Stirling Billy-buttons	no	-	no	v	0 - 25	100	-	-
Cyperus flavidus	Yellow Flat-sedge	no	-	no	v	0 - 25	unknown	unknown	unknown
Cystopteris tasmanica	Bristle-fern	no	R	no	r	0 - 25	90	10	-
Dampiera purpurea	Mountain Dampiera	no	-	no	r	0 - 25	100	-	-
Daviesia genistifolia	Broom Bitter-pea	no	-	no	r	0 - 25	100	-	-
Derwentia nivea	Snow Speedwell	no	R	no	r	25 - 50	100	-	-
Deschampsia caespitosa	Tufted Hair-grass	no	-	no	r	0 - 25	100	-	-
Desmodium varians	Slender Tick-trefoil	no	-	no	r	0 - 25	0	90	10
Deyeuxia affinis	Allied Bent-grass	no	R	no	r	50 - 75	100	-	-
Digitaria coenicola	Finger Panic-grass	no	-	no	v	0 - 25	-	-	100
Digitaria diffusa	Open Summer-grass	no	-	no	v	0 - 25	-	-	100
Digitaria divaricatissima	Spreading Summer-grass	no	-	no	v	0 - 25	-	30	70
Diuris behrii	Golden Cowslips	no	-	no	v	0 - 25	-	100	-
Dodonaea boroniifolia	Hairy Hop-bush	no	-	no	r	0 - 25	80	10	10
Dodonaea rhombifolia	Broad-leaf Hop-bush	no	R	no	r	25 - 50	80	10	10
Eleocharis plana	Flat Spike-sedge	no	-	no	v	0 - 25	100	-	-
Epacris glacialis	Reddish Bog Heath	no	-	no	r	25 - 50	90	10	-
Epilobium pallidiflorum	Showy Willow-herb	no	-	no	d	0 - 25	50	50	-
Epilobium tasmanicum	Tasman Willow-herb	no	-	no	r	25 - 50	100	-	-
Eucalyptus cinerea ssp. *cinerea*	Argyle Apple	no	-	no	r	0 - 25	unknown	unknown	unknown
Eucalyptus mitchelliana	Buffalo Sallee	no	R	no	r	75 - 100	100	-	-

Species Name	Common Name	Conservation Status				% of Aust range	Tenure of North East populations		
		ESP	ROTAP	FFG	VROTS		biological conservation reserve (%)	other public land (%)	private land (%)
Eucalyptus neglecta	Omeo Gum	no	R	no	r	25 - 50	10	90	-
Eucalyptus pauciflora ssp. *hedraia*	Snow Gum	no	-	no	r	75 - 100	20	80	-
Eucalyptus rubida ssp. *septemflora*	Candlebark	no	V	no	v	50 - 75	-	100	-
Eucalyptus yarraensis	Yarra Gum	no	R	reject	r	0 - 25	-	-	100
Euchiton umbricolus	Cliff Cudweed	no	-	no	r	0 - 25	80	20	-
Euphrasia caudata	Tailed Eyebright	no	-	no	r	0 - 25	-	100	-
Euphrasia crassiuscula ssp. *crassiuscula*	Thick Eyebright	no	-	no	r	75 - 100	unknown	unknown	unknown
Euphrasia crassiuscula ssp. *eglandulosa*	Thick Eyebright	no	-	no	r	75 - 100	100	-	-
Euphrasia crassiuscula ssp. *glandulifera*	Thick Eyebright	no	-	no	v	75 - 100	100	-	-
Euphrasia lasianthera	Hairy Eyebright	no	-	no	r	75 - 100	-	100	-
Fimbristylis velata	Veiled Fringe-sedge	no	-	no	r	0 - 25	100	-	-
Genoplesium nudum	Tiny Midge-orchid	no	-	no	r	0 - 25	unknown	unknown	unknown
Goodia medicaginea	Western Golden-tip	no	-	no	r	0 - 25	-	100	-
Grammitis poeppigiana	Alpine Finger-fern	no	-	no	r	50 - 75	-	100	-
Gratiola pumilo	Dwarf Brooklime	no	K	no	-	0 - 25	unknown	unknown	unknown
Grevillea jephcottii	Green Grevillea	no	R	no	r	75 - 100	100	-	-
Grevillea polybractea	Crimson Grevillea	no	-	no	r	25 - 50	100	-	-
Grevillea ramosissima ssp. *hypargyrea*	Fan Grevillea	no	-	no	r	0 - 25	90	10	-
Grevillea willisii	Rock Grevillea	no	R	no	r	0 - 25	-	30	70
Hibbertia humifusa ssp. *erigens*	Euroa Guinea-flower	no	-	no	v	50 - 75	-	40	60
Hierochloe submutica	Holy Grass	no	R	no	v	50 - 75	70	30	-

Species Name	Common Name	Conservation Status				% of Aust range	Tenure of North East populations		
		ESP	ROTAP	FFG	VROTS		biological conservation reserve (%)	other public land (%)	private land (%)
Huperzia australiana	Fir Clubmoss	no	-	no	r	25 - 50	20	80	-
Hydrilla verticillata	Hydrilla	no	-	no	r	0 - 25	-	100	-
Hypsela tridens	Hypsela	no	-	no	v	0 - 25	-	100	-
Indigofera adesmiifolia	Tick Indigo	no	-	no	v	0 - 25	40	60	-
Isolepis wakefieldiana	Tufted Club-sedge	no	-	no	r	0 - 25	-	-	100
Juncus antarcticus	Cushion Rush	no	-	no	v	25 - 50	100	-	-
Juncus brevibracteus	Alpine Rush	no	-	no	r	25 - 50	100	-	-
Juncus thompsonianus	Rush	no	-	no	r	0 - 25	100	0	0
Koeleria cristata	Crested Hair-grass	no	-	no	r	25 - 50	100	-	-
Leptorhynchos elongatus	Lanky Buttons	no	-	no	r	0 - 25	90	10	-
Leptospermum multicaule	Silver Tea-tree	no	-	no	v	0 - 25	0	40	60
Lepyrodia anarthria	Scale-rush	no	-	no	r	0 - 25	100	-	-
Leucopogon montanus	Snow Beard-heath	no	-	no	r	25 - 50	50	50	-
Leucopogon pilifer	Trailing Beard-heath	no	-	no	r	0 - 25	100	-	-
Luzula acutifolia ssp. *acutifolia*	Sharp-leaf Woodrush	no	-	no	r	50 - 75	80	20	-
Lycopodium scariosum	Spreading Clubmoss	no	-	no	r	0 - 25	80	20	-
Olearia adenophora	Scented Daisy-bush	no	R	no	r	25 - 50	60	20	20
Olearia frostii	Bogong Daisy-bush	no	R	no	r	75 - 100	70	30	-
Oreomyrrhis argentea	Silver Carraway	no	-	reject	v	25 - 50	100	-	-
Oreomyrrhis brevipes	Branched Carraway	no	R	no	r	50 - 75	100	-	-
Oreomyrrhis pulvinifica	Cushion Carraway	no	-	no	v	0 - 25	100	-	-
Oxalis magellanica	Snowdrop Wood-sorrel	no	-	no	r	0 - 25	unknown	unknown	unknown
Panicum decompositum	Australian Millet	no	-	no	r	0 - 25	0	50	50
Parantennaria uniceps	Parantennaria	no	R	no	v	25 - 50	100	-	-

Species Name	Common Name	Conservation Status				% of Aust range	Tenure of North East populations		
		ESP	ROTAP	FFG	VROTS		biological conservation reserve (%)	other public land (%)	private land (%)
Persoonia subvelutina	Velvety Geebung	no	-	no	r	25 - 50	20	80	-
Pimelea biflora	Matted Rice-flower	no	-	no	r	0 - 25	100	-	-
Pimelea treyvaudii	Grey Rice-flower	no	-	no	v	25 - 50	60	40	-
Plantago glacialis	Salt Tussock-grass	no	-	no	v	25 - 50	100	-	-
Poa hothamensis var. *parviflora*	Soft Ledge-grass	no	R	no	r	75 - 100	10	90	-
Poa labillardieri var. *acris*	Common Tussock-grass	no	-	no	r	0 - 25	unknown	unknown	unknown
Pomaderris aurea	Golden Pomaderris	no	-	no	r	25 - 50	-	80	20
Prasophyllum campestre	Northern Plains Leek-orchid	no	R	no	e	0 - 25	-	-	100
Pratia gelida	Snow Pratia	no	R	no	v	75 - 100	100	-	-
Prostanthera decussata	Dense Mint-bush	no	-	no	r	25 - 50	80	20	-
Prostanthera monticola	Buffalo Mint-bush	no	R	no	r	25 - 50	100	-	-
Pterostylis aestiva	Long-tongue Summer Greenhood	no	-	no	r	0 - 25	10	90	-
Pterostylis boormanii	Sikh's Whiskers	no	-	no	r	0 - 25	unknown	unknown	unknown
Pterostylis dubia	Blue-tongue Greenhood	no	-	no	e	0 - 25	10	90	-
Pterostylis fischii	Fisch's Greenhood	no	-	no	r	0 - 25	50	50	-
Pterostylis hamata	Scaly Greenhood	no	-	no	r	0 - 25	70	30	-
Pterostylis maxima	Large Rustyhood	no	-	no	v	0 - 25	-	-	100
Pultenaea polifolia	Dusky Bush-pea	no	-	no	r	0 - 25	-	100	-
Pultenaea vrolandii	Cupped Bush-pea	no	-	no	r	25 - 50	20	80	-
Pultenaea williamsonii	Highland Bush-pea	no	K	no	r	75 - 100	70	30	-
Ranunculus eichlerianus	Eichler's Buttercup	no	R	reject	r	75 - 100	70	30	-
Rytidosperma australe	Southern Sheep-grass	no	-	no	r	25 - 50	100	-	-

Species Name	Common Name	Conservation Status				% of Aust range	Tenure of North East populations		
		ESP	ROTAP	FFG	VROTS		biological conservation reserve (%)	other public land (%)	private land (%)
Schizacme montana var. montana	Mountain Mitrewort	no	-	no	r	0 - 25	100	-	-
Schizeilema fragoseum	Alpine Pennywort	no	-	no	v	25 - 50	100	-	-
Scleranthus singuliflorus	Mossy Knawel	no	-	no	r	25 - 50	90	10	-
Sclerolaena birchii	Galvanised Bassia	no	-	no	r	0 - 25	-	-	100
Spiranthes sinensis	Austral Ladies' Tresses	no	-	no	d	0 - 25	10	90	-
Spirodela polyrrhiza	Large Duckweed	no	-	no	v	0 - 25	-	60	40
Sporobolus creber	Rat-tail Grass	no	-	no	r	0 - 25	50	-	50
Taraxacum aristum	Austral Dandelion	no	R	reject	r	25 - 50	80	10	10
Templetonia stenophylla	Leafy Templetonia	no	-	no	d	0 - 25	-	-	100
Tripo 8gon loliiformis	Rye Beetle-grass	no	-	no	r	0 - 25	50	-	50
Uncinia compacta	Compact Hook-sedge	no	-	no	r	0 - 25	100	-	-
Utricularia monanthos	Tasmanian Bladderwort	no	-	no	v	0 - 25	100	-	-
Viola caleyana	Swamp Violet	no	-	no	r	0 - 25	-	100	-
Westringia lucida	Shining Westringia	no	R	no	v	0 - 25	100	-	-
Wurmbea biglandulosa	Glandular Early Nancy	no	-	no	r	0 - 25	-	100	-

Notes:

- ESP categories are endangered (E) or vulnerable (V)
- 'final rec' indicates taxa that have received the Scientific Advisory's final recommendation to be listed
- '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.

4.2.3 Review of the reservation status of North East rare or threatened plants

The purpose of this review is to examine the tenure of rare or threatened species populations within the North East RFA Region.

The approach used in this review was to intersect plant location data from statewide flora databases and the National Herbarium of Victoria with land tenure using a geographic information system (GIS). This data was then updated and augmented with current knowledge of the historical and contemporary distribution and abundance of each species. This is particularly important when dealing with an area such as the North East, where there is a high proportion of cleared land.

This review is based on a qualitative rather than quantitative analysis, due to the lack of accurate, verified information on the current size and location of populations. It relies on a combination of recent records and judgement by experts. Each species was evaluated according to the proportion of its Australian distribution that occurs within the North East (0-25%, 25-50%, 50-75%, 75-100%), and the proportion, to the nearest decile, that occurs in biological conservation reserves, other public land and private property. Results are presented in Table 0.1.

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

Of the 166 rare or threatened plants in the North East, 74 have more than 25% of their geographic range within the Region. For over 90% of these taxa the Region forms an important part of their distribution and effective conservation within the North East Region is critical for their long-term survival.

Of these 74 taxa, 54 have the largest proportion of their North East population within biological conservation reserves. Five of the seven taxa endemic to the North East fall into this category with of all known occurrences within biological conservation reserves (*Acacia phlebophylla*, *Baeckea crenatifolia*, *Eucalyptus mitchelliana*, *Euphrasia crassiuscula* ssp. *eglandulosa* and *Euphrasia crassiuscula* ssp. *glandulifera*). Seven additional taxa endemic to Victoria also fall into this category. Of these *Carex paupera*, *Euphrasia eichleri* and *Pratia gelida* occur solely within biological conservation reserves while *Olearia frostii*, *Pultenaea williamsonii*, *Ranunculus eichlerianus* and *Olearia adenophora* have at least 30% of their regional population outside biological conservation reserves.

Of the remaining 20 taxa, 13 have the largest proportion of their North East population on other public land. One taxon – *Euphrasia lasianthera* – is endemic to the region while *Poa hothamensis* var. *parviflora*, *Eucalyptus cadens* and *Pomaderris aurea* are endemic to Victoria. *Euphrasia lasianthera* is only found within Mt Buller Alpine Resort and although only classified rare in Victoria is considered vulnerable in the North East Region (based on the vulnerability assessment below) by virtue of the small number of populations. *Poa hothamensis* var. *parviflora* and *Pomaderris aurea* are predominantly found on State forest – neither are considered threatened although *Poa hothamensis* var. *parviflora* is classified as vulnerable in the North East due to its restricted area of occupancy. *Eucalyptus cadens* occurs in Mt Pilot Multi-Purpose Park and on private land around the Warby Range. All populations are potentially threatened by further clearing and ongoing disturbance. This species is considered vulnerable in both Victoria and Australia and was rated as critically endangered in the North East in the vulnerability analysis because of its low area of occupancy, severely fragmented population and suspected continuing decline.

Acacia dallachiana and *Leucopogon montanus* have the same proportion of their North East population within biological conservation reserves and other public land. Neither of these species is considered threatened although the vulnerability assessment (below) rates *Acacia dallachiana* as endangered in the North East due to the low number of individual plants.

Pomaderris subplicata occurs solely on private land. This North East endemic is currently known from only one site beside Hurdle Creek. The small population of about 150 plants is threatened by weed invasion, habitat disturbance and grazing by native species. This species is considered vulnerable in Victoria and Australia, and has been rated as endangered in the North East in the vulnerability analysis based on the low number of individual plants.

4.2.4 Vulnerability assessment

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

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

Vulnerable categories. A taxon is considered Data Deficient (DD) when there is inadequate information to make a direct or indirect assessment of its risk of extinction based on its distribution and/or population status (IUCN 1994).

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

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

Of the 166 rare or threatened plants considered in this study sufficient information was available for 106 taxa for adequate assessment. Twenty-four taxa were rated as Critically Endangered, 18 rated as Endangered and 46 rated as Vulnerable. Rating was primarily based on satisfying RULES D, B and A (IUCN 1994) in that order. All plants were rated as Data Deficient for RULES C, E or F (IUCN 1994) as there was insufficient information available to satisfy any one of the criteria.

RULE D rates taxa based on the estimated number of mature individuals, RULE B rates taxa based on a combination of extent of occurrence or area of occupancy with indicators of population variability and RULE A rates taxa based on an observed, estimated, inferred or suspected past or future reduction in the regional population. For species rated as Critically Endangered or Endangered their overall rating was based primarily on satisfying RULE B (IUCN 1994). This contrasts significantly from the Vulnerable taxa for which the overall rating was based almost exclusively on satisfying RULE D. For further details on the categorisation of threatened taxa using the IUCN or RARE rule sets see IUCN (1994) and Keith & Burgman (in press).

Plants rated 'Critically Endangered' in the North East Region

The 'Critically Endangered' category signifies the highest risk of extinction in the wild. Twenty-five of the rare or threatened plant species evaluated during this assessment were categorised as Critically Endangered according to the IUCN Red List Criteria (1994). Most of these have been rated Critically Endangered based on their very small extent of occurrence or area of occupancy and fragmented population or continuing decline in habitat.

Seven of the 24 taxa rated Critically Endangered have more than 25% of their geographic range within the North East and the Region forms an important part of their distribution. These taxa are *Acacia deanei* ssp. *deanei*, *Euphrasia collina* ssp. *muelleri*, *Euphrasia scabra*, *Hibbertia humifusa* ssp. *erigens*, *Thelypteris confluens,* and *Eucalyptus cadens.*

Plants rated as Critically Endangered in the North East Region according to the IUCN Red List Categories (IUCN 1994)

TAXON	IUCN	RARE	TAXON	IUCN	RARE
Acacia deanei ssp. *deanei*	CR	CR	*Euphrasia scabra*	CR	CR
Acacia triptera	CR	CR	*Hibbertia humifusa* ssp. *erigens*	CR	CR
Almaleea capitata	CR	EN	*Juncus antarcticus*	CR	LR
Barbarea grayi	CR	LR	*Kelleria laxa*	CR	CR
Brachyscome obovata	CR	EN	*Oreomyrrhis pulvinifica*	CR	LR
Carex paupera	CR	EN	*Prasophyllum campestre*	CR	CR
Coprosma moorei	CR	CR	*Pterostylis hamata*	CR	CR
Coprosma nivalis	CR	EN	*Taraxacum aristum*	CR	CR
Diuris dendrobioides	CR	CR	*Templetonia stenophylla*	CR	EN
Diuris punctata var. *punctata*	CR	CR	*Thelypteris confluens*	CR	CR
Eucalyptus cadens	CR	EN	*Utricularia monanthos*	CR	LR
Euphrasia collina ssp. *muelleri*	CR	CR	*Viola caleyana*	CR	EN

Plants rated 'Endangered' in the North East Region

The 'Endangered' category signifies that a taxon is facing a very high risk of extinction in the wild. Eighteen of the rare or threatened plant species evaluated during this assessment were categorised as Endangered according to the IUCN Red

List Criteria (1994). Most of these taxa have been rated Endangered based on their low population numbers or their low extent of occurrence with a continuing decline in habitat.

Two of the 18 taxa rated as Endangered have more than 25% of their geographic range within the North East which forms a major part of their distribution. These are *Acacia dallachiana* and *Pomaderris subplicata*.

Plants rated as Endangered in the North East Region according to the IUCN Red List Categories (IUCN 1994)

TAXON	IUCN	RARE	TAXON	IUCN	RARE
Abrotanella nivigena	EN	EN	*Dampiera purpurea*	EN	EN
Acacia ausfeldii	EN	EN	*Daviesia genistifolia*	EN	CR
Acacia dallachiana	EN	EN	*Epilobium tasmanicum*	EN	EN
Acacia dawsonii	EN	EN	*Euphrasia caudata*	EN	VU
Allocasuarina luehmannii	EN	VU	*Hierochloe submutica*	EN	EN
Brachyscome tadgellii	EN	LR	*Lycopodium scariosum*	EN	EN
Carex archeri	EN	LR	*Oreomyrrhis brevipes*	EN	VU
Carex capillacea	EN	VU	*Pomaderris subplicata*	EN	EN
Carex raleighii	EN	VU	*Schizeilema fragoseum*	EN	VU

Plants rated as 'Vulnerable' in the North East Region

The 'Vulnerable' category signifies that a taxon is facing a high risk of extinction in the wild in the medium-term future. Forty-six of the rare or threatened plant species evaluated during this assessment were categorised as Vulnerable according to the IUCN Red List Criteria (1994). Most of these have been rated as Vulnerable based on their low population numbers or their low area of occupancy. All but two are also rated Vulnerable by the alternative RARE ruleset.

Seven of the 46 taxa rated as Vulnerable have more than 25% of their geographic range within the North East and this forms a major part of their distribution. These are *Carex cephalotes*, *Carex echinata*, *Colobanthus affinis*, *Craspedia alba*, *Euchiton nitidulus*, *Euphrasia crassiuscula* ssp. *eglandulosa*, and *Poa hothamensis* var. *parviflora*.

Plants rated as vulnerable in the North East Region according to the IUCN Red List Categories (IUCN 1994)

TAXON	IUCN	RARE	TAXON	IUCN	RARE
Acacia decora	VU	VU	*Euchiton umbricolus*	VU	VU
Acacia penninervis	VU	VU	*Euphrasia crassiuscula* ssp. *eglandulosa*	VU	VU
Aristida calycina var. *calycina*	VU	VU	*Euphrasia lasianthera*	VU	VU
Austrostipa gibbosa	VU	VU	*Glycine latrobeana*	VU	VU
Brachyscome ptychocarpa	VU	VU	*Goodenia macbarronii*	VU	VU
Brachyscome tenuiscapa	VU	VU	*Leptorhynchos elongatus*	VU	VU
Caladenia concolor	VU	VU	*Mitrasacme montana*	VU	VU
Callitris glaucophylla	VU	VU	*Olearia frostii*	VU	VU
Calochilus imberbis	VU	VU	*Pimelea biflora*	VU	VU
Carex cephalotes	VU	VU	*Pimelea treyvaudii*	VU	VU
Carex echinata	VU	VU	*Plantago glacialis*	VU	VU
Colobanthus affinis	VU	VU	*Poa hothamensis* var. *parviflora*	VU	VU
Craspedia alba	VU	VU	*Poa saxicola*	VU	VU
Danthonia richardsonii	VU	VU	*Pratia gelida*	VU	LR
Derwentia nivea	VU	VU	*Prostanthera decussata*	VU	VU
Deschampsia caespitosa	VU	VU	*Pterostylis aestiva*	VU	VU
Digitaria diffusa	VU	VU	*Pultenaea williamsonii*	VU	EN
Dipodium hamiltonianum	VU	VU	*Ranunculus eichlerianus*	VU	VU
Dodonaea boroniifolia	VU	VU	*Rytidosperma australe*	VU	VU
Dodonaea rhombifolia	VU	VU	*Spiranthes sinensis*	VU	VU
Epacris glacialis	VU	VU	*Swainsona galegifolia*	VU	VU
Epilobium pallidiflorum	VU	VU	*Tripogon loliiformis*	VU	VU
Euchiton nitidulus	VU	VU	*Wurmbea biglandulosa*	VU	VU

Information regarding Plants rated as Lower Risk and Data Deficient, and plants for which there was insufficient information to rate is attached at Appendix D.

4.2.5 Conclusion

Species with a high priority for management in the North East Region based on this vulnerability assessment are listed in (Table 0.2). Species have been included in this list if the Region represents a major part of their distribution and they have been rated Critically Endangered, Endangered, or Vulnerable in the Region.

Table 0.2 Plant Species with high Regional priority for management action

TAXON	IUCN	RARE	VROTS	FFG	Action Statement	ROTAP	ESP	Recovery Plan
Acacia deanei ssp. *deanei*	CR	CR	e	yes	no		no	
Euphrasia collina ssp. *muelleri*	CR	CR	e	rec	in prep	E	E	
Euphrasia scabra	CR	CR	v	yes	yes	K	no	
Hibbertia humifusa ssp. *erigens*	CR	CR	v	no			no	
Thelypteris confluens	CR	CR	e	yes	no	K	no	
Eucalyptus cadens	CR	EN	v	yes	yes	V	V	
Acacia dallachiana	EN	EN	r	no		R	no	
Pomaderris subplicata	EN	EN	v	yes	yes	V	V	
Carex cephalotes	VU	VU	v	yes	no	R	no	
Carex echinata	VU	VU	v	no			no	
Colobanthus affinis	VU	VU	r	no			no	
Craspedia alba	VU	VU	k	no		R	no	
Euchiton nitidulus	VU	VU	v	no		V	V	
Euphrasia crassiuscula ssp. *eglandulosa*	VU	VU	r	no			no	
Poa hothamensis var. *parviflora*	VU	VU	r	no		R	no	

As shown in table 4.1, for seven of these species at least 90 per cent of the population is within a biological conservation reserve (*Acacia deanei* ssp. *deanei, Euphrasia scabra, Carex cephalotes, Carex echinata, Colobanthus affinis, Craspedia alba, Euchiton nitidulus)* and for three species the majority of the occurrence is in private land *(Thelypteris confluens, Pomaderris subplicata, Hibbertia humifusa* ssp. *erigens). Euphrasia collina* ssp. *muelleri* is known in the Region only from State forest and an Action Statement is in preparation for this species which has 25-50 per cent of its range in the North East. For the remaining species at least 50 per cent of their occurrence is in other public land (*Eucalyptus cadens, Poa hothamensis* var. *parviflora, Acacia dallachiana).* An Action Statement is completed for *Eucalyptus cadens.*

Management

Both the Commonwealth *Endangered Species Protection Act* 1992 (ESP Act) and the Victorian *Flora and Fauna Guarantee Act* 1988 (FFG Act) include provisions for the preparation of management plans for listed taxa. Recovery Plans and Action Statements outline the actions necessary to maximise the long-term prospects for survival of the 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.

The Department of Natural Resources and Environment has developed a simple monitoring form and database (VROTPOP) for rare and threatened plants populations. It is envisaged that the use of this form and the database will expand to the point where the major populations of all threatened species will be regularly monitored. Active habitat management (environmental weed control, exclusion of predators or browsers, and ecological burning) is the most common form of management being implemented for species whose habitat is degrading or where direct external threats are operating. Where populations have declined to critical levels, active population management techniques (population reinforcement, reintroduction, translocation and artificial pollination) are sometimes recommended. Table 0.2 summarises the status of management planning for high priority listed taxa, further specific information on management planning, monitoring, and habitat and population management for these and other listed plant taxa is available in Appendix E.

5. TERRESTRIAL FAUNA SPECIES ASSESSMENT

5.1 Introduction

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

Data were gathered from an extensive search of the literature, existing data sets, experts and from new information generated by specialist projects including a broad scale regional survey of terrestrial fauna and a series of projects targeted at key threatened fauna (see sections 0 and 0). Critical life history attributes and population parameters were developed with the assistance of local and national experts in the field of population ecology. The information collected fell into two categories:

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

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

5.1.1 Priority species

The assessment of fauna in the North East has focused on a selected group of priority species. These species are classified as threatened in Victoria and listed in *Threatened Fauna in Victoria* (CNR 1995), listed under the Victorian *Flora and Fauna Guarantee Act* 1988 (FFG Act) and the Commonwealth *Endangered Species Protection Act* 1992 (ESP Act). The majority of these priority species are either forest dependent or require a component of their habitat to be within forest or woodland and may be affected by forestry or related activities.

To provide a broader assessment of the status of fauna in the region, a number of species were included because they are representative of taxa at risk from other management activities (not necessarily forestry related) on public or private land. This group of indicator species includes a number occurring in alpine environments and some dependent on small woodland remnants on public roadsides, stream reserves and private land.

The terrestrial species included in this assessment are shown in Table 5.1 with conservation status as classified in *Threatened Fauna In Victoria 1995* (CNR 1995), the existence of Action Statements (for species listed under the FFG Act) and Recovery Plans (for species listed under the ESP Act), and whether the species is secure based on other listings.

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

Threatened: a collective term used to denote taxa that are Extinct, Endangered, Vulnerable, Rare or Insufficiently Known, or have Restricted Colonial Breeding or Roosting Sites.

(E) Endangered: taxa in danger of extinction in Victoria and whose survival is unlikely if the factors causing their decline continue operating. Included are taxa whose numbers have been reduced to a critical level or whose habitats have been so drastically reduced that they are deemed to be in immediate danger of extinction.

(V) Vulnerable: taxa believed likely to move into the Endangered category in the near future if the factors causing their decline continue operating. Included are taxa of which most or all of the populations are decreasing because of over-exploitation, extensive destruction of habitat or other environmental disturbance; taxa with populations that have been seriously depleted and whose ultimate security has not yet been assured; and taxa with populations that are still common but are under threat from severe adverse factors throughout their range.

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

(K) Insufficiently Known: taxa in Victoria that are suspected but not definitely known to belong to any of the above categories because of lack of information.

(C) Restricted Colonial Breeding or Roosting: taxa that may be common but have only a few colonial breeding or roosting sites in Victoria and subsequently may be at risk when many individuals are gathered together, through loss of a significant part of the adult population or the young of the year.

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

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

Table 0.1 Terrestrial fauna species included in the assessment

Species Name	Common Name	TFV 1995	FFG Status	Action State-ment (Vic)	ESP Status	Recovery Plan (C'wlth)	Secure in Other States
Mammals							
Priority species							
Dasyurus maculatus	Spot-tailed Quoll	V	L	Yes	V	No	No
Phascogale tapoatafa	Brush-tailed Phascogale	R	L	In prep			No
Potorous longipes	Long-footed Potoroo	E	L	Yes	E	In prep.	No
Burramys parvus	Mountain Pygmy Possum	V	L	Yes	V	Yes	No
Petaurus norfolcensis	Squirrel Glider	V	L	In prep			No
Mastacomys fuscus	Broad-toothed Rat	R					No
Pseudomys fumeus	Smoky Mouse	V					No
Canis familiaris dingo	Dingo	K					Yes
Rhinolophus megaphyllus	Eastern Horseshoe-bat	C	L	No			Yes
Myotis macropus	Large-footed Myotis	R					No
Miniopteris schreibersii blepotis	Common Bent-wing Bat	C	L	In prep			Yes
Indicator species							
Scotorepens orion	Eastern Broad-nosed Bat						
Perameles nasuta	Long -nosed Bandicoot						
Petaurus australis	Yellow-bellied Glider						
Antechinus flavipes	Yellow-footed Antechinus						
Birds							
Priority species							
Struthidea cinerea	Apostlebird	R					Yes
Lathamus discolor	Swift Parrot	E	L	In prep	V	Yes	No
Neophema pulchella	Turquoise Parrot	R	L	No			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			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
Calyptorhinchus lathami	Glossy Black-Cockatoo	V	L	In prep			No

Species Name	Common Name	TFV 1995	FFG Status	Action State-ment (Vic)	ESP Status	Recovery Plan (C'wlth)	Secure in Other States
Indicator species							
Chthonicola sagittata	Speckled Warbler						
Hylacola pyrrhopygia	Chestnut-rumped Heathwren						
Callocephalon fimbriatum	Gang-Gang Cockatoo						
Alecedo azurea	Azure Kingfisher						
Petroica rodinogaster	Pink Robin						
Eurystomus orientalis	Dollarbird						
Coracina tenuirostris	Cicadabird						
Reptiles							
Priority species							
Pseudemoia cryodroma	Alpine Bog Skink	V	R	No			No
Cyclodomorphus praealtus	Alpine She-oak Skink	V	L	No			Yes
Eulamprus kosiuskoi	Alpine Water Skink	V	L	In prep			Yes
Morelia spilota variegata	Carpet Python	V	L	In prep			Yes
Vermicella annulata	Bandy Bandy	V					Yes
Ramphotyphlops proximus	Woodland Blind Snake	R					Yes
Indicator species							
Ramphotyphlops nigrescens	Gray's Blind Snake						
Bassiana duprerreyi	Red-throated Skink						
Egernia striolata	Tree Skink						
Varanus varius	Tree Goanna						
Amphibians							
Priority species							
Litoria spenceri	Spotted Tree Frog	E	L	In prep	E	In prep	No
Litoria verreauxii alpina	Alpine Tree Frog	K					Yes

Notes: Threatened Fauna in Victoria - 1995 (CNR 1995) - E-endangered, V-vulnerable, R-rare, K-insufficiently known, C-Restricted Colonial Breeding or Roosting.

Flora and Fauna Guarantee Act (**FFG):** L-Listed, R-recommended for listing;
Commonwealth Endangered Species Protection Act (**ESP):** E-endangered, V-vulnerable.

5.2 Life history and population parameters for priority fauna species

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

1. Rarity refers to the static qualities of a population: geographic range, abundance and habitat specificity. Species or populations most predisposed to extinction are those 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.

3. Spatial dynamics, or metapopulation dynamics, is the interaction between colonisation and extinction of sub-populations that make up a population. The parameters that contribute to the potential risk of extinction of a species through metapopulation collapse are the variability in abundance of individual populations and dispersal ability.

4. Life history parameters are aspects of biology that may predispose a species to the threat of extinction under particular circumstances. The two most important parameters identified are reproductive output and longevity.

5.2.1 Assessment Methods

Each species listed in Table 0.1 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 (in prep.). Each rating indicates the relative magnitude of the contribution of each parameter to the probability of extinction, as described below.

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

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

Population dynamics were assessed by identifying those species whose numbers have been relatively stable or increased, and those which have declined over a recent time period (the last 10 years). Past population dynamics (since European settlement 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. It is also assumed that species that have declined in abundance since European settlement, but have remained stable in the last 10 years, would have a higher risk of extinction than species that have remained stable since European settlement. Population trends were classified by experts and from relevant literature, and were generally based on the change in the amount of each species' habitat within the North East.

Spatial dynamics describes the interaction between colonisation and extinction of sub-populations, and can be assessed using estimates of population variability and dispersal ability. Species were classified as having high or low population variability, based on measures or estimates of changes in abundance over time. Species that have high population variability are more likely to be under threat of extinction than species that have low population variability. Species were classified as having high or low dispersal ability, based on measured dispersal distances or inferences from anatomy (eg. 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 at risk of extinction than species that have low mobility.

The two life history parameters considered in this assessment were reproductive output and longevity. Species were classified as having high, medium or low reproductive output, based on measures or estimates of litter or clutch sizes or rates of increase, and as being long or short-lived based on measures or estimates of longevity or inferred from body size. Species that have high reproductive outputs are more likely to recover quickly from major declines in abundance than species with low reproductive outputs. Species that are long-lived tend to be less susceptible to local or regional extinction due to catastrophic events, such as fire and flooding. When abundance is low, species with low adult mortality are more likely to persist in an area than species with high adult mortality.

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

5.2.2 Results and Discussion

Detailed information on the life history and population dynamics for each species is included in Appendix G. Summarised information for the species included in this review is presented in Table 0.2. 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 conservation. This assessment should also be considered in conjunction with the information relating to threatening processes.

The majority of the species assessed have either small or medium geographic ranges within the North East (Table 0.2). Those species with small geographic ranges include all the bats, all but one of the threatened reptiles and amphibians, the Broad-toothed Rat, Long-footed Potoroo, Mountain Pygmy Possum, Smoky Mouse, Apostlebird, Bush Stone-curlew, Glossy Black-Cockatoo, Grey-crowned Babbler, Masked Owl, Painted Honeyeater, Square-tailed Kite, Turquoise Parrot, Chestnut-rumped Heathwren, Speckled Warbler, Tree Goanna and Tree Skink. Species with a small geographic range are more vulnerable to regional extinction as a result of localised disturbance.

As expected for a group of species selected because there is some documented concern for their status, most species have a low abundance. Of the threatened species, the Turquoise Parrot is the only exception; its abundance is classified as medium within the North East. Three threatened species recorded a low abundance with a large geographic range: the Dingo, Spot-tailed Quoll and Carpet Python. These species are represented by small numbers of records on the Atlas of Victorian Wildlife which are widely scattered over the North East. The Dingo has a very low number of existing records, which may be a reflection of the difficulty in distinguishing pure bred animals from Dingo/Dog hybrids; when Dingo and wild Dog records are combined the number increases. The status and distribution of the Dingo within the North East is unknown and requires clarification. There are two Carpet Python records from two widely separated locations in the North East, although there are a number of historical records scattered in between. A record from one of the locations near Wangaratta is thought to be part of populations in the nearby Warby Ranges.

A number of the non-threatened species covered by this review also have a low abundance: Yellow-bellied Glider, Yellow-footed Antechinus, Azure Kingfisher and Tree Skink. The North East represents the northern edge of the range of the Yellow-bellied Glider in Victoria. Yellow-footed Antechinus records are mainly concentrated in one area of the North East. Although Azure Kingfisher records are spread widely over the study region, most of these are over 15 years old. The Tree Skink has a very disjunct distribution in Victoria, the North East records are the only sites of this species in the eastern half of the state (Atlas of Victorian Wildlife).

Many of the species covered by the review have high habitat specificity. These species often depend on a combination of certain habitat components; the Sooty Owl needs large tree hollows and prefers wet forests (Lumsden *et al.* 1991); the Regent Honeyeater appears to rely on nectar from a few key eucalypt species and needs this food source to be produced in copious amounts (Franklin *et al.* 1989); the Carpet Python requires hollows and adequate tree cover and ground debris for nesting sites and shelter (Allen in prep.). As a result, loss or reduction of a critical habitat component is likely to lead to population declines.

A total of 19 species (7 mammals, 5 birds, 5 reptiles and the 2 amphibians) have a small geographic range size, a low abundance and narrow habitat requirements. These are: the Common Bent-wing Bat, Eastern Horseshoe Bat, Large-footed Myotis, Broad-toothed Rat, Long-footed Potoroo, Mountain Pygmy Possum, Smoky Mouse, Bush Stone-curlew, Glossy Black-Cockatoo, Apostlebird, Painted Honeyeater, Chestnut-rumped Heathwren, Alpine Bog Skink, Alpine She-oak Skink, Alpine Water Skink, Bandy Bandy, Woodland Blind Snake, Alpine Tree Frog and Spotted Tree Frog. Consequently, of the species assessed, these species are more predisposed to the threat of decline or extinction within the North East based on the rarity parameter. Many of these species exist in small isolated populations making them particularly vulnerable to disturbances, especially stochastic events such as wildfire which can cause local extinctions. Large populations with widespread distributions are better buffered against environmental changes (Bennett *et al.* 1991).

Factors limiting distribution of species can include habitat availability which is especially important when a species has specific habitat requirements. The Mountain Pygmy-possum, Alpine Bog Skink, Alpine She-oak Skink and Alpine Water Skink are restricted to alpine and sub-alpine habitat in Victoria. Alpine and sub-alpine habitats in the North East are critical to the survival of populations of these species. The Smoky Mouse is uncommonly recorded and its distribution is highly disjunct, it was recorded once in the current RFA general fauna survey (this report), the most recent prior record being from 1995. This species is thought to depend on habitat that is strongly influenced by fire and the resulting successional changes may alter the suitability of particular areas of habitat. The Woodland Blind Snake has only been recorded twice in the North East this century; these records are about 20 years apart from two locations with the most recent in 1995, although there are early records scattered in-between these sites. The distribution of this species in the North East represents the eastern edge of its range in Victoria. Soil characteristics are likely to be an important factor in the presence of this species, which inhabits dry forests (Ehmann and Bamford 1993, Brown and Bennett 1995).

Species with high population variability and low powers of dispersal are more vulnerable to metapopulation collapse. Low powers of dispersal limits the ability of species to recolonise areas where local population extinctions have occurred. Species with low powers of dispersal include most of the reptiles, both the amphibians, ground-dwelling mammals including the Long-footed Potoroo, Mountain Pygmy-possum and Smoky Mouse and some bird species such as the Bush Stone-curlew and Grey-crowned Babbler.

A high population variability and low powers of dispersal in conjunction with either a low reproductive rate or short life span increases the risk of decline. There are four species with a combination of these parameters; the Mountain Pygmy Possum and Spotted Tree Frog both exhibit a low reproductive rate, while the Smoky Mouse and Speckled Warbler are short-lived species. Species with a high reproductive rate can increase from low abundance following disturbances more rapidly than those with low reproductive outputs. Long-lived species are more buffered against sudden population

declines than short-lived species as individuals with a longer lifespan are less likely to die due to age (Dexter in prep.). The Brush-tailed Phascogale and Yellow-footed Antechinus both have a very short lifespan (about 1 year) which is partially off-set by a high reproductive output (many young are born once a year). However, the short lifespan means it is particularly important that breeding is successful each year or local populations may become extinct. There are many species for which a number of these parameters are unknown, highlighting a lack of information and a need for species-specific research. Species such as Spot-tailed Quoll, Common Bent-wing Bat, Dingo, Powerful Owl, Barking Owl, Square-tailed Kite, White Bellied Sea-eagle, Glossy Black Cockatoo and Pink Robin have favourable spatial dynamic attributes that reduce the threat of extinction due to metapopulation collapse.

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 habitat loss through clearing for agriculture and urban development. Species such as the Squirrel Glider, Bush Stone-curlew and Grey-crowned Babbler are now largely confined to roadside and remnant patches of woodland habitat on private land as a result of widespread clearing of habitat. It is thought that Dingo numbers increased to a peak during the later years of European settlement but the number of pure Dingoes has decreased as a result of hybridisation with Dogs (Corbett 1995).

Population trends are the clearest indicators of a likelihood of extinction. However, for many species, the population trend in the past 10 years could not be determined (Table 0.2). This highlights the need for further biological information and long term population monitoring. The effectiveness of species management requires an understanding of ecological requirements and long term records of population changes. Of the species whose population trend in the past 10 years could be determined, the majority have declined. Although Mountain Pygmy Possum, Barking Owl, Powerful Owl and Glossy Black-Cockatoo numbers are thought to have decreased since European settlement (see Appendix G), they appear to have become stable over the past 10 years. One species, the Turquoise Parrot, has increased in abundance. The species has been slowly recovering since a drastic decline during the early period of European settlement and its range now appears to be expanding.

When considering current knowledge of the life history and population parameters presented in Table 0.2, two species in particular, Smoky Mouse and Spotted Tree Frog appear to be at a higher risk of extinction. Both these species have declined in the last 10 years, have small geographic ranges, low abundance and are habitat specific. Population variability is high and powers of dispersal low. The Smoky Mouse has a medium reproductive output and is short-lived, while the Spotted Tree Frog has a low reproductive output but is long-lived. The Spotted Tree Frog is the target of ongoing surveys and research and a Recovery Plan is in preparation (Robertson and Gillespie in prep). The Smoky Mouse is classified as Vulnerable in Victoria and has been recommended for listing under the FFG Act 1988. Table 0.2 also highlights the gaps in published knowledge of various aspects of these priority species.

It should be noted that differences in the life history characteristics and population dynamics between species are not necessarily reflected by their conservation status. For example, the Spot-tailed Quoll and Powerful Owl have characteristics which make them less vulnerable to extinction than the Smoky Mouse or Spotted Tree Frog, yet they are still classified as vulnerable and rare respectively and listed under the FFG Act 1988.

Table 5.3 summarises the significance of a range of threats was assessed for each species on a regional basis. The assessments were made recognising that practices on public land follow minimum prescriptions required under the Code of Forest Practices for Timber Production (NRE 1996) and various State Acts and Regulations and that practices on private land are in accord with the *Planning and Environment Act* 1987 and the *Catchment and Land Protection Act* 1994. However, the assessments do not take account of additional protection afforded in various Action Statements, Park management plans, nor any additional measures that may be established in the North East Forest Management Plan which is currently in preparation. Threats were rated as follows:

- Effect unknown;

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

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

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

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

Table 0.2 Summary of life history and population dynamics information

Species	Population trend in the last 10 years	Rarity Ratings			Spatial Dynamics Ratings		Life History Parameters Ratings	
		Geographic Range	Abundance	Habitat Specificity	Population Variability	Powers of Dispersal	Reproductive Output	Longevity
Broad-toothed Rat	unknown	small	low	narrow	*low	unknown	medium	short-lived
Brush-tailed Phascogale	*declined	medium	low	wide	high	high	high	short-lived
Common Bent-wing Bat	*declined	small	low	narrow	low	high	low	long-lived
Dingo	unknown	*large	low	wide	*low	high	low	long-lived
Eastern Horseshoe Bat	unknown	small	low	narrow	low	low	low	long-lived
Large-footed Myotis	unknown	small	low	narrow	low	unknown	low	long-lived
Long-footed Potoroo	unknown	small	low	narrow	*low	low	low	long-lived
Mountain Pygmy Possum	*stable	small	low	narrow	high	low	low	long-lived
Smoky Mouse	declined	small	low	narrow	high	*low	medium	short-lived
Spot-tailed Quoll	declined	large	low	wide	low	high	medium	unknown
Squirrel Glider	*declined	medium	low	narrow	unknown	high	low	short-lived
Eastern Broad-nosed Bat◆	unknown	small	low	wide	low	unknown	low	*long-lived
Long-nosed Bandicoot◆	*declined	large	medium	wide	unknown	unknown	high	*short-lived
Yellow-bellied Glider◆	unknown	large	low	wide	low	high	low	long-lived
Yellow-footed Antechinus◆	declined	medium	low	wide	high	unknown	high	short-lived
Apostlebird	*declined	small	low	narrow	low	low	low	unknown
Barking Owl	*stable	medium	low	narrow	low	*high	low	*long-lived
Bush Stone-curlew	declined	small	low	narrow	low	*low	low	long-lived
Glossy Black-Cockatoo	*stable	small	low	narrow	*low	high	low	long-lived
Grey Goshawk	unknown	medium	low	narrow	unknown	high	low	*long-lived
Grey-crowned Babbler	declined	small	low	wide	low	low	low	short-lived
Masked Owl	*declined	small	low	medium	unknown	high	low	long-lived
Painted Honeyeater	*declined	small	low	narrow	high	high	high	unknown

Species	Population trend in the last 10 years	Rarity Ratings			Spatial Dynamics Ratings		Life History Parameters Ratings	
		Geographic Range	Abundance	Habitat Specificity	Population Variability	Powers of Dispersal	Reproductive Output	Longevity
Powerful Owl	stable	large	low	wide	low	high	low	long-lived
Regent Honeyeater	declined	large	low	narrow	high	high	low	unknown
Sooty Owl	*declined	medium	low	narrow	low	high	low	long-lived
Square-tailed Kite	unknown	small	low	wide	unknown	high	low	*long-lived
Swift Parrot	declined	medium	low	narrow	high	high	high	*long-lived
Turquoise Parrot	increased	small	medium	wide	high	high	high	unknown
White-bellied Sea-Eagle	unknown	medium	low	wide	low	high	low	long-lived
Azure Kingfisher◆	unknown	medium	low	narrow	high	unknown	medium	*long-lived
Chestnut-rumped Heathwren◆	unknown	small	low	narrow	unknown	low	low	short-lived
Cicadabird◆	unknown	medium	medium	wide	unknown	high	low	long-lived
Dollarbird◆	unknown	medium	medium	narrow	unknown	high	low	*long-lived
Gang-gang Cockatoo◆	*declined	large	medium	wide	unknown	high	low	*long-lived
Pink Robin◆	stable	large	medium	wide	low	high	low	short-lived
Speckled Warbler◆	declined	small	medium	wide	high	low	medium	short-lived
Alpine Bog Skink	unknown	small	low	narrow	*low	low	low	short-lived
Alpine She-oak Skink	declined	small	low	narrow	unknown	low	low	*short-lived
Alpine Water Skink	declined	small	low	narrow	unknown	low	low	*short-lived
Bandy Bandy	unknown	small	low	narrow	unknown	low	low	*short-lived
Carpet Python	declined	large	low	narrow	unknown	unknown	low	unknown
Woodland Blind Snake	unknown	small	low	narrow	unknown	low	low	unknown
Gray's Blind Snake◆	unknown	large	medium	narrow	unknown	low	low	short-lived
Red-throated Skink◆	unknown	medium	medium	narrow	unknown	low	low	short-lived
Tree Goanna◆	unknown	small	medium	wide	unknown	unknown	low	*long-lived
Tree Skink◆	unknown	small	low	wide	unknown	low	low	short-lived

Species	Population trend in the last 10 years	Rarity Ratings			Spatial Dynamics Ratings		Life History Parameters Ratings	
		Geographic Range	Abundance	Habitat Specificity	Population Variability	Powers of Dispersal	Reproductive Output	Longevity
Alpine Tree Frog	declined	small	low	narrow	unknown	low	low	unknown
Spotted Tree Frog	declined	small	low	narrow	high	low	low	long-lived

* denotes unknown, but most likely classification

◆denotes indicator species

Table 0.3 Summary of impacts of threatening processes on priority fauna species.

	DISTURBANCES														
SPECIES	**Clearing of Native Vegetation**	**Timber Harvesting**	**Fuel Reduction Burning**	**Firewood Collection**	**Unplanned Fire**	**Introduced Species**	**Grazing/ Trampling**	**Pest Control**	**Road Construction and Maintenance**	**Mining/ Quarrying**	**Tree Dieback**	**Recreation**	**Illegal Collecting/Harvesting**	**Vandalism**	**Dams/ Impound-ments**
MAMMALS															
Broad-toothed Rat	1	1	2	0	2	2	2	0	-	0	-	1	0	0	1
Brush-tailed Phascogale	3	2	1	2	2	2	1	1	1	1	1	0	0	0	0
Dingo	1	2	1	0	2	2	1	2	-	0	-	0	0	1	1
Common Bent-wing Bat	1	-	-	-	-	2	0	2	0	2	-	0	0	3	0
Eastern Horseshoe Bat	-	-	-	-	-	2	0	2	0	2	-	0	0	3	0
Large-footed Myotis	1	2	-	-	-	1	1	2	2	2	-	1	0	1	0
Long-footed Potoroo	1	3	2	-	2	2	1	1	2	-	-	0	0	0	1
Mountain Pygmy Possum	3	0	0	0	2	2	2	1	2	0	0	3	0	0	0
Smoky Mouse	1	2	3	1	2	2	1	0	1	0	-	1	0	0	1
Spot-tailed Quoll	2	3	2	2	2	2	1	3	1	1	1	1	0	2	1
Squirrel Glider	3	2	2	2	2	1	2	1	2	-	2	1	0	0	0
Eastern Broad-nosed Bat	1	2	-	-	-	1	0	2	-	-	-	0	0	1	0
Long-nosed Bandicoot	2	2	2	0	2	2	1	1	-	1	-	1	0	0	1
Yellow-bellied Glider	2	3	1	1	2	1	1	0	1	1	-	0	0	0	1
Yellow-footed Antechinus	2	2	2	2	2	2	2	1	-	1	-	1	0	0	1
BIRDS															

	DISTURBANCES														
SPECIES	**Clearing of Native Vegetation**	**Timber Harvesting**	**Fuel Reduction Burning**	**Firewood Collection**	**Unplanned Fire**	**Introduced Species**	**Grazing/ Trampling**	**Pest Control**	**Road Construction and Maintenance**	**Mining/ Quarrying**	**Tree Dieback**	**Recreation**	**Illegal Collecting/Harvesting**	**Vandalism**	**Dams/ Impound-ments**
Apostlebird	3	0	0	-	1	1	3	1	2	-	3	0	0	0	0
Bush Stone-curlew	3	1	1	3	-	3	2	2	2	-	1	0	1	1	0
Grey-crowned Babbler	3	0	2	2	-	2	3	1	3	0	2	0	0	0	0
Masked Owl	3	2	2	2	2	1	2	3	1	1	2	0	0	0	0
Barking Owl	3	2	2	2	2	1	2	2	-	-	2	0	0	0	0
Powerful Owl	2	3	2	1	3	0	-	1	1	1	1	0	0	0	0
Sooty Owl	2	3	2	1	3	0	-	1	1	1	1	0	0	0	0
Painted Honeyeater	3	2	1	2	2	-	2	-	-	-	2	0	0	0	0
Regent Honeyeater	3	2	-	2	2	1	2	-	1	-	3	-	0	-	0
Square-tailed Kite	2	2	2	1	2	0	1	-	1	-	1	-	2	2	0
Grey Goshawk	2	2	2	1	2	0	1	2	1	-	1	-	-	2	0
Turquoise Parrot	2	2	2	2	2	3	2	0	1	1	2	0	1	0	0
Swift Parrot	3	2	-	2	-	1	2	-	1	-	2	-	-	-	0
White-bellied Sea-Eagle	2	2	-	1	-	0	-	1	2	1	1	2	-	1	0
Glossy Black-Cockatoo	1	-	1	-	-	-	1	0	0	-	-	0	-	0	0
Azure Kingfisher	1	1	-	-	-	2	1	-	-	-	-	-	0	0	3
Chestnut-rumped Heathwren	2	-	2	2	2	-	1	0	0	0	0	0	0	0	0
Cicadabird	2	2	-	0	1	0	0	0	0	0	1	0	0	0	0
Dollarbird	2	1	1	2	2	-	1	1	-	-	1	-	0	0	0

	DISTURBANCES														
SPECIES	**Clearing of Native Vegetation**	**Timber Harvesting**	**Fuel Reduction Burning**	**Firewood Collection**	**Unplanned Fire**	**Introduced Species**	**Grazing/ Trampling**	**Pest Control**	**Road Construction and Maintenance**	**Mining/ Quarrying**	**Tree Dieback**	**Recreation**	**Illegal Collecting/Harvesting**	**Vandalism**	**Dams/ Impound-ments**
Gang-gang Cockatoo	2	2	1	-	2	0	-	0	-	-	-	0	-	0	0
Pink Robin	1	1	1	0	1	-	1	0	-	0	-	0	0	0	0
Speckled Warbler	2	2	1	2	1	1	2	0	0	-	1	0	0	0	0
REPTILES															
Alpine Bog Skink	3	0	0	0	1	1	3	0	1	1	0	2	0	0	2
Alpine She-oak Skink	3	0	2	1	2	1	3	0	1	1	0	3	1	0	1
Alpine Water Skink	2	0	0	0	1	1	3	0	1	1	0	3	0	0	2
Bandy Bandy	3	2	2	2	2	1	2	2	1	1	0	0	0	0	0
Carpet Python	3	3	3	3	3	3	1	2	1	1	1	1	2	1	0
Woodland Blind Snake	3	1	1	2	1	1	2	2	0	1	0	0	0	0	0
Gray's Blind Snake	3	2	2	2	2	1	2	1	0	1	0	0	0	0	0
Red-throated Skink	2	2	3	2	2	1	2	0	1	1	1	0	0	0	0
Tree Goanna	3	3	2	2	2	1	1	1	1	1	1	1	1	1	0
Tree Skink	2	2	2	2	2	1	1	1	0	1	0	0	0	0	0
AMPHIBIANS															
Alpine Tree Frog	-	0	-	0	-	-	3	1	1	1	0	2	-	-	-
Spotted Tree Frog	1	2	-	1	-	3	2	2	2	3	0	2	-	-	2
TOTAL SCORE	**101**	**77**	**60**	**53**	**70**	**57**	**70**	**46**	**39**	**30**	**34**	**26**	**8**	**19**	**18**
NO. OF SPECIES AFFECTED BY:															
Major threat	18	7	3	2	3	4	6	2	1	1	2	3	0	2	1
Moderate threat	18	25	20	19	27	13	17	12	8	3	7	4	2	3	3

	DISTURBANCES														
SPECIES	**Clearing of Native Vegetation**	**Timber Harvesting**	**Fuel Reduction Burning**	**Firewood Collection**	**Unplanned Fire**	**Introduced Species**	**Grazing/ Trampling**	**Pest Control**	**Road Construction and Maintenance**	**Mining/ Quarrying**	**Tree Dieback**	**Recreation**	**Illegal Collecting/Harvesting**	**Vandalism**	**Dams/ Impound-ments**
Minor threat	11	6	11	9	7	19	18	16	20	21	14	9	4	7	9
Not a threat	0	7	4	9	0	7	4	14	9	8	11	27	36	33	35
Unknown threat	2	4	11	9	12	6	4	5	11	16	15	6	7	4	1
Total no. affected	**47**	**38**	**34**	**30**	**37**	**36**	**41**	**30**	**29**	**25**	**23**	**16**	**6**	**12**	**13**

5.3 Fauna survey

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

Objectives for the study included:

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

5.3.1 Summary

Field surveys for all major fauna groups were conducted within all the Ecological Vegetation Classes throughout the North East Region. A total of 206 survey sites were selected in a randomised manner in proportion to the coverage of EVCs within the Region. These surveys detected a total of 184 species of vertebrates (diurnal birds, reptiles and amphibians, terrestrial mammals and bats) through the area, and a further 121 species of ants, which was the primary invertebrate group investigated. Sites were surveyed intensively during the 1997-98 summer (late October to March), and diurnal birds were also assessed during the 1997 winter. Field teams comprised skilled biologists (14 in total), who spent in excess of 539 person-days in the field to complete this work. A further 477 person-days were spent in the office in the organisation of the project, as well as in field preparation, data entry and analysis.

A complete analysis of the distribution of these taxa in relation to EVCs across the North East Region is currently being undertaken. Of the fauna groups assessed diurnal bird and bat surveys were the most productive in terms of number of individuals detected. Consequently these data sets provide the best prospect for statistical analyses and modeling purposes.

Highlights of these surveys included:

- the execution of perhaps the broadest scale regional fauna surveys ever executed in Victoria.
- the compilation of significant data sets on the distribution of both diurnal birds and bats within North East Victoria. Both of these data sets have contributed greatly to complementing the existing distributional data for a large array of species currently recorded on the Atlas of Victorian Wildlife.
- prospects for modeling the distribution of selected taxa, or groups of taxa from these data sets. Models of faunal distribution provide a basis for more detailed investigations of species, and can assist in suggesting and determining both the fine and coarse scale distribution of species.
- range extensions for species such as Smoky Mouse (*Pseudomys fumeus*), and the Wallaroo or Euro (*Macropus robustus*), based on hair analysis. Other range extensions are still possible following a complete analysis of the data.

5.4 Terrestrial Invertebrates

The diverse environments in the region are occupied by a wide range of terrestrial invertebrate species, the majority of which are poorly characterised in terms of their taxonomy and habitat preferences. There have been few systematic studies of terrestrial invertebrates in the region. A substantial number of the records arise from single specimens or localities.

Epigeal invertebrates were sampled as part of the CRA terrestrial fauna survey in the North-East. Invertebrates were sampled with pitfall traps, which consisted of polyethylene jars dug into the soil with the upper lip continuous with ground level. The traps were set with a 1:1 mixture of ethylene glycol and 70% ethanol. Five traps were set at each site by the hairtubing team and collected 2 weeks later. A total of 970 traps were set during the study for approximately 13,580 trap nights. Samples were sealed and sent for analysis by a specialist team at the Museum of Victoria.

Full analysis of these samples for all invertebrate taxa will be a time consuming and expensive process. While all specimens were retained for later assessment, only ants were subjected to detailed analysis for the purpose of this CRA, as this group has been previously identified as containing useful 'indicator' taxa, responsive to environmental conditions and environmental change. Despite ants having been studied more closely than most other invertebrate groups, many 'species' still remain undescribed as taxonomically legitimate taxa. In order to conduct this analysis efficiently, individual 'morpho-species' were identified and characterised by definable morphological features. Taxonomic keys were created to aid identification, and voucher specimens for each 'morpho-species' has been retained at the Museum of Victoria.

While analyses are still being completed at the time of writing, some preliminary results are available. These indicate that throughout the North East study at least 131 different 'morpho-species' of ants have been identified. In general, between 20 and 25 'morpho-species' were detected at most sites, with some sites having a diversity of up to 40 'morpho-species'. The more common taxa include *Rhytidoponera* spp., *Monomorium* spp., *Pheidole* spp., *Melophorus* spp. and *Iridomyrmex* spp.

The species diversity recorded so far here contrasts to a study at one locality at Mt. Piper, near Broadford, where 146 morpho-species were recorded. Species diversity for ants is known to substantially greater in arid and semi-arid regions, where diversity can approach 150 morpho-species per hectare. The apparent low level of diversity at North East sampling sites is an interesting result, considering the geographical and environmental spread of sites. Confirmation of these results, however, will not be possible until the full analysis is complete.

Knowledge of other invertebrate groups in the Region is generally rudimentary. Of note among existing records are the following:

Other Insecta

A list of insect species collected from the North East Region (from the Australian National Insect Collection database) is presented in Appendix H. While some are apparently restricted to the North East, this may in many cases reflect a lack of methodical survey. Some of the better known groups do exhibit examples of regional affinity. The cicada *Diemeniana neboisi*, for example, is known to be restricted to a narrow band in the region, known only in valley floors from the upper Murray River Valley and its tributaries downstream to Towong and along the Mt Beauty township to Dedorang. The Buprestid jewel beetles *Themognatha barbiventris* and *T. maculoventris* were recorded last century from Beechworth and Wangaratta respectively, but have not appeared in more recent collections.

Many insect species exhibit highly localised patterns of endemicity, which presents a challenge to their effective conservation.

Mollusca

A number of species in the region occur in a range of environments associated with the Great Dividing Range, particularly the Australian Alps and their slopes, extending in a broad arc from south-eastern New South Wales into north-east Victoria. Examples include *Elsothera sericatula*, *Pillomena nivea* and *Flammulops excelsior* (Charopidae). Others, such as *Allocharopa okeana* are effectively restricted to the mountains of eastern Victoria. *A. okeana* is typically found under litter near mountain peaks and alpine woodland.

Onycophora

Onycophorans or velvet-worms are inhabitants of leaf litter and decaying logs in damp forest environments. One species, *Planipapillus biacinaces*, is believed to be confined to the region (known only from Howman Gap).

Oligochaeta

This region was not as intensively sampled for earthworms as were parts of Gippsland and East Gippsland during the last century, so records are much sparser. The montane areas are expected to contain a similar fauna to that of the Kosciusko region. At least one species, *Cryptodrilus willsiensis*, is believed to be restricted to the North-east (known only from Mt Wills).

5.5 Threatened species studies

In addition to the fauna survey reported on above assessments were commissioned to examine the conservation status of a number of fauna species. Assessments were produced for four forest owls:

- Powerful Owl *Ninox strenua*
- Sooty Owl *Tyto tenebricosa*
- Barking Owl *Ninox connivens*
- Masked Owl *Tyto novaehollandiae*

four mammals:

- Brush-tailed Phascogale *Phascogale tapoatafa*
- Spot-tailed Quoll *Dasyurus maculatus*
- Squirrel Glider *Petaurus norfolcensis*
- Long-footed Potoroo *Potorous longipes*

and one Amphibian:

- Spotted Tree Frog *Litoria spenceri*

The aim of the assessments was to provide information which would enhance the understanding of the species' requirements in the context of forest management and to assist in their management in the North East. Key features of each assessment are described below. Reports of these assessments will be published in the near future as part of the NRE flora and fauna technical report series.

Powerful Owl

Australia's largest owl is hollow-dependent and feeds largely on arboreal mammals. It is sedentary and each pair occupies a large home range (between 300 and several thousand hectares). It occurs in tall open-forests, open-forests and woodlands and is regarded as widespread but rare throughout forested land in the North East Region.

The primary ecological requirement of the Powerful Owl is the availability of large tree hollows in which to nest. A key ecological requirement is the availability of sufficient numbers of prey, many of which are also dependent on the availability of tree hollows.

Sooty Owl

Also a hollow-dependent sedentary owl with a large home range, the Sooty Owl has similar ecological requirements to the Powerful Owl, although its habitat preferences include closed forests (rainforests) as well as tall open-forests, and open-forests. The Sooty Owl is widespread but rare throughout the moister forests of the North East Region. It does not occur in the drier Box-Ironbark habitats nor the riparian River Red Gum habitats.

Barking Owl

The hollow-dependent Barking Owl feeds on terrestrial mammals, arboreal mammals and birds; bats and invertebrates are also taken. It is sedentary, mates for life and each pair defends a small territory within a much larger home range.

The Barking Owl occurs in open-woodlands, woodlands and open forests across a range of mainly drier vegetation types. There are estimated to be fewer than 50 breeding pairs in Victoria. These owls also depend on tree hollows for nesting and to support many of their prey species. In the North East Region, the Barking Owl occurs mainly in the drier Box-Ironbark habitats and the riparian River Red Gum habitats, although there are exceptional records from the some of the moister forests.

Masked Owl

This species is not as well known as the other large forest owls, but limited data suggest that it is more adapted to open habitats. It utilises a variety of habitats, including closed eucalypt forest (for roosting and nesting), and forest edge and open woodland (for hunting). The Masked Owl is considered to be sedentary and territorial. In Victoria it is known to nest only in large hollows in eucalypt trees.

Brush-tailed Phascogale

Within the North East Region Phascogale populations are known to exist in fragmented habitat from Seymour and Alexandra to Wodonga. Its distribution still remains poorly defined because it is a shy, nocturnal species that occurs in sparse populations. In broad terms, Phascogales are limited to dry sclerophyll forest and woodland, however general descriptions about habitat preferences are difficult because of: the species' wide distribution in various vegetation communities, the paucity of location records, the species' ecological flexibility, and the propensity of males to disperse great distances. In the North East, the ecological vegetation classes most likely to sustain Phascogale populations are: Box Ironbark Forest, Granitic Hills Woodland, Grassy Dry Forest, Heathy Dry Forest, Herb-rich Foothill forest, and, to a lesser extent, Shrubby Dry Forest.

Like most carnivorous marsupials, Phascogales are insectivorous, although they are very efficient killers of small vertebrates and will occasionally take lizards, frogs, small mammals, and birds up to the size of chickens.

Females inhabit a large home range varying from 20-78 ha. Males are not territorial and their home ranges (68-152 ha) overlap greatly.

Phascogales nest in tree hollows and use, on average, 20 per year. Males, which roam over a very large home range, need to have nests scattered throughout this area. Phascogales breed between May and July. Nursery hollows require a large cavity for an insulated nest of bark, feather and fur, with a narrow access which excludes predators.

Spot-tailed Quoll

The Spot-tailed Quoll is a forest species which, in Victoria is generally restricted to areas with annual rainfall exceeding 600mm, and to riparian vegetation adjacent to the Murray River. It is recorded from a range of habitat types including rainforest, wet sclerophyll forest, dry sclerophyll forest, woodland and heathland. There are few records of this species from the North East Region, they include records from private land, riparian habitat, and herb-rich foothill forest.

Spot-tailed Quolls are predators of predominantly mammals, birds and reptiles. Females occupy exclusive territories while male territories overlap considerably during the breeding season. Home ranges vary between 600-1000 ha for females and 1500-3500 ha for males depending on habitat quality or richness. They appear to be a solitary species, however the use of 'latrines' (communal defecation sites) appears to be an important aspect of their social behaviour.

Factors suggested as responsible for the continuing decline in range and status of the Spot-tailed Quoll include: habitat loss, modification and fragmentation, poison baiting for wild dogs, foxes and rabbits, competition with (and/or predation by) introduced predators, disease, and land management practices including prescribed burning.

Squirrel Glider

There are two major habitat types used by the Squirrel Glider in Victoria; riverine vegetation and dry sclerophyll vegetation of the lower foothills and adjoining the plains. Typically gums boxes and ironbarks dominate and mature wattle is normally present.

In Victoria, there are two major Squirrel Glider populations. The eastern population covers much of the North East Region and is found at Edi and along the King River valley, within and around Chiltern Box-Ironbark National Park, Mt Pilot Multi-purpose Park and along the Kiewa River, around Seymour and Longwood, through Euroa to Benalla along and around the Hume Highway including Reef Hills Regional Park and Warrenbayne. The distribution extends to around Lurg and Greta West in the east.

Although it is considered primarily insectivorous, the Squirrel Glider's diet includes arthropods, pollen and the green seeds of Golden Wattle are sometimes consumed. Small birds appear to be another occasional food source.

Squirrel Gliders are obligate users of tree hollows for diurnal roosting, shelter and breeding and build bowl-shaped nests made of eucalypt leaves within hollow live and dead standing trees. They may use more than one hollow for nightly roosting and some have been observed to use up to five different hollows.

Squirrel Gliders spend the day in hollows alone or in groups of one to ten and display little territorial behaviour. Their home range varies from 4.8-14.0 ha for females and 13.4-25.5 ha for males. They exhibit a high degree of overlap within and between nest groups and with Sugar Glider groups.

Long-footed Potoroo

The Long-footed Potoroo was discovered in the North East in 1995 after previously only being known from East Gippsland and south-eastern New South Wales. It inhabits wet to damp forests with a dense understorey vegetation, feeding largely on underground fungi. It is estimated that the range of the population in the North East is approximately 51,000 ha, about 60% of which falls within the Alpine National Park, the remainder being in State forest.

Spotted Tree Frog

The Spotted Tree Frog is known to occur in only 13 discrete populations - 11 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 Kosciuszko 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.

5.6 Fauna species reservation analysis

5.6.1 Methods

A reservation analysis has been undertaken to assess the extent to which rare or threatened terrestrial vertebrate species in the North East Region are protected in the reserve system.

Using data from the Atlas of Victorian Wildlife, both formal survey and incidental records were intersected with existing land tenure to calculate the total proportion of records for each species in each land tenure category (Table 0.4). Categories used were Parks & Reserve, State Forest & other Public land, and Private Land.

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

5.6.2 Results and discussion

The results of the assessment are presented in Table 0.4. There are 13 species for which less than 20% of records are in Reserves, however none of these species have their major occurrence in the North East Region.

Table 0.4 Reservation analysis of priority species records in the North East Region

Common Name	Scientific Name	Total	Conservation Parks and Reserves		Non Reserve		Private land		Water bodies	
MAMMALS			**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
Spot-tailed Quoll	*Dasyurus maculatus*	13			5	**38**	8	**62**		
Brush-tailed Phascogale	*Phascogale tapoatafa*	61	20	**33**	5	**8**	36	**59**		
Squirrel Glider	*Petaurus norfolcensis*	108	72	**67**	4	**4**	32	**30**		
Mountain Pygmy-possum	*Burramys parvus*	62	35	**56**	26	**42**			1	**2**
Long-footed Potoroo	*Potorous longipes*	60	24	**40**	36	**60**				
Eastern Horseshoe Bat	*Rhinolophus megaphyllus*	20			20	**100**				
Common Bent-wing Bat	*Miniopterus schreibersii*	19			17	**89**	2	**11**		
Large-footed Myotis	*Myotis adversus*	11	2	**18**	8	**73**	1	**9**		
Broad-toothed Rat	*Mastacomys fuscus*	40	23	**58**	15	**38**			2	**5**
Smoky Mouse	*Pseudomys fumeus*	38	15	**39**	23	**61**				
Dingo	*Canis familaris dingo*	6	3	**50**	1	**17**	2	**33**		
BIRDS										
Bush Stone-curlew	*Burhinus grallarius*	58	3	**5**	3	**5**	52	**90**		
Grey Goshawk	*Accipiter novaehollandiae*	1	1	**100**						
White-bellied Sea-Eagle	*Haliaeetus leucogaster*	28	3	**11**	1	**4**	8	**29**	16	**57**
Square-tailed Kite	*Lophoictinia isura*	11	4	**36**	3	**27**	4	**36**		
Barking Owl	*Ninox connivens*	57	20	**35**	13	**23**	24	**42**		
Powerful Owl	*Ninox strenua*	103	33	**32**	56	**54**	14	**14**		
Masked Owl	*Tyto novaehollandiae*	1			1	**100**				
Sooty Owl	*Tyto tenebricosa*	37	12	**32**	25	**68**				
Turquoise Parrot	*Neophema pulchella*	320	191	**60**	31	**10**	98	**31**		
Swift Parrot	*Lathamus discolor*	104	77	**74**	6	**6**	21	**20**		
Grey-crowned Babbler	*Pomatostomus temporalis*	84	4	**5**	2	**2**	78	**93**		
Painted Honeyeater	*Grantiella picta*	37	23	**62**			14	**38**		
Regent Honeyeater	*Xanthomyza phrygia*	174	80	**46**	9	**5**	83	**48**	2	**1**
Apostlebird	*Struthidea cinerea*	13					13	**100**		
Glossy Black Cockatoo	*Calyptorhyncus banksii*	2			2	**100**				
REPTILES										
Alpine Water Skink	*Eulamprus kosciuskoi*	4	4	**100**						
Woodland Blind Snake	*Ramphotyphlops proximus*	2	1	**50**	1	**50**				
Bandy Bandy	*Vermicella annulata*	10	5	**50**	1	**10**	4	**40**		
Carpet Python	*Morelia spilota variegata*	2					2	**100**		
Alpine She-oak Skink	*Cyclodomorphus praealtus*	10	4	**40**	6	**60**				
Alpine Bog Skink	*Pseudemoia cryodroma*	1	1	**100**						
AMPHIBIANS										
Spotted Tree Frog	*Litoria spenceri*	109	36	**33**	73	**67**				
Alpine Tree Frog	*Litoria verreauxii alpina*	39	4	**10**	22	**56**			13	**33**

Notes: Some figures in this table differ from those in Appendix F because of boundary ambiguities at the margin of the Region and because these figures post-date those in Appendix F and include data from the recent Regional fauna survey (Section 0).

Only Records post-1970 and with an accuracy of one minute or better were used in this analysis

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

6.1 Introduction

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

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

Disturbances which impact on flora and fauna in the North East were identified as part of an assessment of vulnerability, population parameters and life history attributes of 261 vascular plants and 49 terrestrial vertebrates. These species were selected for analysis because they are either classified as rare or threatened in Victoria or considered to be indicators, representative of a suite of species which may be vulnerable to the continued action of threatening processes.

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

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

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

6.2 Results and discussion

6.2.1 Timber Harvesting

Within the North East region timber harvesting operations are conducted in montane forests dominated by Alpine Ash *Eucalyptus delegatensis* and in mountain or foothill mixed-species forests. Commercially important eucalypt species present in these forests include: Alpine Ash, Messmate *E. obliqua,* Blue Gum *E. globulus* ssp. *bicostata,* Manna Gum *E. viminalis,* Narrow-leaved Peppermint *E. radiata,* and Mountain Gum *E. dalrympleana*. Mountain Ash *E. regnans,* an important commercial timber source south of the Great Dividing Range, rarely occurs in the North East but where suitable stands occur these are harvested. Although not important for sawlog production, Red Stringybark *E. macrorhyncha* and Red Box *E. polyanthemos* can be locally important for minor produce such as fire wood and fence posts (Ryan 1997, NRE unpublished data, D. Buntine and P. Scales pers. comm.).

The net productive area of Ash type forest in the Region is approximately 40,000 ha (3% of the total forest areas in the Region, while the net productive area of mixed species forest is 80,000 ha (6%) of the forested area in the North East. Timber extraction methods used in the North East include seed tree, selection and clearfell systems.

The seed tree system is generally applied to even-aged and some uneven-aged mixed species stands. This is often favourable for faunal habitat as hollow-bearing over-mature trees are often preferred for retention as they have large crowns and often heavier seed crops. The method involves the felling of all trees excluding five to nine well-spaced trees per hectare (see Ryan 1997). Regeneration is achieved by release of seed from retained trees onto a seed bed prepared by mechanical disturbance or a moderate to high intensity slash burn. Seed trees in excess of habitat requirements are felled or poisoned two to three years after regeneration establishment.

The selection system involves the harvesting of small patches or single mature trees retaining suitable habitat trees and minimising damage to the remaining trees including regrowth. Careful management of retained eucalypt regrowth can negate the need for large scale regeneration treatment. There is some culling (by felling or poisoning) of overstorey trees considered not to be required for habitat or seed. Uneven-aged stands with an adequate stocking of advanced regrowth, potential sawlogs, or the capacity to easily regenerate are suitable for harvesting under this system. Stands may be 200-300 ha. in area and up to 15 percent of a coupe may be harvested at a time.

Clearfelling involves the removal of all the standing timber on the coupe except for designated habitat trees (a minimum of 15 trees per 10 ha), and seed trees (Ryan 1997). The system is generally applied in even-aged ash type forests. 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 and the coupe is prepared for a regeneration burn. Regeneration is achieved in a number of ways depending on site characteristics. The methods include artificial hand or aerial sowing of seed onto a freshly disturbed or burnt seedbed; regeneration from lignotubers or coppice; natural seedfall or slash seed where seedling establishment can occur on disturbed areas and in certain understorey types in the absence of an intense burn; and the use of planted stock. See Ryan (1997) for a detailed description of these methods. The regrowth is harvested on an average 80 year rotation.

The choice of harvesting system is largely determined by the requirements of different eucalypt species for successful regeneration following harvesting.

Potentially Threatening Processes Affecting Individual Plant Species

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

1. the direct impacts of the harvesting operation, including falling, snigging and loading,
2. the indirect impacts on the site and surrounding vegetation subsequent to harvesting (including the compounding effects of subsequent disturbance such as regeneration burning)and
3. the impacts of a cycle of harvesting (in this case, an average of 80 years) on forest structure, ecology and biodiversity

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

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

The potentially threatening processes directly associated with timber harvesting include damage or loss of individuals, particularly as a result of machinery use and falling trees, disturbance to the surface soil structure, disturbance of soil-stored seedbanks, and compaction of the soil surface on snig tracks and log landings. These processes are localised and of moderate overall significance to individual species. The species at greatest risk are those which rely wholly or partially on vegetative reproduction from organs/structures above, at or immediately below the soil surface (resprouters) after disturbance. See Mueck and Ough (1997) and Mueck and Peacock (1992) for effects in forest ecosystems dominated by

Mountain Ash *Eucalyptus regnans*. Tree-ferns (Soft Tree-fern *Dicksonia antarctica* and Rough Tree-fern *Cyathea australis*) are particularly sensitive to mechanical disturbances associated with current clearfelling practices (Mueck and Ough 1997). Other species which are intolerant to mechanical disturbance include Tall Sedge *Carex appressa*, Blackwood *Acacia melanoxylon*, Southern Sassafras *Atherosperma moschatum*, Blanket Leaf *Bedfordia arborescens*, Rough Coprosma *Coprosma hirtella*, Mother Shield-fern *Polystichum proliferum*, Water-ferns *Blechnum* spp. and Musk Daisy-bush *Olearia argophylla*. Also potentially at risk are species which rely totally or partially on soil-stored seed for reproduction (eg. Blanket Leaf *Bedfordia arborescens*, Dusty Daisy Bush *Olearia phlogopappa*, Silver Wattle *Acacia dealbata*, Blackwood *A. melanoxylon* and Tall Sedge *Carex appressa)*.

The potentially threatening processes indirectly associated with harvesting operations include habitat modification, specifically the removal of one or more forest strata and the loss of opportunity to develop habitat elements characteristic of mature and senescent forests (eg tall treefern trunks, decaying logs) on the coupe. This threatening process is considered to be of moderate overall significance but can have a major impact in certain vegetation types (eg. Montane Riparian Thicket, Wet Forest, Damp Forest and Riparian Forest). The alteration of microclimatic conditions both on the coupe and in adjoining vegetation creates sharp boundaries and results in increased exposure and alteration to the humidity, light and temperature conditions in the adjoining vegetation at least until the regrowth canopy reaches the level of the surrounding vegetation. The distance of penetration of these "edge effects" and their significance in causing floristic changes has yet to be clearly demonstrated, but edge effects are likely to be of greatest threat to EVCs that are linear and small (primarily drainage-line vegetation such as Montane Riparian Thicket) and to species which rely on stable, low light, high humidity, moderate temperature regimes (eg. Necklace fern *Asplenium flabellifolium*, Southern Sassafras *Atherosperma moschatum*, Blanket-leaf *Bedfordia arborescens*, Mountain Clematis *Clematis aristata*, Prickly Currant-bush *Coprosma quadrifida*, Mountain Tea-tree *Leptospermum grandifolium*, Veined Bristle-fern *Polyphlebium venosum* and Mother Shield-fern *Polystichum proliferum*). For a review of edge effects and microclimatic changes, see Burgman and Ferguson (1995). On the coupe itself, the microclimatic changes following harvesting are profound. In some cases these changes may mimic the impacts of wildfire. However, the impacts of wildfire may be less extreme than the impacts of clearfelling where some vegetation remains after the fire and species not killed by the fire rapidly resprout and recover (K. Ough, pers. comm.). See Murphy and Ough (1997)**,** Ough and Murphy (1996), Ough and Ross (1992) and Commonwealth of Australia (1996).

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

The additional soil disturbance created by timber harvesting (compared to wildfire or other natural disturbances) has the potential to lead to erosion and sedimentation, both on the coupe and in adjoining vegetation, particularly on steeper sites, on granitic soils and in gullies. Some loss of soil-stored seed may also occur. The severity of this process may vary greatly from site to site. Its overall significance is considered to be low for most plants. Species potentially affected include small forest understorey plants and species of mountain stream margins such as Alpine water-fern *Blechnum penna-marina*, Soft Water-fern *B. minus*, Broad-leaf Rush *Juncus planifolius*, Club-sedge *Isolepis subtilissima*, Swamp Club-sedge *I. inundata* and Tassel Sedge *Carex fascicularis*. The Code of Forest Practices (NRE, 1996) specifies provisions to minimise erosion and sedimentation arising from harvesting operations. Facilitation of the spread of weed species may also occur as a result of soil disturbance (see later section).

The potentially threatening processes associated with the cycle of timber harvesting relate mainly to the frequency and regularity of harvesting (as opposed to that of the natural disturbance regime). A harvesting cycle of an average 80 years applied consistently across the harvested areas of State forest would progressively eliminate mature and old-growth growth stages from these areas, although this effect is mitigated by protection of significant areas in various forest reserve tenures and by the absence of harvesting in some forests of lower productivity. The impact of this on native flora would be greatest in situations where the environmental conditions, structure and floristics of forests continue to change with the age of the stand over hundreds of years. Species dependent on habitat elements or characteristics of mature and old-growth stands are likely to experience a decline concomitant with the decline in the growth stages themselves (eg. Soft Treefern *Dicksonia antarctica*, Veined Bristle-fern *Polyphlebium venosum*, Southern Sassafras *Atherosperma moschatum*, Mother Shield Fern *Polystichum proliferum and* Musk Daisy Bush *Olearia argophylla*. Species which require a long period to reach full reproductive maturity may also be at risk (eg. Soft Treefern, Southern Sassafras *Atherosperma moschatum* and Blanket-leaf *Bedfordia arborescens*).

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

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

Different forest ecosystems/EVCs have varying requirements and will respond differently to the various silvicultural systems applied. The frequency and intensity of disturbance (here the silvicultural system being managed for wood

production) during a harvesting rotation and the length of rotation appear to strongly influence species composition. EVCs affected by timber harvesting include Montane Dry Woodland, Montane Damp Forest, Herb-rich Foothill Forest, Wet Forest and Damp Forest.

The clearfell system of timber harvesting has greatest impact on the structural and age class attributes at a smaller scale (ie. the coupe level) by creating an essentially even-aged regrowth forest. However, this may vary at a large scale (eg. the forest block level) depending on the amount and type of vegetation retained and the frequency of logging. The result may be a simplification of the age class characteristics of the overstorey trees. On a broad scale the result will be a heterogeneous mosaic of unlogged and logged areas of various ages and utility as habitat for other species (Mueck and Ough 1997). Other harvesting methods impact similarly but to a lesser degree.

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

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

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

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

Potentially Threatening Processes Affecting Fauna

Timber harvesting impacts upon a range of fauna species through its immediate and short-term effect of habitat removal and, more importantly, through 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 and floristically diverse than regrowth forests and provide a greater range of foraging substrates. Mature forests may support higher populations and diversity of bird species (Gilmore 1985, Scotts 1991, Traill 1991). Large old eucalypts provide important resources such as hollows, may have heavier flowering and nectar flows, a more plentiful supply of insects, a higher foliage density and specialised sources of food including peeling bark, mistletoe infestations and rotten wood (Bennett 1993, Traill 1993, Robinson and Traill 1996). Fauna species dependent on these resources are likely to be adversely affected by timber harvesting operations that reduce structural and floristic diversity. Disturbance and loss of litter and ground layers during timber harvesting operations will adversely affect ground foraging species. Soil disturbance has the potential to lead to soil erosion and sedimentation of streams. Subterranean species and those dependent on in-stream habitats are particularly vulnerable to these threatening processes. Timber harvesting operations can also result in some areas of forest becoming sub-optimal through habitat fragmentation. Species may need to expend more energy to forage in fragmented habitat, the ability to reproduce and disperse may be restricted, the likelihood of predation and the probability of mortality resulting from changes in fire regimes and other environmental factors may increase (Norton and Dovers 1994). Species with large home range requirements are particularly vulnerable to habitat fragmentation.

As a result, threatening processes related to timber harvesting include the loss of hollow-bearing trees, the conversion of mature stands to young regrowth stands and fragmentation.

Timber harvesting is considered a major threat to the Long-footed Potoroo, Spot-tailed Quoll, Yellow-bellied Glider, Sooty Owl, Powerful Owl, Carpet Python and Tree Goanna. These species generally forage over large areas and most utilise hollow-bearing trees as nest, shelter or foraging sites and a significant proportion of suitable habitat is found in State forest. The Brush-tailed Phascogale is also hollow-dependent and forages over large areas. However, the preferred habitat of this species is generally not commercially important and timber harvesting is therefore considered a moderate threat (T. Soderquist and P. Menkhorst pers. comm). The Squirrel Glider, Masked Owl, Barking Owl, Turquoise Parrot and

Gang Gang Cockatoo also utilise tree hollows for nesting. Hollow tree limbs are important foraging habitat of the largely arboreal Tree Skink; timber harvesting is considered a moderate threat to these species.

The Regent Honeyeater is known to select larger trees for foraging (Webster and Menkhorst 1992). Large old trees which produce high nectar yields in winter are a significant food resource of the Swift Parrot (Brereton 1996). The Grey Goshawk predominantly utilises older age-classes of forest for nesting and foraging. Conversion of older age-classes of forest to young regrowth stands as a result of timber harvesting operations can result in the loss of both nesting and foraging habitat for this species (Mooney 1987, Mooney 1988, Mooney & Holdsworth 1988) and a reduction in the quality of foraging habitat for the Regent Honeyeater and Swift Parrot (Traill 1993). The Square-tailed Kite uses traditional nest sites and has a specialised diet consisting mainly of passerine nestlings and eggs taken from nests in the outer foliage of the canopies of eucalypts (Debus and Czechura 1989). Timber harvesting may result in a loss of nest sites and a reduction in prey availability for this species. The Cicadabird is a canopy feeding species which requires continuous forested areas. Canopy loss and habitat fragmentation resulting from timber harvesting are potentially threatening processes for this species (C. Silveira pers. comm.).

For species reliant on in-stream habitat, timber harvesting may potentially cause siltation downstream which can also increase nutrient levels. Areas of regrowth forest which regenerate following timber harvesting operations may potentially alter stream flow and perenniality within catchments. Loss of forest cover may increase light levels reaching streams and thereby stream temperatures (Campbell and Doeg 1989). Populations of the Spotted Tree Frog may be detrimentally affected by altered streambed conditions and changes to water quality and flow such as increased sedimentation via a reduction in the viability of eggs, the survivorship of tadpoles and the availability of egg deposition sites (Gillespie and Hollis 1996, Robertson and Gillespie in prep.). The full range of habitats used by the Spotted Tree Frog during different growth stages and in different seasons have not been fully identified. Other related riverine species are known to use habitats at great distances from streams. Timber harvesting activities also have the potential to reduce local populations of the Spotted Tree 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). The Large-footed Myotis and Azure Kingfisher feed on aquatic insects and fish; altered stream conditions as a result of timber harvesting operations may indirectly impact on these species by affecting prey (L. Lumsden pers. comm., Shields 1994). For a discussion of the effects of disturbances on freshwater ecosystems and aquatic invertebrates and fish, refer to Chapter 7 on aquatic ecosystems.

Soil disturbance during timber harvesting operations is a potential threat to subterranean species such as the Woodland Blind Snake, Gray's Blind Snake and Bandy Bandy. Loss of soil structure, removal of surface sheltering sites and changes to soil microclimate is likely to reduce habitat quality for these species (Saddlier and Pressy 1994, Brown and Bennett 1995). Litter is important foraging habitat of the Red-throated Skink and Speckled Warbler. Disturbance and loss of litter during timber harvesting operations will adversely affect these species (Brown and Bennett 1995, Tzaros 1996). Soil disturbance and a reduction of litter may also affect the availability of hypogeal (underground fruiting) fungi, an important food of the Long-footed Potoroo. A significant proportion of the records of this species are from State forest, and timber harvesting is considered a major threat (Saxon *et al*. 1994, J. Seebeck pers. comm.).

Potentially Threatening Processes Associated with Timber Harvesting which may impact on Fauna:

Potentially Threatening Process	Attributes predisposing taxa to threat
Conversion of mature stands to young regrowth stands	Species predominantly utilising older age-classes of forest for nesting and foraging.
Disturbance and loss of litter and ground layers during timber harvesting	Ground foraging species, species which live or forage in litter layer. Reliance on hypogeal fungi (eg. Long-footed Potoroo)
Soil disturbance.	Subterranean species and those dependent on in-stream habitats
Habitat fragmentation	Large home range requirement for continuous forested areas.
Loss of hollow-bearing trees	Hollow dependent
Siltation, increase in nutrient levels, altered streambed conditions and changes to water quality and flow	Reliance on in-stream habitat
Loss of soil structure, removal of surface sheltering sites and changes to soil microclimate	Subterranean species

Management

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

The Code of Forest Practices for Timber Production (NRE 1996) sets minimum standards for forest operations. It provides principles and guidelines for regional prescriptions controlling timber production activities in State forest. It aims to ensure that environmental values and water catchments are protected, by careful operation planning, reservation of appropriate areas and vegetation corridors. Such prescriptions particularly benefit certain forest ecosystems (such as riparian EVCs) and the flora and fauna associated with them.

Potentially threatening processes listed under the *Flora and Fauna Guarantee Act* (1988) which may be relevant to timber harvesting are:

- Degradation of native riparian vegetation
- Increase in sediment input into Victorian rivers and streams due to human activities
- The invasion of native vegetation by 'environmental weeds'

Prescriptions for the protection of flora and fauna habitat are specified in Forest Management Plans. The North East RFA region encompasses the Wodonga, Wangaratta and the Benalla/Mansfield FMAs. A forest management plan is currently being prepared. Management strategies for species and threatening processes listed under the *Flora and Fauna Guarantee Act* 1988 are detailed in Action Statements and incorporated into forest management plans where relevant. Direct and indirect taking of protected flora associated with timber harvesting requires authorisation under the *Flora and Fauna Guarantee Act* 1988. Priorities and permitted uses in different parts of State forest are set by forest management zones. In addition to the formal reserve system already in place (National, State, and Wilderness Parks, Conservation Reserves etc.), Special Protection Zones will be defined and managed for conservation (timber harvesting will be excluded). Current prescriptions set a minimum of 15 retained trees per 10 hectares harvested for all forest types for conservation of wildlife habitat within the timber production forest (NRE 1996b). Further research on the requirements of hollow-dependent fauna in timber production forests is required. Previous research is reviewed in Gibbons and Lindenmayer (1997).

6.2.2 Clearing of native vegetation

Clearing of native vegetation occurs as part of development for agricultural, industrial, urban and utility purposes. Clearing of native vegetation associated with road construction and maintenance, mining and quarrying, tourism development, recreation and timber harvesting are threatening processes related directly to these disturbances and are discussed separately.

Historically, the inland slopes and foothills and the riverine plains of the region were among the most attractive lands for pastoral settlement. Areas particularly amenable to agriculture were on the more fertile soils and supported vegetation communities or ecological vegetation classes (EVCs) dominated by overstorey species of Grey Box *Eucalyptus microcarpa*, White Box *E. albens*, Yellow Box *E. melliodora* and Yellow Gum *E. leucoxylon*. These EVCs were cleared extensively and now persist largely as scattered remnants on or adjacent to private land, or as linear strips along roadsides and watercourses. Some flood plains dominated by River Red Gum *E. camaldulensis* were also cleared but not as extensively as the other EVCs (see section on grazing). A high proportion of the remaining forests within these areas were those that were not amenable to agriculture and generally consist of EVCs on poorer soils, rocky areas, upper slopes or alluvial floodplains that are subject to periodic inundation. These forests are mostly dominated by Red Ironbark *E. sideroxylon*, Mugga Ironbark *E. tricarpa*, Red Stringybark *E. macrorhyncha*, Red Box *E. polyanthemos*, River Red Gum and some Grey Box (LCC 1973, 1974, RAC 1992, Bennett 1993, Silveira *et al*. 1997).

Potentially Threatening Processes Affecting Flora and Fauna

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

Within the North East, clearing of native vegetation (as defined, above) is a particularly significant threat to species dependent on plains, woodland and sub-alpine habitats. Few if any detailed studies of the impact of clearing on native flora have been undertaken. The greatest need for research is in the area of the impact of vegetation fragmentation on the reproductive biology of key taxa, and on the long term management of remnants. Few if any native plants can survive

broadscale clearance of vegetation where the result is conversion of the land to intensive human use for urban, industrial, tourism or other purposes. However, clearing for agriculture does not always eliminate all native species. While the conversion of native vegetation to unimproved pasture usually involves the removal of trees and shrubs, many native herbs survive and in some cases prosper. However, as only vigorous reproducers (eg. many weed species) can tolerate such disturbance, its impacts are likely to be greatest on species with relatively low reproductive output. Once pastures are improved with the addition of exotic pasture species and fertiliser almost all native species are eliminated.

Many of the threatening processes indirectly associated with this disturbance result from fragmentation and isolation of habitat. Suitable habitat for species dependent on depleted vegetation types exists only in small, isolated remnants (eg. for fauna including Grey-crowned Babbler, Bush Stone-curlew, Squirrel Glider and Apostlebird (Bennett 1993) and the flora species Yellow Hyacinth Orchid *Dipodium hamiltonianum*, Wedge Diuris *Diuris dendrobioides*, Leafy Greenhood *Pterostylis cucullata* and Silver-leaf Stringybark *Eucalyptus alligatrix ssp. limaensis* etc.). Populations of these species are generally small and are particularly vulnerable to further loss of habitat as a result of clearing. Many local populations now consist of isolated groups persisting in habitat islands within the broader landscape. For flora this presents barriers to the spread of propagules to and from remnants leading to a reduction in the gene pool resulting in inbreeding and reduced fitness for reproductivity and recruitment. Another effect is an increase in vulnerability to extinction as vegetation is less able to recover or regenerate from catastrophic events or threatening processes which cause gradual depletion (eg. road maintenance works, weed invasion, fertiliser drift).

Isolated patches of vegetation may also be more susceptible to decline in response to insect predators and the spread of pathogens or disease. Similarly, large areas of cleared paddocks can be barriers to movement for many animals that depend on forest vegetation. Small animals with low mobility (eg. Bandy Bandy, Woodland Blind Snake) are particularly vulnerable to habitat isolation. Isolated populations of fauna are also more vulnerable to extinction from catastrophic events such as wildfire and drought and are more susceptible to threatening processes including predation and interspecific competition (Bennett 1990, 1993, Robinson 1993). Loss and fragmentation of habitat are also significant threats to species which utilise forest/farmland edge such as the Turquoise Parrot (Quin 1990, B. Quin pers. comm.) and to hollow-dependent species that require large areas for foraging such as the large forest Owls (Hollands 1991, E. McNabb pers. comm.), Brush-tailed Phascogale (Soderquist 1995a Menkhorst 1995a, Atlas of Victorian Wildlife, Rhind 1996, Humphries and Seebeck in prep., T. Soderquist pers. comm.) and Tree Goanna. (Brown and Bennett 1995, G. Brown pers. comm.).

Other indirect effects of the clearing of native vegetation include the facilitation of the spread of introduced species (which quickly colonise after disturbance and often out-compete indigenous species), increased susceptibility to grazing pressure, erosion and soil compaction. In addition, small, isolated populations may not be sufficient to attract and sustain insect pollinators and the cessation of natural processes (eg. fire) which previously maintained diversity and vigour. In addition, the widespread clearing of deep-rooted native vegetation and its replacement with shallow-rooted pastures and crops has resulted in rising water-tables and salinity which is a factor contributing to tree dieback in rural areas (Clunie in prep.).

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

The depletion level of particular EVCs is influenced by many factors including arability, access and topography. See Table 0.4 for percentage remaining of each EVC within the North East. EVCs most threatened by this process are those of the low foothills or plains including Floodplain Riparian Woodland, Plains Grassy Woodland, Valley Grassy Forest, Grassy Dry Forest, Box Ironbark Forest, Gilgai Plains Woodland/Wetland Mosaic, Grassy Woodland, Spring Soak Herbland and Granitic Hills Woodland.

Management

Further clearing of native vegetation is significantly mitigated by the implementation of native vegetation retention controls under the *Planning and Environment Act* 1987. Under the Act, land holders and public authorities must apply for a permit to clear native vegetation from any parcel of land greater than 0.4 ha. For areas less than 10 ha, applications are assessed by Shire Councils and for areas greater than 10 ha, NRE is a referral authority. Minor clearing associated with normal farm and domestic activities are not subject to these controls. Areas of significant vegetation and/or fauna habitat are protected by this process. Fragmentation of native vegetation is also minimised. Permits to clear native vegetation are generally only granted for small areas with little significance or slightly larger areas of degraded native vegetation.

The rate of clearing of private land is monitored by NRE through a database of clearing applications and satellite imagery which allows detailed comparison between current and past extent of tree clearance. 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.

The clearing of native vegetation on public land requires Departmental approval. Planning permission may also be required in some cases. Major developments, including many mining and extractive industry developments, are the subject of Environment Effects Statements, in which the impacts on native flora and fauna are usually considered. The taking of protected flora associated with clearing requires authorisation under the *Flora and Fauna Guarantee Act* (1988).

6.2.3 Fuel Reduction Burning

Fire is a fundamental element of the Australian environment. The effects of fire on flora and fauna vary depending on the scale, frequency, intensity and season of burns (Wilson 1996). Most native terrestrial plants have evolved reproductive mechanisms in response to fire. Fauna also respond to fire and factors such as shelter and food requirements and behavioural patterns will affect these responses (Wilson 1996).

Most fuel reduction burns are low intensity burns that aim to reduce the ground, understorey and bark fuel loadings (CNR 1995c); the upper tree layers are usually not burnt. Frequencies of these burnings vary depending on a priority zoning system, fuel accumulation and climatic and seasonal factors. The lowest frequencies in the North East are usually 6-7 years apart. Fuel reduction burns are usually of low to moderate intensity, and are conducted in spring or autumn when conditions are optimal for maximum effectiveness with low risk of escape or excessive damage to living trees. Other fire prevention activities carried out on public land include fuel reduction on roadsides and other remnants which may include ploughing, slashing and burning.

Within the North East, fuel reduction burns are mainly carried out in Shrubby Dry Forest, Herb-rich Foothill Forest, Heathy Dry Forest and Grassy Dry Forest EVCs (NRE unpublished data). It is also carried out in areas of Montane Dry Woodland and Damp Forest. Other EVCs (eg Box-Ironbark Forest) are also burnt to a lesser extent.

Potentially Threatening Processes Affecting Flora

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

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

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

Species which require long fire intervals include Blanket Leaf *Bedfordia arborescens*, Musk Daisy-bush *Olearia argophylla*, Silver Wattle *Acacia dealbata*, Mountain Clematis *Clematis aristata*, Rough Coprosma *Coprosma hirtella*, Prickly Currant-bush *C. quadrifida*, Rough Treefern *Cyathea australis* and Mountain Tea-tree *Leptospermum grandifolium*. Species sensitive to fire season include Soft Tree-fern *Dicksonia antarctica*, Straw Wallaby-grass *Austrodanthonia richardsonii*, Narrow Goodenia *Goodenia macbarronii*, Purple Diuris *Diuris punctata* var. *punctata*, and Clover Glycine *Glycine latrobeana*.

Species sensitive to fire intensity include Mountain Banksia *Banksia canei*, Musk Daisy-bush *Olearia argophylla*, Mountain Tea-tree *Leptospermum grandifolium*, Gristle Fern *Blechnum cartilagineum*, Hard Water-fern *B. wattsii*. Tall Sedge *Carex appressa*, Clover Glycine *Glycine latrobeana*, Narrow Goodenia *Goodenia macbarronii* and Grey Rice-flower *Pimelea treyvaudii*.

Potentially Threatening Processes Affecting Fauna

Fuel reduction burning in the North East is regarded as a major threat to the Smoky Mouse, Carpet Python and Red-throated Skink. Fuel reduction burning is a threat to a further 32 of the species considered in this assessment (refer to appendix G). The immediate and short-term impacts of fire on fauna populations are related to mortality during the fire, loss of shelter and nesting habitat, increased predation and decreased prey availability. Longer term effects involve

changes to vegetation characteristics. Recolonisation of burnt areas by fauna is influenced by the presence of adequate foraging, shelter and breeding sites (Humphries and Tolhurst 1992).

Potentially Threatening Processes Associated with Fuel Reduction Burning Affecting Fauna:

Potentially Threatening Process	Attributes predisposing taxa to threat
Loss of individuals during fire	Low mobility, ground dwelling
Direct loss of shelter and nesting habitat or foraging habitat	Hollow-dependent species Species which nest, shelter or forage on or near the ground
Simplification of understorey resulting in loss of shelter and foraging sites	Species which nest, shelter or forage on or near the ground Species restricted to fire sensitive habitats (eg. Alpine)
Alteration of floristics or structure	Species adapted to particular successional stages of vegetation
Increased predation	Species which shelter on or near the ground
Decreased prey availability	Species which prey on faunal groups adversely affected by fuel reduction burning regimes

Some fauna may be specially adapted to certain successional stages of vegetation. The Smoky Mouse appears reliant on understorey vegetation components strongly influenced by the frequency and intensity of fires (Menkhorst 1995c). Inappropriate fire regimes resulting in changed floristics and structure represent a major threatening process for the species (P. Menkhorst pers. comm.). However, there is a lack of information on its ecological requirements especially in relation to fire (Lee 1995). Given that the Smoky Mouse exists in small isolated populations and has been recorded in EVCs subject to fuel reduction burning, inappropriate fire regimes have the potential to cause local population extinctions.

Frequent low-intensity burns can simplify and eventually eliminate dense understorey (Catling 1991). This can reduce shelter and foraging sites for a range of species such as Carpet Python, Spot-tailed Quoll, and Yellow-footed Antechinus.

In forest edges, small remnants and roadsides the removal of litter and the death of young trees and shrubs caused by fuel reduction burning may result in an increase in introduced vigorous pasture grasses and other weeds such as canary grass (*Phalaris* spp.). These weeds prevent ready access to the litter layer and therefore reduce the amount of foraging habitat available for species such as the Grey-crowned Babbler (Davidson and Robinson 1992). Loss of litter and logs threatens species that are dependent upon these habitats such as the Red-throated Skink, Bandy Bandy, Woodland Blind Snake and Grey's Blind Snake (P. Robertson pers. comm.)

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 for species reliant on roadside remnants such as Squirrel Gliders, Apostlebirds, Bush Stone-curlews and Grey-crowned Babblers (Menkhorst *et al*. 1988, Davidson and Robinson 1992, Adam and Robinson 1996).

The Square-tailed Kite may face prey shortages if forest and woodland bird communities are adversely affected by modified fire regimes (Debus and Czechura 1992). The effect of fire on hypogeal fungi, an important food resource for the Long-footed Potoroo and Long-nosed Bandicoot, is unclear; research results are contradictory. However, if the effects on the availability of fungi are detrimental, the impact on these species is potentially severe, especially for the Long-footed Potoroo which appears to rely heavily on fungi (Scotts and Seebeck 1989).

The habitats of Mountain Pygmy-possum, Alpine Bog Skink and Alpine Water Skink are very fire-sensitive. However, fuel reduction burning is unlikely to be carried out in the sub alpine and alpine vegetation types within the ranges of these species (DCE 1992a). This process is therefore not considered to be a threat to these species (I. Mansergh and P. Robertson pers. comm.).

Management

Fire management in the North East is guided by the Code of Practice for Fire Management on Public Land (CNR 1995b), which outlines general principles and guidelines for fuel reduction burning and Regional Fire Protection Plans. Each fire protection plan includes a fuel management strategy, based on five zones. 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 Plans. 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 1995b).

Flora and Fauna Guarantee 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, particularly the effect of burning frequencies, is largely unknown. 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. NRE is undertaking long-term research on fuel reduction burns in the Wombat State Forest, which includes vegetation types which are found in the North East.

6.2.4 Regeneration burning

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

Potentially Threatening Processes Affecting Flora

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

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

Management

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

6.2.5 Planned Absence of Fire

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

Potentially Threatening Processes Affecting Flora

The threatening processes associated with the long-term absence of fire are 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 the modified 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 EVCs most prone to structural and floristic changes in the absence of fire include Granitic Hills Woodland, Heathy Dry Forest.

Species dependent on fire for reproduction, or whose reproduction is greatly enhanced by fire include, Wedge Diuris *Diuris dendrobioides*, Phantom Wattle *Acacia phasmoides* and Purple Eyebright *Euphrasia collina* ssp. *muelleri*. Some species which are killed by fire are nevertheless dependent on fire to achieve or enhance reproduction by resprouting and/or seedling establishment (eg. members of the Proteaceae family such as Mountain Banksia *Banksia canei*, Tree Hakea *Hakea eriantha* and Yellow Hakea *H. nodosa*).

Management

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

6.2.6 Unplanned Fire (Wildfire)

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

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

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

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

Potentially Threatening Processes Affecting Flora and Fauna

Wildfire may result in loss of fire sensitive species, encouragement of weed invasion or loss of or decrease in reproductive capacity if the fire occurs in the wrong season.

Effects of fire on vegetation are dependent on the fire frequency, fire intensity and season of burn. These effects include changes in species composition and abundance, and physical and age structure. All species respond uniquely to the combination of fire regime, other disturbances and potentially threatening processes (eg. weed invasion) that may be operating locally or regionally.

The intensity of a fire may determine the degree to which the vegetation is altered initially. High intensities can initially damage all strata while low intensity fires may only damage the lower layers (Meredith 1988). Low intensity fires generally leave more areas of un-burned vegetation but high intensity fires can also be restricted or patchy in extent.

Following a fire a range of environmental factors will interact to determine the characteristics of the vegetation and its suitability for particular fauna species. Vegetation often recovers in a series of stages or successions. Recolonisation of fauna can be related to these stages, with species returning once particular habitat components are again present (Friend 1993). A burnt area of forest may not return to its original form but may provide habitat and resources for a different suite of fauna. Because the system is dynamic, further disturbance such as another fire may result in further changes in structure and floristics depending on the interval between fires, fire intensity, climatic and other factors.

The season of burn may determine how an area and associated fauna respond to fire. For example breeding seasons may be interrupted. Autumn fires are generally hotter than spring burns (Wilson 1996) and the response of vegetation (and associated fauna) may differ depending on the heat and intensity of the burn. The frequency of wildfire can influence the regeneration of vegetation and therefore the recolonisation of animal species. The recolonisation of a species into a particular area is influenced by the dispersal abilities of the species, the existence of any metapopulations within reach of the burnt area and the sizes of those populations (Bennett 1990). Wildfire in fragmented, restricted and fire-sensitive habitats may eliminate important habitat, contracting the distribution of already restricted flora and fauna even further or resulting in loss of local populations with little chance of recolonisation.

Potentially Threatening Processes Associated with Unplanned Fire - Flora and Fauna

Potentially Threatening Process	Attributes predisposing taxa to threat
Loss of individuals	Species with low mobility
Loss of remnant vegetation	Species occurring in fragmented landscapes Species with low mobility

Loss of shelter and nest sites	Hollow dependent species Species nesting on or near the ground
Reduction in numbers of prey species	Predators such as owls
Loss of understorey, litter and ground debris	Species that require understorey or ground layers as a foraging resource
Loss of fire sensitive vegetation	Species restricted to fire sensitive habitats

Fire can cause direct mortalities of animals and may eliminate critical habitat components. Species occurring in small disjunct populations or species with narrow habitat requirements are particularly vulnerable to wildfire. Of the fauna species covered by this review, wildfire is regarded as a major threat to the Carpet Python, Powerful Owl, Sooty Owl and Turquoise Parrot. All species assessed were considered to be under some degree of threat from wildfire. However, the effects of this disturbance on populations of priority bat and frog species is unknown at present.

Adverse effects of wildfire on animal species are related to mortality during the fire and subsequent loss of shelter and nest sites, reduction in prey availability and foraging substrate and increased risk of predation by introduced species (Catling 1991, Wilson 1996). Species with low mobility, such as small ground mammals and skinks, may not be able to escape during a fire and perish. Shelter and food requirements and behavioural patterns of species will affect their responses to a fire (Friend 1993, Wilson 1996). Burrowing species and species able to shelter under rocks or in hollows may survive even intense fires. Continued survival of these species will depend on the availability of resources after the fire.

A reduction in numbers of arboreal and ground dwelling species as a result of wildfire can impact on predators such as the Powerful Owl, Sooty Owl, Tree Goanna and Carpet Python (E. McNabb and P. Robertson pers. comm.). Severe fires may cause loss of hollow-bearing trees reducing nest and shelter sites for many species (see Appendix G).

Populations of species such as the Squirrel Glider which relies on understorey *Acacia* species as an important foraging resource may be locally disadvantaged by a fire which destroys this winter food source. However, fire may also stimulate germination of the *Acacia* seed bank which may eventually benefit the glider population in a particular locality. Damage to the outer canopy of eucalypts may impact on the Square-tailed Kite which feeds on passerine nestlings and eggs taken from nests situated within this section of the tree (Debus and Czechura 1989). Disturbance of the litter and ground debris by wildfire eliminates important foraging and shelter habitat. Species that nest on or near the ground may lose these important sites during a wildfire. The effect of fire on hypogeal fungi, an important food resource for the Long-footed Potoroo and Long-nosed Bandicoot, is not clear although recent research suggests a detrimental effect (Thomas *et al.* 1994). The habitat of the Smoky Mouse appears to be fire-generated although the exact relationship between habitat, fire and the presence of this species is not fully understood (Lee 1995). In addition, the Smoky Mouse exists in small isolated populations which may become locally extinct if a wildfire destroyed all the suitable habitat in an area at the one time.

Vegetation in sub-alpine and alpine areas is especially sensitive to damage caused by wildfire because of a very limited growing season and slow growth rate (McDougall 1982). A range of flora and fauna species are restricted to sub-alpine and alpine areas in the North East and these populations represent the main distribution of these species in Victoria (NRE 1998b, NRE 1998c, NRE 1998d). Wildfire within the ranges of these species may eliminate important habitat and further restrict their distribution or wipe out local populations. The risk of wildfires occurring in these areas is heightened by ski resort and recreation-related human presence (Mansergh *et al.* 1991).

Management

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

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

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

6.2.7 Grazing

Domestic stock and naturalised exotic animals including rabbits, hares, deer, goats and brumbies are the main agents of grazing or browsing and trampling of native vegetation within the North East. Rabbits are widespread within the study area, particularly in areas with granite soils, though they are generally absent or only present in small numbers in the high country. The largest populations of hares are found on the plains of the Murray River. Populations at higher elevations are generally small and scattered although in the Bogong Unit of the Alpine National Park hares are common, particularly on alpine and subalpine plains. Goats are generally uncommon in the study area occurring mainly as small, scattered flocks. Brumbies are mainly recorded from the high country, where herds are generally small and widely scattered. The biggest populations of this species occur in the Bogong Unit of the Alpine National Park. Deer occur in forest environments below the tree line where populations are generally small although increasing (DCE 1992a,b,c, M. Chapman pers. comm).

On public land, licensed grazing of domestic stock, particularly cattle, is practised throughout the North East and includes State forest, parts of the Alpine National Park, roadside reserves and water frontages. Forest grazing is often a significant part of the enterprise of individual licensees. Areas of public land are also made available for graziers who do not normally depend on forest grazing to provide short-term feed in times of drought, fire and flooding (LCC 1977). In the Alpine National Park, the majority of cattle are grazed on alpine and subalpine blocks above 1220 m elevation. A smaller number of cattle also occupy forest areas below 1200 m. Cattle are generally grazed in the higher country between December and early April (DCE 1992a,b,c). Commonly grazed EVCs at high elevations include Montane Dry Woodland, Sub-alpine Woodland and Treeless Sub-alpine Complex and to a lesser extent Montane Damp Forest. At lower elevations grassy and herbaceous EVCs are commonly grazed including Herb-rich Foothill Forest, Valley Grassy Forest, Grassy Woodlands, and riverine and plains environments.). Williams *et al*. (1997) describes the impacts of cattle grazing on alpine and sub-alpine plant communities..

Potentially Threatening Processes Affecting Flora

The impact of grazing will depend on the grazing species, habitat, grazing intensity, timing, duration, stocking rate and type of stock (for cattle grazing) and climatic conditions (Clunie in prep). 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.

Grazing, browsing or trampling can result in direct damage to or loss of plants and the potential for reduced reproductive output, especially where reproductive structures are significantly affected.

Less direct potentially threatening processes associated with grazing are habitat modification, reduction in the litter layer and soil disturbance, compaction 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, feet or coats. These processes can lead to the simplification of the vegetation overall and reduced structural and floristic heterogeneity (Lunt 1991, Brown and Bennett 1995, Robinson and Traill 1996). Grazing may also affect the health and longevity of existing vegetation including the overstorey due to increased nutrient levels, root damage and soil compaction which may lead to dieback (Landsberg *et al*. 1990).

The ecological attributes which predispose plants to threat from grazing include palatability (mainly herbaceous species, but may include woody species when young, such as some *Eucalyptus* spp, some *Acacia* spp, *Coprosma* spp) and occurrence in habitats which tend to be grazed more frequently or heavily, such as grassy habitats (eg. Wire-head Sedge *Carex cephalotes*, Dwarf Sedge *C. paupera*, Rock Poa *Poa saxicola*, Clover Glycine *Glycine latrobeana*, Wedge Diuris *Diuris dendrobioides*, Buloke *Allocasuarina luehmannii*, Candlebark *Eucalyptus rubida* ssp. *septemflora* and Rough Eyebright *Euphrasia scabra)*.

Habitats affected by grazing are principally the grassy and forb-rich EVCs eg. Grassy Woodland, Box Ironbark Forest, Plains Grassy Woodland, Floodplain Riparian Woodland, Grassy Dry Forest, Herb-rich Foothill Forest, Treeless Sub-alpine Complex and Valley Grassy Forest. The historical combination of alienation, grazing and clearing has resulted in most of these ecological vegetation classes being scarce on public land and are often present as degraded remnants on private land.

Potentially Threatening Processes associated with grazing - flora

Potentially Threatening Processes	Attributes predisposing taxa to threat

Changes to composition/structure. Direct damage to or loss of plants as a result of browsing and trampling. In particular, loss of reproductive structures leading to reduced reproductive output	Palatability and occurrence in habitats which tend to be grazed more frequently or intensively
Habitat modification due to soil disturbance or erosion	Occurrence on steep sites, in drainage lines or on heavy clays (pugging), sands, silts and gravels (erosion), peats (physical fragmentation).
Environmental weed invasion	

Potentially Threatening Processes Affecting Fauna

Species particularly vulnerable to threatening processes associated with grazing include those whose habitat is largely restricted to remnant patches of habitat within an agricultural landscape, species which live underground or forage in the sub-soil or litter layers, species which require structural complexity near ground-level, and species restricted to sensitive vegetation types.

Potentially Threatening Processes associated with grazing - fauna

Potentially Threatening Processes	Attributes predisposing taxa to threat
Habitat modification including simplification of understorey and reduced structural heterogeneity	Species which require structural complexity near ground-level for foraging, shelter and nesting.
Disturbance to soil structure including compaction and erosion	Species which live underground or forage in the sub-soil or litter layers
Facilitation of spread of introduced species - weed invasion and invasion of feral animals as a result of habitat modification	Species restricted to sensitive vegetation types. Requirement for structural complexity near ground-level.
Degradation of native riparian vegetation, increase of sediment input to streams, erosion of stream banks. Degradation of sensitive vegetation types	Species utilising riparian habitats. Species restricted to sensitive vegetation types
Habitat loss due to lack of regeneration, trampling and loss of existing vegetation and litter, ringbarking and subsequent death of trees	Species whose habitat is largely restricted to remnant patches of habitat within an agricultural landscape.
Reduced health and longevity of existing trees due to increased nutrient levels, root damage and soil compaction which may lead to dieback	Species whose habitat is largely restricted to remnant patches of habitat within an agricultural landscape.

Lack of regeneration as a result of grazing of remnant patches of native vegetation is a significant threat to the long-term persistence of species such as the Painted Honeyeater, Apostlebird, Regent Honeyeater, Swift Parrot, Bush Stone-curlew, Squirrel Glider, Grey-crowned Babbler, Swift Parrot and Bandy Bandy. A significant proportion of the preferred habitat of these species is found in remnant patches of woodland habitat on private land, roadside reserves and water frontages. Trees in paddocks are particularly vulnerable to dieback processes associated with grazing including soil compaction, increased nutrients causing changes to soil chemistry, girding of trees and consumption of young seedlings (Heatwole and Lowman 1986). Lack of regeneration resulting in loss of habitat in the long-term may also have a significant impact on species which utilise forest farmland edges such as the Masked Owl, Barking Owl and Turquoise Parrot.

Soil disturbance resulting from grazing is likely to adversely affect species such as the Woodland Blind Snake, Gray's Blind Snake and Bandy Bandy. These snakes are subterranean and their presence is influenced by soil characteristics including penetrability, moisture content and particle size (Ehmann and Bamford 1993). Deleterious impacts for fossorial reptile species include: loss of soil structure, removal of surface sheltering sites and changes to soil microclimate (Saddlier and Pressy 1994, Brown and Bennett 1995).

The Azure Kingfisher nests in tunnels which it excavates in stream banks near the water. Erosion and collapse of river banks as a result of grazing of stream-side frontages may result in lost nesting habitat (Shields 1994).

Elimination and simplification of understorey vegetation and trampling of litter accumulations as a result of grazing are threatening processes for a range of reptile species, particularly skinks, and ground-foraging birds (Brown and Bennett 1995, Blakers *et al*. 1984, Emison *et al*. 1987). See Appendix G.

Alpine and sub-alpine vegetation is generally slow growing and seedling establishment is rare (McDougall 1982). As a result it is particularly sensitive to physical disturbance and modification arising from grazing and trampling. In the harsh

alpine environment the light, friable soils are particularly prone to erosion if exposed (LCC 1982). Habitat loss and degradation as a result of grazing and trampling is a significant threat to alpine, sub-alpine and montane species with specialised habitat requirements such as Alpine Bog Skink, Alpine She-oak Skink, Alpine Water Skink, and Mountain Pygmy Possum.

Management

Grazing on public land including State forest is permitted under licence. In State forest grazing licences are issued annually for periods up to twelve months and are subject to regulations under relevant legislation (eg. *Forests Act* 1958). Seven year licences will be introduced for the seasonal bush grazing licences in State Forest. Grazing covers approximately 280,000 hectares of public land in the North East. Licences are issued for seven years for parts of the Alpine National Park and specify the maximum number of stock that may be grazed on the licensed areas. Licences include conditions, which can include the exclusion of cattle from areas of special conservation significance or from areas requiring rehabilitation.

Two of the major impacts of grazing are listed as Potentially Threatening Processes under the *Flora and Fauna Guarantee Act* 1988. These are *The degradation of native riparian vegetation along Victorian rivers and streams* and *Soil erosion and vegetation damage and disturbance in the alpine regions of Victoria caused by cattle grazing.*

It is intended that populations of introduced grazers/browsers (rabbits, hare, deer, brumbies, goats) with the potential to cause environmental damage are monitored in the Alpine National Park and control measures instigated on an as needs basis (DCE 1992a,b,c).

On other public land including State forest deer, brumbies and hares are not actively controlled. Goats are heavy browsers and have the potential to significantly alter vegetation communities. Populations are generally small and transient within the North East and control programs are initiated as required. Rabbits are the most widespread pest species in the study area and have a significant impact on vegetation communities leading to altered structure, floristics and soil erosion. Coordinated public and private land control programs are ongoing (M. Chapman pers. comm.). 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. Over-browsing by native browsers is generally dealt with by issuing permits to reduce the relevant populations.

Management of grazing by domestic stock of stream frontages and roadsides (including unused road reserves) is an important issue for flora and fauna conservation within the North East. Licensed grazing of native vegetation on public land is subject to periodic review, with the option of specifying licence conditions. On public roadsides managed by local government, development of roadside management plans which address issues such as grazing are critical to ensure habitat conservation for many species.

Many stream-side areas have been affected by habitat modification including shrub loss and inadequate regeneration (Weber in prep.). Grazing on stream frontages and other vegetation remnants on public land which are important for understorey species or fauna, such as the Squirrel Glider, needs to be compatible with the maintenance of identified values.

Light or occasional grazing may be compatible with habitat management for some fauna species such as Grey-crowned Babbler and Bush Stone-curlew (Davidson and Robinson 1992, Johnson and Baker-Gabb 1994, Robinson *et al.* in prep.). Provided adequate regeneration of trees and shrubs is maintained, light grazing may reduce the growth of exotic pasture species and help maintain a ground layer of sparse native grasses ensuring Babblers have access to the ground layer for food and that the ground level vision of Stone-curlews is unobstructed by dense, taller grasses. However, even light grazing will be deleterious if the remnant is to be managed for conservation of understorey flora.

6.2.8 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.

In timber harvesting areas throughout the North East there is a requirement for a well constructed and maintained network of roads capable of carrying heavy vehicles. Road construction and maintenance activity is extensive. However, in terms of overall length, narrow tracks constitute the majority of the road and track network in State forests in the North East.

In the agricultural areas of the North East region, road reserves make up a significant proportion of the remnant native vegetation and provide important links between remnant patches. Roadworks such as road-widening and upgrading and installation of utilities, have the potential to degrade native vegetation (particularly the ground layer), reduce habitat and contribute to weed invasion.

Potentially Threatening Processes Affecting Flora

The potentially threatening processes associated with this disturbance include direct damage or loss of plants by machinery, habitat loss and/or fragmentation, altered micro-climatic and light conditions, erosion, sedimentation, introduction of soil or gravel contaminated with weed seed or fungal spores and the facilitation of weed spread (due to continual disturbance of road margins, introduction in soil on vehicles and machinery and contamination via the stream system). The impact of road construction and maintenance is greatest in the construction phase, especially where the road is major and the terrain is steep, requiring large batters. Stream crossings sometimes present major engineering challenges, and have been shown to be the main sources of sediment input to streams. The erosion hazard will also be greatest in steep terrain, particularly in high rainfall areas. Gully vegetation is therefore most at risk from the major impacts of road construction and maintenance (eg. Riparian Forest, Montane Riparian Thicket, Wet Forest, Damp Forest, drainage-line vegetation in alpine areas).

Degradation of native riparian vegetation along Victorian rivers and streams, *Increase in sediment input into Victorian rivers and streams due to human activities*, and *The invasion of native vegetation by environmental weeds* are listed as Potentially Threatening Processes under the *Flora and Fauna Guarantee Act* 1988.

Indirect impacts of road construction and maintenance include potentially threatening processes that lead to habitat modification (soil erosion, sedimentation, microclimatic changes, increase of water turbidity and alteration of hydrological regimes). These processes are most significant in the vicinity of gullies in the steeper, higher-rainfall, mountainous parts of the North East. In addition, gullies and streams act as conduits for the spread of weed propagules downstream. Consequently species associated with gully and riparian environments are most likely to be affected (eg. Blanket-leaf *Bedfordia arborescens*, Southern Sassafras *Atherosperma moschatum*, Hard Water-fern *Blechnum wattsii*, Rough Tree-fern *Cyathea australis* and Veined Bristle-fern *Polyphlebium venosum)*. Other species threatened by road construction and maintenance include Wedge Diuris *Diuris dendrobioides*, Leafy Greenhood *Pterostylis cucullata*, Clover Glycine *Glycine latrobeana* and Smooth Darling-pea *Swainsona galegifolia*.

Potentially Threatening Processes Affecting Fauna

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

Potentially Threatening Processes Associated with Road Construction and Maintenance - Fauna

Potentially threatening process	attributes predisposing species to threat
Introduced predators	
Direct destruction of habitat	Species dependent upon roadside vegetation as habitat Species dependent on sensitive habitat types
Creation of barriers	Species with limited mobility
Erosion	Species dependent on sensitive habitat types Species associated with riparian environments
Weed invasion	Species dependent on sensitive habitat types Species which forage on or near the ground
Increased water turbidity and siltation	Species associated with riparian environments
Alteration of hydrological regimes	Species associated with riparian environments

Roadside vegetation provides a significant proportion of the habitat of the Grey-crowned Babbler, Bush Stone-curlew, Apostlebird and Squirrel Glider. Road-widening and upgrading and installation of utilities degrade and can reduce habitat by removing and damaging mature trees and saplings and shrubs. Roadworks may also result in weed invasion causing a deterioration of ground-layer habitat and contribute to eucalypt dieback as a result of altered drainage patterns, nutrient run-off or introduced plant pathogens (Heatwole and Lowman 1986, Landsberg *et al*. 1990, Robinson *et al*. in prep.).

Roads can create barriers to movement and fragment habitat. Species with limited mobility such as small mammals and skinks are particularly vulnerable. Construction of roads within the Mt Hotham Alpine Resort is known to have caused disruption in the breeding cycle of the Mountain Pygmy Possum by affecting movement of animals between breeding and non-breeding habitat (Mansergh and Scotts 1989, Mansergh *et al*. 1991). The Squirrel Glider 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 connectance (Alexander 1989, J. Alexander pers. comm.). White-bellied Sea-eagles are particularly vulnerable to disturbance while nesting. Road construction and maintenance activities in the vicinity of nest sites may cause breeding pairs to abandon

nests leading to reduced breeding success (Williams 1997, P. Clunie pers. comm.). The establishment of roads through undisturbed forest may allow introduced predators such as Foxes to colonise new areas (May and Norton 1996).

Alpine and sub-alpine vegetation is particularly sensitive to physical disturbance and modification resulting from construction of roads. Construction of roads and tracks can result in increased sedimentation of streams and alteration of riparian habitats. The principal sources of sedimentation associated with roads are likely to be unsealed roads and tracks including fire trails and accessible major and minor roads used for timber harvesting, recreation and management access (O' Shaughnessy and Associates 1997). Increases in sediment load can be detrimental to the Spotted Tree Frog by affecting the growth and survival of eggs and tadpoles. Adult recruitment, breeding and survival of the frog may also be affected by changes to the general characteristics of the riparian habitat (Watson *et al*. 1991). The Large-footed Myotis is largely dependent on aquatic prey. Increased sedimentation and turbidity of streams may indirectly affect this species through reduced prey availability.

Management

In State forest, all new roads and tracks must be built to comply with the Code of Forest Practices for Timber Production (NRE 1996). The Code includes goals and guidelines covering the planning, location, design, construction, maintenance and use of timber extraction roads and stream crossings. In all cases, efforts are made to reduce the environmental impacts consistent with safety considerations, traffic levels and engineering requirements. Such factors will affect the extent to which desired environmental outcomes can be accommodated. A report prepared by O' Shaughnessy and Associates (1997) was commissioned to provide expert advice on means to protect water quality in catchments supporting Spotted Tree Frog populations. Recommendations were made concerning road management including monitoring during periods of heavy rain, application of road standards across complete catchments and standards for stream crossings and culverts. The allocation of resources to the repair of existing road networks was also recommended (O' Shaughnessy and Associates 1997).

The likelihood of new road construction in the North East, in particular within alpine and sub-alpine environments, is low. However, there are a range of processes (eg. Code of Forest Practices) in which flora and fauna values are addressed prior to the approval of the construction of new roads on public land.

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

Local Government Roadside Management Plans which incorporate guidelines for habitat management should assist in achieving conservation objectives for species dependent upon roadside vegetation in the agricultural landscape. Development of Roadside Management Plans requires liaison with major land managers who have impact on roadside vegetation including local government authorities, Country Fire Authorities and local land holders (Davidson and Robinson 1992).

In State forest attention is 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 must be built to standards outlined in the Code of Forest Practices (NRE 1996). However, many roads and tracks were built prior to introduction of the Code and do not meet today's standards. Action is underway to prioritise improvements to existing roads, based on a recent condition assessment (B. Thompson pers. comm.).

6.2.9 Recreation

A wide range of recreational pursuits take place in the North East, but the most significant from a disturbance perspective are vehicle-based activities, fishing, hunting, camping, and skiing. The impacts of vehicles are greatest in localised areas of the major river valleys, such as the Buffalo, Rose, Kiewa, King, Ovens, Murray and Goulburn, especially when they occur within the riparian zone.

Vehicle-based activities can result in disturbance of habitats in the vicinity of focal points such as camping areas and natural features. At stream crossing points high levels of vehicle traffic can result in localised bank erosion and sedimentation. Vehicle use can also result in the erosion and transport of soil, potentially carrying plant diseases and weed propagules.

Snow sport and associated development of facilities is a significant, albeit highly localised, form of recreation in the North East. Its impacts can include clearing, habitat fragmentation and habitat disturbance during the construction and maintenance of facilities (runs, trails, lifts, buildings, utilities infrastructure), pollution and associated indirect impacts such as the spread of environmental weeds.

Potentially Threatening Processes Affecting Flora

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

For flora restricted to alpine and sub-alpine habitats, clearing of native vegetation is potentially a major threat. Species confined to these areas have limited distributions and population size, specialised habitat requirements and are recorded from habitats (EVCs) which are highly sensitive to disturbance. In addition alpine and subalpine vegetation is characterised by slow establishment and growing rates and are slow to recover from damage (McDougall 1982). Any further loss or degradation of habitat as a result of clearing for resort development or other recreational activities is a significant threat to these alpine species and is likely to cause population decline and have a significant impact on their survival in the region. Flora species threatened include Swamp Fern *Thelypteris confluens*, Dwarf Sedge *Carex paupera*, Kelleria *Kelleria laxa*, Mountain Daisy *Brachyscome tenuiscapa* and Silky Daisy *Celmisia sericophylla*.

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

The EVCs likely to be at greatest risk from recreational activities are those associated with alpine or riparian environments where recreation activities are concentrated. Species at risk from recreational activities include those sensitive to weed invasion (eg. Slender Parrot-pea *Almaleea capitata*, Yellow Hyacinth-orchid, *Dipodium hamiltonianum*, Wedge Diuris *Diuris dendrobioides*, Purple Diuris *Diuris punctata* ssp. *punctata* and Fern-leaf Baeckea *Baeckea crenatifolia*), species sensitive to plant pathogens (eg. Rough Tree-fern *Cyathea australis*, Wedge Diuris *Diuris dendrobioides*, Purple Diuris *Diuris punctata* ssp. *punctata*, Crimson Grevillea *Grevillea polybractea*, Fan Grevillea *Grevillea ramosissima* ssp. *hypargyrea*) and species of wet subalpine environments (eg. Swamp Fern *Thelypteris confluens*, Wire-head Sedge *Carex cephalotes*, Rock Poa *Poa saxicola*, Shining Cudweed *Euchiton nitidulus*, Slender Parrot-pea *Almaleea capitata* and Kelleria *Kelleria laxa*).

Potentially Threatening Processes Affecting Fauna

Within the North East, species most vulnerable to threatening processes associated with recreational activities are those dependent on sensitive habitat types and whose distributions are restricted to areas where recreational activities are concentrated.

Potentially Threatening Processes Associated with Recreation - Fauna

Potentially Threatening Process	Attributes predisposing taxa to threat
Significant habitat modification	Species with restricted distributions, specialised habitat requirements and small populations.
Facilitation of spread of disease or pathogens leading to loss or degradation of habitat	Species with restricted distributions, specialised habitat requirements and small populations
Facilitation of spread of introduced species leading to loss or degradation of habitat	Species with restricted distributions, specialised habitat requirements and small populations.
Degradation of native riparian vegetation	Species vulnerable to changes in stream-side vegetation
Increase in sediment input to streams	Species vulnerable to changes in water quality and flow and to altered streambed conditions
Disturbance to soil structure (compaction/ erosion) leading to loss or degradation of habitat	Species with restricted distributions, specialised habitat requirements and small populations
Disturbance of individuals/ nest sites	Species with key habitat within areas used for recreation
Total habitat destruction	Species with restricted distributions, specialised habitat requirements and small populations.

Recreational activity is considered a major threat to the Mountain Pygmy Possum, Alpine She-oak Skink and Alpine Water Skink, a moderate threat to the Alpine Bog Skink, Alpine Tree Frog, Spotted Tree Frog and White-bellied Sea-Eagle and a minor threat to the Broad-toothed Rat, Large-footed Myotis, Squirrel Glider, Grey Goshawk, and Square-tailed Kite.

Recreational activities can damage habitat and can directly affect the animals themselves. The Mountain Pygmy Possum may be disturbed during its winter hibernation period by such activity (Mansergh *et al*. 1991). Within ski resorts, slope grooming and construction of resort infrastructure, such as ski lifts, are additional disturbances to habitat. There are a number of ski resorts in the North East (Falls Creek, Mt Buffalo, Mt Buller, Mt Hotham, Mt Stirling), within which collectively there are records of the Broad-toothed Rat, Mountain Pygmy Possum, Alpine Bog Skink, Alpine She-oak Skink and Spotted Tree Frog.

The Spotted Tree Frog and Squirrel Glider have limited and disjunct distributions in the North East making these species particularly vulnerable to disturbances. 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). Records of the White-bellied Sea-Eagle are concentrated near several large permanent water bodies and include a number of nest sites. Disturbance at the nest site can lead to abandonment resulting in reduced breeding success (Dennis and Lashmar 1996, Williams 1997). Recreational activities near nest sites may cause population declines (P. Clunie pers. comm.). Protection of White-bellied Sea-Eagle nest sites from disturbance is recognised as a significant factor in the conservation of this species (Clunie 1994).

Management

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

Snow sport and associated resort development and management is required to take into account a range of legislation including provisions of the *Flora and Fauna Guarantee Act* 1988 and local planning requirements.

The alpine area, most of which is included in the Alpine National Park, is used year round for a range of recreational activities. These activities are allowed throughout much of the National Park, although certain restrictions apply, for example, horse riding is allowed only during set periods of the year and is excluded from certain areas (DCE 1992a). The Park is divided into a number of zones, including areas set aside as Special Protection Zones, where stricter controls on recreation apply. Recreation activities are not permitted in Reference Areas. Wilderness Zones cater only for non-mechanised recreation. Within the Bogong Unit of the Alpine National Park there are Special Protection Zones for the Mountain Pygmy Possum, Broad-toothed Rat, Alpine Water Skink and Spotted Tree Frog. These are areas of suitable habitat that are managed "primarily to maintain, protect or enhance the special features they encompass" (DCE 1992a,b). Within these zones new recreation-related construction is not to be carried out pending assessment of possible impacts and will only proceed if it can be clearly demonstrated that special features can be adequately protected.

6.2.10 Environmental weed invasion

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

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

Among the most destructive or aggressive exotic weeds are Blackberry *Rubus fruticosus* spp. agg., St Johns Wort *Hypericum perforatum*, Blue Periwinkle *Vinca major*, Quaking Grasses *Briza* spp., Patterson's Curse *Echium plantagineum*, 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*.

Potentially Threatening Processes Affecting Flora

Environmental weed invasion is a potentially threatening process leading to competition and habitat modification. 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. Environmental weed invasion can occur in any EVC and various suites of weeds are often found in particular environments where disturbance regimes and environmental characteristics are suitable. For example Blackberry *Rubus fruticosus* spp. agg. in Riparian Forest and gully environments, St. John's Wort *Hypericum perforatum* in Grassy Dry Forest, annual grasses and herbs in drier and woodland environments, perennial herbs and grasses in environments with adequate moisture and soil fertility (eg. Herb-rich Foothill Forest and Valley Grassy Forest), pasture species in plains environments and in sub-alpine environments Brown-top Bent *Agrostis capillaris*, Sheep Sorrel *Acetosella vulgaris*, English Broom *Cytisus scoparius* and Clovers *Trifolium* spp. EVCs particularly susceptible to environmental weed invasion include Riparian Forest, Plains Grassy Woodland, Grassy Woodland, Creekline Grassy Woodland, Floodplain Riparian Woodland, Wetland Formation, Valley Grassy Forest, Granitic Hills Woodland, Rocky Outcrop Shrubland/Herbland Mosaic and Grassy Dry Forest.

Examples of species likely to be most affected include Slender Parrot-pea *Almaleea capitata*, Crimson Spider-orchid *Caladenia concolor*, Yellow Hyacinth-orchid *Dipodium hamiltonianum*, Warby Swamp Gum *Eucalyptus cadens*, Yarra

Gum *E. yarraensis*, Smooth Darling Pea *Swainsona recta*, Dwarf Sedge *Carex paupera* and Dookie Daisy *Brachyscome gracilis* ssp. *gracilis.*

Potentially Threatening Processes Affecting Fauna

Invasion of habitats by introduced weeds contributes to habitat degradation, particularly for ground-foraging species. Ground-foraging birds whose habitat is largely restricted to roadside vegetation, such as the Apostlebird and Grey-crowned Babbler, are threatened by weed invasion as it reduces foraging habitat by limiting access to ground litter. Invasion of roadside habitats by introduced pasture species, eg. *Phalaris* spp, is an important cause of habitat loss for these species (Robinson *et al*. in prep.). The Pink Robin may lose breeding habitat in stream-side gullies if these sites are invaded by Blackberry *Rubus fruticosus* spp. agg., although the extent of this threat is unknown (C. Silveira pers. comm.).

Management

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

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

The Commonwealth, in consultation with State and Territory agencies, has recently completed the National Weeds Strategy (ARMCANZ & ANZECC 1997) which outlines strategies to address major issues. Limited resources and a general lack of strategic planning, tactical planning, follow-up, monitoring and experimental management were the major issues identified.

The distribution of environmental weeds is generally well understood as a result of their inclusion in floristic surveys conducted in the North East. 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.

6.2.11 Introduced Fauna Species

This disturbance relates to the impact of introduced fauna on native fauna and covers predation by introduced species (eg. 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. Introduced species can also contribute to the spread of weeds (eg. Blackberries) and disease (Mansergh and Marks 1993). The impact of introduced plant species is discussed in a separate section (see 'Environmental Weeds' this report).

Predation by introduced animals (primarily Foxes and Cats) is recognised as a threat to 28 of the fauna species included in this review. Species particularly at risk from predation by introduced animals are those that have a very localised and/or fragmented distribution or occur in specific habitats which have been largely destroyed or modified by humans (Seebeck and Clunie 1997). Introduced carnivores are likely to have their greatest impact on ground-dwelling or ground-nesting animals (Bennett 1993). The Bush Stone-curlew, Carpet Python, Turquoise Parrot and Spotted Tree Frog are particularly at risk in the North East.

Potentially Threatening Processes Affecting Fauna

Foxes and Cats are widespread throughout Victoria, occurring in most habitat types. Predation by both Foxes and Cats are listed as Potentially Threatening Processes under the *Flora and Fauna Guarantee Act* 1988, with a published Action Statement for the Fox (Mansergh and Marks 1993) and the Cat (Seebeck and Clunie 1997). Predation by Foxes and Predation by Feral Cats are both listed as threatening processes under the *Endangered Species Protection Act* 1992 and separate threat abatement plans are being prepared (Environment Australia in prep.). The extent of Cat and Fox predation on native animals is largely determined by prey availability (May and Norton 1996). Rabbits are a major prey item for both species with alternative prey sought (such as native fauna) when rabbit numbers decline (Catling 1988). However, Cats tend to prey on native fauna even when rabbits are readily available (May and Norton 1996). In areas where rabbits are scarce (such as alpine areas and dense forest), native fauna, including mammals, birds, reptiles, invertebrates and amphibians, are more heavily relied upon (May and Norton 1996, Seebeck and Clunie 1997). With the recent introduction

of the Rabbit Calicivirus, predation upon native animals may increase as rabbit numbers decline (Seebeck and Clunie 1997).

Both Cats and Foxes may prey selectively upon certain species (Mansergh and Marks 1993); the Fox was found to prey heavily on the Broad-toothed Rat in Kosciuszko National Park (Green and Osborne 1981). Bird species that nest on or near the ground, such as the Bush Stone-curlew, Turquoise Parrot and Speckled Warbler, are vulnerable to predation by Foxes, Cats and Dogs with both individuals and eggs taken. Fox predation on the Carpet Python is reportedly very high and is considered a major threat to the persistence of existing populations (P. Robertson pers. comm.). Species such as the Long-footed Potoroo, Mountain Pygmy Possum and Smoky Mouse have a limited distribution in the North East region so any predation has the potential to significantly impact on populations, particularly at the local level. Mountain Pygmy Possum populations are known to respond well to predator control measures (I. Mansergh pers. comm.). The Common Bent-wing Bat and Eastern Horseshoe Bat are preyed upon by Cats as they leave their cave/mineshaft roosts (Menkhorst and Lumsden 1995, L. Lumsden pers. comm.).

Predation of the eggs and tadpoles of the Spotted Tree Frog by Trout represents a major threat to this species in the North East (Watson *et al*. 1991, G. Gillespie pers. comm.).

Competition by introduced species for food and nest hollows is recognised as a moderate threat to the Dingo and Spot-tailed Quoll and a minor threat to the Barking Owl, Masked Owl and Regent Honeyeater. There appears to be some dietary overlap between Cats, Foxes and the Spot-tailed Quoll; competition for prey items may potentially threaten the viability of this species in the North East (Mansergh 1984, Mansergh and Belcher 1992). The Fox is also in competition for prey with the Dingo (Brown and Triggs 1990), Barking Owl and Masked Owl (R. Loyn pers. comm.).

Feral European Honey Bees are 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 impact on species such as the Brush-tailed Phascogale (T. Soderquist pers. comm.). Honey production is widespread throughout the region. Hives are moved around from district to district to coincide with the peak nectar flows of various eucalypt species (LCC 1973). The Regent Honeyeater and Swift Parrot are partially dependent on eucalypt nectar and exploit sites with high nectar yield. Honey Bees may compete for nectar with these species.

European Carp stir up water debris increasing water turbidity (S. Sadlier pers. comm.). This threatening process may significantly impact on habitat quality for the Azure Kingfisher, which may have difficulty detecting prey in murky water (R. Loyn pers. comm.).

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

Management

Pest animal control measures in the North East include programs coordinated with adjacent landowners (Good Neighbour Program) and, where feasible, targeted programs throughout the region. Management plans include strategies relating to pest animal control. For example, the Alpine National Park Bogong Unit Management Plan (DCE 1992a) includes strategies specific to wild dogs, brumbies, cats, foxes, hares and other introduced animals. In addition, for threatened species including Mountain Pygmy-possum and Broad-toothed Rat, strategies are provided aimed at reducing the threat from predation from introduced animals.

6.2.12 Pest Control

Control of pest plants and animals potentially impacts on native fauna through non-target poisoning (eg. native species consuming poison baits), secondary poisoning as a result of ingestion of poisoned prey and food chain contamination by herbicides, pesticides and other chemicals. Loss of significant food sources following control programs for introduced species such as Rabbits may also significantly impact on native fauna. This disturbance was identified as a major threat to the Spot-tailed Quoll and Masked Owl, and a moderate threat to the Common Bent-wing Bat, Eastern Horseshoe Bat, Large-footed Myotis, Dingo, Eastern Broad-nosed Bat, Bush Stone-curlew, Barking Owl, Grey Goshawk, Bandy Bandy, Carpet Python, Woodland Blind Snake and Spotted Tree Frog.

Foxes and wild Dogs are controlled in the North East by snaring and baiting, mainly along the private land/State forest interface (M. Chapman pers. comm.), which may impact on native species. The Spot-tailed Quoll is especially at risk from non-target poisoning. Ingestion of 1080-poisoned baits meant for Foxes and Dogs can cause death of individual animals or local populations (Mansergh and Belcher 1992, Belcher 1995). Although baits are buried to minimise the risk of non-target poisoning, Spot-tailed Quolls are known to dig up and ingest buried baits (Belcher 1995). Non-target poisoning is a minor threat to the Brush-tailed Phascogale as baits are sometimes not buried as required (T. Soderquist pers. comm.). The Dingo is declared a pest species under the *Catchment and Land Protection Act* 1994 and is therefore also a target for these methods of pest control. The Dingo is afforded some protection within the Alpine National Park where it is

considered an indigenous species, although control methods for wild Dogs and Foxes are carried out in certain areas of the park (DCE 1992a,b,c).

Rabbits are probably a major prey item for the Masked Owl and Carpet Python and a reduction in Rabbit numbers due to control programs, such as poisoned-baiting and the Calicivirus, is considered a major threat to these species. There is also a risk of secondary poisoning from consuming poisoned Rabbits or Rats (Peake *et al*. 1993, R. Loyn and P. Robertson pers. comm.). Secondary poisoning via ingestion of poisoned prey is also a threat to the Spot-tailed Quoll (Mansergh and Belcher 1992, Belcher 1995) and the Grey Goshawk (Mooney 1988). Rabbit control can also involve destroying burrows and piles of logs and debris that might contain these animals. These control activities are a potential threat for species that use these sites for shelter and foraging including the Tree Goanna and Tree Skink (P. Robertson pers. comm.).

There is a risk that some mammals may get caught in traps set for pest species. This is a potential threat for the Long-footed Potoroo, Long-nosed Bandicoot, Yellow-footed Antechinus and Yellow-bellied Glider (J. Seebeck pers. comm.).

Insectivorous bats such as the Common Bent-wing Bat, Eastern Horseshoe Bat and Eastern Broad-nosed Bat may be susceptible to poisoning through accumulation of pesticides ingested via prey (Dunsmore *et al*. 1974), although the full extent of this threatening process is unknown. Top order predators such as the Grey Goshawk and White-bellied Sea Eagle may also be susceptible to food chain contamination by pesticides (Bilney and Emison 1983, Clunie 1994, Mooney and Holdsworth 1988). Pesticide use may result in a decrease in insect prey availability for the Woodland Blind Snake and Gray's Blind Snake causing a reduction in their numbers (Ehmann 1992). This may affect Bandy Bandy populations as Blind Snakes are the sole prey item for this species (Shine 1980, Ehmann 1992). Pesticides and herbicides may drain into streams reducing water quality which could impact on the Large-footed Myotis by affecting its prey of aquatic invertebrates and fish (L. Lumsden pers. comm.). The Spotted Tree Frog may also be affected by such chemicals either by direct poisoning or loss of prey (G. Gillespie pers. comm.).

The effect of pest control methods on most species is not well-documented. It is important that pest control programmes are closely monitored for any adverse impacts on native fauna and effectiveness on the target species. Overall the ecological implications for native fauna of pesticide use is unknown but is potentially significant given the importance of insects and other invertebrates as prey; this issue requires investigation.

6.2.13 Firewood Collection

In Victoria, firewood represents one of the highest volume forest products with a total annual consumption in the range of 1.2 - 2.5 million cubic metres (RAC 1992, Read Sturgess and Associates 1995). Within the North East region the majority of firewood collected from public land including State forest and public roadsides, is by private or domestic collectors for their own use. Harvesting of firewood by commercial collectors who collect firewood for sale, either to merchants or directly to consumers, is mainly concentrated on private land. Commercial collection on public land currently only occurs in Toombullup State Forest (NRE unpublished data). Within State forest, firewood is collected from coupes following timber harvesting operations, as well as from fallen timber and debris on the forest floor in unharvested areas. Most firewood collection occurs near major population centres; major collection areas include Mt Pilot Multi Purpose Park, Barambogie State Forest and Beechworth State Forest (NRE unpublished data). Within State forest, the most commonly harvested species across the region include: Red Stringybark (*E. macrorhyncha)* and Messmate Stringybark *(E. obliqua*), Narrowleaf and Broadleaf Peppermints (*E. radiata* and *E. dives*) and Red Box (*E. polyanthemos*). Other harvested species include River Red Gum (*E. camaldulensis)*, Yellow Box (*E. melliodora*), Alpine Ash (*E. delegatensis*) and Long-leaf Box (*E. goniocalyx* s.l.). However, the proportions of each of these species harvested depends on their availability within different areas; within Mt Pilot Multi Purpose Park at least 50% of firewood consists of box eucalypts while in Beechworth State Forest, at least 80% is Red Box, River Red Gum and Yellow Box (NRE unpublished data).

Potentially threatening processes Affecting Flora

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

Indirect impacts of firewood collection may result in weed invasion and the spread of pathogens, increased erosion and sedimentation and disturbance to understorey by vehicles. EVCs directly affected by firewood collection include Valley Grassy Forest. Grassy Dry Forest is affected in terms of weed invasion resulting from this disturbance.

Potentially threatening processes Affecting Fauna

During firewood collection, fallen logs, branches and timber debris are removed and the litter layer is disturbed. On private land, standing live and dead trees may also be removed. Fallen timber provides shelter, refuge, foraging and breeding sites for many fauna species (Brown and Bennett 1995, Silveira *et al*. 1997). Firewood collection is likely to be a significant threat to species that utilise fallen branches, logs or hollows in dead standing trees (Robinson 1994). Logs, litter and debris are important microhabitats for many reptiles providing foraging areas for invertebrate prey, breeding and

basking sites and shelter from predators (Webb 1985, Greer 1989). Fallen logs provide shelter for the Woodland Blind Snake, Grey's Blind Snake and Bandy Bandy and foraging and basking sites for the Tree Skink and Red-throated Skink (Ehmann 1992, Brown and Bennett 1995, Cogger 1996). Loss of large logs is thought to have contributed to the decline of the Carpet Python in parts of its range (Allen in prep.) and is also likely to contribute to the decline of other reptile species. Fallen timber also provides foraging substrates for mammals such the Brush-tailed Phascogale. Loss of this habitat component is a moderate threat to this species in the North East (Humphries and Seebeck in prep., T. Soderquist pers. comm.).

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

The loss of old trees from woodland remnants on private land is a particularly significant threat to species which utilise these habitats. Woodland species affected by firewood collection on private land include the Barking Owl (Emison *et al*. 1987), Masked Owl (Hollands 1991), Brush-tailed Phascogale, Turquoise Parrot (Quin 1990), Dollarbird (Blakers *et al*. 1984, Emison *et al*. 1987), Tree Skink, Tree Goanna (Ehmann 1992, Green and King 1993, Brown and Bennett 1995), Regent Honeyeater, Swift Parrot, Painted Honeyeater and Squirrel Glider.

Potentially threatening processes associated with firewood collection - fauna

Potentially Threatening Process	Attributes predisposing taxa to threat
Severe habitat modification due to loss of fallen timber, logs and disturbance of litter layer	Species which utilise fallen timber as a foraging substrate
Total habitat loss	Species living in fallen timber
Removal of hollow-bearing trees	Hollow dependent fauna
Removal of standing trees, living or dead	Species which utilise large trees for foraging

Management

Harvesting of standing trees for firewood is not permitted on public land within the North East. However, in some areas, significant numbers of standing dead trees are felled and removed for firewood illegally (J. Macdonald pers. comm.). On private land harvesting of firewood for domestic use and the cutting of standing dead trees is exempt under the Native Vegetation Retention Controls (Planning and Environment Act 1987). One of the major impacts of firewood collection, *The loss of hollow-bearing trees* is listed as a Potentially Threatening Process under the *Flora and Fauna Guarantee Act* 1988.

Firewood collection for domestic use on public land is controlled by the issue of licences which stipulate the amount of timber to be collected and the duration of the licence. Licences are for the collection of fallen or felled timber only. Green firewood harvesting may be allowed as part of silvicultural thinning programs (eg. Moyhu Timber Reserve). Maps of collection areas are included with licences. These areas may be specifically designated collection areas or more general, but specified areas of forest. Firewood collection is also allowed in parts of Mt Pilot Multi Purpose Park and along roadsides in Reef Hills Regional Park. Firewood collection has been phased out in Chiltern Box-Ironbark National Park. Local government permission and a licence is required for firewood collection along roadsides. Some shires have roadside management plans which may control firewood collection on roadsides, prohibiting removal of timber from certain high conservation value sites. The number of licences issued for commercial firewood operations on public land depends on an assessment of the amount of wood available in accordance with the Wood Utilisation Plan in each Forest Management area. Commercial cutters must also hold a forest operators licence and operate in accordance with the Code of Forest Practices for Timber Production (NRE 1996) and local NRE prescriptions.

A large proportion of the firewood collected from within the North East region is from woodland remnants on private land. The *Flora and Fauna Guarantee Act* 1988, *Conservation, Forests and Lands Act* 1987 and the *Planning and Environment Act* 1987 provide some controls for firewood collection on private land. Commercial harvesting of firewood on private land requires a permit issued by NRE. Domestic collection on private land is exempt under the Native Vegetation Retention Controls.

Action Statements for the Grey-crowned Babbler (Davidson and Robinson 1992) and the Regent Honeyeater (Menkhorst 1993) include management actions which address the impacts of firewood collection. However, for the majority of listed species covered by this review, Action Statements are yet to be published and for these and other species, threatening process associated with firewood collection is recognised and documented. Research is required to address the long-term ecological effects of firewood harvesting on vertebrate fauna which to date are largely unknown (Robinson 1994).

6.2.14 Illegal collecting/harvesting

This disturbance includes direct interference to plants and animals by humans in the form of collection or deliberate hunting, poisoning, or trapping.

Potentially Threatening Processes Affecting Flora

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

Potentially Threatening Processes Affecting Fauna

Illegal collecting is considered a moderate threat to the Carpet Python which may be captured for the live pet trade (Allen in prep.). The Square-tailed Kite is under threat from egg collectors (Garnett 1992a, Marchant and Higgins 1993), and although the extent of this activity within the North East is unknown, it is potentially significant given the small population size of this species in the region. Egg collection of the Bush Stone-curlew is known to have occurred in the past, though presently it is considered a minor threat (Johnson and Baker-Gabb 1994). Cockatoos and parrots are prized for the live pet trade although the extent of illegal collection within the North East is unknown. The Turquoise Parrot is known to be trapped and taken from nest sites, however, this is regarded as a minor threat for this species (Quin 1990).

Management

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

6.2.15 Dieback

Dieback describes the protracted decline of health and vigour of plants. In eucalypts it is characterised by progressive general deterioration, beginning with a decline and thinning of the crown, and often ends in death of the tree (Heatwole and Lowman 1986). Isolated trees or whole forests may be affected although dieback is generally more severe for isolated trees or small remnants amongst pasture, than for larger protected blocks (Bennett 1993). Causes of tree dieback are not fully understood although it is likely many factors interact to contribute to tree stress which may lead to dieback (Landsberg and Wylie 1983). Possible contributing factors include insect defoliation, fungal diseases, drought, fire, altered water tables and increased salinity, nutrient imbalances as a result of applications of fertilisers, soil erosion and reduced soil aeration, land clearing, lack of regeneration and overgrazing (Heatwole and Lowman 1986). Nutrient redistribution and enrichment by livestock may be a key factor contributing to the abundance of defoliating insects and hence dieback in woodland remnants used by grazing stock (Landsberg *et al*. 1990). Grazing can also contribute to dieback through soil compaction, root damage, tree girding and prevention of regeneration.

In forest blocks, dieback is generally associated with fungal pathogens (eg. Cinnamon Fungus *Phytophthora cinnamomi* or *Armillaria* spp.) or defoliation by phasmatid insects. Within the North East there have been few incidences of dieback in forest stands. Occurrences of both *Phytophthora cinnamomi* and *Armillaria* spp are isolated and there have been no major outbreaks of either pathogen. Defoliation of Alpine Ash *Eucalyptus delegatensis* stands caused by the Target Spot fungus was recorded in 1995/96 at Mt Wills. Crowns subsequently fully recovered (O. Bassett pers. comm.). There have been minor incidences of insect attack but these remained isolated and did not cause significant problems (O. Bassett pers. comm.)

Potentially Threatening Processes Affecting Flora

The direct impact of dieback and related processes involves the damage or loss of plants. This can lead to changes in vegetation structure, composition and diversity, the alteration of microclimatic conditions and the loss or modification of habitat.

Potentially Threatening Processes Affecting Fauna

Dieback is not a significant threat to fauna species which are mainly recorded from large blocks of forest. However, for the fauna of remnant vegetation in agricultural land eucalypt dieback is a significant threat.

Remnants of habitat amongst farmland provide important foraging resources and shelter sites for a number of species. They often contain large old trees on fertile soils that provide copious and relatively predictable sources of nectar which is critical for the survival of species such as the Regent Honeyeater (Menkhorst 1997) and Swift Parrot (Tzaros and Davidson 1996, Tzaros 1997). Trees suffering from dieback may produce fewer flowers and lower quantities of nectar. The defoliation of eucalypts (particularly *Eucalyptus sideroxylon*) results in a reduction of foraging substrate for insectivores and reduces protection from predators and environmental effects. This may lead to a decrease in subcanopy bird species (Er 1997). Dieback may also result in the loss of nest and den sites for species such as Squirrel Glider, Grey-crowned Babbler, Turquoise Parrot and Masked Owl. (Davidson and Robinson 1992, Weber in prep, Quin 1990, Hollands 1991).

Management

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

The use of *Phytophthora cinnamomi*-infected gravel in construction of roads, bridges and reservoirs is listed as a potentially threatening process under Schedule 3 of the *Flora and Fauna Guarantee Act*, 1988.

The National Parks Service Guidelines and Procedures Manual (CNR 1995) addresses *Phytophthora cinnamomi* control in parks. Management plans for Parks in the region include strategies addressing pathogens in Parks. Environmental care principles relating to minimising spread of weeds/pathogens are also included in exploration and mining licences in Victoria. The Code of Forest Practices identifies gravel pits and soil stockpiles must not be located at sites where soil-borne plant pathogens are prevalent unless approved sanitation measures are observed.

6.2.16 Mining/Quarrying

Gold is the most commonly mined mineral within the North East region. Although intensive alluvial, sluice and reef mining for gold occurred in the past, there are now far fewer operations which are generally small, or reworkings of old tailings, shafts and adits. Rock, gravel, clay, sand and soil are extracted from a number of quarries within the region.

Potentially Threatening Processes Affecting Flora and Fauna

Issues associated with mining/quarrying include tailings disposal and treatment, disposal of effluents or treatment and disposal of other wastes and surface disturbance which may result in loss of habitat elements that are not easily replaced during rehabilitation (DCE 1992a, Silveira *et al.* 1997). Poorly planned and located quarries and borrow pits can have an adverse effect on water quality which may have deleterious effects on the vegetation downstream and on the in-stream fauna. These effects may also impact upon species dependent on aquatic prey, such as the Large-footed Myotis (L. Lumsden pers. comm).

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. Effects include direct loss of species and habitat both as a result of digging and associated activities. Mining/quarrying has the potential to impact a large number of species, but due to the small scale and number of operations in the North East, this disturbance is currently considered only a minor threat to the majority of species covered by this review. Species and EVCs directly affected by mining and quarrying include those associated with riparian habitats (eg. Riparian Forest), Box Ironbark Forest and Heathy Dry Forest. Grassy Dry Forest may be indirectly affected by weed invasion, in particular St. John's Wort *Hypericum perforatum.* Fauna likely to be threatened by mining activities include Spotted Tree Frog, Large-footed Myotis and bats which utilise old mines (Common Bent-wing Bat, Eastern Horseshoe Bat).

Eductor dredging is illegal in Victoria. Mining in and around upland streams can cause deterioration of upland riparian environments. Eductor dredging is believed to alter the natural ecology of streams (Watson *et al.* 1991) and 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), direct loss of species and habitat, alteration of stream flow, siltation and facilitation of the spread of weed propagules. Disappearances and declines of Spotted Tree Frog populations appear to be linked to eductor dredging activities which can be deleterious to 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).

Quarrying (gravel and stone extraction) involves direct loss of vegetation, habitat destruction, contributes to erosion and sedimentation and can alter the drainage characteristics of the soil. This can particularly impact on vegetation of alpine areas such as the sphagnum mossbed and bog communities which are slow growing and therefore very sensitive to damage (LCC 1982, McDougall and Papst in prep.). These communities serve as habitat for the Alpine Bog Skink, Alpine She-oak Skink and Alpine Water Skink whose small, restricted populations are vulnerable to threatening processes associated with this disturbance (P. Robertson pers. comm.). There is a requirement that the continued operation of the quarry at Basalt Hill in the Alpine National Park not adversely affect the viability of the local population of the Alpine She-oak Skink.

Management

Operating quarries within the region are currently sited in State forest, Chiltern Box-Ironbark National Park and the Alpine National Park (NRE unpublished data). Mineral exploration, mining and extractive industries are not permitted in Reference Areas, nor in National, State or Wilderness Parks except where a tenement or application pre-dates the Park and the Minister responsible for the National Parks Act consents. The Red Robin Mine located in the Bogong Unit of the Alpine National Park predates the park. The Chiltern Box-Ironbark National Park Draft Management Plan strategies require that gravel extraction lease is not extended and any exploration and mining is carried out in accordance with relevant

consents. For restricted Crown land, including most conservation reserves, the consent of the responsible Minister is required, which may be conditional, but must not be unreasonably withheld. 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.

6.2.17 Other Disturbances

Dams/Impoundments

Within the North East region the major dam/impoundments include: Lake Hume, Lake Dartmouth, Lake William Hovel, Lake Moodemere, the Rocky Valley Reservoir, Lake Buffalo, Lake Nillahcootie and Lake Eildon. Water is released from these storage facilities for irrigation and hydroelectric power into the Murray, King, Mitta Mitta, Kiewa, Buffalo, Broken and Goulburn Rivers.

Potentially Threatening Processes Affecting Flora and Fauna

Potentially threatening processes associated with dam/impoundment construction and subsequent operation include increases in sediment input to rivers and streams, modifications to natural temperature fluctuations and flow rates (Koehn *et al*. 1996) and degradation of adjacent native riparian vegetation. These processes are listed under the *Flora and Fauna Guarantee Act* (1988). Loss and fragmentation of habitat is also a potentially threatening process associated with dams and impoundments. Species particularly sensitive to this disturbance are those dependent upon riparian habitats and species or vegetation communities/ EVCs with restricted distributions and specialised habitat requirements which occur in the vicinity of dams and those EVCs which occupy the site of the dam itself. The pre-1750 mapping exercise highlights these EVCs. Altered flooding regimes can affect Floodplain Riparian Woodland which occurs on the Goulburn, Ovens and Murray Rivers. This vegetation is adapted to and has a requirement for a natural flooding regime which has been altered with the increased requirement of water for agricultural and other purposes via controlled release from water impoundments. Salinity is an associated threatening process resulting from large-scale irrigation together with extensive clearing of native vegetation. This threatening process, its effect on flora and fauna and recommendations for amelioration are outlined in Clunie (in prep).

Changes in surrounding soil hydrology as a result of dam operations can contribute to degradation of the sensitive sphagnum mossbed/heath associations and other vegetation characteristic of the Bogong High Plains which provide important habitat for the Alpine Bog Skink, Alpine Water Skink and Alpine She-oak Skink (McDougall and Papst in prep., Meredith in prep.). These skinks have restricted distributions in the North East with specialised habitat requirements; further habitat loss would have a significant impact on populations (P. Robertson pers. comm.).

The Rocky Valley Storage Dam (built as part of the Kiewa Hydroelectric Scheme) inundated Alpine Bog Skink and Alpine Water Skink habitat. Any raising of the level of the dam potentially could further reduce the amount of suitable habitat for these skinks (P. Robertson pers. comm.).

Siltation, alteration of stream flow and degradation of riparian vegetation are major threats to the Azure Kingfisher and Spotted Tree Frog (Shields 1994, R. Loyn pers. comm., Watson *et al*. 1991, Gillespie *et al*. 1995, Robertson and Gillespie in prep).

Management

The environmental impacts of dams/impoundments have been the subject of numerous studies and it is recognised that construction and operation of these structures have many adverse effects on downstream fauna. There are processes to minimise these impacts such as environmental flow allocations, construction of fish ladders and regulating the temperature of water flowing out of storages. For major developments Environment Effect Statement processes would apply and these must take account of the full range of impacts.

Interspecific Competition

Loss of high quality habitat and fragmentation can lead to increased competition for limited resources. Competition for resources such as food and shelter with other native species has been identified as a threat in the North East for a number of fauna species.

Mobs of Noisy Miners are known to destroy Grey-crowned Babbler nests, especially when they are in small groups and contain young, which may threaten their survival (Tzaros 1995, Robinson *et al*. in prep.). Noisy Miners are known to exclude other nectivores from areas of suitable habitat, particularly in fragmented woodland remnants (Grey *et al*. 1997, Menkhorst 1997, M. Clarke pers. comm.). Species potentially impacted include Painted Honeyeater, Regent Honeyeater and Swift Parrot. The effect of interspecific aggression on accessibility of nectar, breeding success, use of optimum habitat and the survival of individuals was highlighted for monitoring and research by the Regent Honeyeater Action Statement (Menkhorst 1993).

Competition between White-bellied Sea-Eagles and Wedge-tailed Eagles for nest sites and food has been recorded although its significance is not known (Clunie 1994, Wiersma 1996).

Pasture Improvement

Livestock production is the predominant rural land use in the North East region. Since the 1960s there has been substantial development in improved pastures (LCC 1973). Pasture improvement involves the replacement of native grasses with exotic pasture species. Activities associated with pasture improvement such as higher rates of clearing, higher stocking rates and increased use of fertilisers are likely to impact on many species. However, these activities are included in other disturbance categories in this review. Species identified as being adversely impacted by pasture improvement were ground foraging or ground nesting species with a substantial proportion of habitat on private land. EVCs predominantly affected by pasture improvement include Plains Grassy Woodland, Floodplain Riparian Woodland, Creekline Grassy Woodland and Valley Grassy Forest.

Potentially Threatening Processes Affecting Fauna

Remnant patches of native vegetation on private land provide important habitat for the Bush Stone-curlew, Grey-crowned Babbler and Apostlebird. These species require a relatively sparse ground layer with abundant ground litter. Replacement of native grasses with introduced pasture species reduces foraging and nesting habitat for these species (Robinson *et al*. in prep, D. Robinson pers. comm.). Pasture improvement was considered to be the principal cause of population declines of the Bush Stone-curlew in north eastern Victoria between 1985 and 1991 (Webster and Baker-Gabb 1994). Turquoise Parrots favour ecotone habitats, particularly grassland bordering woodland or forest (Quin and Baker-Gabb 1993). Although some species of introduced grasses and weeds are important components of Turquoise Parrot diet, many of the improved pasture species appear not to be eaten. As a result, pasture improvement results in lost sources of food (Quin 1990).

Pasture improvement activities are restricted to private land. Education programs which inform land mangers of the ecological effects of intensified land use practices such as pasture improvement is a management issue identified by the Bush Stone-curlew Action Statement (Robinson and Johnson in prep.). A range of actions undertaken through programs such as *Land for Wildlife* and Landcare in conjunction with land owners can also assist in mitigating impacts on native fauna.

Potentially Threatening Processes Associated with Pasture Improvement - fauna

Potentially Threatening Processes	Attributes predisposing taxa to threat
Severe habitat modification and reduced foraging habitat and invertebrate prey	Ground foraging or ground nesting species with a substantial proportion of habitat on private land.

Mineshaft Collapse

Disused mine shafts are important roosting sites for the Common Bent-wing Bat and the Eastern Horseshoe Bat. Recent records of lactating and heavily pregnant female Eastern Horseshoe Bats from the Strathbogie Ranges indicate the presence of a maternity site, most likely in a mine in the area, which is yet to be located (L. Lumsden pers. comm.).

Mineshaft collapse and mineshaft entrances becoming overgrown are recognised as major threats to the Eastern Horseshoe Bat and Common Bent-wing Bat. These species are dependent on caves and mineshafts for roosting and breeding. Restricted access to and loss of breeding habitat due to these processes is likely to lead to a decline of population numbers in the North East (L. Lumsden pers. comm.).

Vandalism

This category covers the direct interference of animals by humans such as shooting and disturbance at nest and roost sites. This category does not include interference for animal collection. Vandalism is a major threat to the Common Bent-wing Bat and Eastern Horseshoe Bat, a moderate threat to the Spot-tailed Quoll, Square-tailed Kite and Grey Goshawk and a minor threat to the Carpet Python, Dingo, Large-footed Myotis, Bush Stone-curlew, White-bellied Sea-Eagle, Eastern Broad-nosed Bat and Tree Goanna.

Human disturbance of roost sites of the Common Bent-wing Bat, Eastern Horseshoe Bat and Eastern Broad-nosed 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). The White-bellied Sea-Eagle is also 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 (Clunie 1994).

The Square-tailed Kite and Bush Stone-curlew are known to have been targets of illegal shooting (Jolly 1989, Johnson and Baker-Gabb 1994). Similarly, shooting of the Grey Goshawk is known to occur in Tasmania (Brereton and Mooney 1994) and although there are no known incidences of illegal shooting in the North East, small populations would be significantly

impacted by loss of individuals. Carpet Pythons are sometimes killed by people in the belief that they are dangerous (Allen in prep.). Tree Goannas may also be the target of random acts of vandalism (P. Robertson pers. comm.).

Rock Harvesting

Rock harvesting involves the removal of rocks and boulders from the environment to be used in the garden trade. This eliminates potential shelter sites for the Bandy Bandy and is regarded as a minor threat to this species (P. Robertson pers. comm

Climate Change

The Enhanced Greenhouse Effect refers to the increase of greenhouse gases caused by human activities and the resultant warming of the atmosphere (Bennett *et al*. 1991). Potential effects of this process include changes in the distribution of natural ecosystems and, consequently, flora and fauna. Species identified to be especially at risk from this phenomenon include those with small, disjunct populations, species with narrow habitat requirements and restricted habitats and those that are poor dispersers. Species with these characteristics will be less capable of adapting to the resultant environmental changes such as alterations in climate patterns. This process has been identified as a possible threat to the Alpine Tree Frog, Spotted Tree Frog, Broad-toothed Rat, Mountain Pygmy Possum, Alpine Bog Skink, Alpine She-oak Skink, Alpine Water Skink, Sooty Owl and Pink Robin.

Species living in sub-alpine and alpine areas typically exist in small isolated populations and are particularly vulnerable to environmental change. These species may have few options as their habitat contracts uphill in response to climatic warming (Bennett *et al*. 1991). Sub-alpine and alpine species under threat due to their limited habitat requirements include the Broad-toothed Rat, Mountain Pygmy Possum, Alpine Bog Skink, Alpine She-oak Skink, Alpine Water Skink and Spotted Tree Frog (Bennett *et al*. 1991, Mansergh *et al*. 1991, SAC 1992c, SAC 1996b, G. Gillespie pers. comm.). The Alpine Tree Frog is likely to be affected by alterations to breeding conditions as a result of climate changes associated with the Greenhouse Effect. Increases in ultraviolet radiation is known to cause death of eggs and larvae, and it is thought that this has contributed to population declines (Hunter *et al*. 1997, Tyler 1997, G. Gillespie pers. comm.). EVCs with narrow habitat requirements in these areas include those of alpine and sub-alpine environments.

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

Loss of Genetic Diversity

Loss of genetic diversity is a threat to small, fragmented or isolated populations or less mobile species. It is considered to be a potential threat to the Squirrel Glider. This species exists in largely fragmented populations which are in danger of becoming isolated resulting in loss of genetic diversity within populations (R. van der Ree pers. comm.). This can lead to a reduced capacity to resist recessive lethal genetic changes or to respond to altered environmental conditions (Bennett 1990).

Genetic dilution has been identified as a potential threat to the Dingo (Corbett 1995). Dingoes and Dogs have a history of interbreeding; producing hybrids and reducing the proportion of pure bred Dingoes. The exact extent of this hybridisation is not clear, partly due to the difficulty in distinguishing pure Dingoes from Dingo/Dog hybrids. However, it is believed that this process represents a significant threat to the pure Dingo breed in the North East (Corbett 1995).

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

7. AQUATIC FAUNA SPECIES ASSESSMENT

7.1 Introduction

The quality of stream habitats, and their biota, can be greatly influenced by a wide range of activities within the catchment, including many that occur away from the stream system. The impact of these activities may be felt far downstream from the actual site of disturbance, often outside the forest areas in which they occur. To reduce the impact of these activities, management prescriptions need to be based on accurate and adequate scientific information. This includes information on the distribution, biology and habitat requirements of individual species and communities, along with data on how successful ameliorative actions are at protecting those species and communities.

The aquatic species assessment provides an overview of information on fish and aquatic macroinvertebrates, mainly to address the issue of the viability of maintaining populations of aquatic native species throughout their natural ranges.

To meet this objective, the following assessments 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 priority aquatic species;
- identification of the threatening processes (disturbances) affecting all aquatic species and their habitat, and a description of the current management action;
- a description of the current management prescriptions for aquatic species and their habitat, with priority given to those species which are rare or threatened; and
- identification of the gaps in survey and research on aquatic species, habitats and threatening processes.

7.1.1 Fish and Aquatic Macroinvertebrates of the North East Region

Fish

The North East region is generally bordered on its southern edge by the Great Dividing Range (the Divide) and all streams in the region flow into the Murray River, other than the Wongungarra River which flows in the Wonnangatta River**.** There are 5 major catchments that comprise the region - the Upper Murray (including the Mitta Mitta River), Kiewa, Ovens, Broken and Goulburn Rivers (based on the Australian Water Resources Commission classification).

Fourteen native freshwater fish have been recorded from the North East region to date (Victorian Fish Database). Of these, eight are listed as threatened fauna in Victoria (CNR 1995) and four of these are also listed under the *Flora and Fauna Guarantee Act* 1988. Two of the species are listed under the Commonwealth *Endangered Species Protection Act* 1992 (Table 0.1).

The fish fauna of the North East region can be divided into three distinct groups based on distribution. One group consists of two species restricted to the upland reaches of streams north of the Divide (Two-spined Blackfish, Barred Galaxias), a second consists of five species that are more widespread but are only found to the north of the Divide (Flat-headed Galaxias, Trout Cod, Murray Cod, Golden Perch, Macquarie Perch), and a final group contains seven wide-ranging species which occur in rivers both north and south of the Divide (Mountain Galaxias, Australian Smelt, Broad-finned Galaxias, Southern Pygmy Perch, River Blackfish, Flat-headed Gudgeon, Western Carp Gudgeon). Four of the northern species (28% of the native fauna) are known to migrate as part of their life cycle (Table 0.1).

Table 0.1 Conservation status and presence of migration of native freshwater fish.

Scientific name	Common Name	Conservation Status	FFG/ESP Act status	Migratory
Galaxias fuscus	Barred Galaxias	Endangered	FFG/ESP Act Listed**	
Maccullochella macquariensis	Trout Cod	Endangered	FFG/ESP Act Listed+	
Maccullochella peelii peelii	Murray Cod	Vulnerable	FFG Act Listed*	+
Macquaria australasica	Macquarie Perch	Vulnerable	FFG Act Listed	+
Gadopsis bispinosus	Two-spined Blackfish			
Gadopsis marmoratus	River Blackfish	Ins. Known		
Galaxias brevipinnis	Broad-finned Galaxias			+
Galaxias olidus	Mountain Galaxias	Ins. Known		

Scientific name	Common Name	Conservation Status	FFG/ESP Act status	Migratory
Galaxias rostratus	Flat-headed Galaxias	Rare		
Hypseleotris klunzingeri	Western Carp Gudgeon			
Macquaria ambigua	Golden Perch	Rare		+
Nannoperca australis	Southern Pigmy Perch			
Philypnodon grandiceps	Flat-headed Gudgeon			
Retropinna semoni	Australian Smelt			+**?**

Notes: **FFG** *Flora and Fauna Guarantee Act* 1988; **ESP** *Endangered Species Protection Act* 1992. *FFG Action Statement draft; **FFG Action Statement completed; [†]National Recovery Plan completed. +**?** migratory status suspected but not confirmed; Conservation status from (CNR 1995).

Aquatic Macroinvertebrates

There are insufficient data to estimate the total number of aquatic macroinvertebrate species in the North East region. However, 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 Department of Natural Resources and Environment (NRE) list of threatened Victorian fauna (CNR 1995 - Table 0.2, Table 0.3). Adequate distributional information exists for only two of these (*Thaumatoperla flaveola* and *Hemiphlebia mirabilis*) while the distribution of the remaining taxa remains poorly known in the North East.

Table 0.2 Conservation status of non-decapod aquatic macroinvertebrates.

Scientific Name	Class, Order	Conservation Status	FFG/ESP Act Status
Thaumatoperla alpina	Insecta, Plecoptera	Rare	FFG Act Listed
Thaumatoperla flaveola	Insecta, Plecoptera	Vulnerable	FFG Act Listed**
Riekoperla intermedia	Insecta, Plecoptera	Vulnerable	FFG Act Listed
Riekoperla isosceles	Insecta, Plecoptera	Vulnerable	FFG Act Listed
Archeophylax canarus	Insecta, Trichoptera	Rare	FFG Act Listed
Tamasia furcilla	Insecta, Trichoptera	Vulnerable	
Hemiphlebia mirabilis	Insecta, Odonata	Vulnerable	FFG Act Listed**
Canthocamptus longipes	Crustacea, Copepoda	Ins. Known	

Note: **FFG** *Flora and Fauna Guarantee Act* 1988; **ESP** *Endangered Species Protection Act* 1992. *FFG Action Statement draft; **FFG Action Statement completed, Conservation status from (CNR 1995)

The decapod crustacea (crays, prawns and shrimp) fauna of the area is better known, having been the target of taxonomic studies (Morgan 1986; Horwitz 1990) and collected as part of fish surveys conducted by NRE since 1990 (see below). Numerous incidental records also exist. Species known to occur in the North East region are shown in Table 0.3.

Table 0.3 Conservation status of native freshwater decapod crustacea.

Scientific name	Common name	Conservation Status	FFG/ESP Act status
Parastacidae			
Cherax destructor	Common Yabby		
Cherax sp. nov.[1]	Murray Swamp Yabby		
Engaeus lyelli	Upland Burrowing Cray		
Engaeus cymus	North Eastern Burrowing Cray		
Engaeus affinis	Central Highlands Burrowing Cray		
Euastacus armatus	Murray Spiny Cray	Ins. Known	
Euastacus woiwuru	Central Victorian Spiny Cray		
Euastacus crassus	Alpine Spiny Cray	Rare	

Scientific name	Common name	Conservation Status	FFG/ESP Act status
Atyidae	**Shrimps**		
Caridina maccullochi	Murray Freshwater Shrimp		
Macrobrachium australiensis	Southern Freshwater Prawn		
Paratya australiensis	Freshwater Shrimp		

Note: **FFG** *Flora and Fauna Guarantee Act* 1988; **ESP** *Endangered Species Protection Act* 1992. *FFG Action Statement draft; **FFG Action Statement completed, Conservation status from (CNR 1995)

[1.] The Murray Swamp Yabby has recently been discovered and recognised as a distinct species but has not been formally described.

7.2 Review of existing site-based data

The data review process involved systematically working through databases to determine the adequacy of existing site-based biological data. 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.

7.2.1 Fish

Intensive inventory surveys of fish assemblages in the North East region have primarily been conducted by the Department of Natural Resources and Environment (NRE). Some investigations which incidentally recorded fish species were conducted by other government agencies, universities or private individuals. The distribution of survey sites where adequate community data on fish exists is shown in Map 14.

Pre-1990 fish surveys

Very few historical records (pre-1970) exist for the North East region, and prior to 1970, records were spasmodic, consisting of observations of individual species from only a few locations. The first comprehensive survey of fish assemblages was conducted at 46 sites on the Mitta Mitta River from 1973 to 1976 (Tunbridge, 1977). Between 1973 and 1990, a total of 11 recognised major surveys, and a number of minor surveys, occurred in the area. A total of 240 sites (Table 7.4), exclusive of re-sampled sites, were sampled during this period**.**

Six of the major surveys conducted prior to 1990 were fisheries orientated, only targeting the larger, recreational species, using techniques not designed to capture all fish species (eg. netting with large mesh sizes). These types of surveys are referred to in this report as "partial surveys". As a result of the goals and techniques used in these surveys, many of the smaller fish species would not have been sampled by these surveys. They were also generally conducted in the larger reaches of the main rivers in lowland to foothill areas only.

Table 7.4 Major surveys (5 or more sites sampled) conducted for freshwater fish in the North East region prior to 1990.

Date	Catchments or Rivers surveyed	Sites surveyed	Source
1973-1976	Mitta Mitta	46	Tunbridge 1977
1974-1977	Ovens	13	Tunbridge (unpub. data)*
1975-1978	Goulburn	38	Cadwallader 1979
1978-1984	Upper Murray, Mitta Mitta, Broken, Kiewa, Ovens and Goulburn	60	Baxter 1985*
1979-1983	Ovens	5	Sanger 1984
1985	Upper Murray, Mitta Mitta and Ovens	9	Baxter 1986*
1985	Goulburn	8	Koehn *et al* 1991
1985-1986	Goulburn	6	O'Connor 1993
1986	Ovens and Goulburn	5	Baxter 1987*
1989	Kiewa, Ovens and Goulburn	6	Baxter *et al* 1990*
1989-1990	Broken	24	Unmack (unpub. data)

* indicates fisheries surveys.

Post-1990 fish surveys

Since 1990, survey intensity and coordination has improved significantly for the region, with 506 new sites (exclusive of re-sampled sites) being assessed in major surveys. Importantly, the majority of surveys used techniques which potentially sampled the entire community rather than just selected species (eg. electrofishing - termed "full" surveys), and many were also conducted in foothill to upland areas in smaller streams.

Of the larger surveys, 29 new sites were sampled in the Mitta Mitta catchment as part of an assessment of the impacts of Dartmouth Dam on aquatic fauna (Koehn et al., 1995), Morison and Anderson (1991) surveyed 32 new sites in the upper Murray and Mitta Mitta catchments in an assessment of broad-finned galaxias populations in north eastern Victoria, and Raadik and Saddlier (NRE, unpublished data) surveyed 39 new sites in the Goulburn catchment in surveys for the endangered Barred Galaxias (*Galaxias fuscus*). Peter Unmack (unpublished data) also sampled 17 new sites in the Goulburn catchment. A number of new sites have also been sampled in fisheries and miscellaneous surveys. Unfortunately, the majority of information recorded since 1990 remains unpublished. (Table 7.5).

There is generally wide spatial coverage of sampling records across the region, though many survey sites fall into fairly restricted areas where survey intensity has been very high (Map 14). This is due to specific projects such as the Barred Galaxias project, impacts of Dartmouth Dam, and the Broad-finned Galaxias project (see earlier). Consequently there is extensive knowledge of fish from only a few areas within the region.

As part of the RFA research program a further 112 sites were sampled over 1997-98 to systematically fill identified gaps in survey data from the North-East region.

Table 7.5 Major surveys (5 or more sites sampled) conducted for freshwater fish in the North East region since 1990.

Date	Catchment or River surveyed	Sites surveyed	Source
1990	Upper Murray, Mitta Mitta and Kiewa	40	Morison and Anderson 1991
1990	Goulburn	5	Hall and Harrington (unpub. data)
1990-1994	Upper Murray and Mitta Mitta	6	Douglas (unpub. data)
1991	Goulburn	9	Anderson (unpub. data)
1992	Ovens and Goulburn	5	Baxter and Vallis 1993*
1992-1993	Ovens, Broken and Goulburn	35	Harrington (unpub. data)*
1992-1993	Mitta Mitta	29	Koehn *et al*. 1995
1992-1994	Goulburn and Ovens	25	Unmack (unpub. data)
1992-1995	Ovens and Goulburn	8	O'Connor (unpub. data)
1992-1995	Goulburn	39	Raadik and Saddlier (unpub. data)
1993-1994	Goulburn	14	Harrington and Saddlier (unpub. data)
1993-1995	Upper Murray and Mitta Mitta	19	Closs (unpub. data)
1994	Upper Murray, Mitta Mitta, Kiewa, Ovens and Goulburn	9	Baxter and Vallis 1995*
1994	Ovens	7	Moore *et al* 1996
1994	Broken	7	Balcombe (unpub. data)
1995	Broken	14	VFRI (unpub. data)*
1995	Kiewa and Ovens	9	Raadik (unpub. data)
1996	Upper Murray and Mitta Mitta	6	Metacom (unpub. data)
1997-1998	Upper Murray, Mitta Mitta, Kiewa, Ovens and Goulburn	112	Raadik (unpub. data)

* indicates fisheries surveys.

The number of freshwater survey sites in the North East region appears to be fairly extensive at 746 (Table 7.6). Of these, 439 sites are considered to be full surveys (full coverage of species diversity) which provide adequate data quality for distributional analyses.

By comparison, Jackson and Davies (1983) surveyed 115 sites in the Grampians region, in an area approximately 20% the size of the North-East region, and Cadwallader (1979) surveyed 38 sites in a single tributary system (Seven Creeks). If the North-East region were to be surveyed with the same intensity to that conducted in the Grampians, approximately 575 sites would be required. The current number of full survey sites (439) represents 76% of this value, suggesting that survey intensity is adequate.

Table 7.6 Summary of information on fish survey sites in the North East region 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**
Upper Murray and Mitta Mitta	20	-	98	72	13	1	**204**
Kiewa	4	-	12	18	5	1	**40**
Ovens	25	4	30	73	14	15	**161**
Broken	16	2	18	44	-	-	**80**
Goulburn	41	12	135	59	8	6	**261**
Sub total	106	18	293	266	40	23	
Total sites	**124**		**559**		**63**		**746**
% of total	16.6%		75.0%		8.4%		

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

Because of the nature of individual survey objectives, only 63 sites (8.4% of all sites) have been located in areas set aside for conservation purposes, 559 (75.0%) were located in private land and other areas of public land (eg. stream frontages) and 124 sites (16.6%) have been located in State forest. The majority of sites in State forest have been sampled as part of the RFA research program.

7.2.2 Aquatic macroinvertebrate fauna

Inventory surveys of aquatic macroinvertebrates in the North East region have primarily been conducted by a number of Government Departments, Monash and Latrobe Universities and the Murray-Darling Freshwater Research Centre based in Albury. Some investigations which incidentally recorded invertebrate species (eg. as part of taxonomic studies), have been conducted by universities or private individuals.

Pre-1990 macroinvertebrate surveys

The Department of Water Resources (DWR 1989) recorded 36 sites where aquatic macroinvertebrate surveys have been conducted as part of several studies in the North East region prior to 1990 (Table 7.7). In the main study, the Museum of Victoria investigated the impact of Dartmouth Dam on the Mitta Mitta River (13 sites). Other sites were part of a series of surveys by the State Rivers and Water Supply Commission and the Latrobe Valley Water and Sewerage Board around Dinner Plain (4 sites), and a survey of House Creek, Wodonga (5 sites). Sites in the North East were collected as parts of other surveys, including a broad survey of the Murray River by the Albury-Wodonga Development Corporation (3 sites) and of rivers above Lake Eildon (7 sites). The final historical data were from a post-graduate project at Monash University (4 sites).

Unfortunately, a variety of different survey techniques was employed in each of these studies. As these have often used different sampling methods and regimes, data comparisons between these surveys for the purposes of assessing aquatic macroinvertebrate diversity and distribution should be treated with caution.

Table 7.7 Surveys conducted for aquatic macroinvertebrates in the North East region prior to 1990

Dates	Catchment	Sites surveyed	Institutions responsible
1981-1984	Mitta Mitta	13	Museum of Victoria
1982	Mitta Mitta	2	State Rivers and Water Supply Commission
1984	Mitta Mitta	2	Latrobe Valley Water and Sewerage Board
1979	Kiewa	5	State Rivers and Water Supply Commission
1977	Mitta Mitta, Ovens, Kiewa	3	Albury-Wodonga Development Corp.
1979	Ovens, Kiewa	4	Monash University
1985	Goulburn	7	Museum of Victoria

from DWR 1989

Post-1990 macroinvertebrate surveys

Since 1990, various surveys have continued sporadically in some catchments. A number of graduate and post-graduate projects at Latrobe University have been conducted. A further survey of the Mitta Mitta River below Dartmouth has been conducted (Koehn *et al*. 1995). Prior to 1990, all these surveys have been conducted using a variety of sampling techniques and have been identified to different taxonomic resolutions. Therefore, there has been no comprehensive or systematic study of the aquatic macroinvertebrate fauna of the entire North East region. Numerous individual studies have been conducted for specific purposes, but the data cannot be amalgamated to provide a description of the entire North East macroinvertebrate fauna.

More recently, as part of the Monitoring River Health Initiative (MRHI), a program of sampling is being conducted to produce a technique to predict aquatic macroinvertebrate communities in streams throughout Australia. Although not intended as a biodiversity measurement (it is designed as a monitoring tool) this program produces good quality data on the distribution of many species and communities. Thirty-nine sites are currently being monitored in the North East region (L. Metzeling, EPA, pers. comm. - Table 0.8, Map 14). Additional sampling at 61 sites using the same methodology as the MRHI, has been conducted over autumn and spring 1997 by NRE as part of the RFA research program.

These sites surveyed under the MRHI and RFA research program will provide some baseline data for the region, particularly for some of the more common taxa. However, more significantly, the data from these 101 sites are being used to construct a regional predictive model, allowing the invertebrate fauna at an unknown site to be predicted on the basis of the river characteristics (eg. water quality, altitude, bed structure).

Table 0.8 Number of sites sampled as part of the MRHI and NRE in each catchment in the North East region.

Catchment	Number of sites - MRHI	Number of sites - NRE
Upper Murray (inc. Mitta Mitta)	14	23
Kiewa	9	5
Ovens	10	16
Broken	4	3
Goulburn	2	14

To provide an adequate inventory of all macroinvertebrate species in the region (including rare species), an overall survey intensity at a greater density than 100 sites in the North East region will be required. For example, accurate determination of the distribution of a single threatened species, the Stirling Stonefly *Thaumatoperla flaveola* in the Mt Buller/Stirling area, required about 90 sampling sites in an area 30x30km around the probable distribution (T. Doeg, NRE, unpublished data). There are a number of other recorded taxa that may show similar restricted distributions (Table 0.2) and, of course, other as yet undiscovered or undescribed macroinvertebrate taxa in the region. For example, a survey for the flatworm *Spathula tryssa* in the Victorian alps discovered two undescribed flatworm species with restricted distributions (R. St. Clair, EPA, unpublished data).

7.3 Life history and population parameters for aquatic species

7.3.1 Priority species

A priority list of 20 aquatic species (Table 7.9) was compiled for inclusion in the more detailed assessment of species' response to disturbance, and life history and population dynamics. The list consists mainly of species which occur in the North East Region and are listed under the *Flora and Fauna Guarantee Act* 1988, the Commonwealth *Endangered Species Protection Act* 1992 and the Threatened Fauna of Victoria (CNR 1995) list.

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

Species Name	Common Name
Fish	
Galaxias olidus	Mountain Galaxias
Galaxias fuscus	Barred Galaxias
Galaxias rostratus	Flat-headed Galaxias
Maccullochella peelii peelii	Murray Cod
Maccullochella macquariensis	Trout Cod
Macquaria ambigua	Golden Perch
Macquaria australasica	Macquarie Perch
Gadopsis marmoratus	River Blackfish
Decapod Crustacea	
Cherax sp. nov.[1]	Murray Swamp Yabby
Euastacus armatus	Murray Spiny Cray
Euastacus crassus	Alpine Spiny Cray
Euastacus woiwuru[1]	Central Highlands Spiny Cray
Non-decapod invertebrates	
Thaumatoperla alpina	Stonefly
Thaumatoperla flaveola	Stonefly
Riekoperla intermedia	Stonefly
Riekoperla isosceles	Stonefly
Archeophylax canarus	Caddisfly
Tamasia furcilla	Caddisfly
Hemiphlebia mirabilis	Damselfly
Canthocamptus longipes	Copepod

1. The Murray Swamp Yabby is included as it is probably rare or patchily distributed and the Central Highlands Spiny Cray is included because its distribution in the North East region is restricted to the south-west corner (although it is abundant in the Central Highlands area).

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 *Galaxias fuscus*, a species not covered in those sources, was from Raadik *et al.* (1996).

Galaxias olidus (Mountain Galaxias)

A small (adults to 15 cm) non-migratory species, located both sides of the divide. Adults live in stony fast-flowing streams. Spawning occurs in freshwater during winter/spring. Spawning trigger is unknown. Adult females (maturity occurs at 2 years old) lay few (<500) eggs onto the substrate. Incubation time is unknown.

Galaxias fuscus (Barred Galaxias)

A small (adults to 15 cm) non-migratory species, located north of the divide. Adults live in slow-flowing pools in stony fast-flowing upland streams. Spawning occurs in freshwater during late 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 approximately 30 days.

Galaxias rostratus (Flat-headed Galaxias)

A small (adults to 15 cm and 26g) non-migratory species, located north of the divide. 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.

Maccullochella macquariensis (Trout Cod)

A large (adults to 16kg) non-migratory species, located north of the divide. In the Murray River, adults live among woody debris in fast-flowing water. Spawning occurs during spring-early summer in association with rising water levels and temperature. Adult females (maturity occurs at 3-5 years old) most likely lay adhesive eggs on or in logs, amongst rocks or on hard clay surfaces. Eggs hatch 5-10 days after fertilisation and the newly hatched larvae are 6-9 mm long.

Maccullochella peelii peelii (Murray Cod)

A large (adults to 1800 cm and 100 kg) migratory species, located north of the divide. Adults live among wood debris in deep holes in lowland areas. 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 divide. 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 divide (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 divide. Adults live in relatively quiet upland and lowland streams. Spawning occurs in freshwater during spring, triggered by rising water temperatures. Adult females (maturity occurs at 3-4 years old) lay few (<500) eggs attached to the substrate in hollow logs. The parental males guard the eggs. Eggs hatch after about 2 weeks. Larvae are believed to live among leaf litter for at least 12 months.

Aquatic macroinvertebrates

Little is known about the life history of most of the aquatic macroinvertebrates species listed in Table 7.9. The majority of priority macroinvertebrate species have been recorded from alpine areas. Information was mainly derived from a variety of sources, including Horwitz (1990) and T. Raadik (NRE, pers. comm.) for decapod crustacea.

Cherax sp. nov. (Murray Swamp Yabby)

A large (adults up to 30 cm in length) decapod crayfish. Nothing is known about its life history and biology, or its distribution. No specific surveys or studies have been conducted. The species was only recently discovered in the Barmah State Forest and its range is known to extend to the Ovens River and up the Goulburn River system, though this is based on very few records. It appears that this species prefers wetlands and can exist in wetlands which are infrequently inundated.

Euastacus armatus (Murray Spiny Cray)

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

Euastacus crassus (Alpine Spiny Crayfish)

Euastacus crassus is a relatively small (up to 58 mm) freshwater crayfish found on both sides of the divide in semi-alpine regions in Victoria. This species is found as far west as the Mt Beauty-Mt Hotham region at altitudes above 1000 m. Little is known about the life history or biology of the species.

***Euastacus woiwuru* (Central Highlands Spiny Cray)**

Euastacus woiwuru is a medium size (maximum size 75 mm) freshwater crayfish found on both sides of the Great Dividing Range in foothill to alpine regions in Victoria. It usually occurs at altitudes above 200m a.s.l. North of the Divide the distribution is mainly located within the Goulburn River basin (only parts of which are within the NE RFA region) and extends eastward to tributaries of the Ovens River basin. Little is known about the life history or biology of this species.

***Hemiphlebia mirabilis* (Damselfly)**

A small damselfly 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 (Trueman *et al*. 1992).

***Archeophylax canarus* (Caddisfly)**

Small alpine caddisfly. Nothing is known specifically of its life history or habitat requirements. However, the genus is in need of taxonomic work as several undescribed species are known to be present (which may have previously been recorded as *A. canarus*).

***Thaumatoperla alpina* (Stonefly)**

A large, eustheniid stonefly, found only in streams on the Bogong High Plains, Mt Mackay, Mt Fainter and Falls Creek. Nothing specific is known about it's habitat preference or life history, but like other eustheniids, it probably spends a number of years within the stream system as juveniles before emerging as reproductive adults.

***Thaumatoperla flaveola* (Stonefly)**

A large, fairly cryptic eustheniid stonefly, found only in streams on Mt Buller and Mt Stirling often deep in the bed of streams (Pettigrove 1991). It is most abundant in streams with low flow, composed of a series of terraces, separated by steep sections. The flow mainly percolates through an open bed (T. Doeg, NRE, unpublished data). The species is also probably long-lived, spending a number of years within the stream system as juveniles before emerging as reproductive adults. Adults have reduced powers of flight and hence, a low ability to recolonise if disturbed.

***Riekoperla intermedia* (Stonefly)**

Small stonefly known only from alpine areas around Mt Mackay, Mt Bogong and Mt Feathertop. Nothing is known specifically of its life history or habitat requirements.

***Riekoperla isosceles* (Stonefly)**

Small stonefly known only from alpine areas around Mt Buller. It appears that adults emerge early in summer, but the resultant eggs remain inert (diapause) over summer. This allows the species to survive desiccation if the small streams dry up (Rhithroecology 1993). However, no more detailed information is known of its life history or habitat requirements.

***Tamasia furcilla* (Caddisfly)**

Small case-building caddisfly species known only from the type locality on Mt Buller (AGPS 1988). Nothing is known specifically of its life history or habitat requirements.

***Canthocamptus longipes* (Copepod)**

Small (about 0.4mm) harpacticoid copepod known only from Sphagnum bogs on Mt Buffalo (Horwitz 1990). Nothing is known specifically of its life history.

7.4 Review of disturbances and their implications for aquatic fauna

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 and research during the development of the North East RFA. The review covered priority aquatic species (Table 7.9) in the North East, and was based on existing scientific literature and expert opinion.

A number of processes have either been shown to have, 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 in forested areas 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 (eg. natural increases during high flows), several activities lead to additional sediment (often to very high levels) input to 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 the gills, 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, reducing this variation, and exposing fish to increased predation and stress. High levels of sediment can even fill in deep pools, destroying the entire habitat for some species. Crevices in the substrate between rocks or bits of wood serve as critical habitat for fish, mainly as egg deposition sites and rearing areas for juveniles. Sediment settling out can fill these spaces and subsequently destroy important habitat. Increased sedimentation of rivers is a listed Potentially Threatening Process under the *Flora and Fauna Guarantee Act* 1988.

Other disturbances potentially alter the natural stream chemistry, increasing levels of nutrients (fire, timber harvesting, grazing, waste disposal) or toxic chemicals (pest control, fire 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 off-takes are used (many older dams) water temperature can be lowered substantially. Storage and release of water at different times also changes the natural flow regimes. Dams can also present a barrier to migratory fish species, increased sedimentation can occur either during construction or cleaning. *Altered temperature regimes, Altered flow regimes of rivers,* and *Barriers to fish passage* are all listed Potentially Threatening Processes under the *Flora and Fauna Guarantee Act* 1988.

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 0.10 Broad disturbance category with potential large 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 in water
Dams	• Changed flow regimes • Increased sedimentation and turbidity • Decreased water temperature • Barriers to fish passage
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
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 on aquatic species. In most cases, the impact on priority species has been predicted from the results of similar studies conducted elsewhere. For example, no direct data are available on the impact of timber harvesting on the 3 upland Galaxias species (*G. fuscus*, *G. olidus* and *G. rostratus*). However, Graynoth (1979) showed that clearfelling without buffers in New Zealand severely reduced numbers of the local species *G. divergens* in streams, concluding it was probably through increased sedimentation (Table 7.10). The Code of Forest Practices requires that all streams be buffered from timber harvesting to minimise any impacts associated with increased sedimentation.

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 1994).

With these considerations in mind, species affected by each of the disturbance impacts listed in Table 7.10 are presented in Table 0.11. 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 0.11 Species affected by each of the disturbance impacts listed in Table7.10

Disturbance impact	Species Affected	Comments
Increased sedimentation and turbidity	*Galaxias rostratus*, *Galaxias olidus*, *Galaxias fuscus*, *Maccullochella peelii peelii*, *Macquaria australasica*, *Maccullochella macquariensis, Gadopsis marmoratus*	Fish which lay demersal eggs
	Euastacus armatus, Euastacus crassus, Euastacus woiwuru	Decapod crustacea which live in-stream
	Thaumatoperla alpina, Thaumatoperla flaveola, Tamasia furcilla, Riekoperla intermedia, Riekoperla isosceles, Archeophylax canarus	Stream dwelling non-decapod invertebrates
Increased nutrient concentrations	No data	
Increased pesticide concentration	No specific data	Unlikely that species would be affected by herbicides, Likely that most species would be affected by other biocides
Stream bed degradation	All species affected	
Stream bank degradation	All species indirectly affected	
Competition with or predation on native species	*Galaxias olidus*, *Galaxias fuscus*, *Galaxias rostratus* *Euastacus armatus, Euastacus crassus, Euastacus woiwuru*	Predation on juveniles and adults, competition with adults
Increased toxic chemical concentrations	No specific data	However, likely that all species affected, depending on nature of toxin
Changed flow regimes	*Maccullochella peelii peelii*, *Maccullochella macquariensis*, *Macquaria ambigua*,	Species known to require floods, other fish species also likely to be affected
Changed water temperatures	*Maccullochella peelii peelii*, *Maccullochella macquariensis, Macquaria ambigua*, *Macquaria australasica, Gadopsis marmoratus*	Breeding temperature dependant
Barriers to fish passage	*Maccullochella peelii peelii*, *Macquaria ambigua*, *Macquaria australasica,*	Migratory species
Reduction of swamp/headwater habitat	*Hemiphlebia mirabilis, Canthocamptus longipes, Cherax* sp. nov.	
Reduction in population through harvesting	*Euastacus armatus*	

7.5 Conservation measures for fish and aquatic macroinvertebrates

Apart from the inclusion of a significant number of streams and catchments in parks and reserves (in which the general aim is to protect their natural condition), a range of conservation measures is currently in place or proposed for the protection of streams and catchments in the North East.

Following the Land Conservation Council's (LCC) Rivers and Streams Special Investigation (LCC 1991) the corridors of the Howqua (above Lake Eildon) and Goulburn (below Eildon Weir) Rivers in the North East Region were designated as Heritage River Areas under the *Heritage Rivers Act* 1992 because of their significant natural, scenic, cultural heritage and recreational values. Timber harvesting is excluded from the Heritage River corridor on the Goulburn River section in the North East. Timber harvesting in the Howqua River corridor is permitted. Draft management plans for these heritage rivers have been produced (NRE 1997).

The designation of 8 small Natural Catchment Areas in State forest in the North East (LCC 1991) under the *Heritage Rivers Act* 1992 excludes timber harvesting. These are Log Bridge, Mt Tabor, Banimboola, Devils, Yarrarabulla, Long Jack and Williams Creeks and Wongungarra River Headwaters.

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

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

Specific conservation guidelines have been produced for some priority aquatic species listed under the *Flora and Fauna Guarantee Act* 1988.

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.

Table 0.12 Specific Conservation guidelines and activities (apart from standard FMA Timber harvesting prescriptions - see above) for priority aquatic species.

Species Name	Conservation guidelines or activity
Fish	
Galaxias fuscus	FFG collecting restrictions; Minimum stream-side buffer widths extended to 30m and filter strip width to 10m for highly permeable soils; Minimum stream-side 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 rostratus	None
Galaxias olidus	None
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

Species Name	Conservation guidelines or activity
Maccullochella macquariensis	FFG collecting restrictions; No fishing 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) and until 18 December 1999 (Lake Eildon), no netting allowed
Macquaria ambigua	Fishing regulations: Closed season last Sunday in August-last Friday in November, no mesh netting allowed during closed season
Gadopsis marmoratus	None
Decapod Crustacea	
Cherax sp. nov.	None (recently described)
Euastacus armatus	Fishing regulations: 10 per day bag limit, 9 cm size limit, restrictions on equipment used, no taking of females with berry or young, no taking of soft-shelled individuals
Euastacus crassus	Fishing regulations: 10 per day bag limit, 9 cm size limit, restrictions on equipment used, no taking of females with berry or young, no taking of soft-shelled individuals[1]
Euastacus woiwuru	Fishing regulations: 10 per day bag limit, 9 cm size limit, restrictions on equipment used, no taking of females with berry or young, no taking of soft-shelled individuals[1]
Other invertebrates	
Hemiphlebia mirabilis	FFG collecting restrictions
Archeophylax canarus	FFG collecting restrictions
Riekoperla intermedia	FFG collecting restrictions
Riekoperla isosceles	FFG collecting restrictions
Tamasia furcilla	None
Thaumatoperla alpina	FFG collecting restrictions
Thaumatoperla flaveola	FFG collecting restrictions
Canthocampus longipes	None

Fishing regulations from NRE (1997). 1. 9cm size limit effectively means that these smaller spiny crayfish cannot be taken in Victoria

7.6 Data gaps

7.6.1 Fish

There are no significant gaps in fish distributional data from the North East region following the sampling of an additional 112 sites under the RFA research and survey program.

Significant data gaps exist on life history and population characteristics for all priority fish species. Much of the current information is derived from casual observations during other research, rather than well-conducted scientific surveys and research. In particular, the most significant gaps relate to spawning behaviour, including induction cues and location of egg laying sites, both within the catchment and within the stream (Table 7.13). Cues for migration are generally poorly known, particularly for small upland species (Table 0.14), as are preferred larval habitats, and tolerances to turbidity and temperature.

Table 0.13 Summary of missing or inadequate spawning data for fish species.

Species Name	Age at spawning	Breeding cues	Egg laying site	Location in catchment	Number of eggs laid	Incubation time of eggs
Galaxias fuscus						
Galaxias olidus						
Galaxias rostratus						
Maccullochella peelii peelii						
Maccullochella macquariensis						
Macquaria ambigua						
Macquaria australasica						
Gadopsis marmoratus						

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

Table 0.14 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
Galaxias fuscus						
Galaxias olidus						
Galaxias rostratus						
Maccullochella peelii peelii	+					
Maccullochella macquariensis						
Macquaria ambigua	+					
Macquaria australasica	+					
Gadopsis marmoratus						

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

Few data are available relating priority fish species to particular disturbances. The most serious gap is the lack of data on reactions to increased sedimentation and turbidity from a number of disturbances (Table 7.10). Tolerances to increased turbidity are generally unknown (Table 0.14). For species where egg laying sites are unclear (Table 7.13), the impact of deposited sediment cannot be determined.

7.6.2 Aquatic Macroinvertebrates

There are still considerable gaps in the knowledge of aquatic macroinvertebrates in the North East. The sampling of most use to the RFA process has occurred at only 100 sites in order to produce regional scale models of distribution. Whether this is a sufficient density to accurately model aquatic macroinvertebrate communities in the North East has yet to be determined.

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. In addition, there are likely to be other macroinvertebrate species that have not yet been discovered that would qualify for inclusion in the threatened fauna list or under the *Flora and Fauna Guarantee Act* 1988.

Taxonomically, the North East 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 significantly 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 specific scientific surveys and research.

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