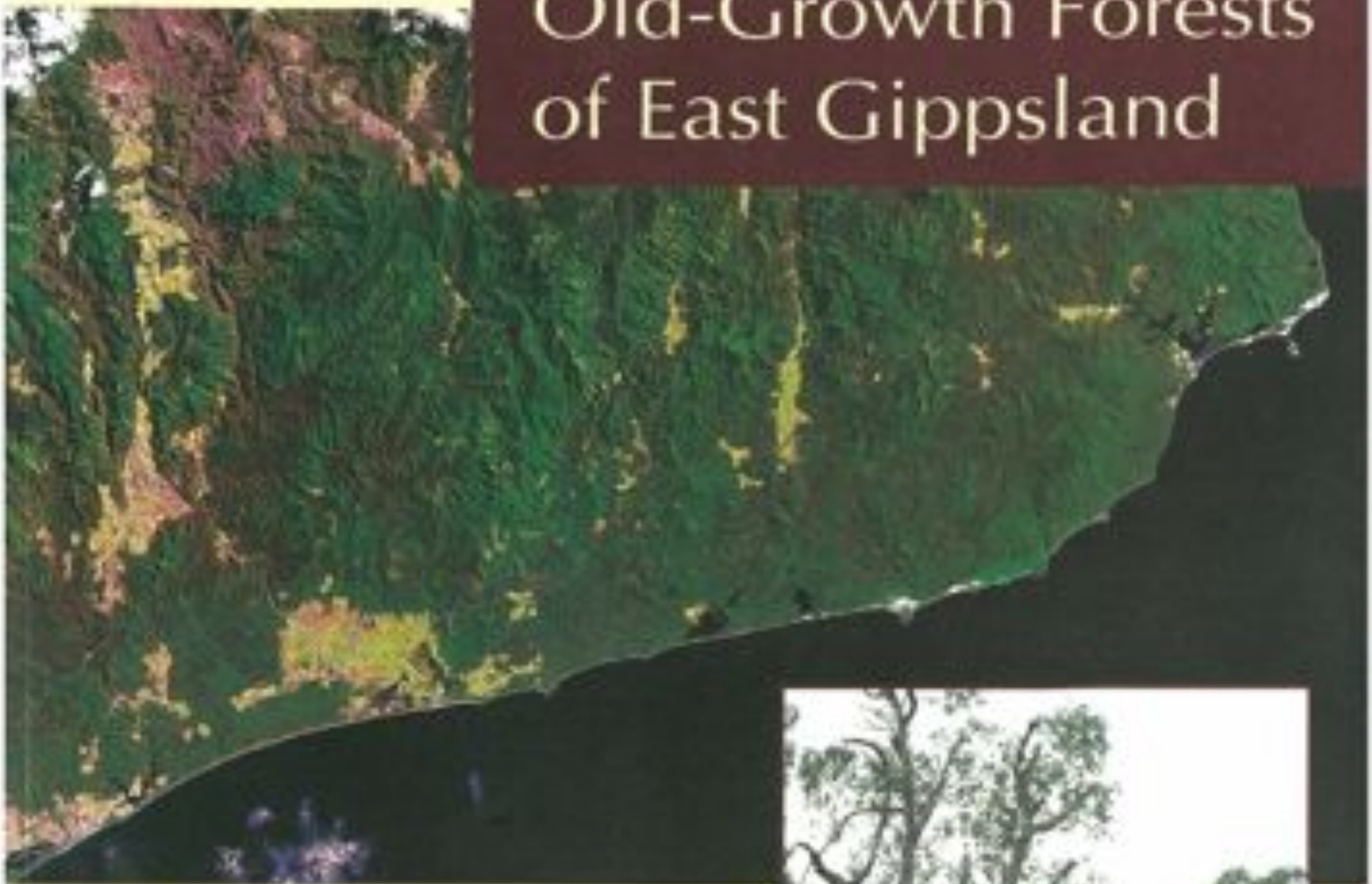
CONSERVATION & NATURAL RESOURCES

A Study of the Old-Growth Forests of East Gippsland



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A STUDY OF

THE OLD-GROWTH FORESTS

OF

EAST GIPPSLAND

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FOREWORD

The concept of old-growth forest has come to prominence in recent years as conservation and resource use issues have captured the attention of the public and governments; yet until very recently there has been no generally accepted definition of what constitutes old-growth forest and therefore the extent and composition of these forests has never been quantified.

The issue of old-growth forest was one of many addressed in 1992 by federal, state and territory governments, in the process leading to the National Forest Policy Statement, a strategy for the ecologically sustainable management of Australia's public and private forests. The policy statement outlines an agreed approach to conserving and managing old-growth forests, including the need to undertake assessments as a prelude to developing strategies for their protection, and the formulation of appropriate management plans.

In early 1991, however, Victoria had already begun a study of the age classes, disturbance history and floristic composition of the forests of the East Gippsland Forest Management Area, comprising just over one million hectares. This Old-growth Forest Study was undertaken by field surveys over 12 months (focusing on those primary characteristics which could be measured objectively, consistently and efficiently) using remote sensing techniques, and building on existing information contained in maps, computer databases and archives.

This document is the result of that study. Firstly, it develops a working definition of old-growth forest and a standard methodology for surveying, assessing and classifying forest of different age classes and vegetation communities, an approach which can be applied to other forest areas of the state. Secondly, it provides detailed maps of the old-growth forests of East Gippsland which will be used in the next stage of the regional assessment of national estate values in the East Gippsland Forest Management Area being undertaken jointly by the Department of Conservation and Natural Resources and the Australian Heritage Commission.

The results of the study will also be important in the preparation of the Forest Management Plan that will document the actions to be taken within State forest to ensure the maintenance of these and other important natural values whilst also providing for the production of a range of goods and services for the benefit of this and later generations.

I wish to acknowledge the support of the Commonwealth in this study by way of funding through the East Gippsland Forest Agreement and the National Forest Inventory. This study is the first of its kind in Victoria and will provide the basis for future studies of old-growth forest elsewhere in Victoria.

Alan Thompson
Secretary, Department of Conservation and Natural Resources

SUMMARY

The concept of old-growth forest embraces both tangible and intangible characteristics, and in recent years there has been considerable debate over its definition. At the commencement of this study, there was no agreed definition at the national level in Australia that could be readily used to physically delineate these old-growth forests.

Old-growth forest was one of many issues addressed in 1992 by the federal, state and territory governments, culminating in the National Forest Policy Statement which is a strategy for the ecologically sustainable management of Australia's public and private forests.

The National Forest Policy Statement sets out an agreed approach to conserving and managing old-growth forests, including the need to undertake assessments as a prelude to developing strategies for their protection, including the formulation of appropriate management plans. This document describes the results of the study of old-growth in East Gippsland, the first such assessment to be conducted in Victoria.

The study area comprises the most easterly region of the state of Victoria, in Australia's south-east. Of the total area of 1.22 million hectares, 87% is public land and 13% is private property. Forest extends over 977 802 hectares (81%) in the study area, with 918 833 hectares on public land and 58 969 hectares on freehold land (Chapters 1 and 4).

This study has examined the spectrum of characteristics of old-growth forest; from the tangible (including growth stage, disturbance and species) to the intangible (including aesthetics and antiquity). The study concentrated on those primary characteristics that are most closely associated with the term old-growth forest, that is, forest age and disturbance. A range of existing definitions of old-growth forest was also examined (Chapter 2).

The study determined that a practical approach was required to clearly delineate old-growth forest. This approach should be applicable to all forests and form part of a methodology that is consistent and repeatable. The study firstly defined forest as "all woody vegetation with potential height generally greater than 5 metres and crown cover projection generally greater than 10%". The survey parameters used to delineate old-growth characteristics in this study were growth stage and crown cover of the upper stratum, forest type (dominant species, density and height), ecological vegetation class (reflecting floristics and ecological processes) and disturbance type and level. Most were mapped using remote sensing techniques, field checking and the collation of archival records (Chapter 3).

Although forests are dynamic entities, the trees in these forests all pass through a series of definable growth stages. For simplicity these are described as regeneration, regrowth, mature and senescing. In practice any forest stand may comprise one or more of these growth stages. Each growth stage was identified and mapped by aerial photo interpretation and ground checking. Growth stages were mapped for all forest areas, irrespective of land tenure. This study identified 218 combinations of growth

stages within the study area and these are summarised to 32 combinations for the final analysis (Chapter 4).

The morphological characteristics of the growth stages are dependent upon the structural (height, density) and floristic properties of the forest. Thirty-one structural forest types were described using earlier mapping from the 1970s (Chapter 5). Floristic properties (floristic vegetation communities), delineated by earlier studies, were significantly refined during this study by reference to the existing forest type mapping, floristic mapping, floristic databases, and maps of geology and climate, to produce maps of ecological vegetation classes. This study has demonstrated clear relationships between vegetation structure, floristics and the ecological processes within a particular environment, and in doing so has described and mapped 44 ecological vegetation classes for all native vegetation on public land within the study area. Four ecological vegetation classes, Lowland Forest (245 131 ha), Damp Forest (238 288 ha), Shrubby Dry Forest (209 982 ha) and Wet Forest (90 288 ha) together account for 76% of the public forest estate (Chapter 6).

Eight disturbance types were comprehensively researched from existing records and mapped for the study area. These were agricultural clearing, clear felling, selective logging, mining, grazing, dieback, wildfires, and fuel reduction burns. Areas for which there is no disturbance record are described as undisturbed, although it is acknowledged that fire at least has probably affected all forests at some time in the past. All disturbances were considered to be un-natural (human-induced in the context of post-European settlement) except wildfire (Chapter 7).

Limited tree ageing (dendrochronology) studies were undertaken for eight trees from the regrowth, mature and senescing growth stages of Damp Forest in the Cobon forest block. Damp Forest is the second most extensive ecological vegetation class in the study area. Senescing trees in the oldest growth stage were found to be between 260 and 311 years old, and approximately twice the age of the trees in the mature growth stage. The studies suggest that, in this vegetation class, senescence begins at about 250 years of age. Even larger and older trees were present but were not sampled due to the risk of injury to the tree faller. The mature trees sampled were between 158 and 171 years of age, and the data suggest that these trees could be expected to remain in the mature growth stage for about another 80 years. A 300 year forest fire history was also derived and this indicated that 12 fires passed through the stand with an average frequency of 22 years. There was no conclusive evidence of an increase in fire frequency at this site since European settlement (Chapter 8).

From the outset it was assumed that old-growth forests are composed of the oldest and least disturbed forest stands for a given ecological vegetation class. The two primary characteristics which were pre-eminent in delineating old-growth forests were growth stage and disturbance level (Chapter 9).

Old-growth forest is therefore defined as:

Forest which contains significant amounts of its oldest growth stage in the upper stratum — usually senescing trees — and has been subjected to any disturbance, the effect of which is now negligible.

The definition is accompanied by a set of important technical notes which expand and explain the definition to facilitate the mapping of old-growth forest. In general terms it is a refinement of the National Forest Policy Statement definition of old-growth forest. In an ecological context, forests which have been subjected to either natural or un-natural disturbances some time in the past may once again be considered old-growth provided they meet the growth stage requirements and have recovered their structural and floristic properties. However, from an intangible perspective these same forests may be considered to have been significantly affected by un-natural disturbance and could be excluded from consideration as old-growth. The importance of these intangible characteristics was recognised by the study, however they were not used to assist in the identification of old-growth forest. Further work is needed to clarify the role of these intangible characteristics in assessing the range of values within the old-growth domain (Chapter 9).

The information gathered during the study was entered into a geographic information system and an analysis procedure was developed to assess, rank, classify and describe forests according to their disturbance level, growth stage, ecological vegetation class and forest type. The disturbance levels comprised undisturbed, negligible natural, negligible un-natural, significant natural and significant un-natural disturbance. This allowed old-growth forest to be derived and mapped (Chapter 10).

Old-growth forest was identified on 21.2% (224 364 hectares) of public land, occurring in 26 of the 33 forested ecological vegetation classes. About 75% of the identified old-growth forest occurred in three ecological vegetation classes; Shrubby Dry Forest (88 013 ha), Damp Forest (42 749 ha) and Wet Forest (36 585 ha). Only 3.5% of all forest on public land was found to be undisturbed, 47% negligibly disturbed and 49.5% significantly disturbed. No old-growth forest was mapped on freehold land due to the assumed high levels of disturbance. The study found that old-growth forests vary greatly in appearance from the cathedral-like Wet Forests to the stunted and gnarled Coast Banksia Woodlands (Chapter 11).

The old-growth forests identified in this way are a snapshot in time. Forests are a dynamic entity and the distribution of old-growth forest will change as a result of the forces of nature and human management. Careful and active management will be required to ensure that the old-growth forest domain is maintained on an ecologically sustainable basis. This management will require an understanding of the essential values of old-growth forest, including fauna values, naturalness values and intangible values which have not been considered in detail in this study. Such values warrant further analysis in order to identify their position in the context of the broader old-growth domain (Chapter 12).

The study has therefore addressed the key words in the term old-growth forest, firstly by defining forest, secondly by assessing the relative age of forests through analysis of growth stages, and finally by considering the implications of disturbance through the examination of a range of disturbance types and levels. This approach has lead to a definition of old-growth forest and, more importantly, has established a method for both delineating these forests in practice and for describing their values.

The old-growth survey has provided a comprehensive information base, including maps, for the East Gippsland forests, which will enable the Department of Conservation and Natural Resources to meet its commitments under the National Forest Policy Statement.

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INTRODUCTION

1.1 BACKGROUND

In February 1990 the Victorian and Federal governments entered into an agreement to formalise a decision-making process to be used by the respective governments in deciding under what conditions timber harvesting would be undertaken in the forests of East Gippsland, which were listed on the Register of the National Estate.

This agreement, known as the East Gippsland Forest Agreement, was designed to seek prudent and feasible alternatives to timber harvesting in National Estate forests within the East Gippsland Forest Management Area. Under the East Gippsland Forest Agreement the Commonwealth Government, through the Department of Primary Industries and Energy, provided funding over two years for a number of projects, one of which was this study of old-growth forests. Funding of this study was also assisted by the National Forest Inventory as part of its regional inventory program.

In February 1991 the then Victorian Department of Conservation and Environment (DCE) entered into an agreement with the Australian Heritage Commission to investigate, identify and assess national estate values in the forests of East Gippsland. The Agreement acknowledged that, because old-growth forests have particular value under the criteria for assessing national estate significance, it would be necessary to undertake a definitive study of these forests. To this end, a five-person study team was established in June 1991, along with a Technical Advisory Committee (TAC) to provide guidance and expert advice on the old-growth study. The TAC comprised scientists with relevant technical qualifications and included representatives of organisations with policy and management responsibilities.

A national workshop on old-growth forest attributes held by the National Forest Inventory in May 1991 discussed the key attributes of old-growth forest, and its findings significantly influenced the design of this study.

At the time of commencement of the study, the Resource Assessment Commission's (RAC) Forest and Timber Inquiry was well under way. In its final report in 1992, the RAC made specific recommendations about old-growth forest, recognising the need for appropriate definitions and consistent management principles to be part of a national forest strategy which included the following elements:

- an acceptance of the urgent need for Commonwealth, State and Territory governments to conduct a systematic and comprehensive survey and inventory of unlogged and ecologically mature forests to identify old-growth attributes and determine the extent of old-growth forest; and
- a clarification of the distinction between ecologically mature forests, negligibly disturbed forests, unlogged forests, and old-growth forests.

Following the RAC inquiry, and after the completion of the field component of this survey, the National Forest Policy Statement was signed by the Commonwealth, all states and territories in December 1992, with the exception of Tasmania. This Statement outlines an agreed approach to conserving and managing old-growth forests, a basic element of which was that the relevant state agencies would, as a matter of high priority, undertake an assessment of old-growth forest. The study is the first of its kind in Victoria and possibly Australia. The early initiative taken by Victoria in commencing its survey in East Gippsland is consistent with the subsequent directions of the National Forest Policy Statement.

1.2 STUDY OBJECTIVES

The primary purpose of the study was to describe the characteristics, attributes and values of the range of age classes in the forests of East Gippsland with a major focus on the older age classes.

The specific objectives of the study were as follows:

- Undertake a field survey, using aerial photographs and satellite imagery and data obtained from other sources, to determine the nature and extent of older forests on all classes of land in the study area. Gaps in the existing databases were to be identified as a precursor to this study.
- Undertake research into, and analysis of, historical data and archival records relevant to the use and utilisation of lands and forests in the study area.
- Define a set of age classes of forest that are ecologically significant and that would facilitate modelling of spatial and temporal changes in forest age structure for management and research purposes in the future.
- Assess and map the nature and degree of human induced disturbance and its impact on the environment using quantitative measures such as weed indices, dendrochronology and growth staging.
- From this information, create a digital database and integrate this with other data layers in the Department's Geographic Information System (GIS) for analysis at a scale of 1:100 000. These layers were to include topography, logging and fire history, forest type, floristic vegetation, land systems, land tenure and land use.
- Using overlay analysis techniques, identify and describe the attributes of old growth forests in the study area as well as their natural and cultural values.

A detailed description of the original project brief, schedule and costings is given in Appendix A.

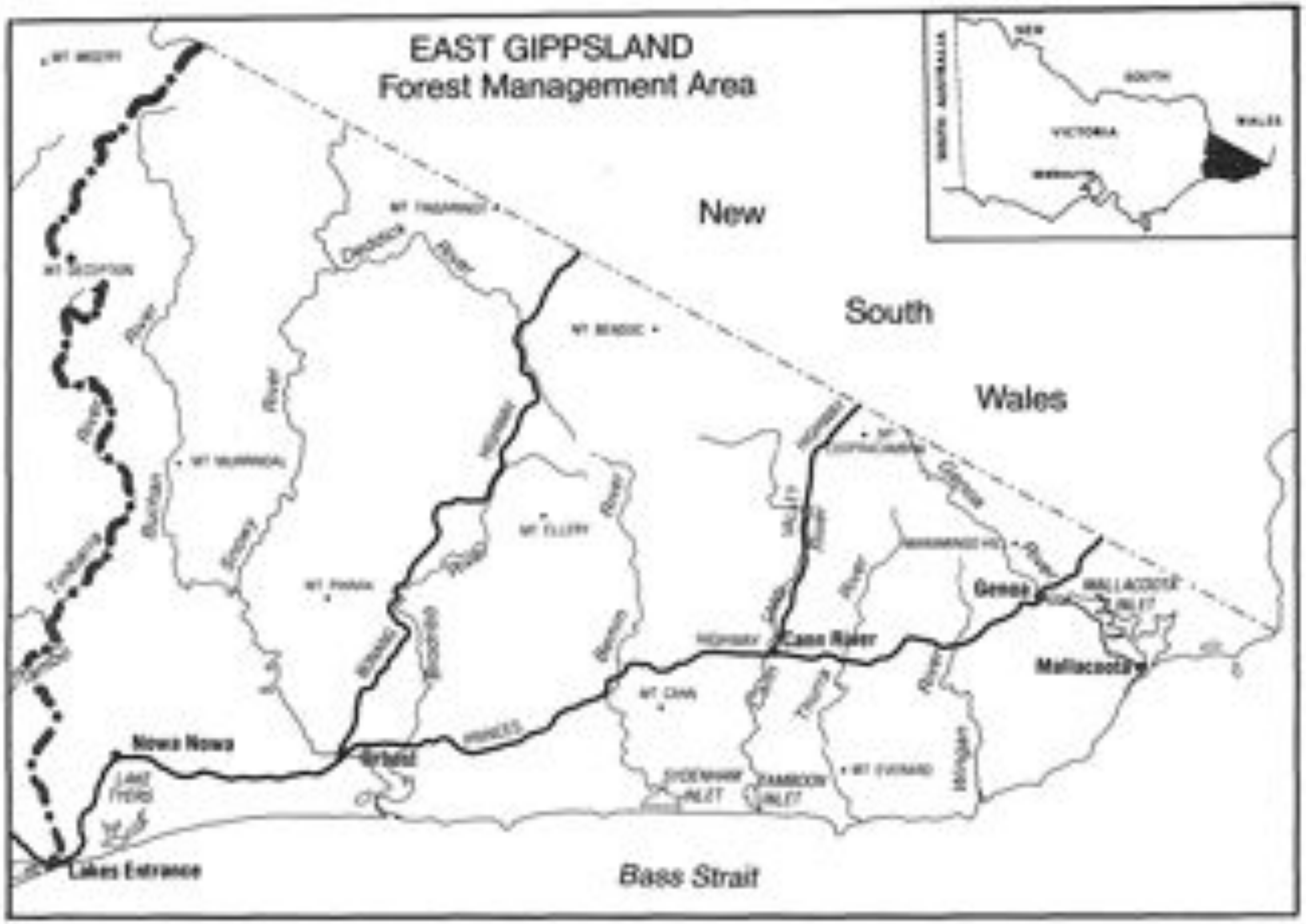
1.3 STUDY AREA

The study area is the East Gippsland Forest Management Area (EGFMA), one of fifteen forest management areas in Victoria identified in the Timber Industry Strategy. It comprises the most easterly region of the state and is sparsely populated, with Orbost being its major population centre. It covers that part of Victoria south of the Black–Allan Line (the straight eastern section of the NSW–Victoria border). The western margin is defined by various features, including the main ridge of the Great Dividing Range, the Timbarra River, and various forest roads and tracks. The southern and eastern boundaries are formed by the coastline from Gabo Island to Lakes Entrance. The location of the study area is shown in Map 1.

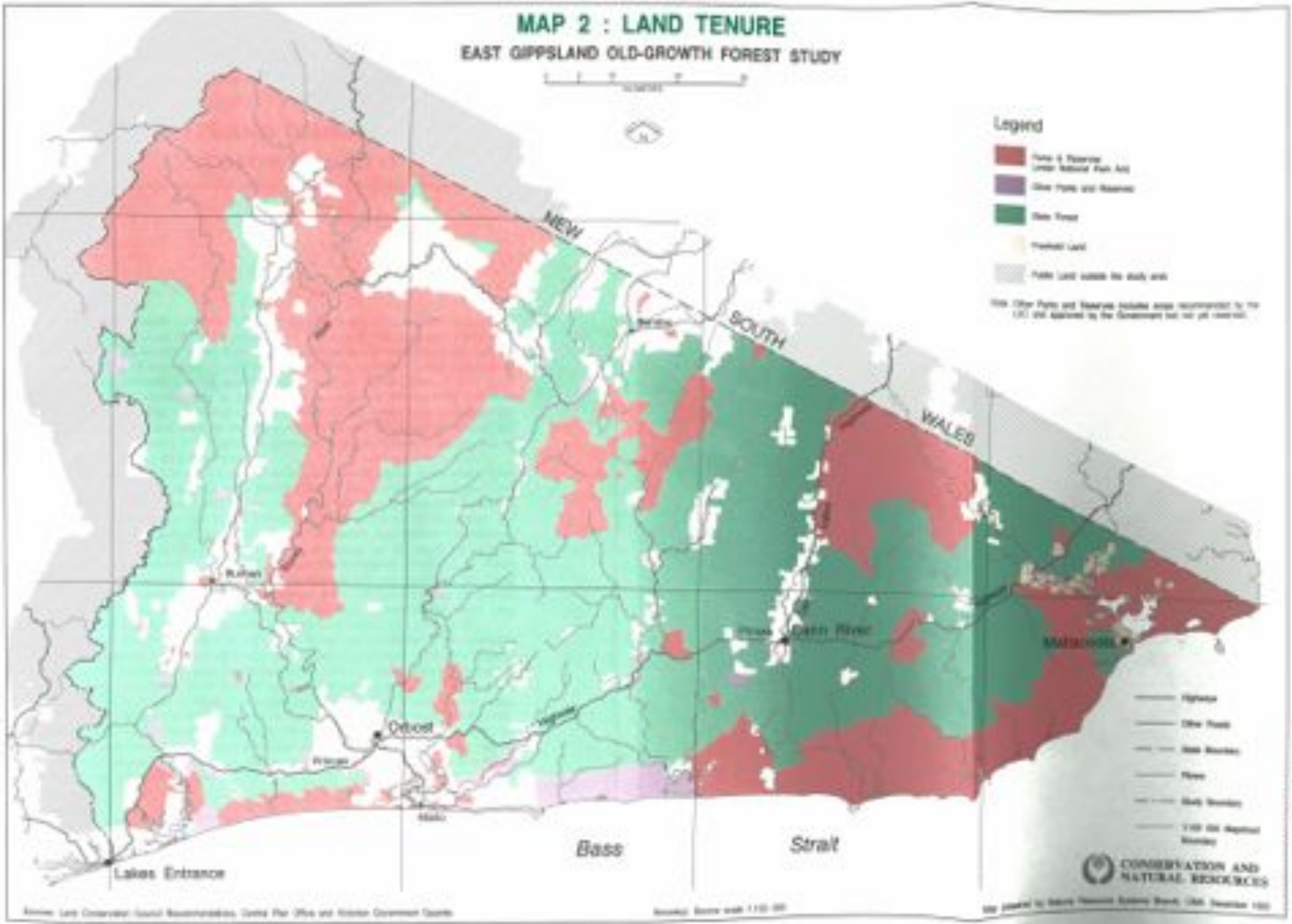
Geomorphologically the study area has a wide variety of landforms that range through coastal dunes and plains to dissected foothills and a hinterland that rises to over 1400 m with a variety of intermontane basins and montane plateaus. Unlike the rest of Victoria the climate is subjected to a strong easterly influence. Rainfall is spread evenly throughout the year and ranges from less than 700 mm in the rain shadow country of the upper Snowy River to 2000 mm on the Errinundra Plateau. The average rainfall is in the range of 900–1000 mm.

Of the 1 216 685 ha of land in the EGFMA, 87% (1 057 760 ha) is public land and 13% (158 925 ha) is freehold land. The land-use recommendations for East Gippsland and parts of other Land Conservation Council (LCC) study areas (Alpine and Gippsland Lakes Hinterland) include the reservation of 415 000 ha (40% of the public land) as national park and other conservation reserves and 643 000 ha (60% of public land) as predominantly State forest. The relationship between public land and private land is shown in Map 2, together with a broad classification of public land use.

A total of 443 000 ha of public land in the EGFMA is listed on the Register of the National Estate. Of this, 83% is within national parks and other conservation reserves, 16% (70 109 ha) is within State forest, with the remainder (2724 ha) being freehold and Commonwealth land.



Map 1 The location of the East Gippsland Forest Management Area.



MAP 2 : LAND TENURE

2

CONCEPTS AND DEFINITIONS OF OLD-GROWTH FOREST

2.1 INTRODUCTION

Over the past decade 'old-growth forests' have been the subject of debate amongst both the scientific and the wider communities in Australia and overseas. Widespread alteration of the world's forests has resulted in a reduction in total forest area and the fragmentation of remaining forests into progressively smaller patches isolated by agricultural, industrial or urban development or regrowth forests (Harris, 1984).

The 'natural' environment in Australia has developed as the result of extensive Aboriginal influence. Contemporary custodians of the Australian landscape are seeking to understand, manage and conserve this natural environment. It is in this context that the impact of European occupation is generally viewed as having had an 'un-natural' impact on the environment.

Within Australia, extensive modification and loss of forest ecosystems since European occupation has led to a perception that old forests are now rare and diminishing (Humphries, 1990), yet there has been no generally accepted definition of what constitutes an 'old-growth forest' and little is known of the extent and distribution of remaining 'old-growth forests' (Resource Assessment Commission, 1992). The concept of old-growth varies according to different viewpoints, encompassing a complex mixture of measurable ecological attributes of forest ecosystems and intangible personal values associated with experience of the forest environment (Resource Assessment Commission, 1992). For some people, old-growth forests are significant for their antiquity and the sense of spirituality which they invoke. They can also be significant for the high-value timber they may contain.

From an ecological perspective, old-growth forests are considered to be significant for their diversity of structure (Resource Assessment Commission, 1992), low rates of change in composition and structure (Dyne, 1991), and complex ecological relationships involving many wildlife species and other organisms (Franklin and Forman, 1987). Whilst all these viewpoints are important, there is consensus that any definition of old-growth should have an ecological basis (Thomas *et al.*, 1988; Early, 1990; Scotts, 1991). The issue of defining old-growth is complicated, however, by the different characteristics of old-growth evident in different forest types, and the various types and degrees of disturbance which may preclude old age forest from being considered 'old-growth' forest.

2.2 CHARACTERISTICS OF OLD-GROWTH FORESTS

Although it may be difficult to generate a single definition of 'old-growth' forests, a range of factors have been recognised as providing a quantitative description of the old-growth state (Dyne 1991). These CHARACTERISTICS may be described as ATTRIBUTES that contribute to the description of the forest and DISTURBANCE INFLUENCES which either physically or metaphysically influence the state of old-growth forest. They can be summarised as:

- structural and functional attributes, which are either measurable or inferred, and which directly contribute to a description of the old-growth state;
- contextual attributes, partially measurable and partially a function of human perceptions;
- intangible attributes, difficult to measure and largely a function of human perceptions; and
- disturbance influences which diminish, or detract from, the old-growth state.

The correlation between various characteristics and old-growth forests can vary; some characteristics (PRIMARY old-growth characteristics such as age) have a high correlation with old-growth forest, whilst others (SECONDARY old-growth characteristics such as type of habitat) have a weaker correlation and may also be found in younger forests.

Structural attributes
Physical structure is among the most recognisable features of old-growth forests. Aspects of tree morphology such as tree height, tree diameter, crown dimensions and presence of hollows meet many of the commonly perceived attributes of old-growth forest and are frequently used in existing definitions.

Age is often used as a criterion to define old-growth forests, and may be a measure of the likely development of hollows in branches and boles (Humphries, 1990). Although strong correlations have been shown between morphological criteria and the age of individual trees or stands (Mackowski, 1984), age may or may not have a direct relation to the physical state of development of a tree or stand. Thomas *et al.* (1988) observe that the age of trees should not be the sole measure of the old-growth condition, because structural characteristics develop over different lengths of time depending on site conditions and stand history. From a practical point of view, assigning ages to south-eastern Australian forests is often difficult, because most Australian trees, with some exceptions, produce growth rings that are determined by the vagaries of the growing seasons and ring counts do not necessarily correlate with distinctive annual seasons, as they do in the cool temperate regions of the northern hemisphere (Banks, 1982).

The developmental stages of a forest can also be included in definitions of old-growth forest and are often referred to in terms of the growth stages of individual trees (Early, 1990). These growth stages have been variously described by forest scientists as regrowth, mature and overmature (Jacobs, 1955), and by ecologists as regrowth, ecologically mature or old (Franklin *et al.*, 1981).

The typical growth stages of old-growth forests vary with floristic composition, structural forest type and site quality, being influenced by aspect, altitude, soil type, geology and climate. The floristic composition of forests determines both the morphological properties of forest growth stages and the effect that various disturbances will induce. Lowland forests in East Gippsland experience frequent fires (Christenson and Maisey, 1987) and typically exhibit a multi-aged structure with a variety of growth stages because of the resilience of the dominant overstorey species to such fire regimes. In contrast the natural fire regime of damper forests is less frequent, but the fire intensity may be much higher (Early, 1990). Occasionally, in the Alpine Ash (*Eucalyptus delegatensis*) dominated Montane Wet Forests of East Gippsland, a severe wildfire will kill all the standing overstorey in a small area and an even-aged forest will develop. Regeneration and recovery of mature trees of the dominant tree species is therefore dependent upon both the adaptations of the species, and the severity of disturbances such as wildfire or severe storms.

Functional attributes

Ecological functions of forest ecosystems include reproduction, energy flow, conservation and cycling of nutrients, and regulation of water flow (Franklin *et al.*, 1981). The primary functional attributes of old-growth forests are closely related to structural characteristics.

Although old-growth forests are regarded as having low productivity because of their low or negative net growth rates in standing (living) biomass (Resource Assessment Commission, 1992), total organic matter (living and dead) continues to increase in old-growth forests, mainly in the form of woody debris and fallen logs which accumulate more rapidly than they decompose (Franklin *et al.*, 1981; Ashton, 1986).

The slow decomposition of dead matter through the actions of micro-organisms, plants and fungi through a 'closed-cycle, detrital-based system' (Odum, 1971) leads to extremely conservative ecosystem functioning where energy and nutrients are tightly retained (Franklin *et al.*, 1981).

In old-growth forests in the USA, large accumulations of carbon and nutrients in trunks and logs (biological legacies) are considered to be a significant source of stored energy and nutrients and one which can bridge major disturbances such as wildfire, unlike more easily burned organic components such as leaves on the forest floor (Franklin *et al.*, 1981). In Australia research has shown that the amount of nutrients in the trunks is concentrated in the sapwood or leaves which provide a potential buffer of nutrients from low-level fires. Nutrients may also be made available to old-growth systems through biological activities; for example, the amount of nitrogen fixed by lichens and bacteria in old-growth Douglas-fir forests in the USA is significantly higher than the amount fixed in young regrowth forests (Franklin *et al.*, 1981).

Organic debris and fallen trees also play an important functional role in streams in older forests, creating a diversity of habitats and stabilising channels and sediment. Beside physically shaping small streams, large logs are rarely moved downstream and must therefore be biologically broken down in situ, providing a major source of energy and nutrients for the stream ecosystem (Franklin *et al.*, 1981).

Other important functional attributes of old-growth forests include the maintenance of gene pools, amongst them the range of species available for recolonising an area after a severe disturbance; and the ability of the ecosystem to maintain its integrity over the longer term (Dyne, 1991). These functional attributes are less closely associated with old-growth forests and may be seen as secondary characteristics.

Contextual attributes

The viability of a particular patch of old-growth forest depends on its structural characteristics (content), its size and shape (configuration), and may also depend on the matrix of forest age class and disturbance histories within which it occurs (context). Patches of old-growth forest fragmented by clearing or harvesting (or both) may become so small and isolated that their continued existence is threatened by microclimatic change and by the lack of connectivity with similar patches, and they may ultimately become at risk of ceasing to function as habitats for fauna dependent on old-growth forests (Lindenmayer 1992a). Remnant old-growth 'islands' could be degraded by edge effects and isolation and hence not maintain their complement of fauna and flora or the processes of evolutionary development which may characterise larger stands. There is, however, very little knowledge of the specific role of contextual attributes in the long-term survival of old-growth forest stands.

Naturalness of forests is an important issue in its own right, but it is also considered to be an important contextual attribute of old-growth forests. Usher 1986 (cited in Early, 1990) notes that 'the more natural an ecosystem, the more it tends to be valued. This is not only because of the variety of plants and animals that it contains, but also because other features of the ecosystem may have been conserved'. These naturalness qualities can be partially measured by biological surveys or indirectly by using a measure of remoteness from access and settlement such as that used in the assessment of 'wilderness' values by Preece and Leslie (1987).

Intangible attributes

Old-growth forests can have highly significant, non-scientific values, which are less easily defined than those with a scientific basis but which are no less important (Early, 1990). These 'intangible' values stem from personal experiences and include feelings of a sense of beauty or wonder, or of spiritual uplifting (Resource Assessment Commission, 1992). They may also include perceptions of aesthetic quality, antiquity and grandeur. The cultural and religious relationships of Aboriginal peoples to the land is an example of the influence of these values.

There is a view that once the values associated with intangible attributes are known to have been modified by disturbance, they can never be replaced.

Disturbance influences which affect old-growth attributes

Part of the value placed on old-growth forests in Australia relates to the clearing and modification of forests over the 200 years since European settlement (Early, 1990). Much of the remaining older forest has been changed by a number of disturbances which vary greatly in their intensity, spatial extent, the time taken for their consequences to become apparent and the time needed to recover from the disturbance. The effects of different disturbance types upon physical and biological characteristics also vary according to forest type and are not well-understood, as most research on disturbances is both short-term and limited in its scope (Resource Assessment Commission, 1992).

The significance of disturbances on the intangible attributes of old-growth forests can be perceived as varying according to whether they are human-induced (anthropogenic) or not human-induced (natural). Some types of natural disturbances (for example, wind and precipitation) are essential to the maturation processes of forests and are not normally regarded as disturbances which degrade old-growth attributes unless they rise above a significant level. Many disturbances, however, result from human influence and their effects on the old-growth attributes of a forest stand may be regarded as long-lasting and even irreversible. This view, of course, supposes that human-induced disturbances are not natural, an issue that is also highly contentious given that the Australian environment has been significantly influenced by aboriginal Australians for many thousands of years.

The selective logging of older forests practised in the past may have left the original old-growth structure and composition reasonably intact (Early, 1990), although tree species composition may have been modified through the depletion or removal of species highly valued for timber. Nonetheless, the structural features and floristic diversity of such selectively logged forests are regarded as being important to wildlife when present in comparable proportions to those in undisturbed forests (Jenkins and Recher, 1990; cited in Humphries, 1990). Under current forest management practices, some areas of older forest are removed and replaced by regeneration and retained areas are fragmented during the initial cycle of timber harvesting, for example, through clear-felling silvicultural systems. Subsequent forest management, if its objective is to maximise further wood production, may prevent the forest from redeveloping into the older growth stages before the next logging cycle commences (Early, 1990).

Fires can have effects ranging from short-term to catastrophic and may arise from anthropogenic or natural sources, and thus the issue of when they constitute a detrimental influence in the development of old-growth forests is highly contentious. In the view of the Resource Assessment Commission (1992), 'the occurrence of fires, either deliberately or accidentally lit by humans, does not necessarily reduce the old-growth characteristics of a forest. Intense wildfires may kill most trees and thus severely modify any characteristics associated with maturity, but mild fires, including occasional prescribed burning, may have little impact on these same characteristics'. Other viewpoints contend that repeated prescribed burning which removes leaf litter and fallen logs or alters floristic composition and understorey structure reduces habitat diversity (Catling, and Recher, cited in Lunney, 1991) and this may have a significant impact on old-growth values.

Very little research has been carried out on the biological effects of disturbance of older forests in Australia. In East Gippsland the spread of dieback fungus (for example, *Phytophthora cinnamomi*) is known to be promoted by movement of soil and gravel for road construction or on machinery, and by increased run-off due to soil compaction from vehicles as well as rising water tables in logged forests with impeded drainage (Purdie *et al.*, 1990). The influence of exotic plant species introduced by vehicular traffic on forest roads and by grazing varies according to floristic community but may be extensive, particularly within the understorey and the herb layer.

2.3 SOME DEFINITIONS OF OLD-GROWTH FOREST

It can be seen from the foregoing discussion that the features that are perceived to characterise old-growth forests are many and varied. They range from the scientific to the intangible, from being highly correlated with old forests to being only loosely associated, and from being readily measurable to being almost impossible to quantify. This suite of characteristics can be summarised as a spectrum of perceptions of old-growth forest (Figure 2.1). The characteristics of old-growth forests included in Figure 2.1 relate specifically to East Gippsland and may not be universally applicable; however, the framework of the figure should be relevant to most old-growth forest areas in the temperate environments of Australia.

Many definitions of old-growth forest have been produced as a result of contemporary debate about old-growth forests. In its review of these definitions the Resource Assessment Commission (1992) noted the following frequently used phases '... the absence of disturbance associated with European activity; the presence of old trees described as "overmature" or "senescent"; and high structural diversity'. Very often, however, these definitions are non-specific and use qualitative criteria such as '*relatively* free from disturbance', '*most* of the original structure still present', and '*largely* unmodified'; whereas definitions which attempt to quantify attributes such as tree age and size are rarely justified.

A selection of old-growth forest definitions is listed below. The list is by no means exhaustive and is in no particular order:

- 'Those communities which are the older developmental stages of the forests and characterised, at least in part, by the following: low growth rates for trees in the highest stratum, low to zero biomass production of trees in the tallest stratum, trees in the tallest stratum mature to senescent, very high biomass of individual trees in the highest stratum, trees in the tallest stratum usually more than 100 years old.' (Australian Heritage Commission, 1990).
- ' ... primeval ... forest whose trees predate European settlement.' (Clark and Blakers, 1989).
- ' ... those forests in which most of the original diversity of species and structure is still present which have not been subject to removal of more than 50% of their canopy within the past 60 years, or subject to severe wildfire over the past 30 years.' (Kestel Research, 1988).
- 'Forest units in which the continuity of natural ecological processes has been maintained for at least 200 years, exhibiting natural levels of biotic and structural diversity and in which low to zero biomass production is occurring in trees in the tallest stratum; with no or minimal introduced pathogens or weed species present.' (National Forest Inventory draft definition, 1990, cited in Dyne, 1991).
- '... forest in which the dominant tree species are beyond the age of maximum growth rate, and in which the understorey has developed relatively free of disturbance. This is commonly over 100 years old, beyond the age regarded as optimum for wood production (usually about 80 years) and at or above the age at which hollows suitable for tree-dwelling fauna begin to form.' (Government of Victoria, 1987).
- ' ... largely unmodified forest of whatever age or mixture of ages of trees.' (Kirkpatrick, 1990).
- ' ... forest dominated by trees which have passed the age where linear dimensions have completed vertical and horizontal expansion and senescence is facilitating the development of hollows utilised by a range of hollow-dependent fauna.' (Gruen *et al.*, 1989).
- ' ... unlogged forest, but may also include those logged forests that contain a high proportion of mature and overmature trees comparable to an unlogged forest of the same type.' (Jenkins and Recher, 1990).
- ' ... characterised by stands with a deep, multi-layered canopy often resulting from the presence of more than one tree age-class and/or dominant and subdominant members of the major age-classes, individual live trees (present at a basal area comprising at least 50% of the total stand basal area) that are either old (well past the phase of maximum exponential growth, e.g 150 years) or large (>1.0 dbh), and contains stags and logs of large dimensions (>0.5 m diameter and >6 m length) present at significant levels (e.g 4/ha for stags and 10/ha for logs).' (Scotts, 1991).
- 'A stand well past the age of maximum growth, frequently showing a great horizontal and vertical diversity of structure and plant species composition, and possessing one or more features not seen in younger forests, such as snags, down woody material or arboreal lichens.' (Nyberg *et al.*, 1987).
- '... Forest with dominant trees older than a particular age. The age varies according to the species and the history of fire and logging, but it is often taken

to be older than the earliest period of logging in the area ... or older than one full commercial harvesting rotation...' (Meagher, 1991).

- ' ... forest in which we can reasonably expect that there will be no temporal hiatus in the continuing availability of old-growth attributes [such as] ... large trees, overmature trees, stags, logs, dependent fauna, biogeochemical cycling, hydrological features, etc.' (Gilmour, in Dyne, 1991).
- ' ... one in which the trees with old-growth characteristics would normally contribute about 30% or more of the gross canopy area (including emergents) provided by all the tree species. At this level of canopy area contribution old-growth trees are considered to dominate the site. Other essential old-growth characteristics include: trees that have attained an old age and that are usually a large diameter for the species and site; and, no obvious evidence of recent human disturbance. Additional characteristics which are often present in an old-growth forest include: individual trees which often exhibit branch or trunk hollows, sparse crown, epicormic growths, protruding dead limbs, evidence of decay processes and a low or negative net growth rate; trees that are normally more widely spaced than in a younger forest; a considerable amount of woody debris, including trunks and branches on the forest floor; possibly large amounts of epiphytic and parasitic vegetation associated with the old trees; often suites of plants and animals particularly dependent upon old-growth forest; and, the forests may give an impression of grandeur and very old age.' (Institute of Foresters of Australia, 1990).
- ' ... forest that has not been, or has been minimally, affected by timber harvesting and other exploitative activities by Australia's European colonisers.' (Australian Conservation Foundation, 1991).
- ' ... forests that are both negligibly disturbed and ecologically mature and which have high conservation and intangible values.' (Resource Assessment Commission, 1992).
- ' ... forest that is ecologically mature and has been subjected to negligible unnatural disturbance such as logging, roading and clearing. The definition focuses on forest in which the upper stratum or overstorey is in the late mature to overmature growth phases.' (National Forest Policy Statement, Commonwealth of Australia, 1992).

This last definition, developed for the National Forest Policy Statement, was agreed to by Victoria. The definition developed during the current survey and recommended for use by the Department of Conservation and Natural Resources is consistent with the National Forest Policy Statement, but provides more technical detail and explanation. This is discussed in Chapter 11.

Figure 2.1 The spectrum of some of the perceived old-growth forest characteristics.

CHARACTERISTICS		
Scientific & Objective [Readily mappable, measurable and quantifiable, contain ecological values]	*Quasi-scientific/Intangible* [Partially quantifiable through indirect measurements and assumptions]	*Intangible & Subjective* [Difficult to quantify, descriptive only, and are experiential; contain social or human values]
PRIMARY CHARACTERISTICS — highly correlated with old forests		
Structural and Functional • structural (height, density) composition • plant community species composition • growth stage • age *Absence of Disturbance Influences* Anthropogenic: • timber utilisation • agricultural clearing • mining • grazing • fuel reduction burning • weeds • dieback Natural • wildfire	*Contextual* • integrity • connectivity • viability • naturalness *Absence of Localised Disturbance Influences* Anthropogenic • cultural features such as urban settlement, roads, railways and powerlines.	*Intangible* • antiquity • naturalness
SECONDARY CHARACTERISTICS — less strongly correlated with old forests		
Structural and Functional • faunal values and habitat • other vegetative growth forms (e.g. epiphytes) • functional processes including biomass and productivity, and nutrient cycles *Disturbance influences* • broad biophysical disturbance including climate change, geologic and land form alteration	*Contextual* • wilderness • remoteness • aesthetics	*Intangible* • grandeur • spirituality

3

SURVEY OF OLD-GROWTH ATTRIBUTES AND INFLUENCES — AN OVERVIEW

3.1 INTRODUCTION

The project began in the absence of an Australian precedent for defining and surveying old-growth forests. A truly comprehensive study of old-growth forests would have involved the assessment of all of the characteristics of old-growth forests, both primary and secondary characteristics, that were identified in the many definitions of old-growth (summarised in Figure 2.1, Chapter 2). This would have been impractical in the time frame of this project so priority was given to assessing the primary attributes and influences that could be measured efficiently and objectively using remote sensing techniques and archival research. The attributes and influences which were measured in the survey are described as survey parameters. Table 3.1 shows the relationships between old-growth characteristics, attributes, influences and survey parameters.

3.2 SURVEY PARAMETERS

Forest

The first stage of the study was to identify areas of 'forest' in the East Gippsland Forest Management Area. However, no standard definition of forest existed for Australia at the commencement of the study. The National Forest Inventory subsequently defined forest as 'woody vegetation usually with a single stem, having a mature or potentially mature stand height exceeding 5 m with existing or potential projective foliage cover of overstorey strata about equal to or greater than 30% (or crown separation ratio about equal to or less than 0.25)'. This definition does not include woodland categories, and thus a broader definition was adopted for the current survey which defines forest as:

> all woody vegetation with potential height generally greater than 5 metres and crown cover projection generally greater than 10%.

Using a similar definition (with density defined as crown cover foliage projection), a previous study (Gilbee and Goodson, 1992) identified all patches of tree cover in Victoria more than 2 m tall and larger than one hectare through the digital classification of Landsat Thematic Mapper satellite imagery from March 1990. This mapping, presented for all classes of land in the study area at a scale of 1:100 000 and entered into the Department's Geographic Information System, delineated the forest and woody vegetation outlines for the study area (see Map 3). Although over-

Table 3.1 Relationship between old-growth characteristics, attributes, influences and survey parameters.

Characteristics	Attributes or Influences	Survey Parameters	Sources Used in this Study
Structural Attributes			
Structural composition	Growth stage and density	Proportion of canopy by growth stage	Aerial photos, 1990
	Dominant overstorey species, height	Forest type – species and height	Buntine (1974 unpubl.) maps 1:63 630
	Forest	Woody vegetation >5 m tall, and >10% density	Tree cover mapping using Landsat TM 1990 (CNR)
Plant community and diversity	Species composition	Ecological vegetation class and biogeography	Parkes *et al.* (1984), 1:250 000; Geology, 1970s 1:250 000
Oldest trees	Age (years)	Selectively surveyed	Existing studies
Fauna habitat	For example, number and type of hollows	Not surveyed, but linked to growth stage	—
Other vegetative growth forms	For example, epiphytes	Not surveyed	—
Functional Attributes			
Biomass production	For example, gross biomass	Not surveyed	—
Nutrient cycling for; hydrology, energy flow, soil formation succession etc.	Not determined	Not surveyed	—
Proximity to other stands with negligible disturbance histories	Integrity, viability	'Naturalness' indices	Data generated during old-growth forest study
Remoteness from roads and settlement	Wilderness values	Wilderness indices (e.g. Preece and Leslie, 1987)	—

Table 3.1 (continued)

Intangible Attributes			
Engenders feelings of spirituality, wonder	Aesthetic and awe-inspiring qualities	Not surveyed, although considered in descriptions of old-growth forest	—
Appearance of grandeur and antiquity	Apparent age or size of trees	Not surveyed, although considered in descriptions of old-growth forest	—
Disturbance Influences			
Characterised by type and severity	Agricultural clearing	Extent of agricultural selection and clearing within selection	Crown selection records, and growth stage mapping
	Grazing	Intensity, duration and extent of grazing	Historical and contemporary records
	Mining	Extent of timber getting and excavation associated with mining	Historical records
	Weeds	Weed type, influence and distribution	Literature and existing records
	Timber harvesting	Selective logging (pre-1970s)	Historical log allocation licences, interpretation of 1940s and 1950s aerial photographs
	Timber harvesting	Clearfell logging (last 25–30 years)	Compilation of regional utilisation maps; interpretation of 1960s and 1970s aerial photos; interpretation of satellite imagery, 1970s on; interpretation of 1990 aerial photos
	Fire	Fire type (wildfire or fuel reduction burning), extent	Historical records, regional records, interpretation of satellite images, 1970s on
	Pathogen distribution	Historical pathogen distribution	Existing maps (Ward and McKimm (1982)

estimating the extent of forest-only vegetation, the tree cover layer formed a basis for planning mapping and field survey work by clearly depicting the likely extent of the entire forest estate and additional non-forest woody vegetation, on both public and freehold land.

Growth stage and crown cover projection

The ages of forest stands were assessed through the relative stage of growth of the conspicuous strata, usually the upper canopy of the overstorey. Although tree growth stages are considered to be primary old-growth attributes, the rate of development and resultant characteristics of any growth stage are likely to be specific to each ecological vegetation class and forest type and are dependent on site quality.

The study thus initially identified the typical morphological expressions of growth stages for each of the woody vegetation types within the study area by reference to literature and through field inspection. These characteristics were then refined for interpretation from aerial photos and mapped for the entire study area. Crown cover density was mapped simultaneously from the aerial photos. A discussion of this work is given in Chapter 4.

Forest type

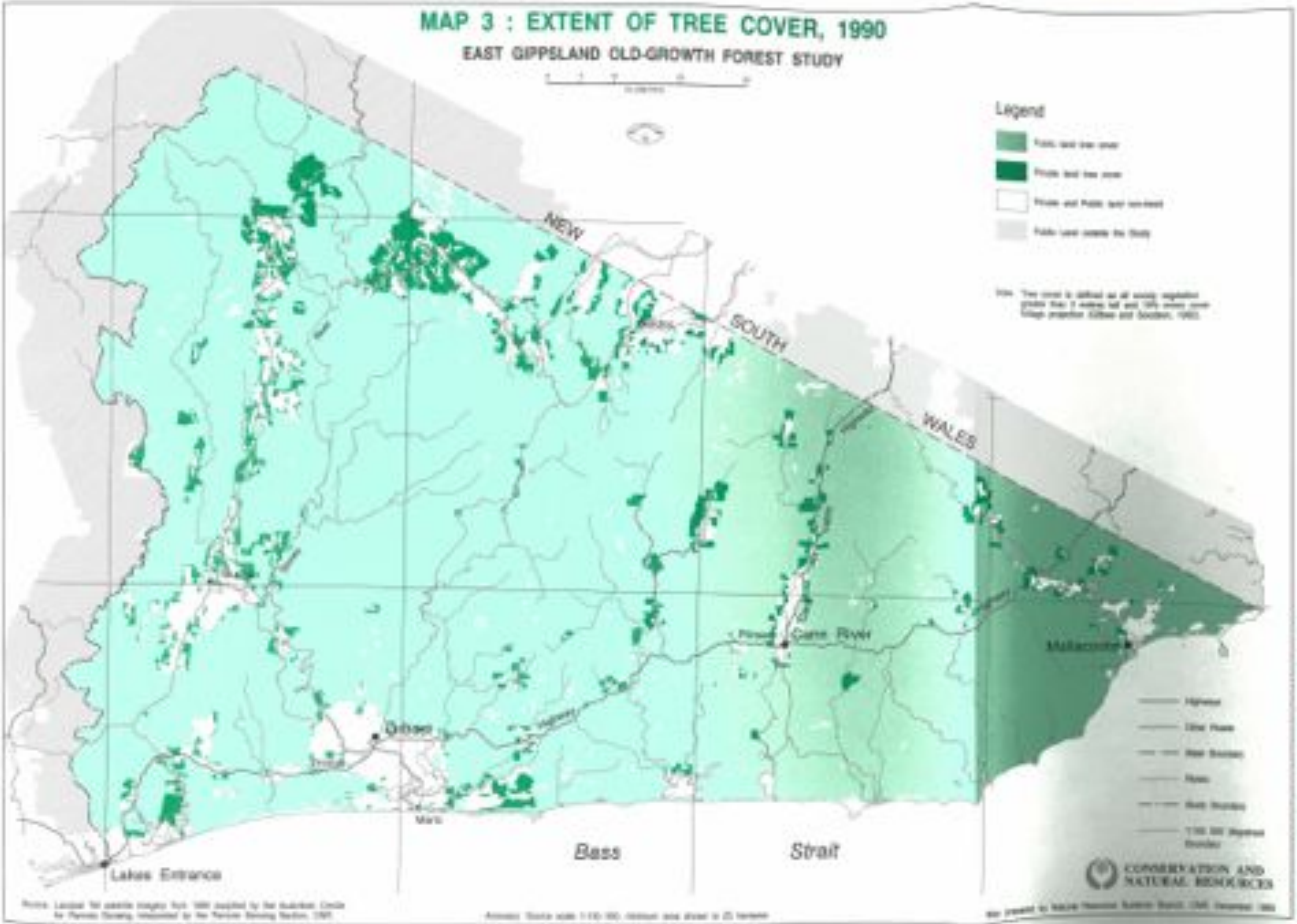
As part of Land Conservation Council's Alpine (1977), Gippsland Lakes Hinterland (1982) and East Gippsland (1974) studies, the public land vegetation of the study area was comprehensively mapped by the former Forests Commission of Victoria at a scale of 1:63 360 for dominant vegetation by species and height. This work produced a series of maps describing the structural vegetation of the area. Where the dominant structural vegetation comprised forest species, it was described in terms of forest types. This forest type mapping was adopted for this survey, and is described in detail in Chapter 5 and Appendix C.

Ecological vegetation classes

Ecological vegetation classes are part of a hierarchy of floristic vegetation descriptions that display correlations with certain quantifiable environmental attributes. Ecological vegetation classes were mapped using a number of sources including the structural forest type mapping, previous floristic vegetation mapping, a comprehensive quadrat dataset, additional aerial photograph interpretation and other data sources. This work is described in detail in Chapter 6 and Appendix E.

Disturbance influences

Research using historic and contemporary records was undertaken to delineate and map the extent and severity of the major disturbances known to have altered the primary attributes (floristics, structure or growth stages) of the forests in the study area. These disturbances were stratified according to their intensity, and were identified as either 'natural' or 'un-natural' (human-induced) disturbances. In the context of this study these un-natural disturbances are intended to refer to European disturbances. Although Aboriginal influences were apparent prior to and during the early years of European settlement, the absence of records of Aboriginal disturbances prevent any useful mapping. It is also noted that Aboriginal influence is likely to have quite different effects on the intangible characteristics of old-growth forests from European influences, although it would be very difficult to qualify these effects. Chapter 7 and Appendix F provides a discussion of this work.



MAP 3 : EXTENT OF TREE COVER, 1990

Tree ageing
Limited investigations into the ages of selected trees were undertaken through dendrochronology studies. This work is discussed in Chapter 8 and Appendix I.

Spatial analysis of survey parameters
A review of the primary characteristics and the survey parameters permitted the creation of a workable definition of old-growth forest. Having mapped and entered this information into the Department's Geographic Information System, it was possible to overlay (combine) and identify the forest type, ecological vegetation class, growth stage and disturbance history of individual forest stands. Thresholds were set for the maximum levels of disturbance and youngest growth stages which could be considered as old-growth forest, and forest stands within these thresholds were identified as old-growth forest. This analysis is discussed in Chapters 9 and 10 and Appendix G.

Old-growth forest values
The concept of old-growth forest values and their role in the ecologically sustainable management of forests is discussed in Chapter 11. Fauna values, contextual (naturalness) values, and intangible values are specifically considered.

Fauna
Although faunal composition is regarded as an important secondary attribute of old-growth forests, time and resources did not allow the inclusion of a faunal survey in this survey. However the results from this survey establish primary habitat variables, such as the growth stages, which are directly related to hollow development and biotic processes associated with old-growth forests. These could be the basis for any subsequent analysis of faunal data. Further discussion of fauna and old-growth forests is provided in Chapter 11 and Appendix H.

4

FOREST GROWTH STAGES — CONCEPTS, CLASSIFICATION AND SURVEY

4.1 CONCEPTS AND DEFINITIONS

Crown cover and growth stage are distinctive forest attributes which characterise the developmental stages of different forest types. Areas that have been disturbed can have an altered proportion of growth stages or crown cover compared to those of undisturbed areas of the same forest type. This can be important in mapping the extent and degree of disturbances which are often only indicated imprecisely on maps in historic records.

Crown cover

Crown cover is used as a description of the amount of foliage in a given area of vegetation. A number of definitions of crown or foliage cover have been developed for vegetation, together with a variety of techniques for their measurement (McDonald *et al.* 1990):

- *Crown cover* is the percentage of the sample site within the vertical projection of the periphery of tree crowns; crowns are treated as opaque.
- *Foliage cover* is the percentage of the sample site occupied by the vertical projection of foliage and branches (if woody).
- *Projective foliage cover* is the percentage of the sample site occupied by the vertical projection of foliage only.

As crown cover is the simplest to measure and use, especially when mapping from aerial photographs, it was adopted for this study.

Growth stages

At different stages in their development, trees can exhibit different forms or growth stages. While the growth stages of some species are distinctive and well-documented, our understanding of the stages of other species is far from complete. Jacobs (1955) described typical eucalypt growth stages in terms of tree morphologies. These are summarised below. (Jacobs did not identify the early or late mature growth stages; these have been interpreted by this study from the detailed descriptions in Jacobs [1955]).

Initially, in the JUVENILE stage, all leaves have a juvenile form and grow on the main stem. As the seedling exceeds around 60 cm in height, second and third order branches develop.

At the SAPLING stage, competing branches vying for dominance form a crown of small branches which is typically pointed in profile. The leaves may be a combination of juvenile, intermediate and mature forms.

The POLE stage is characterised by a strongly developed main stem. Semi-permanent branches growing on the main stem below the upper crown develop from some of the competing branches of the sapling stage, and the leaves are mostly mature. A young eucalypt enters this stage after it has gained a certain height, and the age at which it enters this stage is dependent on site quality.

In the EARLY MATURE stage, large permanent 'shaping' branches develop and form the framework of the crown. Semi-permanent branches grow not only from the main stem but also from these permanent branches.

The MATURE stage persists for a long time, and, although branches thicken, height and crown spread may change very little over this time in dense stands. As branches grow further from the main trunk and lose their apical dominance, epicormic shoots develop from dormant buds on the top and sides of the shaping branches closer to the main trunk.

In the LATE MATURE stage the tree may develop large numbers of 'bayonets', dead branches from deceased leaf-bearing units, warts and burls, and some dead shaping branches.

The OVERMATURE stage is characterised by declining crown leaf area. As major shaping branches are shed, epicormic growth develops from the trunk, to replace the lost leaf area, but which is never as persistent as the permanent shaping branches. The trunk and shaping branches are eventually weakened by fungal attack, causing shaping branches and often the top of the tree to fail and break. The trunk or tree bole is characteristically covered in burls and bumps.

The growth stages of some eucalypt and non-eucalypt species do not conform to the typical growth habit described by Jacobs and are not well understood. These differences in growth habits may be due to genetic factors (e.g. mallee form trees) or environmental factors (such as poor sites). These species are assumed to pass through the same growth stages as described by Jacobs. However, there is a need for further work to generate descriptions of the typical growth forms of these species.

4.2 SURVEY METHOD

The old-growth study mapped the forests of the East Gippsland Forest Management Area according to the primary attributes of growth stages and crown cover through the use of aerial photograph interpretation (API).

Aerial photograph interpretation is performed by stereoscopically viewing pairs of adjoining photographs and is a technique widely used in forest resource inventory and also in surveys of land use, landform, geology and vegetation. Besides being able to establish physical attributes of a particular forest stand such as the percentage crown cover, API is capable of identifying different growth stages of eucalypt and some non-eucalypt trees. The eucalypt growth stages described by Jacobs (1955) are discernible from aerial photographs, although the level of detail varies with the scale and quality of photographs used. A diagrammatic representation of the typical shape of trees of the older growth stages, both in cross section and viewed vertically from aerial photographs, is given in Figure 4.1.

Aerial photograph interpretation was used to identify the crown cover projection and relative proportion of growth stages in the upper stratum in each distinct stand (polygon) of forest. Complete air photo coverage of the study area was available from a combination of air photo projects from 1987, 1990 and 1992. All photos were at a scale of 1:40 000.

The crown cover projection percentage of each stand (polygon) of forest was estimated according to the classes in Table 4.1.

Table 4.1 Crown cover projection classes

Class	Crown cover (%)
1	<10
2	10–29
3	30–49
4	50–69
5	>70

The growth stage categories used in this project were based on Jacobs (1955) description but were modified according to the detail evident from 1:40 000 scale air photos (Table 4.2). Very young regeneration (juvenile trees) appeared flat in texture and individual crowns were not evident, whereas regrowth (saplings and poles) presented small, tight and discrete crowns. The mature growth stage was characterised by full, rounded crowns, compared with late mature and overmature trees which displayed a more open crown with large numbers of dead and dying branches and which appeared lighter in colour than younger trees of the same species. These late mature and overmature growth stages were combined for the purposes of this study and re-named the SENESCING growth stage.

All of the Jacobs growth stages were apparent from aerial photograph interpretation in most vegetation classes. However, in non-Jacobs forest stands (that is, stands not exhibiting typical form as described by Jacobs (1955)) particularly on poorer quality sites where crown size was small, senescing features were not apparent from air photos and the forest stands could only be classified as 'regrowth' or 'mature'. Consequently eucalypt dominated non-Jacobs forest stands classified in this way were of a more senescent growth stage than the classification suggested (for example, a Shrubby Dry forest classified as 'mature' from air photos was actually found to be 'senescing' through field inspection). Note that no growth stage mapping from aerial photo interpretation was undertaken for non-Jacobs forests that did not contain eucalypts (eg rainforest, callitris stands and some areas of blackthorn scrub) because time did not permit the development of detailed growth stage morphologies for these species. Thus, in this study, non-Jacobs forests were composed of two categories; eucalypt forests which produced senescing characteristics that were not visible from air photos, and forest which did not produce any classic Jacobs senescing characteristics even when examined on the ground.

However, for future studies it is recommended that the term non-Jacobs be reserved specifically for those forests that do not produce any evidence of classic Jacobs senescing characteristics.

The relationship between the growth stages apparent from aerial photograph interpretation and the actual growth stage present is shown for Jacobs, non-Jacobs and non-eucalypt forest in Table 4.3 and Figure 4.2.

For the purposes of this study the actual growth stages of senescing, mature, regrowth and regeneration were adopted as the critical growth phases through which all forest stands must pass in order to reach an old-growth state. For the oldest mapped growth stages of non-Jacobs forest stands, which were mapped as a mature class, a reclassification to a senescing class was required. Vegetation classes which exhibit non-Jacobs growth forms were identified in Table 6.2 (Chapter 6) and re-classified in Step 4, Chapter 8 (see also Appendix G for details).

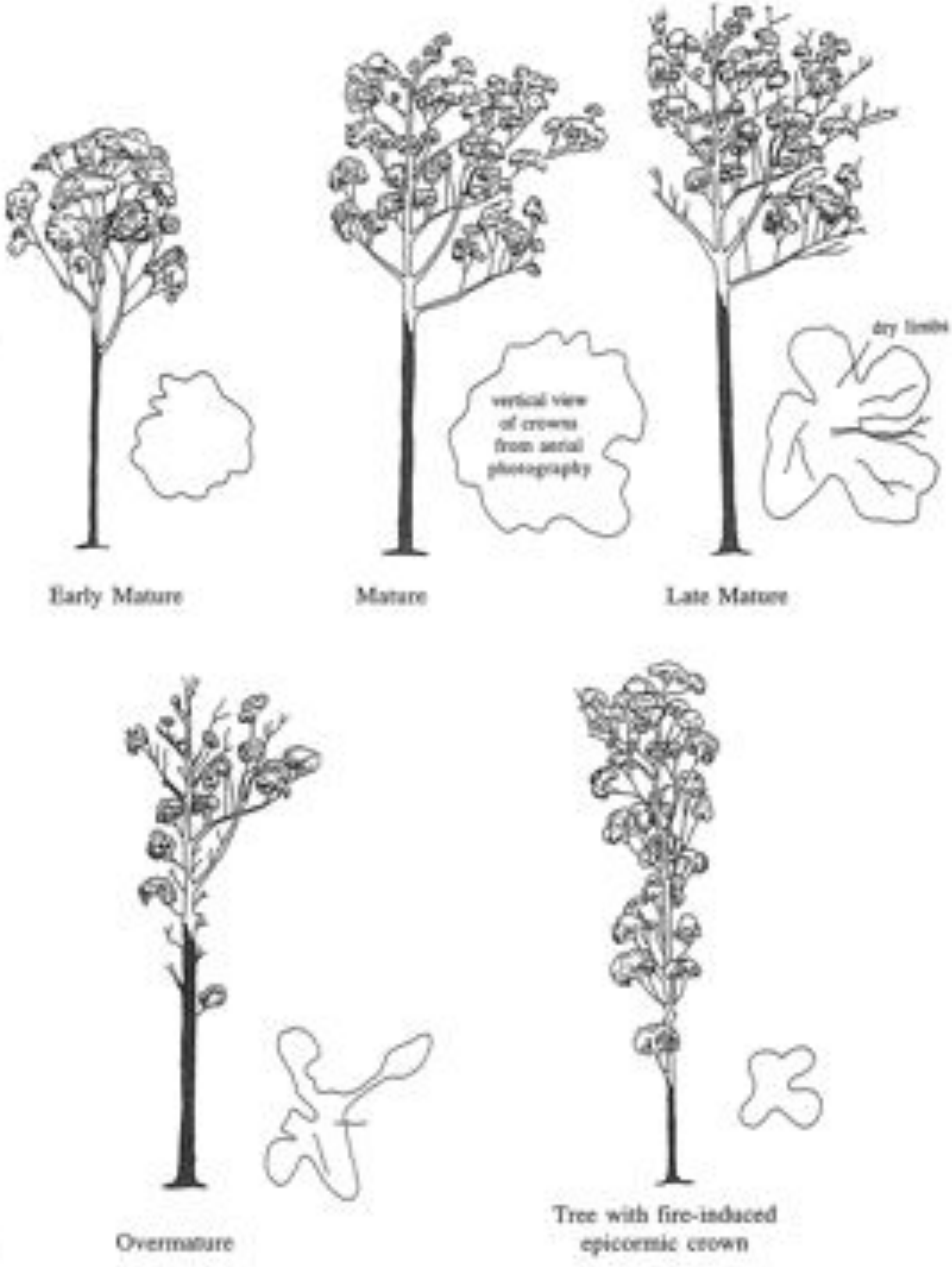


Figure 4.1 The morphological relationship between tree shape when viewed in cross section (from the ground) and vertically (from the aerial photography) for the mature growth stages of Jacobs (1955).

Table 4.2 Classification of growth stages from aerial photo interpretation

Jacobs (1955)	Old-growth project	Morphological characteristics identifiable from air photographs
overmature late mature	senescing	some crown units dead and dying; crowns less rounded and lighter in colour than in younger mature trees of the same species
mature early mature	mature	rounded crown view; well-foliated crown; may be taller than regrowth of the same species
pole	regrowth	narrow, conical crown
sapling juvenile	regeneration	smooth, flat appearance (individual crowns not discernible)

Table 4.3 The relationship between actual growth stages and the classifications made in Jacobs and non-Jacobs forests

Actual growth stage	Jacobs forest	Classification for non-Jacobs forest as detected by aerial photo-interpretation
senescing	senescing	mature
mature	mature	mature
regrowth	regrowth	regrowth
regeneration	regeneration	regeneration

Table 4.4 Crown cover proportions for each growth stage within each mapped stand of forest

Class	Description[1]	Proportion of each growth stage within the stand (from an air photo perspective)
d	dominant	occupies larger crown area than other growth stages that may be present (approximately twice the area of any other growth stage present, generally >50%)
c	codominant	occupies equal crown area with other growth stage(s) (broadly ranging from 30–50%)
s	subdominant	lesser crown area than other dominant growth stages that may be present (approximately half the area of dominant or codominant growth stage(s), maximum range 11–50%)
t	sparse	generally less than 10% of the total crown area
–	absent	not apparent in the upper stratum

1 The use of the word dominant refers to the area occupied by the crowns of each growth stage in the upper stratum of each forest stand (or polygon). It does not refer to the vertical structure through the profile of crowns.

Characteristics detectable from aerial photographs	Pointed crowns. Low height		Rounded crown view. Reasonable height compared to regrowth	Crown opening up. Crown limbs still healthy	Good proportion of crown limbs dead or dying, but not fallen. Crown shapes may be distorted due to exposure	Stag headed. Numerous trunk epiphytes. Crown view no longer rounded
API growth stages (non-Jacobs)	Regeneration	Regrowth	Mature		Not detectable from API	
API growth stages (Jacobs)	Regeneration	Regrowth	Mature		Senescing	
Modified Jacobs (1955)	Regeneration	Regrowth	Early mature	Mature	Late mature	Overmature
Jacobs (1955) growth stages	Juvenile / Sapling	Pole	Mature			Overmature

Figure 4.2 The relationship between the growth stage characteristics apparent from aerial photo interpretation (API) and the growth stages of both Jacobs and non-Jacobs trees.

Morphological characteristics and stand structure for a broad range of typical species in a variety of ecological vegetation classes are illustrated in Figures 4.3 to 4.8. These figures contrast the features of both Jacobs and non-Jacobs tree morphologies for several growth stages.

Most stands of forest contained more than one growth stage in the upper stratum or canopy, and it was therefore necessary to estimate the relative proportion of each growth stage present in the upper stratum of each patch of forest. This was done through aerial photo interpretation of the proportion of each growth stage (senescing, mature and regrowth or younger) present in the upper stratum of each stand that was mapped as a discrete patch (or polygon) of forest cover. Categories used to assign crown cover projection densities for each growth stage are shown in Table 4.4.

The precise meaning of each crown cover projection class varied depending on which other classes were also present. For example, when only one growth stage was evident, 'dominant' signified 100% crown cover projection. However, 'dominant' could also signify only 50% in the context of two other subdominant (approximately 25% crown cover projection) growth stages.

Each stand (polygon) of forest identified on the aerial photograph, was described with a four-character label *axyz*, where *a* represented the total crown cover percentage class (classes 1 to 5), and *x*, *y* and *z* represented the relative proportions of the senescing, mature and regrowth stages respectively (classes *d*,*c*,*s*,*t*,–). For example, a polygon label might be 4*sd*–, where:

- 4 indicates that the total crown cover projection class for that polygon is 50–69%
- *s* indicates that senescing crowns are subdominant in the upper stratum.
- *d* indicates that mature crowns dominate the upper stratum of the polygon.
- – indicates that no regrowth (or younger crowns) are present.

In some instances other more subjective features of individual polygons were also noted on the air photos with a fifth symbol; for example, the likelihood of fire disturbance was surmised from polygons with a high proportion of senescing trees with dense regeneration or regrowth; and probable selective logging was surmised from polygons dominated by mature and senescing trees but with a lower crown cover percentage than adjacent stands. These observations were not intended to be diagnostic but were included to provide some descriptive information for the interpretation of the data during the analysis stage later in the project.

No attempt was made to map emergent stags although it is recognised that these form an important component of the habitat for old-growth dependent fauna. Surveys at larger scales than this one would be required to detect and adequately map stags.

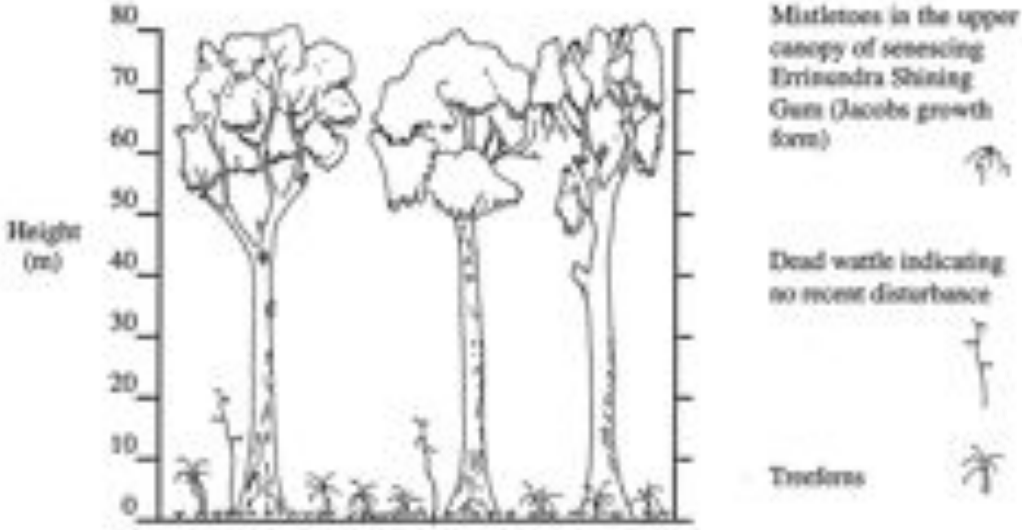


Figure 4.3 Senescing and mature growth stages of Errinundra Shining Gum *E. denticulata* (Jacobs growth form) in Wet Forest (high environmental site quality). (Gap Road 2 km east of the Bonang Highway south of Bonang.)
Forest type: Shining Gum
Growth Stage: Senescing subdominant, mature dominant, no regrowth

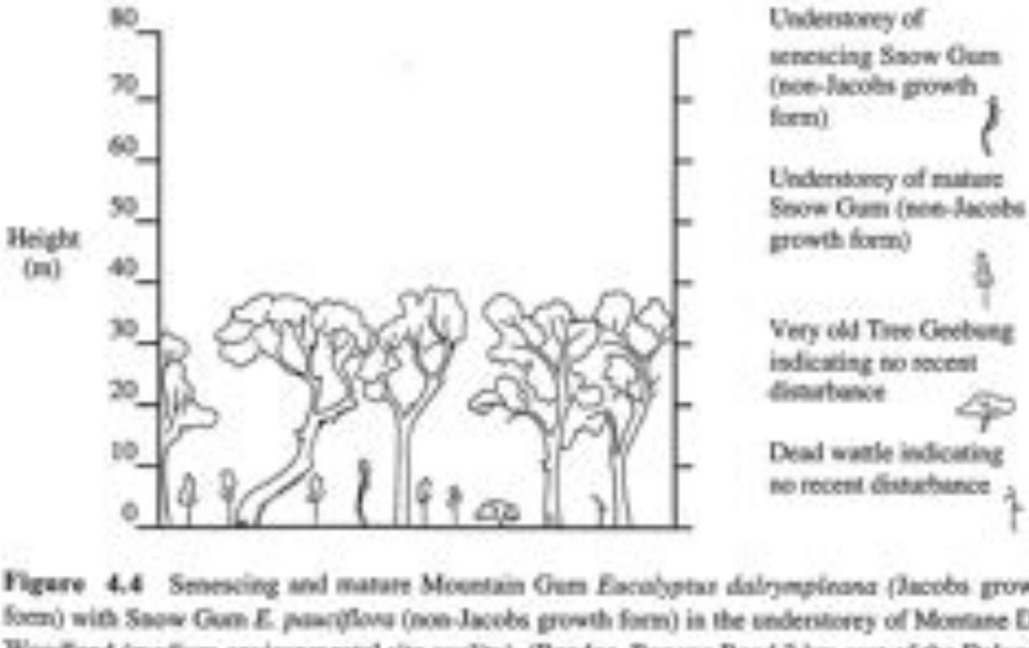


Figure 4.4 Senescing and mature Mountain Gum *Eucalyptus dalrympleana* (Jacobs growth form) with Snow Gum *E. pauciflora* (non-Jacobs growth form) in the understorey of Montane Dry Woodland (medium environmental site quality). (Bendoc–Bonang Road 2 km east of the Delegate River.)
Forest type: Peppermint–Gum
Growth stage: Senescing subdominant, mature dominant, no regrowth

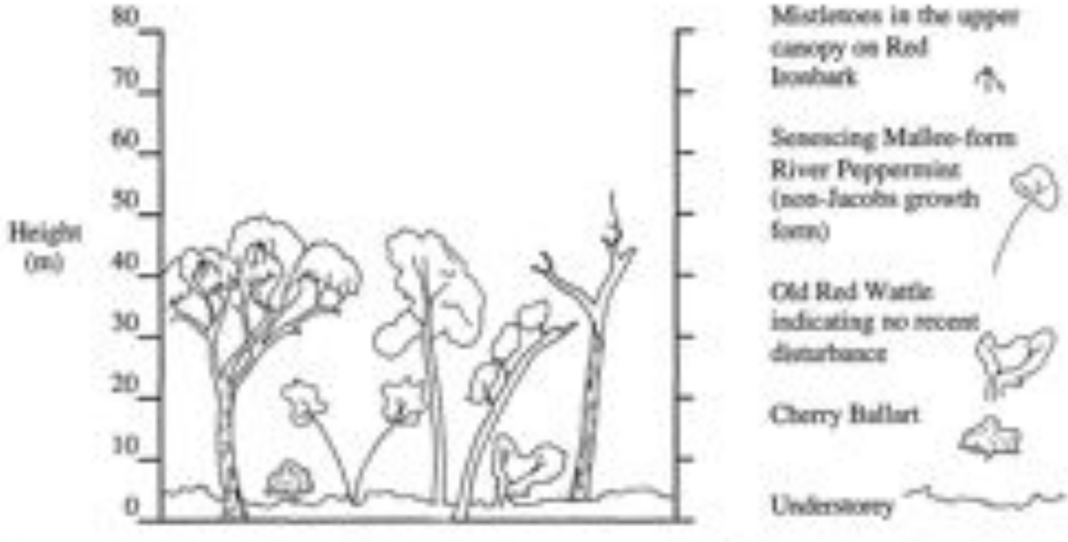


Figure 4.5 Senescing Red Ironbark *Eucalyptus tricarpa*, Red Box *E. polyanthemos* (Jacobs growth form) and mature Gippsland Blue Gum *E. globulus ssp. pseudoglobulus* (both Jacobs growth form) with an occasional mid-storey of mallee-form senescing River Peppermint *E. elata* (non-Jacobs growth form) in Box-Ironbark Forest (low to medium environmental site quality). (Scanlon's Creek Track 700 m from Paradise Ridge Road, south of Goongerah.)
Forest type: Stringybark
Growth stage: Senescing subdominant, mature dominant, no regrowth

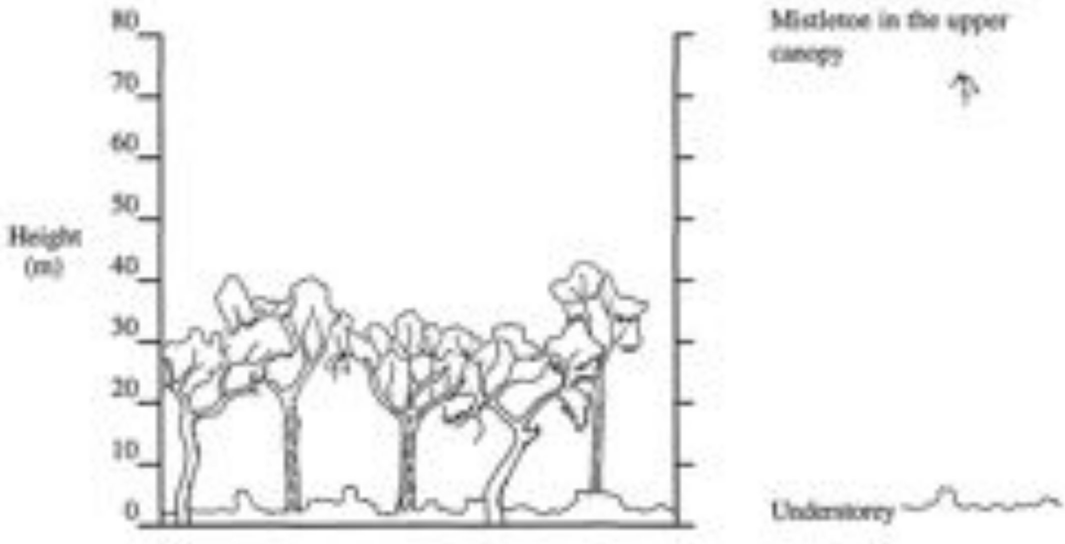


Figure 4.6 Senescing Silvertop Ash *Eucalyptus sieberi* and Bloodwood *E. gummifera* (with Jacobs growth form) over a diverse shrubby understorey in Lowland Forest (medium environmental site quality). (The corner of Rocky Ridge Track and Shipwreck Track west of Mallacoota.)
Forest type: Silvertop-Bloodwood
Growth Stage: Senescing subdominant, mature dominant, no regrowth

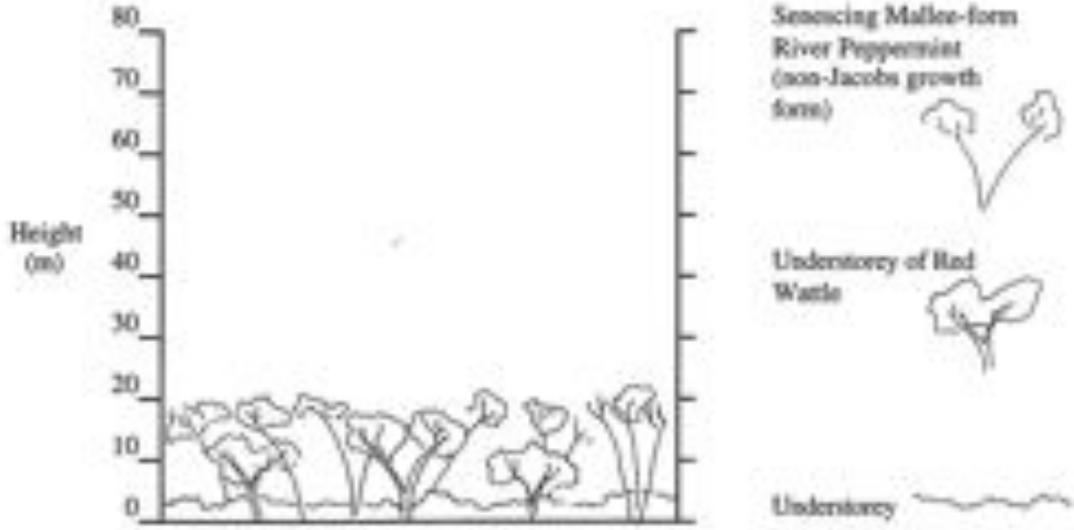


Figure 4.7 Senescing mallee-form River Peppermint *Eucalyptus elata* (non-Jacobs growth form) with a mid-storey of Red Wattle *Acacia silvestris* in Rocky Outcrop Scrub (low site quality). (Between Raymond Creek and West's Track north-west of Orbost.)
Forest type: Stringybark
Growth Stage: Mature only

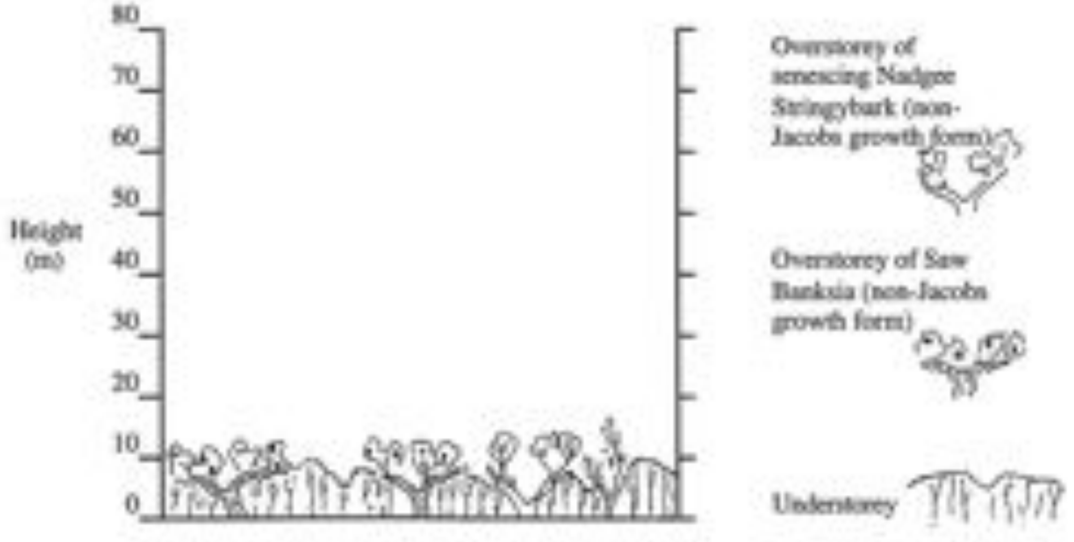


Figure 4.8 Senescing Nadgee Stringybark *Eucalyptus* sp. aff. *globoidea* (non-Jacobs growth form) with Saw Banksia *Banksia serrata* (non-Jacobs growth form) in Coast Banksia Woodland (low site quality). (Pearl Point Road south-west of Bemm River Township.)
Forest type: Stringybark
Growth Stage: Mature Only

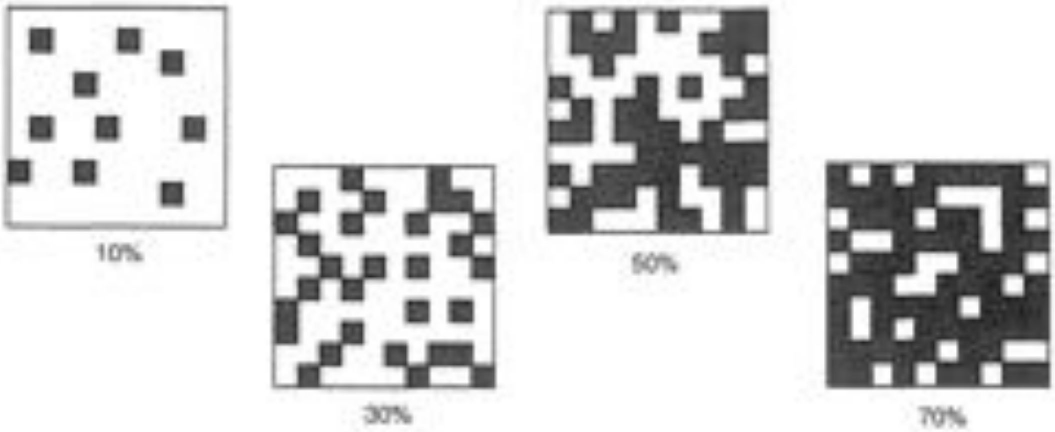


Figure 4.9 Crown densities used to assist the aerial photo interpretation. The black squares represent tree crowns which are taken to be opaque when assessing crown cover.

Field checking was conducted throughout the survey to assess the accuracy of growth stage identification and crown cover mapping. Prior to the mapping of crown cover, the air photo interpreters established ground trials to calibrate measurements from the photographs. A series of diagrams (Figure 4.9) were also used as an aid to maintain uniform assessments of crown density throughout the study. The crown cover mapping was further checked on selected stands through the application of the field-based crown cover estimation technique of McDonald *et al.* (1990) and Walker *et al.* (1988), which is described in Appendix B.

Limitations

The API provides a valuable assessment of structural forest attributes in East Gippsland. For any and every given hectare of forest however, there are a number of factors which constrain the absolute accuracy of the information collected by API:

- Although API was confirmed in the field, field checking was generally restricted to areas accessible by road or track.
- Field inspection indicated that senescing features apparent from the ground were not always fully apparent from an aerial perspective and as a consequence the actual proportion of senescing trees was sometimes underestimated. Regrowth crowns beneath the overstorey are difficult to detect from API and were specifically excluded from the mapping.
- As the 'mature' class embraces a long period of forest development, 'older mature' forests were not differentiated from 'young mature' forests.
- The relatively small scale of the air photos resulted in the API being most accurate in Jacobs forests with large crowned trees. In non-Jacobs forests with small crowns (for example, on fire-prone and low site quality locations in Shrubby Dry Forests), no differentiation between senescing and mature growth stages was possible from the air photos. On-ground inspection revealed that senescing features *sensu* Jacobs (1955) did not develop in the lower height classes of some species in these ecological vegetation classes (refer to discussion in Section 4.2).
- Some stands which were mapped as senescing were likely to have been of a younger growth stage subject to the influence of recent wildfire. However, wherever possible the mapping attempted to indicate recently fire affected crowns.
- No assessment of the growth stages of non-eucalypt forests was attempted.
- There was no field checking of forest type or growth stages on private land.

Despite the limitations discussed above, field checking and ground truthing has confirmed the value of API as a technique for mapping growth stages and crown cover. Given the scale of the maps and photographs, the time available, the large area surveyed and the presentation scale of the results, the survey has produced a comprehensive and reliable database of forest growth stages and crown cover.

4.3 RESULTS

Approximately 700 aerial photographs at a scale of 1:40 000 were interpreted to produce a map of the current growth stages and crown cover projection of all forested areas, public and private, within the study area. The total number of distinct growth stage polygons in the study area was in excess of 11 000, representing 977 802 ha of forested vegetation. The total number of unique combinations of polygons by growth stage and crown cover projection was 218 or 68 if the crown cover projection classes were disregarded. These were further reduced to 32 classes for the final analysis by aggregating those growth stages which were only a few hectares in size. The minimum polygon size was approximately 10 ha; however, the average polygon size was approximately 80 ha.

The 32 growth stage classes are shown in Table 4.5. They are ranked in descending order of relative proportions of oldest growth stages. These growth stage class rankings do not necessarily reflect absolute ages of individual stands. For example it is not known for certain if senescing trees from a Wet Forest class within the wet climate refuges at Errinundra Plateau are any older than senescing trees from the same vegetation class in gullies outside the Plateau.

The area statements for the forest growth stage classes on public and freehold land are presented in Table 4.6. Over 86% (918 833 ha) of public land contains forest for which growth stage classes were identified compared with 37% (58 969 ha) for freehold land.

The area of senescing dominated, mature dominated and regrowth dominated growth stages on public land as determined through aerial photo interpretation prior to any re-assignment of growth stage for non-Jacobs vegetation types was 25 019 ha (3%), 791 459 ha (86%) and 102 355 ha (11%) respectively. On freehold land these figures were 892 ha (<2%), 50 398 (85%) and 7679 ha (13%) respectively.

As previously mentioned, the aerial photo interpretation underestimated the area of senescing growth stages in those vegetation classes which did not show classic Jacobs growth form (Table 6.2, Chapter 6). This limitation was corrected later in the analysis (Chapter 10) following the identification of those vegetation classes. The growth stage mapping was captured digitally and added as a thematic layer to CNR's corporate GIS database.

Table 4.5 Mapped growth stage classes broadly ranked in descending order of relative proportions of oldest growth stages.

Growth stages		Label
Senescing		
S_1	senescing only	*d – –*
S_2	senescing dominant, sparse mature, no regrowth	*d t –*
S_3	senescing dominant, mature subdominant, no regrowth	*d s –*
S_4	senescing dominant, sparse mature and regrowth	*d t t*
S_5	senescing and mature codominant, no regrowth	*c c –*
S_6	senescing and mature codominant, sparse regrowth	*c c t*
S_7	senescing dominant, sparse mature, regrowth subdominant	*d t s*
S_8	senescing dominant, no mature, regrowth subdominant	*d – s*
Mature		
M_1	senescing subdominant, mature dominant, no regrowth	*s d –*
M_2	senescing subdominant, mature dominant, sparse regrowth	*s d t*
M_3	sparse senescing, mature dominant, no regrowth	*t d –*
M_4	sparse senescing, mature dominant, sparse regrowth	*t d t*
M_5	senescing, mature and regrowth codominant	*c c c*
M_6	senescing subdominant, mature dominant, regrowth subdominant	*s d s*
M_7	senescing subdominant, mature and regrowth codominant	*s c c*
M_8	sparse senescing, mature dominant, regrowth subdominant	*t d s*
M_9	mature only	*– d –*
M_{10}	no senescing, mature dominant, sparse regrowth	*– d t*
M_{11}	no senescing, mature dominant, regrowth subdominant	*– d s*
Regrowth		
R_1	senescing and regrowth codominant, no mature	*c – c*
R_2	senescing and regrowth codominant, sparse mature	*c t c*
R_3	senescing and mature subdominant, regrowth dominant	*s s d*
R_4	senescing subdominant, sparse mature, regrowth dominant	*s t d*
R_5	senescing subdominant, no mature, regrowth dominant	*s – d*
R_6	sparse senescing, mature and regrowth codominant	*t c c*
R_7	sparse senescing, mature subdominant, regrowth dominant	*t s d*
R_8	sparse senescing, sparse mature, regrowth dominant	*t t d*
R_9	sparse senescing, no mature, regrowth dominant	*t – d*
R_{10}	no senescing, mature and regrowth codominant	*– c c*
R_{11}	no senescing, mature subdominant, regrowth dominant	*– s d*
R_{12}	no senescing, sparse mature, regrowth dominant	*– t d*
R_{13}	regrowth only	*– – d*

Table 4.6 Forest growth stage classes (ha) on public and freehold land within the study area as mapped through aerial photo interpretation.[1,2]

Growth Stages		Public Land	F'hold Land	Total
Senescing				
S_1	senescing only	6 946	273	7 219
S_2	senescing dominant, sparse mature, no regrowth	2 597	47	2 644
S_3	senescing dominant, mature subdominant, no regrowth	1 358	14	1 372
S_4	senescing dominant, sparse mature and regrowth	1 215	0	1 215
S_5	senescing and mature codominant, no regrowth	9 431	513	9 944
S_6	senescing and mature codominant, sparse regrowth	361	0	361
S_7	senescing dominant, sparse mature, regrowth subdominant	2 357	45	2 402
S_8	senescing dominant, no mature, regrowth subdominant	754	0	754
Mature				
M_1	senescing subdominant, mature dominant, no regrowth	156 721	4 651	161 372
M_2	senescing subdominant, mature dominant, sparse regrowth	23 402	1 104	24 506
M_3	sparse senescing, mature dominant, no regrowth	235 470	13 597	249 067
M_4	sparse senescing, mature dominant, sparse regrowth	20 322	816	21 138
M_5	senescing, mature and regrowth codominant	1 337	0	1 337
M_6	senescing subdominant, mature dominant, regrowth subdominant	14 532	733	15 265
M_7	senescing subdominant, mature and regrowth codominant	995	126	1 121
M_8	sparse senescing, mature dominant, regrowth subdominant	35 978	1 432	37 410
M_9	mature only	244 090	23 181	267 271
M_{10}	no senescing, mature dominant, sparse regrowth	19 292	1 287	20 579
M_{11}	no senescing, mature dominant, regrowth subdominant	39 320	3 471	42 791
Regrowth				
R_1	senescing and regrowth codominant, no mature	2 744	82	2 826
R_2	senescing and regrowth codominant, sparse mature	4 494	93	4 587
R_3	senescing and mature subdominant, regrowth dominant	5 381	124	5 505
R_4	senescing subdominant, sparse mature, regrowth dominant	2 841	32	2 873
R_5	senescing subdominant, no mature, regrowth dominant	5 009	342	5 351
R_6	sparse senescing, mature and regrowth codominant	7 003	723	7 726
R_7	sparse senescing, mature subdominant, regrowth dominant	16 652	1 065	17 717
R_8	sparse senescing, sparse mature, regrowth dominant	9 015	1 036	10 051
R_9	sparse senescing, no mature, regrowth dominant	4 736	112	4 848
R_{10}	no senescing, mature and regrowth codominant	12 359	702	13 061
R_{11}	no senescing, mature subdominant, regrowth dominant	17 602	1 414	19 016
R_{12}	no senescing, sparse mature, regrowth dominant	3 382	118	3 500
R_{13}	regrowth only	11 137	1 836	12 973
All Growth Stages	Total	918 833	58 969	977 802

1 Growth stage classes M_1 to M_4, M_9 and M_{10} contain some areas of non-Jacobs vegetation classes that were known to be of senescing dominated growth stages (see discussion Section 4.2). Only by examining the growth stages in combination with the vegetation mapping (Chapters 5 and 6) could these growth stages be revised for public land (Chapter 10). The procedure for this revision is detailed in the 'GIS Analysis Stages Table' in Appendix G. However, as no vegetation class mapping was undertaken on freehold land growth stage class revisions could not be undertaken for freehold land.

2 Areas (ha) shown are reliable to the nearest 5 ha (approx.).

5
FOREST TYPE AND STRUCTURE

5.1 PREVIOUS WORK

Forest type mapping is a form of structural vegetation mapping which combines common dominant overstorey assemblages with top height class categories and is modified from Specht (1970). This form of forest vegetation mapping is common in Australia, notably that of Baur (1965) in New South Wales and many workers in Victoria. This form of vegetation classification has been widely applied in Victoria and provides a good guide to environmental site productivity and hence the location quality and economic value of timber resources. It is also valuable for wildlife habitat research and planning. The forest type information is most reliable, being based on large scale mapping with intensive ground truthing.

The vegetation of the public land in the study area had been thoroughly mapped for dominant species, crown cover and height during the 1970s (Buntine, 1974, unpubl.) to provide vegetation maps for land use studies by the Land Conservation Council.

The classification of the structural vegetation (Table 5.1) was based on four primary characteristics; species type, life form and height of the tallest stratum, and projective foliage cover as follows:

(i) Species type: For each density and height class three structural layers were described:
- major species of the tallest stratum,
- associated tree species,
- very sparse (<10%) tree species.

(ii) Life form and height of tallest stratum:
- trees (>40 m, 28–40 m, 15–28 m, and 5–15 m),
- shrubs (2–8 m, and 0–2 m),
- herbs, sedges, lichens, forbs and grasses.

(iii) Projective foliage cover (density of the tallest stratum) based on four classes:
- dense (70–100%),
- mid-dense (30–70%),
- sparse (10–30%),
- very sparse (<10%).

Forest types were mapped onto 1:63 360 base maps from stereo air photo interpretation, extensive field work and by reference to existing assessments. This information was summarised in land use surveys published as a series of Land Conservation Council reports (LCC 1974, 1977, 1982).

Table 5.1 Structural forms of vegetation (modified from Specht, 1970) as mapped for LCC Land Use Studies by Buntine 1974 (unpublished).

Form and height of tallest stratum	Projective foliage cover of tallest stratum			
	Dense (70–100%)	Mid dense (30–70%)	Sparse (10–30%)	Very Sparse (<10%)
Trees[1,2] >40 m	—	Open forest IV (M_1, M_2, Wb, Ni, A, F)	—	—
28–40 m	—	Open forest III (M_3, S_3, Rb_3, As, P_3)	Woodland III (M_3, S_3, Rb_3, As, P_3)	—
15–28 m	Closed forest[3] (W, Ac)	Open forest II (Y, S_4, Rb, P_4, B)	Woodland II (Y, S_4, Rb, P_4, B, Ca, 6)	Open woodland II (Y, S_4, Rb, P_4, B, Ca)
5–15 m	Closed forest[3] (W, Ac, Po)	Open forest I (B, Ca, Sag)	Woodland I (Po, B, Ca, 6, Y)	Open woodland I (Po, B, Ca, 6)
Shrubs[2] 2–8 m	Closed scrub (O)	Open scrub (O)	—	—
0–2 m	Closed heath (O)	Open heath (O)	—	—
Herbs, including grasses, moss, ferns, lichens <2 m	Closed herbland, including: closed tussock grassland, herbfield, sedgeland (O)	Herbland including: tussock grassland, grassland, herbfield, sedgeland (O)	—	—

Notes:
The symbols contained in brackets are Buntine's (1974, unpubl.) original descriptors. They are keyed in Table 5.2 to more detailed descriptions of each class, together with the overlapping codes of the LCC and former FCV mapping, and described at length in Appendix C. For those Buntine codes not contained in Appendix C there are no known original descriptions.

1 Isolated trees (emergents) may project from the canopy of some forest types. Heights are of mature forest types.

2 A tree is defined as a woody plant more than 5 m tall, usually with a single stem. A shrub is a woody plant less than 8 m tall, frequently with many stems arising at or near the base.

3 Closed forest included rainforest and blackthorn scrub (Rocky Outcrop Scrub). Small areas of Closed Forest (Type 'a') were denoted Po, however most rainforest had no descriptor, instead it was represented by a hatching, whilst blackthorn scrub had the symbol W or Ac.

The line work for these forest type maps was manually combined with the ecological vegetation class mapping (Chapter 6) and converted to a digital form using a scanner for entry to the GIS at a nominal scale of 1:63 360. This digital database was registered to the 1:100 000 AMG base map.

5.2 MAPPING REVISION

In general the mapping of forest types was excellent and suitable for immediate use. Little updating of the original mapping was necessary. However, the mid elevations of the Alpine Study Area between 300–1000 m required some revision. In the area to the south of Gelantipy and north of Buchan between the Timbarra and the Murrindal rivers more recent species mapping was used (Roberts, 1992, unpubl.). This mapping provided detailed dominant eucalypt assemblages without height class information. The only other section of the Alpine Study Area that required revision was between the Murrindal and Snowy Rivers (south of Gelantipy and North of Buchan). Aerial photographic interpretation at the scale of 1:40 000 was used to overcome deficiencies in the original information.

5.3 RESULTS

Table 5.2 details the forest type classes and their major tree species for the mapping of the East Gippsland, Gippsland Lakes Hinterland and Alpine study areas that are of relevance to the old-growth forest study for the East Gippsland Forest Management Area. Four different coding systems were used for the forest types of the study area. These disparate codes have been reconciled into a consolidated suite of area statements by making some assumptions about the precise meaning of each code.

For the purposes of this report 31 forest types on public land in the study area have been described. The most extensive forest types were found to be Stringybark A (28–40 m height) with 258 184 ha, Messmate Gum B (28–40 m height) with 231 216 ha and Red Stringybark–Yertchuk (15–28 m) with 57 199 ha. Box forests also occupy a significant area with 32 283 ha. A generalised version of the forest types for public land within the study area is shown in Map 4.

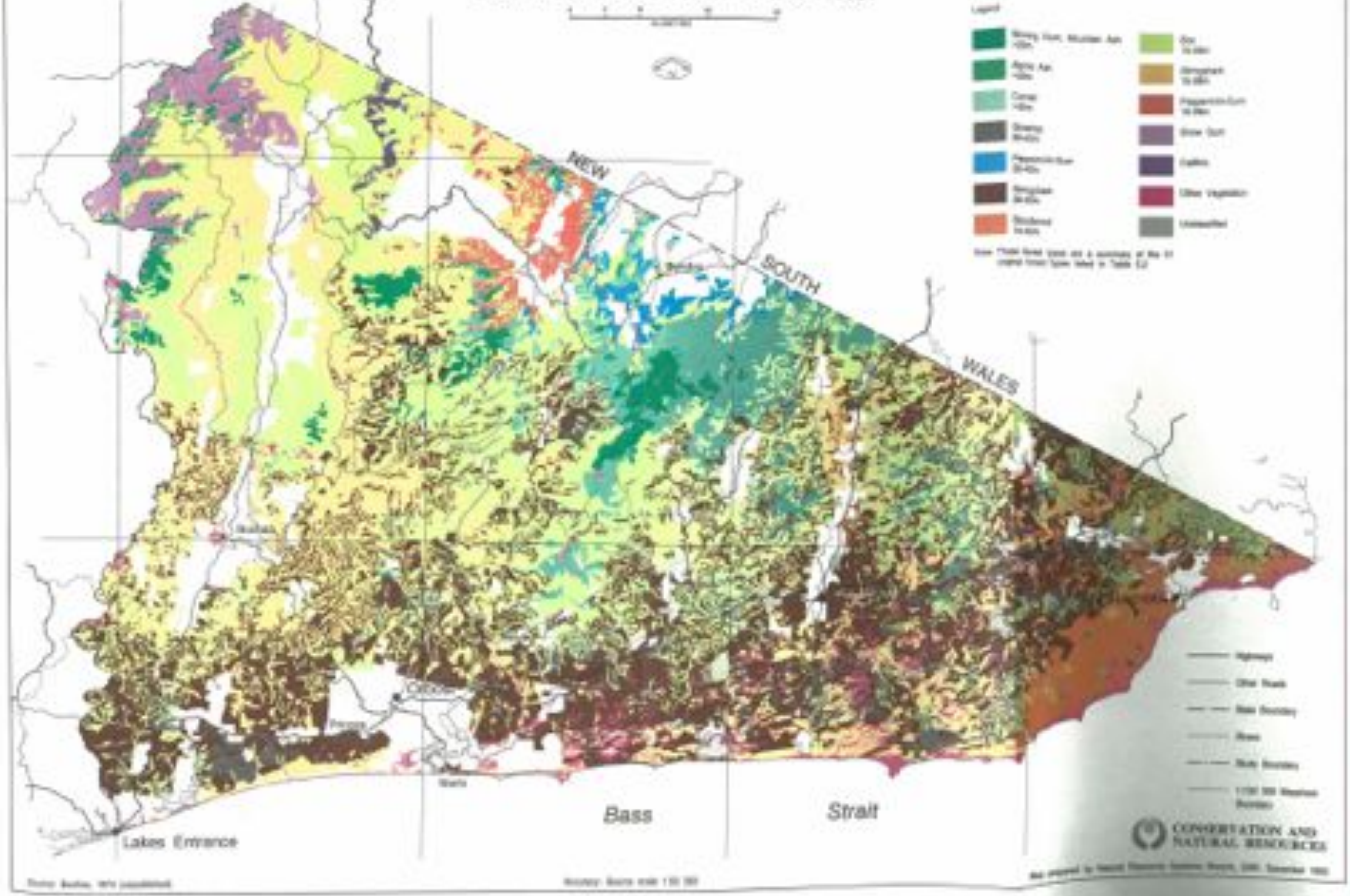
Table 5.2 (continued)

Height	Forest Type	FCV[1] Code ALP	FCV[2] Code GLH	FCV[3] Code EG	LCC[4] Code EG	Major Species	Area (ha)
Various	Podocarpus			Po		*Podocarpus lawrencei*	57
	Wattle		W	Ac		Various *Acacia* spp.	3 109
	Open	5d		O	7	Heath, tea-tree species	13 565
	Alpine Wet Heath	1				Heath, shrubs, grasses	129
	Closed Forest			Hatched	1a, 1b	Numerous non eucalypt species	—
	Other (dunes, lakes etc.)					Other	49 829
Total All Classes							1 057 760

Notes:
1 Former FCV CODE ALP = Alpine study area mapping (circa 1977).
2 Former FCV CODE GLH = Gippsland Lakes Hinterland study area mapping (circa 1982).
3 Former FCV CODE EG = East Gippsland study area mapping (Buntine 1974 unpublished).
4 LCC CODE EG = East Gippsland study area mapping (1974).
5 Combined area statement for Box classes 3f, 4b and 6b.
6 Areas (ha) reliable to nearest 5 ha (approx.)

MAP 4 : FOREST TYPES ON PUBLIC LAND

EAST GIPPSLAND OLD-GROWTH FOREST STUDY



MAP 4 : FOREST TYPES ON PUBLIC LAND

6

ECOLOGICAL VEGETATION CLASSES

6.1 INTRODUCTION

In 1980 the National Herbarium of Victoria conducted a vegetation survey of the Gippsland Lakes Catchment and East Gippsland. The analysis of 1312 vegetation quadrats produced a vegetation classification which consisted of 23 plant communities (Forbes *et al.*, 1981). In 1982 the Herbarium utilised this plant community information to construct the floristic map of East Gippsland vegetation (Parkes *et al.*, 1984). Extensive field work was undertaken to delineate plant community boundaries on the ground, with aerial photography being employed to interpret boundaries in remote or contentious areas. At the time of the map's publication the authors discussed the existence of restricted or inaccessible plant communities that had not been sampled adequately during the 1981 survey and that were therefore not described or mapped.

Eleven years on, as a component of the current study, the original floristic communities map was reviewed. By the time of this study there were 4820 quadrats available for the verification of community typology and mapping of these boundaries in the field. These were derived from a range of surveys conducted by the Department of Conservation and Natural Resources, its predecessors and consultants working in the area. The expanded database has thus enabled the inclusion of communities that workers subsequent to Forbes *et al.* (1981) have described as occurring in East Gippsland. In areal extent the largest such community is Damp Forest (formerly Damp Sclerophyll Forest). Forbes *et al.* (1981) referred to Damp Forest as only occurring in the Gippsland Lakes Catchment (at that time) and as a consequence Damp Forests were not mapped by Parkes *et al.* (1984). Other important additions are the communities referred to by Parkes *et al.* (1984) which have been described through subsequent floristic analysis. Hence the rocky cliffs of the Snowy River gorge have now been mapped as Rocky Outcrop Shrubland, the coastal swamps of Ewing's Marsh are now mapped as Wet Swale Herbland and the lagoonal margins of Lake Barracoota are now mapped as Coastal Lagoon Wetland.

6.2 CONCEPTS AND DEFINITIONS

Plant Community Typology

In order to understand the complex relationship between the physical environment, vegetation and the landscape, an hierarchical system of classification of plant communities called floristic communities was used by Forbes *et al.* (1981). This plant community typology has been refined and increasingly formalised over the last decade enabling the description of consistent floristic entities. The floristic communities so described display specific correlations with certain quantifiable environmental attributes as well as illustrating a biogeographical context. The refined typology used in this study is considered to be more process oriented than other systems which place the emphasis on species or on structure. Figure 6.1 illustrates the relationships between these systems as well as providing the hierarchy for the process-oriented typology.

The entities described by Forbes *et al* (1981) as floristic communities are called ecological vegetation classes under today's typology. With a more contemporary analysis of the current database, it is apparent that most ecological vegetation classes have more than one constituent floristic community whose distribution across the landscape is related to geology in drier areas and climatic and biogeographic gradients more generally.

Formation

Formations are defined on the basis of their structure and life form, without specific reference to their floristic composition. Generic references to life forms represented in the formation, such as palms, lianes and grasses, are usually given as part of the description of this structural entity. This enables biogeographers to compare the vegetation of different continents in a consistent way. Some Australian examples include rainforest, heathland, grassland and open forest. This level of the hierarchy was not mapped during this study.

Figure 6.1 Illustration of the process oriented typology that was used during this study and its relationship with other typologies which emphasise species structure or life form.

Ecological vegetation class

Ecological vegetation classes represent the highest level in the hierarchy of the vegetation typology developed and used across Victoria by the Department of Conservation and Natural Resources. They consist of one or a number of floristic communities that exist under a common regime of ecological processes within a particular environment at a regional, state or continental scale. In addition to sharing the features already outlined, it is expected that at the continental scale such floristic vegetation communities that occur in different biogeographic regions (but are united under one ecological vegetation class) would have some of their species shared, with many genera, families and life forms in common. Some floristic communities that occur in the same ecological vegetation class may however have very few species in common. Nevertheless, these floristic communities are still united by the one vegetation class because they respond to a similar environmental regime that is manifested in comparable life-forms, genera, families and similar vegetation structure.

At the regional level a lack of shared species is related to geology. Several East Gippsland examples are given in the description of Rocky Outcrop Shrubland (Appendix D), where they occur across a range of geologies. Where the vegetation class is dependent on a particular geology such as the Limestone Pomaderris Shrublands of East Gippsland, the stratigraphy of the geology may account for species differences between floristic communities of the vegetation class (Peel, 1993).

Thus, in contrast to formations and floristic communities, ecological vegetation classes are defined at a qualitative level by both their floristics and structure, but more importantly their description includes the ecological processes which characterise them. Ecological vegetation classes include such well established entities as Riparian Forest (high fertility sites with deep, well-watered soils replenished by periodic flooding with silt-laden fresh water), Rainshadow Woodland (well-drained soils derived from fertile granodiorite geology under low (<700 mm) and unreliable rainfall regimes) and Coastal Saltmarsh (anaerobic peaty muds inundated by salt water one or more times daily, but less frequently in summer). Such classes illustrate the vegetation's specific ecological response to a particular environment which occurs throughout the landscape. As such, ecological vegetation classes permit the link to be made between vegetation patterns and broad landscape features such as coasts, lakes, plains, dissected terrain, plateaus and mountains, and their respective climates. Ecological vegetation classes are usually floristically and structurally distinct from each other, whilst floristic vegetation communities are regional or sub-regional variants of ecological vegetation classes.

This is the level of the hierarchy that was mapped by this study. Ecological vegetation classes may be synonymous with sub-formations but are described in a different manner to them by including floristics and a qualitative consideration of the environmental processes operative for each class (see Figure 6.2).

Floristic vegetation community

Floristic vegetation communities *sensu* Forbes *et al.* (1981) are derived from floristic analysis using the classificatory program 'NEAR' and a method outlined by Gullan (1978).

The results of the analysis are presented in a two-way table which arranges species and classified quadrats on two axes and contains the cover–abundance data in the body of the table. Hand sorting this information involves the subjective arrangement of quadrats within small groups, small groups within large groups, large groups with respect to each other and of species (which are not given a fixed order by the classification). This is performed to permit the display of the floristic gradients within the data. Occasionally individual quadrats may be moved from one group to another on the basis of considering the importance of cover-abundance values rather that just presence/absence data.

The groups generated are then subjectively evaluated with respect to the floristic gradient between groups, relative cover-abundance values (particularly of the more ecologically dominant species) between groups and the ecological sensibility of groups and aggregations of groups. Those sites which are close to the boundaries of these centroid clustered groups may then be moved according to the cover-abundance of their constituent species.

Floristic communities consist of one or more sub-communities and typically relate to the large groups derived from the preliminary classification. A floristic community reflects the vegetation's response to environmental influences at the regional or sub-regional scale. These influences include geology, soils, minor altitudinal changes, landform, aspect and recurrent disturbances such as fire.

Note that in this report the term plant community is taken to be a generic reference that may include floristic vegetation community or ecological vegetation class.

Floristic sub-community

Sub-communities are based on small groups or aggregations of quadrats (Mueck and Peacock, 1992). Sub-communities may relate to different temporal phases of the vegetation type or a single floristic community under different disturbance regimes and are somewhat arbitrary steps along a floristic continuum. A sub-community groups vegetation samples from one floristic community as a function of subtle floristic differences that are mediated by microclimate variations across the localised landscape. Such variations include position on a slope, aspect, fire history, disturbance or proximity to another community. A sub-community is synonymous with the term 'nodum' of Poore (1955). Sub-communities typically occur over relatively small areas and are difficult to map at the regional scale and so were not mapped in this work.

Typologies operate most effectively on an extensive data set; the position of an entity within the hierarchy is likely to change if the data set was small in geographic extent or small in sample size and scattered over a wide area when the initial determinations were made. In this way the development of the typology of the state's vegetation is analogous to the dynamic nature of plant taxonomy: both systems are seen to be evolving and must be updated as better information comes to hand. As the data set used by Forbes *et al.* (1981) was relatively small (considering the geographic area covered), some of the floristic entities initially described as sub-communities in that study were found to require reclassification and have been redefined as floristic vegetation communities or ecological vegetation classes in this work. The vastly improved data set available for the study area has enabled the revision of the plant typology for East Gippsland. This revision is consistent with the state-wide vegetation typology currently being developed by the Department.

An example of this process-oriented typology is given in Figure 6.2.

6.3 METHODS

Mapping ecological vegetation classes as a part of the old-growth study was undertaken in order to provide an ecological context for stands of old-growth forest identified by forest mappers during this study. Vegetation classes exhibit different structural and floristic responses to their environment. The advantage of describing old-growth forests in terms of their constituent vegetation classes is that it is possible to circumscribe the particular environmental conditions which produce and perpetuate the old-growth state for that class. Because the typology is based an ecological processes, disturbance regimes which may effect the old-growth status of a stand can be consistently assessed. The major advantage of this approach is that it will allow a more refined and focused management response for areas of old-growth forest so defined.

Forest type and structural vegetation mapping at a scale of 1:63 360 (Buntine 1974 unpubl.) covered all of the LCC East Gippsland Study Area and parts of the Gippsland Lakes Hinterland and Alpine Study Areas (Chapter 5). Although the focus of this mapping was as a basis for land use determinations, including the discrimination of commercially productive categories of forest, this mapping also reflects environmental site quality. Plant community maps are also a reflection of the vegetation's interaction with particular environmental site qualities, but are created from a broader ecological perspective.

Both approaches to mapping employ detailed analysis of remotely sensed information and subsequent field checking. In East Gippsland, where accurate and detailed forest type mapping was available but floristic mapping had only been completed at a broad scale, it was desirable to use the information of the former to assist in upgrading the latter. By also including data on geology, soils, climate, landform, biogeographic context and the currently available floristic quadrat data set, this approach modified the line work of forest types to produce ecological vegetation class mapping.

There are several advantages to linking forest type information and ecological vegetation class information:

- efficient use of existing information,
- broader understanding and acceptance of improved mapping by management staff, and
- encouragement of the synthesis of silvicultural site quality parameters with ecological considerations, which has profound implications and advantages for forest management.

The method for transforming forest type boundaries into ecological vegetation class boundaries is relatively straightforward provided there are good floristic, edaphic and bio-geographic data for the area. The strongest, most persistent and stable influences will define the distribution of an ecological vegetation class in the broad landscape context, while the floristic vegetation communities are regional variants.

The ecological vegetation class was undertaken by overlaying information about the physical environment, biogeography and existing floristic quadrat information with the forest type maps. The synthesised maps of vegetation classes were then field-checked to ensure that assumptions about the influence of abiotic and biogeographic factors on vegetation in the landscape had been correct. Whilst field-checking the accuracy of the revised mapping for vegetation class boundaries, more specific information about the ecological vegetation classes was collected.

Maps were verified during eight months of field work by driving all the major roads and tracks. Where necessary and as time permitted the field verification of vegetation classes boundaries away from the track network was achieved through bushwalking. Additional information was obtained from the work of field botanists who had worked in the area or who were still engaged in biological survey in the study area.

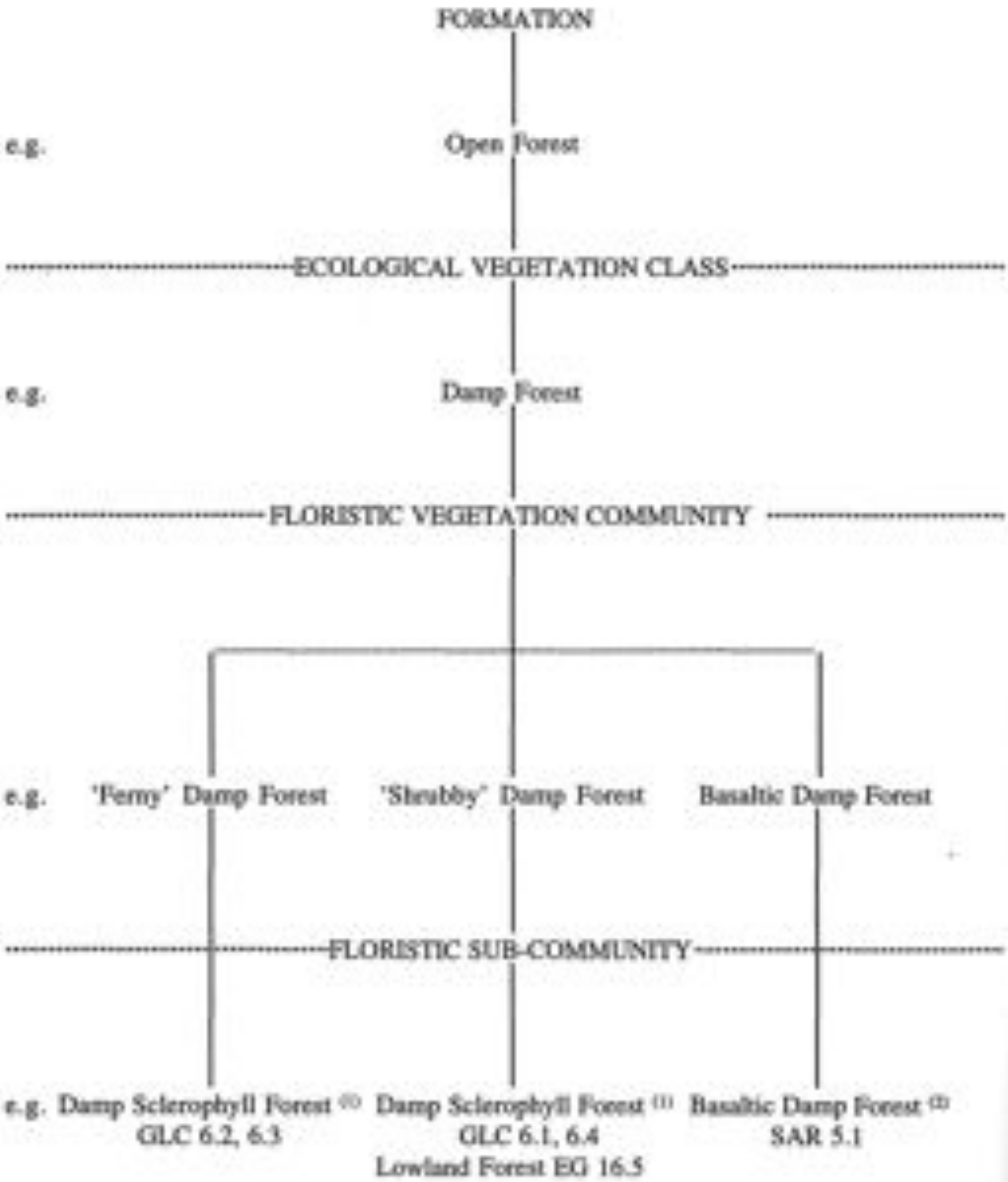


Figure 6.2 An example of plant community typology for damp forests in East Gippsland.
Notes:

1 The name for this sub-community has been superseded by the new typology nomenclature (refer to Section 6.3) but is used here because it is the original name as cited by Forbes *et al.* (1981)

2 Peacock *et al.* (1992).

Aerial photography, geological boundaries and landform were used to interpret remote ecological vegetation class boundaries throughout the study area where time did not permit on-the-spot verification of such boundaries.

During the course of the field-checking it became obvious that certain vegetation classes were not catered for by the structural classes in the forest type mapping. They were delineated by the use of aerial photo interpretation (API) where equivalent structural classes were absent or inadequate. See Appendix D.

Data sources

Data sources used in the mapping procedure included:

- vegetation maps at 1:100 000, Land Conservation Council study area reports for; East Gippsland (1974), Gippsland Lakes Hinterland (1982) and Alpine (1977);
- forest type maps at 1:63 360, former Forests Commission of Victoria, Buntine (1974, unpubl.);
- logging history at 1:100 000 (Chapter 7);
- dieback caused mostly by *Phytophthora cinnamomi* Ward and McKimm (1982);
- land systems at scale 1:100 000 (east of the Snowy River), 1:250 000 (west of the Snowy River) Department of Conservation and Natural Resources (1993);
- geology; Geological Survey of Victoria at 1:250 000 — Mallacoota (1976), Tallangatta (1976), and Bairnsdale (1977); and 1:100 000 — Bendoc (1990), and Murrindal (in prep.);
- the Geology of the Cann River Forest District; 1:100 000 (Beams and Hough, 1979b);
- Floristic Map of East Gippsland (Parkes *et al.*, 1984);
- floristic analyses of the quadrat data set for East Gippsland using CNR's Flora Information System; and
- numerous floristic analyses from pre-logging flora and fauna survey reports in the Ecological Survey Report Series (CNR) cited by author in the References.

Field reconnaissance

Field work to check the revised mapping and to refine ecological vegetation class descriptions was conducted from September 1990 to April 1991. Additional site specific data was collected as defined species lists from 77 locations across the study area (FIS quadrats U00601–U00677).

Plant taxonomy

The taxonomy follows Ross (1993) and the periodic taxonomic updates of the National Herbarium of Victoria.

Vegetation class nomenclature

The names for the ecological vegetation classes have been formulated through reference to previous work in Victoria and Australia and are referrable to Census of Victorian Plant Communities, CNR (in prep). The ecological vegetation class names are designed to convey a simple picture of the vegetation and its context. They are not intended to be detailed descriptions. Each name gives the usual structural form such as woodland, heathland, or sedgeland, although not all examples of ecological vegetation classes are restricted to the one structural category. For example, Banksia Woodland may be a low open woodland on exposed near-coastal dunes or an open forest on more sheltered inland sites. A variety of adjectives are employed to describe a particular and consistent feature about the vegetation class; for example, coastal, damp, vine-rich or grassy.

After much careful consideration and consultation, the term sclerophyll has been removed from the Victorian plant community nomenclature. The change was made because 'sclerophyll' is a term that is not familiar to non-specialists, it is applicable to many communities and thus adds little to discriminating between them. Furthermore, it was originally intended to be applied strictly to either the overstorey or the understorey, but this distinction has rarely been made.

Limitations

The vegetation mapping of this study in some instances encapsulates several ecological vegetation classes across the study area that occur in patterns too complex to map at 1:100 000. It is therefore reasonable to expect that a revision of this mapping at a finer scale in the future may lead to the delineation of more ecological vegetation classes.

6.4 RESULTS

The relationships between the forest type mapping (Chapter 5) and ecological vegetation classes are described in Appendix D. This table also provides descriptions of landform, geology, rainfall and elevation for each forest type and ecological vegetation class.

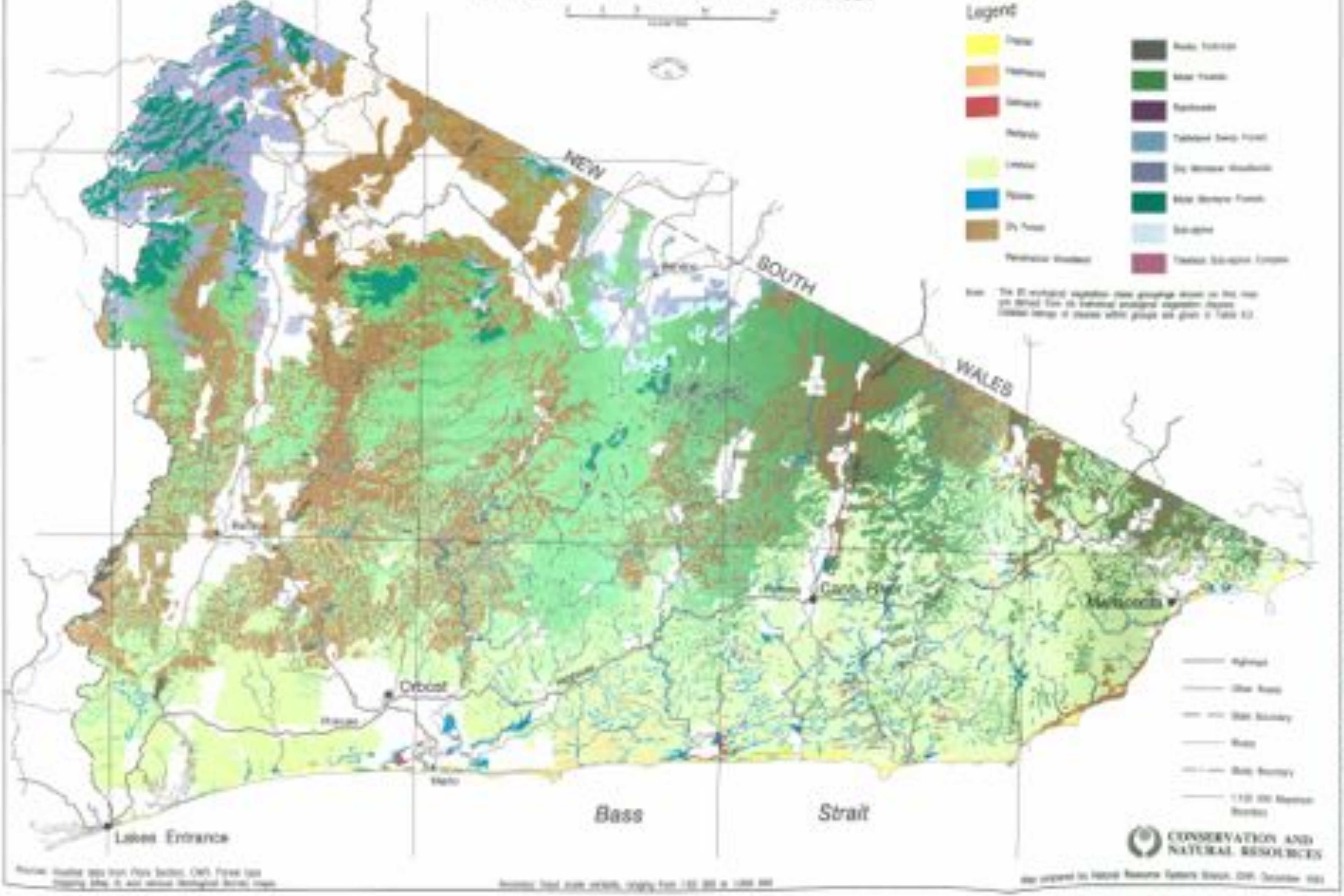
The complete revision of the floristics of East Gippsland produced 44 ecological vegetation classes. These are listed in Table 6.2 along with their area (in hectares) on public land. Detailed class descriptions are given in Appendix E. These revised descriptions include 24 plant communities in addition to those recorded on the original Floristic Map of East Gippsland (Parkes *et al.*, 1984). Note that the vegetation class mapping was not completed for freehold land.

Over 98% of the public land in the study area was found to be vegetated. The remainder of the area comprised water-bodies, inlets and bare areas such as blow-outs on coastal sand dunes. Forested vegetation comprises 1 027 377 ha (97%) of public land (of which 918 833 ha was mapped as forest by the more detailed growth stage mapping — see Chapter 4). The most extensive class is Lowland Forest (245 131 ha) which together with Damp Forest (238 288 ha), Shrubby Dry Forest (209 982 ha) and Wet Forest (90 288 ha) account for 76% of the public forest estate. The four rainforest classes together only occupy 9619 ha.

A generalised map of the ecological vegetation classes is depicted as vegetation groups in Map 5. The groups comprise: Coastal (ecological vegetation classes 1–4), Heathlands (classes 5–8), Saltmarsh (class 9), Wetlands (classes 10–13), Lowland (classes 14–16), Riparian (classes 17–19), Dry Forest (classes 20–25), Rainshadow Woodland (class 26), Rocky Outcrops (classes 27–28), Moist Forests (29–30), Rainforests (classes 31–34), Tableland Damp Forest (class 35), Montane Dry Woodlands (classes 36–37), Moist Montane Forests (classes 38–41), Sub-alpine (classes 42–43) and Treeless Sub-alpine Complex (class 44).

MAP 5 : ECOLOGICAL VEGETATION CLASSES ON PUBLIC LAND

EAST GIPPSLAND OLD-GROWTH FOREST STUDY



MAP 5 : ECOLOGICAL VEGETATION CLASSES ON PUBLIC LAND

Table 6.2 Ecological vegetation classes and area (ha) on public land of the East Gippsland Forest Management Area [1,7].

Vegetation class	Area (ha)	Vegetation Class	Area (ha)
1. **Coastal Dune Scrub Complex**[3,5]	3 109	24. **Foothill Box Ironbark Forest**[3,5]	595
2. **Coast Banksia Woodland**[3]	3 397	25. **Limestone Grassy Woodland**[2]	471
3. **Coastal Grassy Forest**[2]	90	26. **Rainshadow Woodland** [3]	22 179
4. **Coastal Vine-rich Forest**[2,5]	122	27. **Rocky Outcrop Scrub** [3,5]	5 052
5. Coastal Sand Heathland	681	28. **Rocky Outcrop Shrubland**[3,5]	1 606
6. Sand Heathland	44	29. **Damp Forest**[2]	238 288
7. Clay Heathland	1 781	30. **Wet Forest**[2]	90 288
8. Wet Heathland	9 514	31. **Cool Temperate Rainforest**[3,6]	2 563
9. Coastal Saltmarsh	904	32. **Warm Temperate Rainforest**[3,6]	6 777
10. Estuarine Wetland	795	33. **Cool/Warm Temperate**	
11. Coastal Lagoon Wetland	718	**Rainforest Overlap**[3,6]	268
12. Wet Swale Herbland	789	34. **Dry Rainforest**[3,6]	11
13. Brackish Sedgeland	195	35. **Tableland Damp Forest**[2,5]	7 000
14. **Banksia Woodland**[3]	36 980	36. **Montane Dry Woodland**[2]	48 517
15. **Limestone Box Forest**[2,5]	4 658	37. **Montane Grassy Woodland**[2,5]	4 825
16. **Lowland Forest**[2]	245 131	38. **Montane Damp Forest**[2]	13 962
17. **Riparian Scrub Complex**[3,4,5]	17 664	39. **Montane Wet Forest**[2]	13 506
18. **Riparian Forest**[2,4,5]	12 656	40. **Montane Riparian Woodland**[3,5]	516
19. Riparian Shrubland	659	41. **Montane Riparian Thicket**[3,4,5]	36
20. **Heathy Dry Forest**[3,5]	2 989	42. **Sub-alpine Shrubland**[3,5]	202
21. **Shrubby Dry Forest**[3]	209 982	43. **Sub-alpine Woodland**[2]	7 310
22. **Grassy Dry Forest**[2,5]	16 903	44. Treeless Sub-alpine Complex[5]	1 071
23. **Herb-rich Forest**[2]	9 724	Other	13 232
Total all classes			1 057 760

Notes:

1 Vegetation classes (in bold) which conform with the definition of 'forest' adopted for this study (classes 1–4, 14–18, & 20–43).

2 Jacobs forest classes. These classes mostly show classic eucalypt growth form (classes 3–4, 15–16, 18, 22–23, 25, 29–30, 35–39 & 43).

3 Non-Jacobs forest classes. These classes mostly exhibit atypical eucalypt growth form (classes 1–2, 14, 17, 20–21, 24, 27–28 & 40–42).

4 The revision of mapping for riparian classes was not completed because the structural mapping was unable to adequately delineate these vegetation classes. As a consequence the area statements for these linear riparian vegetation classes are provisional.

5 Ecological vegetation classes that were not adequately delineated by forest type structural mapping. These were mapped with the aid of aerial photography and other vegetation mapping techniques (see Appendix D). A complex comprises two or more ecological vegetation classes that are indivisible at this scale of mapping.

6 The total area for rainforest vegetation classes is based on structural mapping not floristic mapping. The partition of the area of rainforest into four vegetation classes is based on floristic criteria. A floristic-based mapping approach would see a revision of the area of these classes.

7 Areas (ha) are reliable to the nearest 5 ha (approx.).

7
FOREST DISTURBANCE — IDENTIFICATION AND SURVEY

7.1 INTRODUCTION

A list of disturbances known to have altered the primary attributes (floristics, structure or growth stage) of the forests in the study area was prepared. These disturbances were described according to their cause; natural or un-natural (post-European human-induced). Research using historical and contemporary records was undertaken to delineate and map the extent and severity of these disturbances. The following discussion indicates the most important of these disturbances and is a summary of more detailed histories and sources which are presented in Appendix F.

7.2 AGRICULTURAL SELECTION

Agriculture represents less than 15% of land use by land area in East Gippsland. Agricultural activities are concentrated in fertile country around Buchan, Gelantipy and Wulgulmerang; on the alluvial river flats, coastal plains and adjoining cleared foothills around Orbost; in the north near Bendoc, Bonang and Tubbut; and in the far east of the region at Combienbar, Cann River, Mallacoota and along the Genoa River valley. The first settlements were established in the north and far east of the study area in the late 1830s and 1840s, mostly for grazing. Crown land selection, the process of sub-division and forest clearance that led to closer settlement, had the greatest impact on the more marginally productive country of the region from the 1880s.

Archival Crown Lands and Survey files show that, for the period generally between the 1880s and 1930s, about 135 Crown Land selections within the study area were taken up, partially or wholly ringbarked, later abandoned or forfeited, and reverted to the Crown. Most of these selections are now within State forests or National Parks. Selection blocks were abandoned because of difficult access, remoteness from markets and the vigorous regrowth of native vegetation following clearing.

Many of these blocks were cleared and have subsequently revegetated. Clearing was mostly done by ringbarking trees and later grubbing the stumps, and burning the dried and dead vegetation. Deforested areas were then sown with pasture grasses, while the more fertile alluvial flats were planted with cereal or vegetable crops. In some instances agricultural blocks were cleared and farmed more than once before being permanently abandoned. As the average size of the selection blocks was 150 ha, this represents approximately 20 000 ha of land that may have been affected by early agricultural activity (Table 7.2). Today, most of this land is forested.

Data relating to agricultural clearing has been obtained from the archival files, collated into a textual database and entered into the GIS. The database contains information on the location, extent and approximate period of clearing for each selection. Where clearing was undertaken on a portion of the allotment area, the percentage is based upon data found in the reports of Crown Bailiffs who inspected the selections for the Lands Department. Parish plans (historic and current) have been used to situate allotments within the spatial database (GIS), with each receiving a unique number to link the allotment with the textual database. The current extent of tree clearing on freehold land has been determined from Landsat TM satellite imagery (Goodson and Gilbee, 1992). Map 6 depicts the location of crown land selections which have reverted to public land. It also shows current freehold land.

7.3 GRAZING

Cattle grazing commenced in the study area in the 1830s and has continued to the present day, though within a much reduced geographical area. The first cattle were depastured in the forests of East Gippsland by graziers from the Monaro district of southern New South Wales, driven into the region through industry expansion and a run of dry seasons in the 1830s and 1840s. A series of nineteenth century land acts and amendments made provision for grazing on unoccupied Crown land in Victoria, recognising that extensive forested areas in East Gippsland were more suited to intermittent grazing than to intensive agricultural development. This regional land use has continued through the current century, with grazing leases administered by the former Department of Crown Lands and Survey, the former Forests Commission of Victoria, the former Department of Conservation and Environment and more recently the Department of Conservation and Natural Resources.

The current survey identified five categories of grazing licences and leases which represent different forms of administration rather than different types of forest grazing. Information on significant grazing leaseholds was researched from a variety of sources including historic plans and maps, archival Crown Lands and Survey files, Forests Commission records and Victorian Government Gazettes. A textual database has been compiled which holds information on the area of the leasehold, the period of grazing, the relevant Government file numbers, and a unique number that links this data to the spatial database.

There is some chronological overlap between the categories of grazing, and the size and boundaries of individual leases could vary significantly over time. Leases were taken up intermittently, sometimes abandoned in good seasons, and not necessarily held continuously over a given period. The date-range for a grazing area is therefore only an indication of the period of grazing. Information concerning stocking rates and stock numbers was not consistent nor of sufficient quality to be included in the textual database. Data relating to the earliest grazing leases, or Pastoral Runs, have been excluded due to the inconsistency of available information, specifically the location of early leaseholds.

The original maps of grazing areas show the extent of the leaseholds, somewhere within which grazing has occurred. During the construction of the GIS database it was decided that the grazing leaseholds be depicted within a matrix of 2 km grids covering the entire study area. If a lease overlapped more than 50% of a grid square the grid was marked with the attributes of that lease. Data on leases greater than 400 ha, excluding current licences which range down in size to 2 ha, were entered into the GIS for presentation at a scale of 1:100 000. Map 7 depicts the extent of current and historic grazing leases.

7.4 MINING

Gold was discovered in the study area in the early 1850s, and copper and silver-lead from the 1870s onwards. The first gold fields of the region were situated near Bendoc and Bonang, where alluvial gold, and later quartz, were mined throughout the 1850s and 1860s. In the 1880s and 1890s a new round of gold discoveries was made in the region when mining tracks were opened up, providing access to the auriferous areas. The gold fields of East Gippsland tended to be short-lived, however, yielding poor to moderate returns, and were not as geographically extensive nor productive as those of central Victoria.

Gold prospecting and extraction has occurred along many river and stream systems in the region. In the Bendoc district payable gold was eventually found in most streams flowing north from the Coast Range. In the south of the study area prospecting tended to be concentrated at the heads of the river systems. Copper and silver-lead were mined in the Deddick district in the 1870s and 1890s. Silver mining was undertaken in the Buchan area in the early years of this century. Large areas of the region have in recent decades been subject to mineral exploration licences.

Records indicate that large-scale forest clearance for mining was not commonplace in the region, though forests in the immediate vicinity of mines and associated settlements were destroyed. Mining activity was, however, very destructive of the local environment, with trees felled for fuel and building purposes, and streams and stream banks heavily disturbed in the search for alluvial gold.

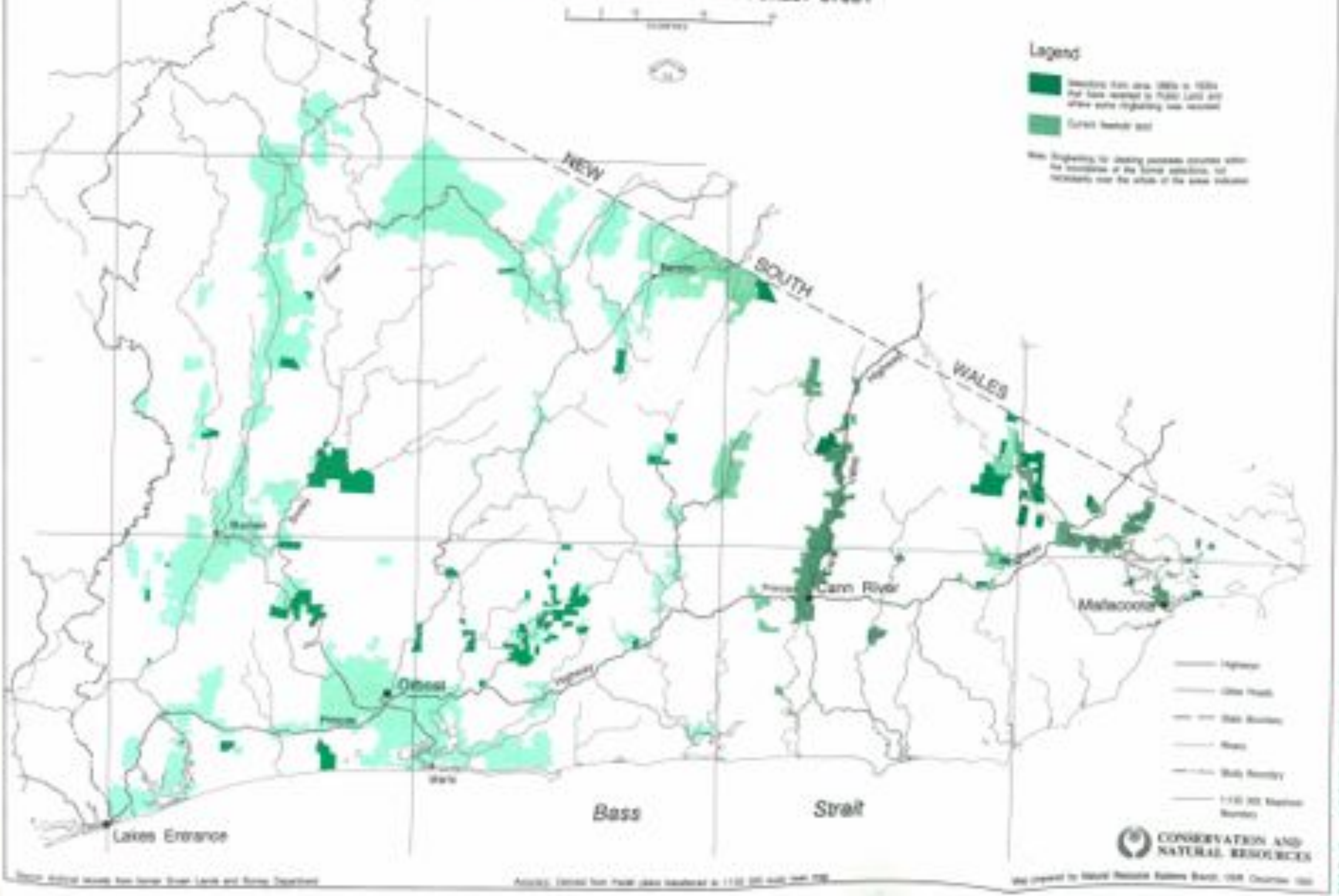
Information was obtained from the records of the Geological Survey of Victoria, reports of the former Department of Minerals and Energy, and a range of secondary sources. The significant mines and mineral extraction sites of the region were loaded into a textual database which indicates the location (AMG to 1:100 000 scale accuracy), the name, the type and the dates of operation of the mine. These data were then directly entered into the GIS with the textual attributes linked with point locations. Some historic mining access tracks have also been entered. It was not possible to determine the location of all mines and mineral extraction sites in the study area. Map 8 depicts the location of historic mining sites and tracks.

7.5 DIEBACK

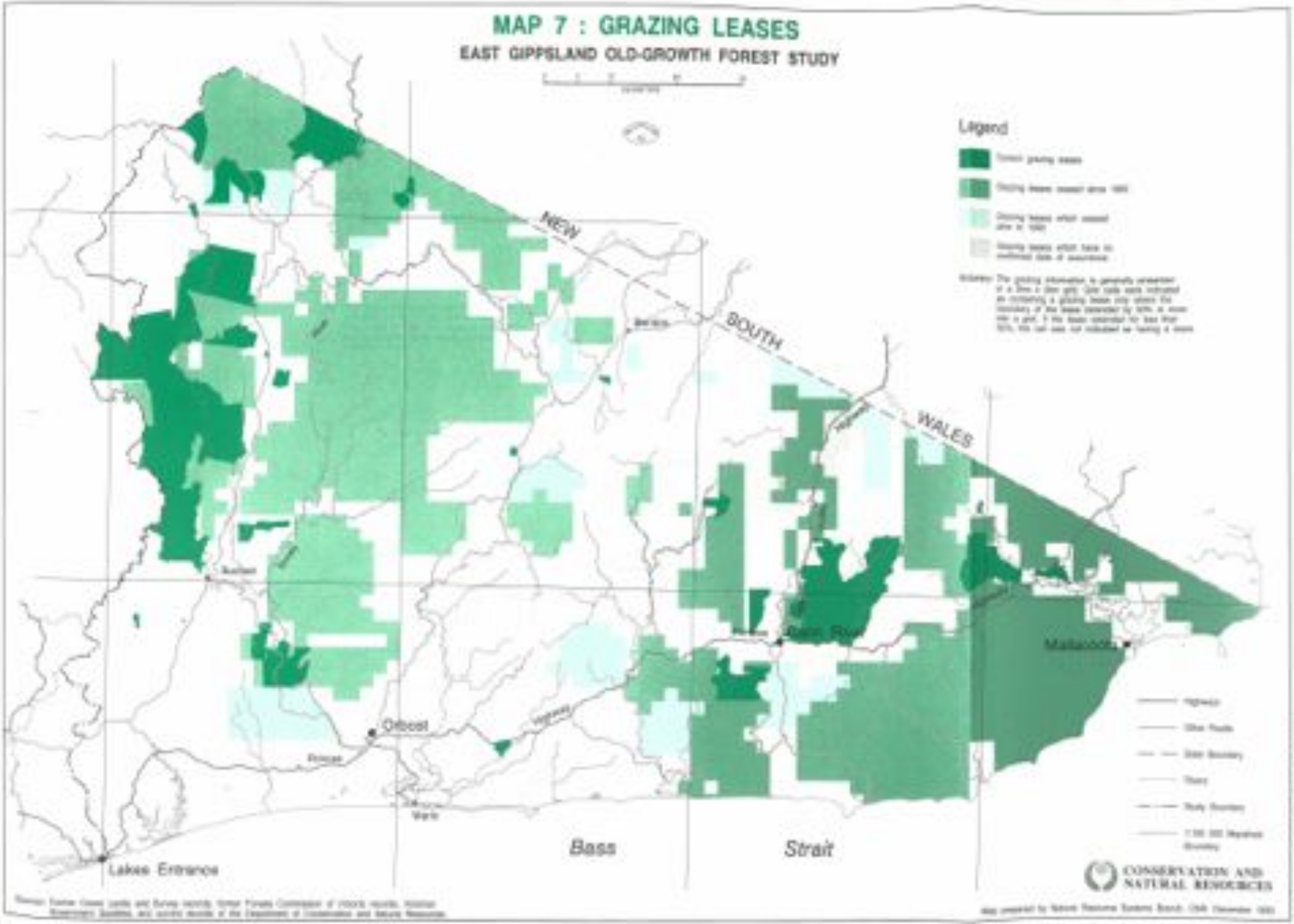
The major pathogen mapped in the study area is the root rot fungus *Phytophthora cinnamomi*. This fungus has profound effects on the structure and floristics of the forest communities within which it occurs, causing large scale crown defoliation and death of plants in both the overstorey and understorey in its most severe expression. The mapping was undertaken in 1973 by the former Forests Commission of Victoria using aerial photography and field inspection. This mapping is still an accurate description of the likely extent of dieback following an epidemic event (pers. comm. Ian Smith). The origins of the disease are uncertain. Although Marks and Smith (1991) and others consider the fungus to be introduced, it is also acknowledged by Burbidge (1960), cited in Marks and Smith (1991), that there is evidence which suggests the fungus has been in Australia for many thousands of years. However for the purposes of this study, the extent and severity of dieback caused by *Phytophthora cinnamomi* was considered to be anthropogenic (Ian Smith, pers comm.). This mapping was entered into the GIS database and is depicted in Map 9.

MAP 6 : AGRICULTURAL SELECTIONS

EAST GIPPSLAND OLD-GROWTH FOREST STUDY



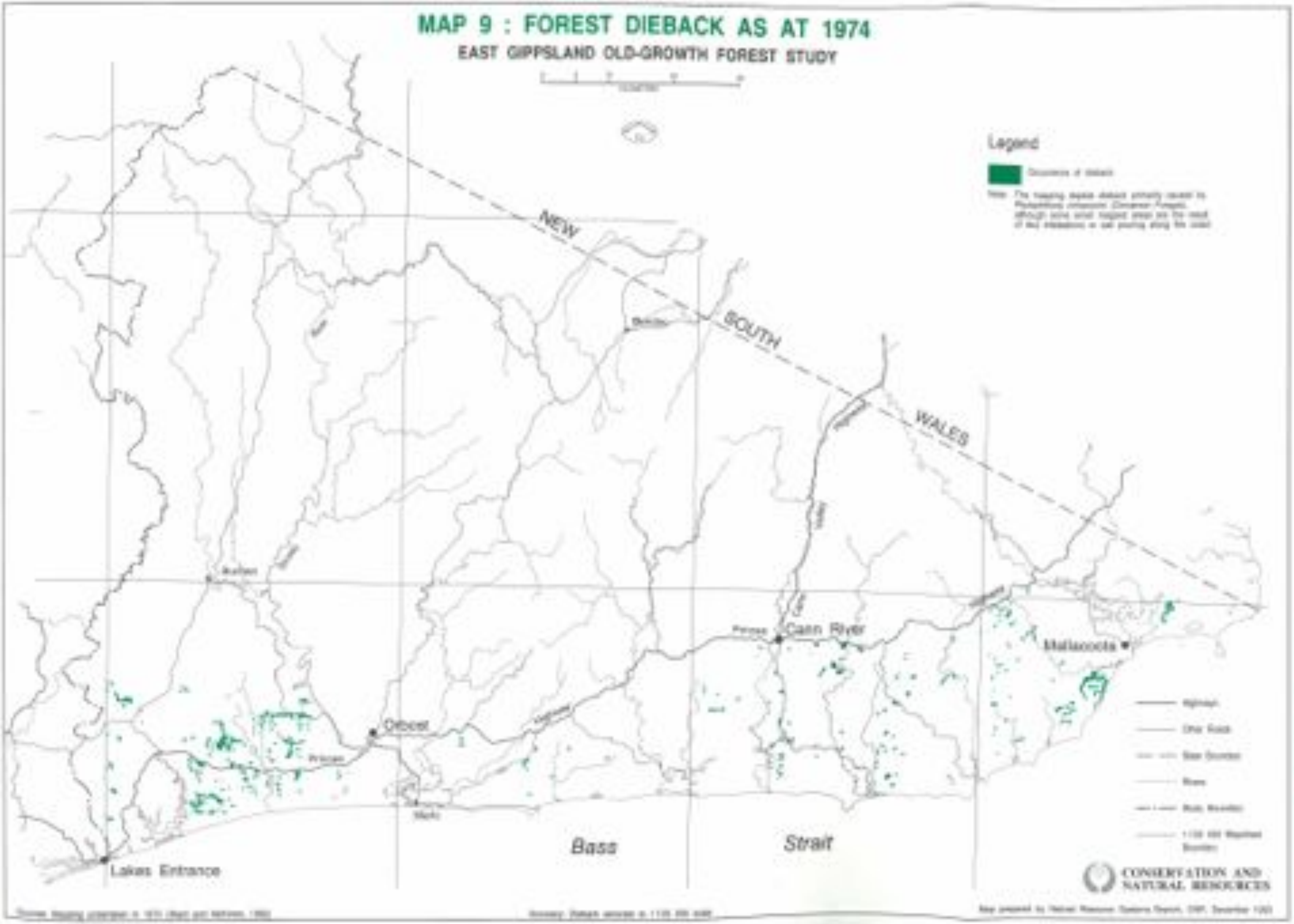
MAP 6 : AGRICULTURAL SELECTIONS



MAP 7 : GRAZING LEASES

MAP 8 : HISTORIC MINING SITES AND TRACKS

EAST GIPPSLAND OLD-GROWTH FOREST STUDY



MAP 9 : FOREST DIEBACK AS AT 1974

7.6 TIMBER HARVESTING

Extensive utilisation of timber has occurred throughout the forests of the study area. This begun in the 1840s with the early graziers felling trees for their immediate needs, such as huts, yards and fuel, and continued with the mining settlements of the 1850s and the agricultural settlements from the 1870s. During the 1880s and 1890s the durable timbers of the area were selectively harvested and shipped by rail or sea to markets in Melbourne. Utilisation increased after the extension of the rail head from Bairnsdale to Orbost in 1916. Hardwood railway sleepers were hewn in the study area for many decades during the 20th century, and piles, poles and beams cut and removed from the forests.

The primary customers for the durable species were the public utilities, the former Victorian Railways Department (sleepers), State Electricity Commission (light poles), the former Public Works Department (heavy construction beams) and the former Melbourne Harbour Trust (piles for piers and docks). Gippsland Grey Box was especially prized for wharf construction because of its resistance to Toredo Worm attack, whilst the abundance of Box and Red Ironbark made the Orbost district the premier sleeper hewing area for Victoria from 1920 to the early 1930s. The hewn products of the Cann River and Mallacoota districts were used by the New South Wales Railways or shipped out to New Zealand via the port at Eden in southern New South Wales.

Large scale timber harvesting began in the 1950s in response to a significant loss of resources in the Victorian Central Highlands from the 1939 bushfires and the increased demand associated with the post-war housing boom. With the merchantable forests of the coastal plain largely logged over, the attention of timber-getters moved to the foothills of the hinterlands around Buchan and to the north of Orbost and Cann River. Access to this hilly country was facilitated by the improvement in roading machinery such as bulldozers and graders during the post-war period.

Historically, timber utilisation tended to follow the easterly extension of the rail into East Gippsland, though in the era after the Second World War increased road construction assisted the expansion of the hardwood industry in the region. There was a steady increase in sawlog output throughout the 1950s and 1960s through a system of selective harvesting. A type of clearfelling system was introduced in the late 1960s and early 1970s and by 1974–75 the forests of the region were producing 40% of the state's log output. This system was a modified form of clearfelling where some trees were retained for environmental protection or conservation (DCE 1990).

During the 1970s there was a reduction in the number of mills in East Gippsland following amalgamation and take-overs with the issuing of larger individual log allocations against licences of three year duration. Hardwood log output returns for Nowa Nowa, Orbost and Cann River districts declined slightly between 1970 and 1974, then fluctuated with a trend of increased output by 1981, particularly in the Orbost forest district. Regional sustainable yield harvesting was introduced in the late 1980s following the Victorian Government's (1986) Timber Industry Strategy.

Accurate information on the areal extent of selective logging was difficult to find. Air photos (black and white, scale 1:40 000, large format) from the early 1940s were available for parts of the study area. They provided clues as to the possible location of disturbed forest but precise boundaries were difficult to derive. A few contemporary maps of these early logging activities were also found. What were available were detailed log allocation records by licence area for the period 1945 to 1970 approximately. These were reorganised to conform with current forest block and compartment boundaries and together with information on species were entered into the GIS database. It should be noted that selective harvesting within a forest compartment indicates only that this form of harvesting occurred, not its precise distribution or intensity.

A variety of forms of remote sensing and investigative techniques were employed to assist with the mapping of the clearfelling history. Landsat TM imagery (bands 3, 4 and 5) in transparency form at scale 1:1 000 000 (March 1990) and 1:250 000 (April 1992) was interpreted at scale 1:100 000 using a Kartoflex photogrammetric map revision instrument to map the clearfelling coupe boundaries from the late 1980s to the present. Landsat MSS transparencies (band 1, 3 and 4) at scale 1:1 000 000 from August 1972 to February 1987 (with scenes from August and December 1972, February 1978, October and November 1980, March 1984, January and July 1986, and January and February 1987) were also interpreted on the Kartoflex in order to map clear felling boundaries at a scale of 1:100 000 back to the early 1970s.

It was a fortunate coincidence that the advent of Landsat 1 in 1972 coincided with the shift in logging practices from selective harvesting, which is difficult to identify from either aerial photos or satellite imagery, to clearfelling and seedtree silvicultural systems in the early 1970s, which are more readily detectable from remotely sensed imagery. Nevertheless some of the early satellite images suffered from severe line striping and contrast deficiencies which significantly impaired the quality of mapping. Despite these deficiencies the mapping was comparable with local regional records that had been compiled over the years by interpretation of both small and large format aerial photos and associated field mapping. Prior to the study, the existing regional records were incomplete and were substantially up-dated as a result of the satellite image interpretation.

The extent of selective logging and clearfell harvesting are shown on Maps 10 and 11 respectively.

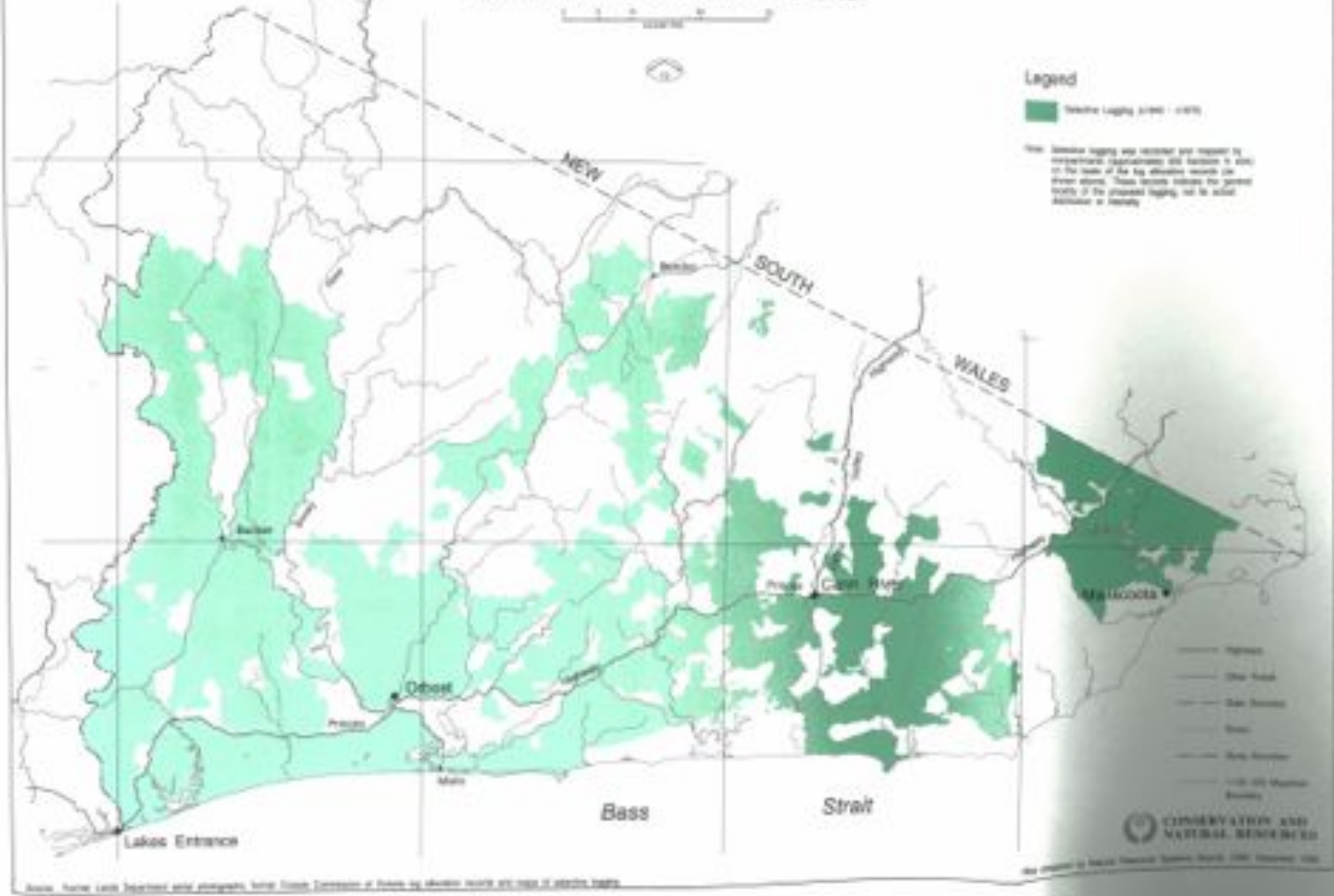
7.7 WILDFIRE

Wildfire is a particularly important disturbance to the growth stage characteristics and floristics of old-growth forest. Wildfires maintain the ecological dynamics of regeneration and decline for most eucalypt communities (Gill 1981), whilst having the potential to physically affect the morphological characteristics of growth stages. Clearly the period of time taken to recover from such a disturbance is dependent upon the fire intensity and frequency and the vegetation class involved. Since the advent of intensive wild-fire suppression techniques in recent decades, the truly 'natural' characteristics of contemporary wildfires have been questioned. Even if a wildfire has not been started by human forces, human intervention is usually used to help suppress the fire. Wildfires occur regularly in East Gippsland and major fires are known to have occurred in 1923, 1938–39, 1943–44, 1945–46, 1951–52, 1958–59, 1962–63, 1967–68, 1978–79, 1980–81, 1982–83 and 1987–88 (CFL, 1990, and Foley, 1947).

The Department of Conservation and Natural Resources (CNR) and its predecessors have routinely recorded the outer boundary of most wildfires for the last three decades on base maps for fire management planning. Prior to that only the 1952 and 1939 fire boundaries were available in map form. Unfortunately, little information on the severity of burn was available from historic records. These maps formed the basis of the fire mapping for this study. The regional base maps of wildfire history recorded by CNR (1960 to 1991) and the available historic maps (1939 and 1952 fires) were redrafted onto one complete map layer for the GIS

MAP 10 : TIMBER HARVESTING - SELECTIVE LOGGING BASED ON COMPARTMENT

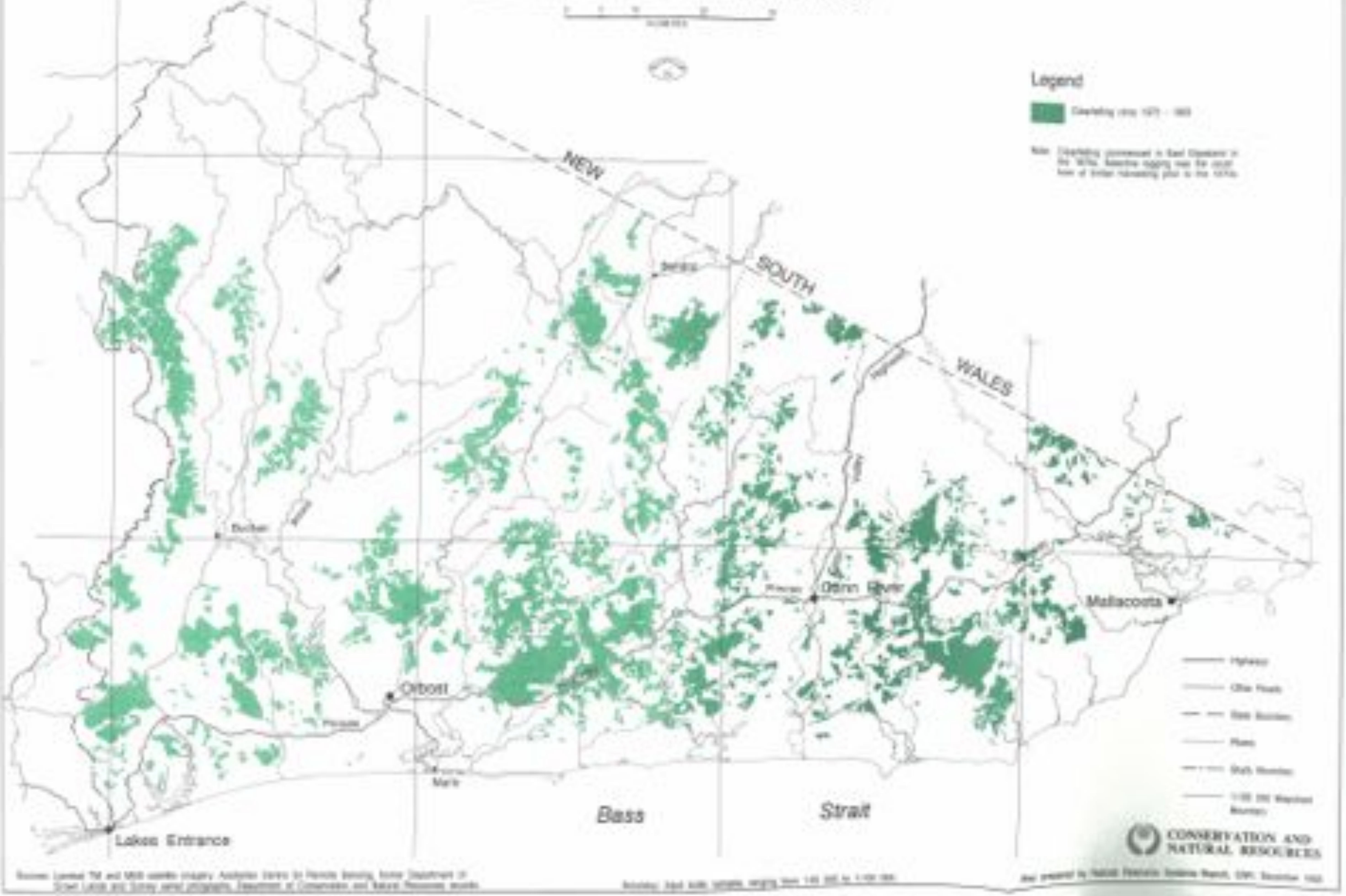
EAST GIPPSLAND OLD-GROWTH FOREST STUDY



MAP 10 : TIMBER HARVESTING - SELECTIVE LOGGING BASED ON COMPARTMENT

MAP 11 : TIMBER HARVESTING - CLEARFELL

EAST GIPPSLAND OLD-GROWTH FOREST STUDY



MAP 11 : TIMBER HARVESTING - CLEARFELL

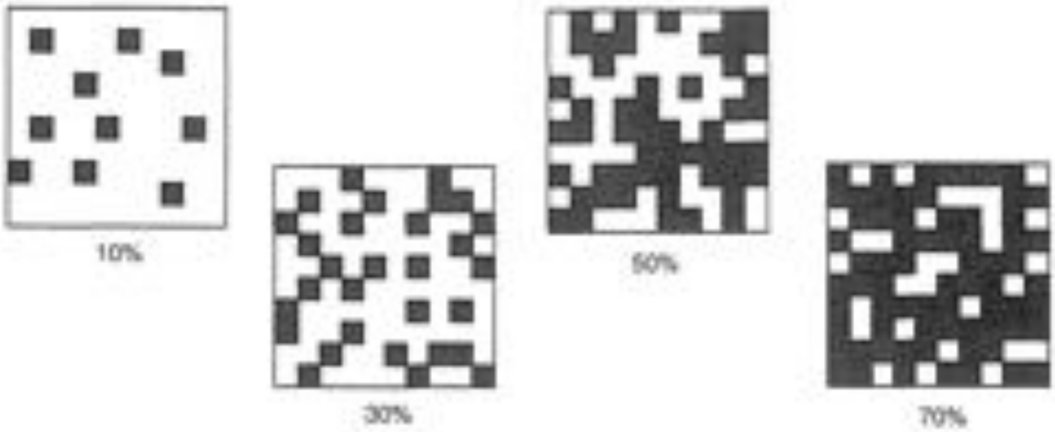


Figure 4.9 Crown densities used to assist the aerial photo interpretation. The black squares represent tree crowns which are taken to be opaque when assessing crown cover.

Field checking was conducted throughout the survey to assess the accuracy of growth stage identification and crown cover mapping. Prior to the mapping of crown cover, the air photo interpreters established ground trials to calibrate measurements from the photographs. A series of diagrams (Figure 4.9) were also used as an aid to maintain uniform assessments of crown density throughout the study. The crown cover mapping was further checked on selected stands through the application of the field-based crown cover estimation technique of McDonald *et al.* (1990) and Walker *et al.* (1988), which is described in Appendix B.

Limitations

The API provides a valuable assessment of structural forest attributes in East Gippsland. For any and every given hectare of forest however, there are a number of factors which constrain the absolute accuracy of the information collected by API:

- Although API was confirmed in the field, field checking was generally restricted to areas accessible by road or track.
- Field inspection indicated that senescing features apparent from the ground were not always fully apparent from an aerial perspective and as a consequence the actual proportion of senescing trees was sometimes underestimated. Regrowth crowns beneath the overstorey are difficult to detect from API and were specifically excluded from the mapping.
- As the 'mature' class embraces a long period of forest development, 'older mature' forests were not differentiated from 'young mature' forests.
- The relatively small scale of the air photos resulted in the API being most accurate in Jacobs forests with large crowned trees. In non-Jacobs forests with small crowns (for example, on fire-prone and low site quality locations in Shrubby Dry Forests), no differentiation between senescing and mature growth stages was possible from the air photos. On-ground inspection revealed that senescing features *sensu* Jacobs (1955) did not develop in the lower height classes of some species in these ecological vegetation classes (refer to discussion in Section 4.2).
- Some stands which were mapped as senescing were likely to have been of a younger growth stage subject to the influence of recent wildfire. However, wherever possible the mapping attempted to indicate recently fire affected crowns.
- No assessment of the growth stages of non-eucalypt forests was attempted.
- There was no field checking of forest type or growth stages on private land.

Despite the limitations discussed above, field checking and ground truthing has confirmed the value of API as a technique for mapping growth stages and crown cover. Given the scale of the maps and photographs, the time available, the large area surveyed and the presentation scale of the results, the survey has produced a comprehensive and reliable database of forest growth stages and crown cover.

4.3 RESULTS

Approximately 700 aerial photographs at a scale of 1:40 000 were interpreted to produce a map of the current growth stages and crown cover projection of all forested areas, public and private, within the study area. The total number of distinct growth stage polygons in the study area was in excess of 11 000, representing 977 802 ha of forested vegetation. The total number of unique combinations of polygons by growth stage and crown cover projection was 218 or 68 if the crown cover projection classes were disregarded. These were further reduced to 32 classes for the final analysis by aggregating those growth stages which were only a few hectares in size. The minimum polygon size was approximately 10 ha; however, the average polygon size was approximately 80 ha.

The 32 growth stage classes are shown in Table 4.5. They are ranked in descending order of relative proportions of oldest growth stages. These growth stage class rankings do not necessarily reflect absolute ages of individual stands. For example it is not known for certain if senescing trees from a Wet Forest class within the wet climate refuges at Errinundra Plateau are any older than senescing trees from the same vegetation class in gullies outside the Plateau.

The area statements for the forest growth stage classes on public and freehold land are presented in Table 4.6. Over 86% (918 833 ha) of public land contains forest for which growth stage classes were identified compared with 37% (58 969 ha) for freehold land.

The area of senescing dominated, mature dominated and regrowth dominated growth stages on public land as determined through aerial photo interpretation prior to any re-assignment of growth stage for non-Jacobs vegetation types was 25 019 ha (3%), 791 459 ha (86%) and 102 355 ha (11%) respectively. On freehold land these figures were 892 ha (<2%), 50 398 (85%) and 7679 ha (13%) respectively.

As previously mentioned, the aerial photo interpretation underestimated the area of senescing growth stages in those vegetation classes which did not show classic Jacobs growth form (Table 6.2, Chapter 6). This limitation was corrected later in the analysis (Chapter 10) following the identification of those vegetation classes. The growth stage mapping was captured digitally and added as a thematic layer to CNR's corporate GIS database.

Table 4.5 Mapped growth stage classes broadly ranked in descending order of relative proportions of oldest growth stages.

Growth stages		Label
Senescing		
S_1	senescing only	*d – –*
S_2	senescing dominant, sparse mature, no regrowth	*d t –*
S_3	senescing dominant, mature subdominant, no regrowth	*d s –*
S_4	senescing dominant, sparse mature and regrowth	*d t t*
S_5	senescing and mature codominant, no regrowth	*c c –*
S_6	senescing and mature codominant, sparse regrowth	*c c t*
S_7	senescing dominant, sparse mature, regrowth subdominant	*d t s*
S_8	senescing dominant, no mature, regrowth subdominant	*d – s*
Mature		
M_1	senescing subdominant, mature dominant, no regrowth	*s d –*
M_2	senescing subdominant, mature dominant, sparse regrowth	*s d t*
M_3	sparse senescing, mature dominant, no regrowth	*t d –*
M_4	sparse senescing, mature dominant, sparse regrowth	*t d t*
M_5	senescing, mature and regrowth codominant	*c c c*
M_6	senescing subdominant, mature dominant, regrowth subdominant	*s d s*
M_7	senescing subdominant, mature and regrowth codominant	*s c c*
M_8	sparse senescing, mature dominant, regrowth subdominant	*t d s*
M_9	mature only	*– d –*
M_{10}	no senescing, mature dominant, sparse regrowth	*– d t*
M_{11}	no senescing, mature dominant, regrowth subdominant	*– d s*
Regrowth		
R_1	senescing and regrowth codominant, no mature	*c – c*
R_2	senescing and regrowth codominant, sparse mature	*c t c*
R_3	senescing and mature subdominant, regrowth dominant	*s s d*
R_4	senescing subdominant, sparse mature, regrowth dominant	*s t d*
R_5	senescing subdominant, no mature, regrowth dominant	*s – d*
R_6	sparse senescing, mature and regrowth codominant	*t c c*
R_7	sparse senescing, mature subdominant, regrowth dominant	*t s d*
R_8	sparse senescing, sparse mature, regrowth dominant	*t t d*
R_9	sparse senescing, no mature, regrowth dominant	*t – d*
R_{10}	no senescing, mature and regrowth codominant	*– c c*
R_{11}	no senescing, mature subdominant, regrowth dominant	*– s d*
R_{12}	no senescing, sparse mature, regrowth dominant	*– t d*
R_{13}	regrowth only	*– – d*

Table 4.6 Forest growth stage classes (ha) on public and freehold land within the study area as mapped through aerial photo interpretation.[1,2]

Growth Stages		Public Land	F'hold Land	Total
Senescing				
S_1	senescing only	6 946	273	7 219
S_2	senescing dominant, sparse mature, no regrowth	2 597	47	2 644
S_3	senescing dominant, mature subdominant, no regrowth	1 358	14	1 372
S_4	senescing dominant, sparse mature and regrowth	1 215	0	1 215
S_5	senescing and mature codominant, no regrowth	9 431	513	9 944
S_6	senescing and mature codominant, sparse regrowth	361	0	361
S_7	senescing dominant, sparse mature, regrowth subdominant	2 357	45	2 402
S_8	senescing dominant, no mature, regrowth subdominant	754	0	754
Mature				
M_1	senescing subdominant, mature dominant, no regrowth	156 721	4 651	161 372
M_2	senescing subdominant, mature dominant, sparse regrowth	23 402	1 104	24 506
M_3	sparse senescing, mature dominant, no regrowth	235 470	13 597	249 067
M_4	sparse senescing, mature dominant, sparse regrowth	20 322	816	21 138
M_5	senescing, mature and regrowth codominant	1 337	0	1 337
M_6	senescing subdominant, mature dominant, regrowth subdominant	14 532	733	15 265
M_7	senescing subdominant, mature and regrowth codominant	995	126	1 121
M_8	sparse senescing, mature dominant, regrowth subdominant	35 978	1 432	37 410
M_9	mature only	244 090	23 181	267 271
M_{10}	no senescing, mature dominant, sparse regrowth	19 292	1 287	20 579
M_{11}	no senescing, mature dominant, regrowth subdominant	39 320	3 471	42 791
Regrowth				
R_1	senescing and regrowth codominant, no mature	2 744	82	2 826
R_2	senescing and regrowth codominant, sparse mature	4 494	93	4 587
R_3	senescing and mature subdominant, regrowth dominant	5 381	124	5 505
R_4	senescing subdominant, sparse mature, regrowth dominant	2 841	32	2 873
R_5	senescing subdominant, no mature, regrowth dominant	5 009	342	5 351
R_6	sparse senescing, mature and regrowth codominant	7 003	723	7 726
R_7	sparse senescing, mature subdominant, regrowth dominant	16 652	1 065	17 717
R_8	sparse senescing, sparse mature, regrowth dominant	9 015	1 036	10 051
R_9	sparse senescing, no mature, regrowth dominant	4 736	112	4 848
R_{10}	no senescing, mature and regrowth codominant	12 359	702	13 061
R_{11}	no senescing, mature subdominant, regrowth dominant	17 602	1 414	19 016
R_{12}	no senescing, sparse mature, regrowth dominant	3 382	118	3 500
R_{13}	regrowth only	11 137	1 836	12 973
All Growth Stages	Total	918 833	58 969	977 802

1 Growth stage classes M_1 to M_4, M_9 and M_{10} contain some areas of non-Jacobs vegetation classes that were known to be of senescing dominated growth stages (see discussion Section 4.2). Only by examining the growth stages in combination with the vegetation mapping (Chapters 5 and 6) could these growth stages be revised for public land (Chapter 10). The procedure for this revision is detailed in the 'GIS Analysis Stages Table' in Appendix G. However, as no vegetation class mapping was undertaken on freehold land growth stage class revisions could not be undertaken for freehold land.

2 Areas (ha) shown are reliable to the nearest 5 ha (approx.)

5
FOREST TYPE AND STRUCTURE

5.1 PREVIOUS WORK

Forest type mapping is a form of structural vegetation mapping which combines common dominant overstorey assemblages with top height class categories and is modified from Specht (1970). This form of forest vegetation mapping is common in Australia, notably that of Baur (1965) in New South Wales and many workers in Victoria. This form of vegetation classification has been widely applied in Victoria and provides a good guide to environmental site productivity and hence the location quality and economic value of timber resources. It is also valuable for wildlife habitat research and planning. The forest type information is most reliable, being based on large scale mapping with intensive ground truthing.

The vegetation of the public land in the study area had been thoroughly mapped for dominant species, crown cover and height during the 1970s (Buntine, 1974, unpubl.) to provide vegetation maps for land use studies by the Land Conservation Council.

The classification of the structural vegetation (Table 5.1) was based on four primary characteristics; species type, life form and height of the tallest stratum, and projective foliage cover as follows:

(i) Species type: For each density and height class three structural layers were described:
- — major species of the tallest stratum,
- — associated tree species,
- — very sparse (<10%) tree species.

(ii) Life form and height of tallest stratum:
- — trees (>40 m, 28–40 m, 15–28 m, and 5–15 m),
- — shrubs (2–8 m, and 0–2 m),
- — herbs, sedges, lichens, forbs and grasses.

(iii) Projective foliage cover (density of the tallest stratum) based on four classes:
- — dense (70–100%),
- — mid-dense (30–70%),
- — sparse (10–30%),
- — very sparse (<10%).

Forest types were mapped onto 1:63 360 base maps from stereo air photo interpretation, extensive field work and by reference to existing assessments. This information was summarised in land use surveys published as a series of Land Conservation Council reports (LCC 1974, 1977, 1982).

Table 5.1 Structural forms of vegetation (modified from Specht, 1970) as mapped for LCC Land Use Studies by Buntine 1974 (unpublished).

Form and height of tallest stratum	Projective foliage cover of tallest stratum: Dense (70–100%)	Mid dense (30–70%)	Sparse (10–30%)	Very Sparse (<10%)
Trees[1,2] >40 m	—	Open forest IV (M_1, M_2, Wb, Ni, A, F)	—	—
28–40 m	—	Open forest III (M_3, S_3, Rb_3, As, P_3)	Woodland III (M_3, S_3, Rb_3, As, P_3)	—
15–28 m	Closed forest[3] (W, Ac)	Open forest II (Y, S_4, Rb, P_4, B)	Woodland II (Y, S_4, Rb, P_4, B, Ca, 6)	Open woodland II (Y, S_4, Rb, P_4, B, Ca)
5–15 m	Closed forest[3] (W, Ac, Po)	Open forest I (B, Ca, Sng)	Woodland I (Po, B, Ca, 6, Y)	Open woodland I (Po, B, Ca, 6)
Shrubs[2] 2–8 m	Closed scrub (O)	Open scrub (O)	—	—
0–2 m	Closed heath (O)	Open heath (O)	—	—
Herbs, including grasses, moss, ferns, lichens <2 m	Closed herbland, including: closed tussock grassland, herbfield, sedgeland (O)	Herbland including: tussock grassland, grassland, herbfield, sedgeland (O)	—	—

Notes:
The symbols contained in brackets are Buntine's (1974, unpubl.) original descriptors. They are keyed in Table 5.2 to more detailed descriptions of each class, together with the overlapping codes of the LCC and former FCV mapping, and described at length in Appendix C. For those Buntine codes not contained in Appendix C there are no known original descriptions.

1 Isolated trees (emergents) may project from the canopy of some forest types. Heights are of mature forest types.
2 A tree is defined as a woody plant more than 5 m tall, usually with a single stem. A shrub is a woody plant less than 8 m tall, frequently with many stems arising at or near the base.
3 Closed forest included rainforest and blackthorn scrub (Rocky Outcrop Scrub). Small areas of Closed Forest (Type 'a') were denoted Po, however most rainforest had no descriptor, instead it was represented by a hatching, whilst blackthorn scrub had the symbol W or Ac.

The line work for these forest type maps was manually combined with the ecological vegetation class mapping (Chapter 6) and converted to a digital form using a scanner for entry to the GIS at a nominal scale of 1:63 360. This digital database was registered to the 1:100 000 AMG base map.

5.2 MAPPING REVISION

In general the mapping of forest types was excellent and suitable for immediate use. Little updating of the original mapping was necessary. However, the mid elevations of the Alpine Study Area between 300–1000 m required some revision. In the area to the south of Gelantipy and north of Buchan between the Timbarra and the Murrindal rivers more recent species mapping was used (Roberts, 1992, unpubl.). This mapping provided detailed dominant eucalypt assemblages without height class information. The only other section of the Alpine Study Area that required revision was between the Murrindal and Snowy Rivers (south of Gelantipy and North of Buchan). Aerial photographic interpretation at the scale of 1:40 000 was used to overcome deficiencies in the original information.

5.3 RESULTS

Table 5.2 details the forest type classes and their major tree species for the mapping of the East Gippsland, Gippsland Lakes Hinterland and Alpine study areas that are of relevance to the old-growth forest study for the East Gippsland Forest Management Area. Four different coding systems were used for the forest types of the study area. These disparate codes have been reconciled into a consolidated suite of area statements by making some assumptions about the precise meaning of each code.

For the purposes of this report 31 forest types on public land in the study area have been described. The most extensive forest types were found to be Stringybark A (28–40 m height) with 258 184 ha, Messmate Gum B (28–40 m height) with 231 216 ha and Red Stringybark–Yertchuk (15–28 m) with 57 199 ha. Box forests also occupy a significant area with 32 283 ha. A generalised version of the forest types for public land within the study area is shown in Map 4.

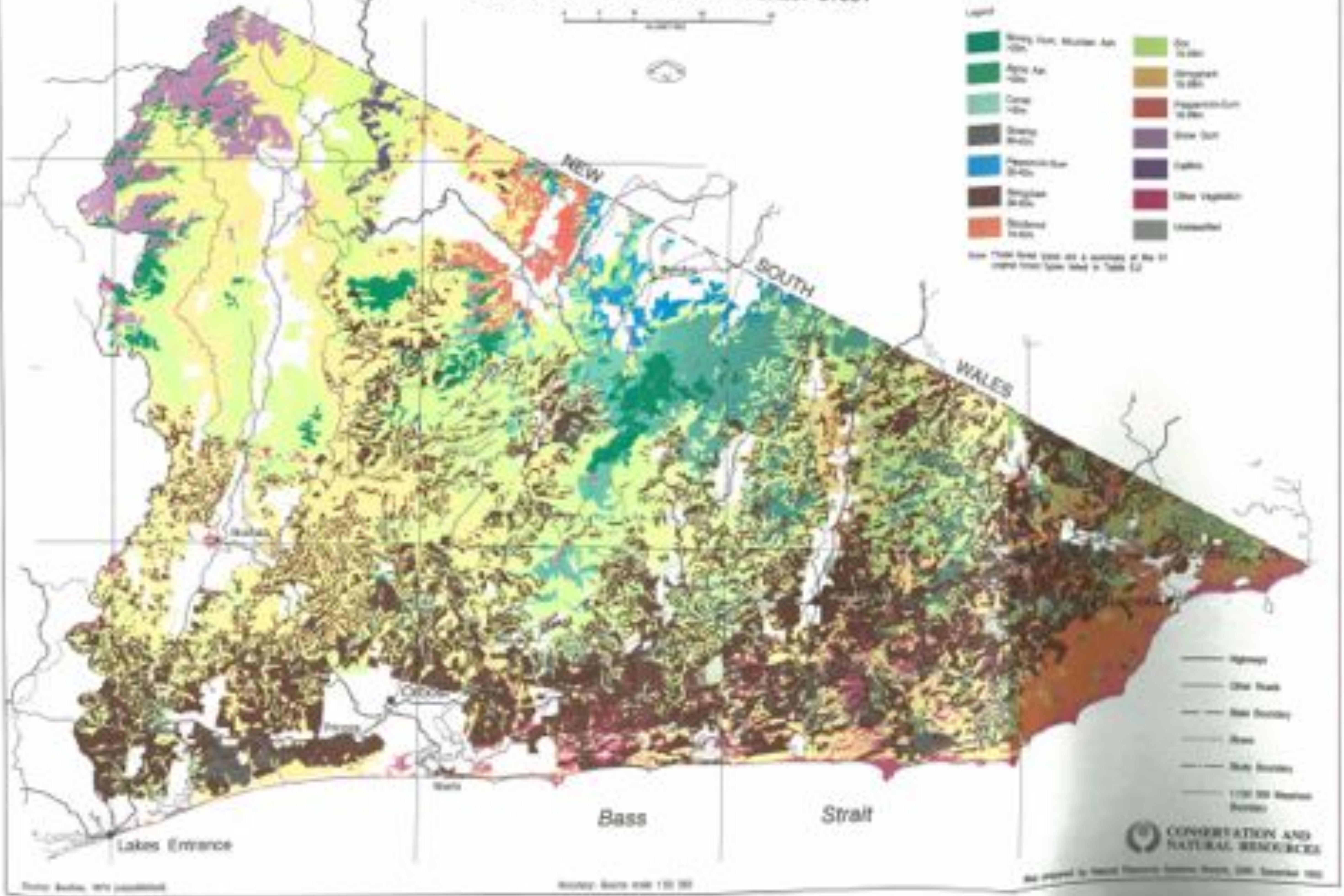
Table 5.2 (continued)

Height	Forest Type	FCV[1] Code ALP	FCV[2] Code GLH	FCV[3] Code EG	LCC[4] Code EG	Major Species	Area (ha)
Various	Podocarpus			Po		*Podocarpus lawrencei*	57
	Wattle		W	Ac		Various *Acacia* spp.	3 109
	Open	5d		O	7	Heath, tea-tree species	13 565
	Alpine Wet Heath	1				Heath, shrubs, grasses	129
	Closed Forest			Hatched	1a, 1b	Numerous non eucalypt species	—
	Other (dunes, lakes etc.)					Other	49 829
Total All Classes							1 057 760

Notes:
1 Former FCV CODE ALP = Alpine study area mapping (circa 1977).
2 Former FCV CODE GLH = Gippsland Lakes Hinterland study area mapping (circa 1982).
3 Former FCV CODE EG = East Gippsland study area mapping (Bustine 1974 unpublished).
4 LCC CODE EG = East Gippsland study area mapping (1974).
5 Combined area statement for Box classes 3f, 4b and 6b.
6 Areas (ha) reliable to nearest 5 ha (approx.)

MAP 4 : FOREST TYPES ON PUBLIC LAND

EAST GIPPSLAND OLD-GROWTH FOREST STUDY



MAP 4 : FOREST TYPES ON PUBLIC LAND

6

ECOLOGICAL VEGETATION CLASSES

6.1 INTRODUCTION

In 1980 the National Herbarium of Victoria conducted a vegetation survey of the Gippsland Lakes Catchment and East Gippsland. The analysis of 1312 vegetation quadrats produced a vegetation classification which consisted of 23 plant communities (Forbes *et al.*, 1981). In 1982 the Herbarium utilised this plant community information to construct the floristic map of East Gippsland vegetation (Parkes *et al.*, 1984). Extensive field work was undertaken to delineate plant community boundaries on the ground, with aerial photography being employed to interpret boundaries in remote or contentious areas. At the time of the map's publication the authors discussed the existence of restricted or inaccessible plant communities that had not been sampled adequately during the 1981 survey and that were therefore not described or mapped.

Eleven years on, as a component of the current study, the original floristic communities map was reviewed. By the time of this study there were 4820 quadrats available for the verification of community typology and mapping of these boundaries in the field. These were derived from a range of surveys conducted by the Department of Conservation and Natural Resources, its predecessors and consultants working in the area. The expanded database has thus enabled the inclusion of communities that workers subsequent to Forbes *et al.* (1981) have described as occurring in East Gippsland. In areal extent the largest such community is Damp Forest (formerly Damp Sclerophyll Forest). Forbes *et al.* (1981) referred to Damp Forest as only occurring in the Gippsland Lakes Catchment (at that time) and as a consequence Damp Forests were not mapped by Parkes *et al.* (1984). Other important additions are the communities referred to by Parkes *et al.* (1984) which have been described through subsequent floristic analysis. Hence the rocky cliffs of the Snowy River gorge have now been mapped as Rocky Outcrop Shrubland, the coastal swamps of Ewing's Marsh are now mapped as Wet Swale Herbland and the lagoonal margins of Lake Barracoota are now mapped as Coastal Lagoon Wetland.

6.2 CONCEPTS AND DEFINITIONS

Plant Community Typology

In order to understand the complex relationship between the physical environment, vegetation and the landscape, an hierarchical system of classification of plant communities called floristic communities was used by Forbes *et al.* (1981). This plant community typology has been refined and increasingly formalised over the last decade enabling the description of consistent floristic entities. The floristic communities so described display specific correlations with certain quantifiable environmental attributes as well as illustrating a biogeographical context. The refined typology used in this study is considered to be more process oriented than other systems which place the emphasis on species or on structure. Figure 6.1 illustrates the relationships between these systems as well as providing the hierarchy for the process-oriented typology.

The entities described by Forbes *et al* (1981) as floristic communities are called ecological vegetation classes under today's typology. With a more contemporary analysis of the current database, it is apparent that most ecological vegetation classes have more than one constituent floristic community whose distribution across the landscape is related to geology in drier areas and climatic and biogeographic gradients more generally.

Formation

Formations are defined on the basis of their structure and life form, without specific reference to their floristic composition. Generic references to life forms repeesented in the formation, such as palms, lianes and grasses, are usually given as part of the description of this structural entity. This enables biogeographers to compare the vegetation of different continents in a consistent way. Some Australian examples include rainforest, heathland, grassland and open forest. This level of the hierarchy was not mapped during this study.

Figure 6.1 Illustration of the process oriented typology that was used during this study and its relationship with other typologies which emphasise species structure or life form.

Ecological vegetation class

Ecological vegetation classes represent the highest level in the hierarchy of the vegetation typology developed and used across Victoria by the Department of Conservation and Natural Resources. They consist of one or a number of floristic communities that exist under a common regime of ecological processes within a particular environment at a regional, state or continental scale. In addition to sharing the features already outlined, it is expected that at the continental scale such floristic vegetation communities that occur in different biogeographic regions (but are united under one ecological vegetation class) would have some of their species shared, with many genera, families and life forms in common. Some floristic communities that occur in the same ecological vegetation class may however have very few species in common. Nevertheless, these floristic communities are still united by the one vegetation class because they respond to a similar environmental regime that is manifested in comparable life-forms, genera, families and similar vegetation structure.

At the regional level a lack of shared species is related to geology. Several East Gippsland examples are given in the description of Rocky Outcrop Shrubland (Appendix D), where they occur across a range of geologies. Where the vegetation class is dependent on a particular geology such as the Limestone Pomaderris Shrublands of East Gippsland, the stratigraphy of the geology may account for species differences between floristic communities of the vegetation class (Peel, 1993).

Thus, in contrast to formations and floristic communities, ecological vegetation classes are defined at a qualitative level by both their floristics and structure, but more importantly their description includes the ecological processes which characterise them. Ecological vegetation classes include such well established entities as Riparian Forest (high fertility sites with deep, well-watered soils replenished by periodic flooding with silt-laden fresh water), Rainshadow Woodland (well-drained soils derived from fertile granodiorite geology under low (<700 mm) and unreliable rainfall regimes) and Coastal Saltmarsh (anaerobic peaty muds inundated by salt water one or more times daily, but less frequently in summer). Such classes illustrate the vegetation's specific ecological response to a particular environment which occurs throughout the landscape. As such, ecological vegetation classes permit the link to be made between vegetation patterns and broad landscape features such as coasts, lakes, plains, dissected terrain, plateaus and mountains, and their respective climates. Ecological vegetation classes are usually floristically and structurally distinct from each other, whilst floristic vegetation communities are regional or sub-regional variants of ecological vegetation classes.

This is the level of the hierarchy that was mapped by this study. Ecological vegetation classes may be synonymous with sub-formations but are described in a different manner to them by including floristics and a qualitative consideration of the environmental processes operative for each class (see Figure 6.2).

Floristic vegetation community

Floristic vegetation communities *sensu* Forbes *et al.* (1981) are derived from floristic analysis using the classificatory program 'NEAR' and a method outlined by Gullan (1978).

The results of the analysis are presented in a two-way table which arranges species and classified quadrats on two axes and contains the cover–abundance data in the body of the table. Hand sorting this information involves the subjective arrangement of quadrats within small groups, small groups within large groups, large groups with respect to each other and of species (which are not given a fixed order by the classification). This is performed to permit the display of the floristic gradients within the data. Occasionally individual quadrats may be moved from one group to another on the basis of considering the importance of cover–abundance values rather that just presence/absence data.

The groups generated are then subjectively evaluated with respect to the floristic gradient between groups, relative cover–abundance values (particularly of the more ecologically dominant species) between groups and the ecological sensibility of groups and aggregations of groups. Those sites which are close to the boundaries of these centroid clustered groups may then be moved according to the cover–abundance of their constituent species.

Floristic communities consist of one or more sub-communities and typically relate to the large groups derived from the preliminary classification. A floristic community reflects the vegetation's response to environmental influences at the regional or sub-regional scale. These influences include geology, soils, minor altitudinal changes, landform, aspect and recurrent disturbances such as fire.

Note that in this report the term plant community is taken to be a generic reference that may include floristic vegetation community or ecological vegetation class.

Floristic sub-community

Sub-communities are based on small groups or aggregations of quadrats (Mueck and Peacock, 1992). Sub-communities may relate to different temporal phases of the vegetation type or a single floristic community under different disturbance regimes and are somewhat arbitrary steps along a floristic continuum. A sub-community groups vegetation samples from one floristic community as a function of subtle floristic differences that are mediated by microclimate variations across the localised landscape. Such variations include position on a slope, aspect, fire history, disturbance or proximity to another community. A sub-community is synonymous with the term 'nodum' of Poore (1955). Sub-communities typically occur over relatively small areas and are difficult to map at the regional scale and so were not mapped in this work.

Typologies operate most effectively on an extensive data set; the position of an entity within the hierarchy is likely to change if the data set was small in geographic extent or small in sample size and scattered over a wide area when the initial determinations were made. In this way the development of the typology of the state's vegetation is analogous to the dynamic nature of plant taxonomy: both systems are seen to be evolving and must be updated as better information comes to hand. As the data set used by Forbes *et al.* (1981) was relatively small (considering the geographic area covered), some of the floristic entities initially described as sub-communities in that study were found to require reclassification and have been redefined as floristic vegetation communities or ecological vegetation classes in this work. The vastly improved data set available for the study area has enabled the revision of the plant typology for East Gippsland. This revision is consistent with the state-wide vegetation typology currently being developed by the Department.

An example of this process-oriented typology is given in Figure 6.2.

6.3 METHODS

Mapping ecological vegetation classes as a part of the old-growth study was undertaken in order to provide an ecological context for stands of old-growth forest identified by forest mappers during this study. Vegetation classes exhibit different structural and floristic responses to their environment. The advantage of describing old-growth forests in terms of their constituent vegetation classes is that it is possible to circumscribe the particular environmental conditions which produce and perpetuate the old-growth state for that class. Because the typology is based an ecological processes, disturbance regimes which may effect the old-growth status of a stand can be consistently assessed. The major advantage of this approach is that it will allow a more refined and focused management response for areas of old-growth forest so defined.

Forest type and structural vegetation mapping at a scale of 1:63 360 (Buntine 1974 unpubl.) covered all of the LCC East Gippsland Study Area and parts of the Gippsland Lakes Hinterland and Alpine Study Areas (Chapter 5). Although the focus of this mapping was as a basis for land use determinations, including the discrimination of commercially productive categories of forest, this mapping also reflects environmental site quality. Plant community maps are also a reflection of the vegetation's interaction with particular environmental site qualities, but are created from a broader ecological perspective.

Both approaches to mapping employ detailed analysis of remotely sensed information and subsequent field checking. In East Gippsland, where accurate and detailed forest type mapping was available but floristic mapping had only been completed at a broad scale, it was desirable to use the information of the former to assist in upgrading the latter. By also including data on geology, soils, climate, landform, biogeographic context and the currently available floristic quadrat data set, this approach modified the line work of forest types to produce ecological vegetation class mapping.

There are several advantages to linking forest type information and ecological vegetation class information:

- efficient use of existing information,
- broader understanding and acceptance of improved mapping by management staff, and
- encouragement of the synthesis of silvicultural site quality parameters with ecological considerations, which has profound implications and advantages for forest management.

The method for transforming forest type boundaries into ecological vegetation class boundaries is relatively straightforward provided there are good floristic, edaphic and bio-geographic data for the area. The strongest, most persistent and stable influences will define the distribution of an ecological vegetation class in the broad landscape context, while the floristic vegetation communities are regional variants.

The ecological vegetation class was undertaken by overlaying information about the physical environment, biogeography and existing floristic quadrat information with the forest type maps. The synthesised maps of vegetation classes were then field-checked to ensure that assumptions about the influence of abiotic and biogeographic factors on vegetation in the landscape had been correct. Whilst field-checking the accuracy of the revised mapping for vegetation class boundaries, more specific information about the ecological vegetation classes was collected.

Maps were verified during eight months of field work by driving all the major roads and tracks. Where necessary and as time permitted the field verification of vegetation classes boundaries away from the track network was achieved through bushwalking. Additional information was obtained from the work of field botanists who had worked in the area or who were still engaged in biological survey in the study area.

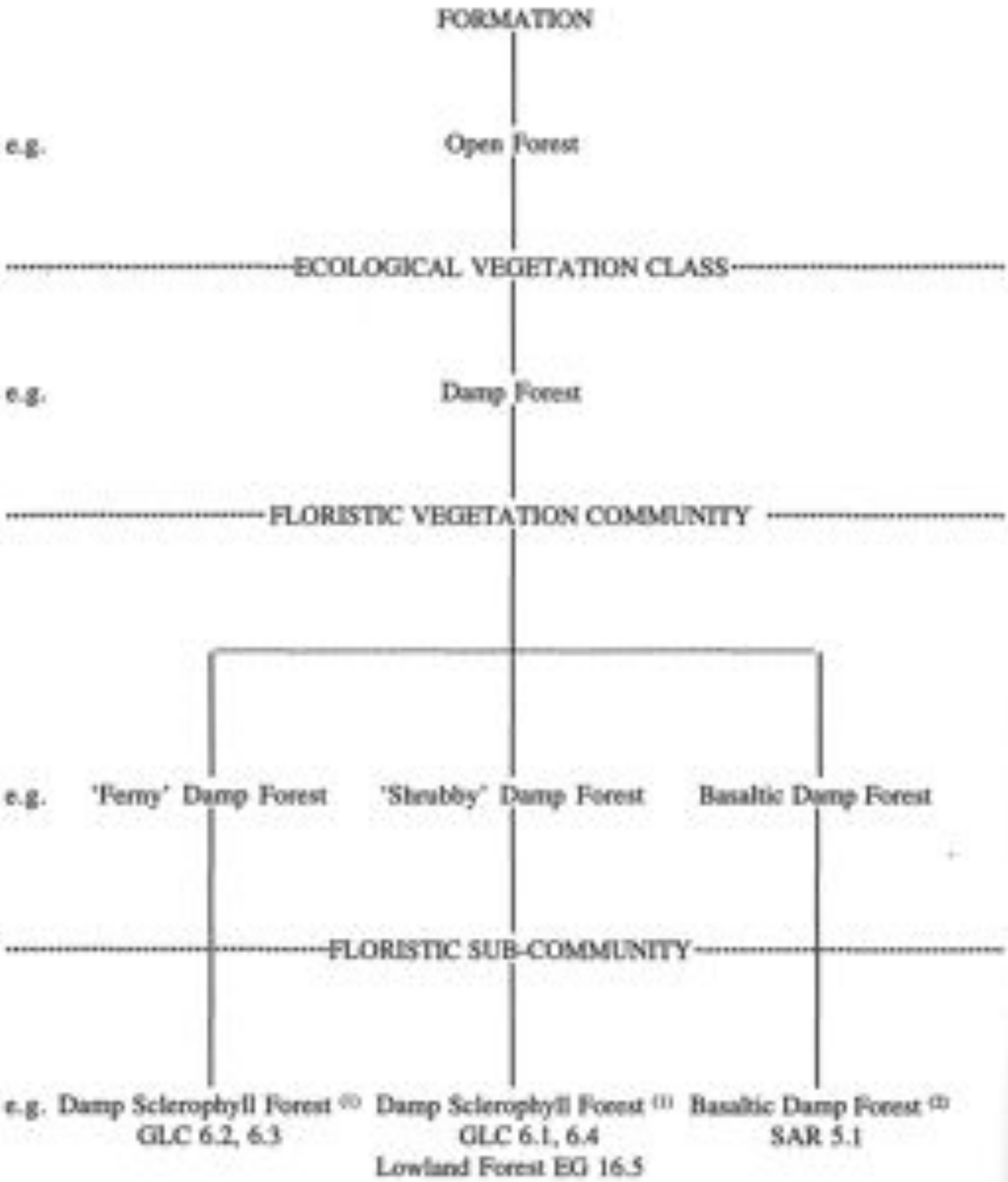


Figure 6.2 An example of plant community typology for damp forests in East Gippsland.

Notes:

1 The name for this sub-community has been superseded by the new typology nomenclature (refer to Section 6.3) but is used here because it is the original name as cited by Forbes *et al.* (1981)

2 Peacock *et al.* (1992).

Aerial photography, geological boundaries and landform were used to interpret remote ecological vegetation class boundaries throughout the study area where time did not permit on-the-spot verification of such boundaries.

During the course of the field-checking it became obvious that certain vegetation classes were not catered for by the structural classes in the forest type mapping. They were delineated by the use of aerial photo interpretation (API) where equivalent structural classes were absent or inadequate. See Appendix D.

Data sources

Data sources used in the mapping procedure included:

- vegetation maps at 1:100 000, Land Conservation Council study area reports for; East Gippsland (1974), Gippsland Lakes Hinterland (1982) and Alpine (1977);
- forest type maps at 1:63 360, former Forests Commission of Victoria, Buntine (1974, unpubl.);
- logging history at 1:100 000 (Chapter 7);
- dieback caused mostly by *Phytophthora cinnamomi* Ward and McKimm (1982);
- land systems at scale 1:100 000 (east of the Snowy River), 1:250 000 (west of the Snowy River) Department of Conservation and Natural Resources (1993);
- geology; Geological Survey of Victoria at 1:250 000 — Mallacoota (1976), Tallangatta (1976), and Bairnsdale (1977); and 1:100 000 — Bendoc (1990), and Murrindal (in prep.);
- the Geology of the Cann River Forest District; 1:100 000 (Beams and Hough, 1979b);
- Floristic Map of East Gippsland (Parkes *et al.*, 1984);
- floristic analyses of the quadrat data set for East Gippsland using CNR's Flora Information System; and
- numerous floristic analyses from pre-logging flora and fauna survey reports in the Ecological Survey Report Series (CNR) cited by author in the References.

Field reconnaissance

Field work to check the revised mapping and to refine ecological vegetation class descriptions was conducted from September 1990 to April 1991. Additional site specific data was collected as defined species lists from 77 locations across the study area (FIS quadrats U00601–U00677).

Plant taxonomy

The taxonomy follows Ross (1993) and the periodic taxonomic updates of the National Herbarium of Victoria.

Vegetation class nomenclature

The names for the ecological vegetation classes have been formulated through reference to previous work in Victoria and Australia and are referrable to Census of Victorian Plant Communities, CNR (in prep). The ecological vegetation class names are designed to convey a simple picture of the vegetation and its context. They are not intended to be detailed descriptions. Each name gives the usual structural form such as woodland, heathland, or sedgeland, although not all examples of ecological vegetation classes are restricted to the one structural category. For example, Banksia Woodland may be a low open woodland on exposed near-coastal dunes or an open forest on more sheltered inland sites. A variety of adjectives are employed to describe a particular and consistent feature about the vegetation class; for example, coastal, damp, vine-rich or grassy.

After much careful consideration and consultation, the term sclerophyll has been removed from the Victorian plant community nomenclature. The change was made because 'sclerophyll' is a term that is not familiar to non-specialists, it is applicable to many communities and thus adds little to discriminating between them. Furthermore, it was originally intended to be applied strictly to either the overstorey or the understorey, but this distinction has rarely been made.

Limitations

The vegetation mapping of this study in some instances encapsulates several ecological vegetation classes across the study area that occur in patterns too complex to map at 1:100 000. It is therefore reasonable to expect that a revision of this mapping at a finer scale in the future may lead to the delineation of more ecological vegetation classes.

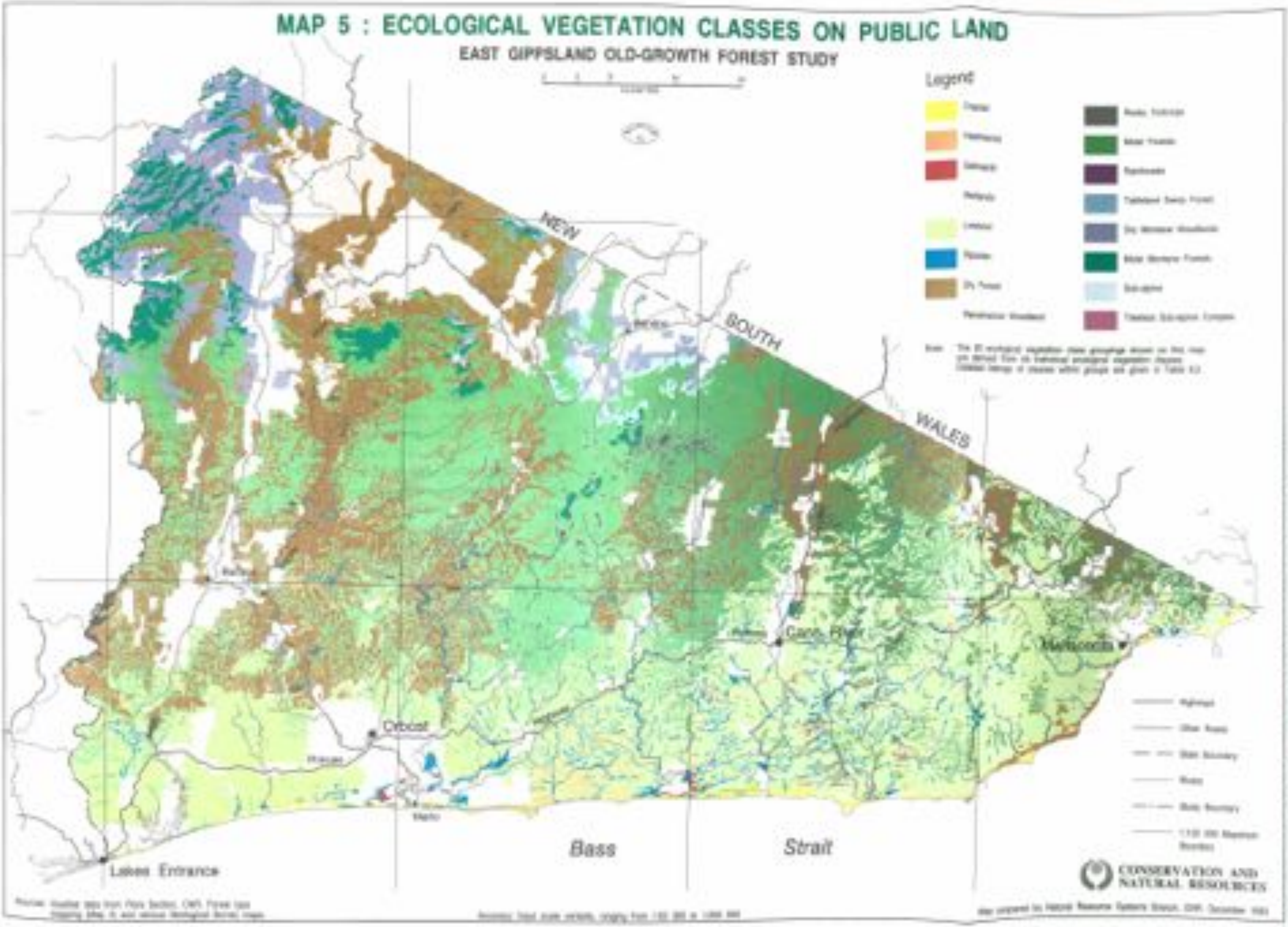
6.4 RESULTS

The relationships between the forest type mapping (Chapter 5) and ecological vegetation classes are described in Appendix D. This table also provides descriptions of landform, geology, rainfall and elevation for each forest type and ecological vegetation class.

The complete revision of the floristics of East Gippsland produced 44 ecological vegetation classes. These are listed in Table 6.2 along with their area (in hectares) on public land. Detailed class descriptions are given in Appendix E. These revised descriptions include 24 plant communities in addition to those recorded on the original Floristic Map of East Gippsland (Parkes *et al.*, 1984). Note that the vegetation class mapping was not completed for freehold land.

Over 98% of the public land in the study area was found to be vegetated. The remainder of the area comprised water-bodies, inlets and bare areas such as blow-outs on coastal sand dunes. Forested vegetation comprises 1 027 377 ha (97%) of public land (of which 918 833 ha was mapped as forest by the more detailed growth stage mapping — see Chapter 4). The most extensive class is Lowland Forest (245 131 ha) which together with Damp Forest (238 288 ha), Shrubby Dry Forest (209 982 ha) and Wet Forest (90 288 ha) account for 76% of the public forest estate. The four rainforest classes together only occupy 9619 ha.

A generalised map of the ecological vegetation classes is depicted as vegetation groups in Map 5. The groups comprise: Coastal (ecological vegetation classes 1–4), Heathlands (classes 5–8), Saltmarsh (class 9), Wetlands (classes 10–13), Lowland (classes 14–16), Riparian (classes 17–19), Dry Forest (classes 20–25), Rainshadow Woodland (class 26), Rocky Outcrops (classes 27–28), Moist Forests (29–30), Rainforests (classes 31–34), Tableland Damp Forest (class 35), Montane Dry Woodlands (classes 36–37), Moist Montane Forests (classes 38–41), Sub-alpine (classes 42–43) and Treeless Sub-alpine Complex (class 44).



MAP 5 : ECOLOGICAL VEGETATION CLASSES ON PUBLIC LAND

Table 6.2 Ecological vegetation classes and area (ha) on public land of the East Gippsland Forest Management Area [1,7].

Vegetation class	Area (ha)	Vegetation Class	Area (ha)
1. **Coastal Dune Scrub Complex**[3,5]	3 109	24. **Foothill Box Ironbark Forest**[3,5]	595
2. **Coast Banksia Woodland**[3]	3 397	25. **Limestone Grassy Woodland**[2]	471
3. **Coastal Grassy Forest**[2]	90	26. **Rainshadow Woodland** [3]	22 179
4. **Coastal Vine-rich Forest**[2,5]	122	27. **Rocky Outcrop Scrub** [3,5]	5 052
5. Coastal Sand Heathland	681	28. **Rocky Outcrop Shrubland**[3,5]	1 606
6. Sand Heathland	44	29. **Damp Forest**[2]	238 288
7. Clay Heathland	1 781	30. **Wet Forest**[2]	90 288
8. Wet Heathland	9 514	31. **Cool Temperate Rainforest**[3,6]	2 563
9. Coastal Saltmarsh	904	32. **Warm Temperate Rainforest**[3,6]	6 777
10. Estuarine Wetland	795	33. **Cool/Warm Temperate Rainforest Overlap**[3,6]	268
11. Coastal Lagoon Wetland	718	34. **Dry Rainforest**[3,6]	11
12. Wet Swale Herbland	789	35. **Tableland Damp Forest**[2,5]	7 000
13. Brackish Sedgeland	195	36. **Montane Dry Woodland**[2]	48 517
14. **Banksia Woodland**[3]	36 980	37. **Montane Grassy Woodland**[2,5]	4 825
15. **Limestone Box Forest**[2,5]	4 658	38. **Montane Damp Forest**[2]	13 962
16. **Lowland Forest**[2]	245 131	39. **Montane Wet Forest**[2]	13 506
17. **Riparian Scrub Complex**[3,4,5]	17 664	40. **Montane Riparian Woodland**[3,5]	516
18. **Riparian Forest**[2,4,5]	12 656	41. **Montane Riparian Thicket**[3,4,5]	36
19. Riparian Shrubland	659	42. **Sub-alpine Shrubland**[3,5]	202
20. **Heathy Dry Forest**[3,5]	2 989	43. **Sub-alpine Woodland**[2]	7 310
21. **Shrubby Dry Forest**[3]	209 982	44. Treeless Sub-alpine Complex[5]	1 071
22. **Grassy Dry Forest**[2,5]	16 903	Other	13 232
23. **Herb-rich Forest**[2]	9 724		
Total all classes			1 057 760

Notes:

1 Vegetation classes (in bold) which conform with the definition of 'forest' adopted for this study (classes 1–4, 14–18, & 20–43).

2 Jacobs forest classes. These classes mostly show classic eucalypt growth form (classes 3–4, 15–16, 18, 22–23, 25, 29–30, 35–39 & 43).

3 Non-Jacobs forest classes. These classes mostly exhibit atypical eucalypt growth form (classes 1–2, 14, 17, 20–21, 24, 27–28 & 40–42).

4 The revision of mapping for riparian classes was not completed because the structural mapping was unable to adequately delineate these vegetation classes. As a consequence the area statements for these linear riparian vegetation classes are provisional.

5 Ecological vegetation classes that were not adequately delineated by forest type structural mapping. These were mapped with the aid of aerial photography and other vegetation mapping techniques (see Appendix D). A complex comprises two or more ecological vegetation classes that are indivisible at this scale of mapping.

6 The total area for rainforest vegetation classes is based on structural mapping not floristic mapping. The partition of the area of rainforest into four vegetation classes is based on floristic criteria. A floristic-based mapping approach would see a revision of the area of these classes.

7 Areas (ha) are reliable to the nearest 5 ha (approx.).

7
FOREST DISTURBANCE — IDENTIFICATION AND SURVEY

7.1 INTRODUCTION

A list of disturbances known to have altered the primary attributes (floristics, structure or growth stage) of the forests in the study area was prepared. These disturbances were described according to their cause; natural or un-natural (post-European human-induced). Research using historical and contemporary records was undertaken to delineate and map the extent and severity of these disturbances. The following discussion indicates the most important of these disturbances and is a summary of more detailed histories and sources which are presented in Appendix F.

7.2 AGRICULTURAL SELECTION

Agriculture represents less than 15% of land use by land area in East Gippsland. Agricultural activities are concentrated in fertile country around Buchan, Gelantipy and Wulgulmerang; on the alluvial river flats, coastal plains and adjoining cleared foothills around Orbost; in the north near Bendoc, Bonang and Tubbut; and in the far east of the region at Combienbar, Cann River, Mallacoota and along the Genoa River valley. The first settlements were established in the north and far east of the study area in the late 1830s and 1840s, mostly for grazing. Crown land selection, the process of sub-division and forest clearance that led to closer settlement, had the greatest impact on the more marginally productive country of the region from the 1880s.

Archival Crown Lands and Survey files show that, for the period generally between the 1880s and 1930s, about 135 Crown Land selections within the study area were taken up, partially or wholly ringbarked, later abandoned or forfeited, and reverted to the Crown. Most of these selections are now within State forests or National Parks. Selection blocks were abandoned because of difficult access, remoteness from markets and the vigorous regrowth of native vegetation following clearing.

Many of these blocks were cleared and have subsequently revegetated. Clearing was mostly done by ringbarking trees and later grubbing the stumps, and burning the dried and dead vegetation. Deforested areas were then sown with pasture grasses, while the more fertile alluvial flats were planted with cereal or vegetable crops. In some instances agricultural blocks were cleared and farmed more than once before being permanently abandoned. As the average size of the selection blocks was 150 ha, this represents approximately 20 000 ha of land that may have been affected by early agricultural activity (Table 7.2). Today, most of this land is forested.

Data relating to agricultural clearing has been obtained from the archival files, collated into a textual database and entered into the GIS. The database contains information on the location, extent and approximate period of clearing for each selection. Where clearing was undertaken on a portion of the allotment area, the percentage is based upon data found in the reports of Crown Bailiffs who inspected the selections for the Lands Department. Parish plans (historic and current) have been used to situate allotments within the spatial database (GIS), with each receiving a unique number to link the allotment with the textual database. The current extent of tree clearing on freehold land has been determined from Landsat TM satellite imagery (Goodson and Gilbee, 1992). Map 6 depicts the location of crown land selections which have reverted to public land. It also shows current freehold land.

7.3 GRAZING

Cattle grazing commenced in the study area in the 1830s and has continued to the present day, though within a much reduced geographical area. The first cattle were depastured in the forests of East Gippsland by graziers from the Monaro district of southern New South Wales, driven into the region through industry expansion and a run of dry seasons in the 1830s and 1840s. A series of nineteenth century land acts and amendments made provision for grazing on unoccupied Crown land in Victoria, recognising that extensive forested areas in East Gippsland were more suited to intermittent grazing than to intensive agricultural development. This regional land use has continued through the current century, with grazing leases administered by the former Department of Crown Lands and Survey, the former Forests Commission of Victoria, the former Department of Conservation and Environment and more recently the Department of Conservation and Natural Resources.

The current survey identified five categories of grazing licences and leases which represent different forms of administration rather than different types of forest grazing. Information on significant grazing leaseholds was researched from a variety of sources including historic plans and maps, archival Crown Lands and Survey files, Forests Commission records and Victorian Government Gazettes. A textual database has been compiled which holds information on the area of the leasehold, the period of grazing, the relevant Government file numbers, and a unique number that links this data to the spatial database.

There is some chronological overlap between the categories of grazing, and the size and boundaries of individual leases could vary significantly over time. Leases were taken up intermittently, sometimes abandoned in good seasons, and not necessarily held continuously over a given period. The date-range for a grazing area is therefore only an indication of the period of grazing. Information concerning stocking rates and stock numbers was not consistent nor of sufficient quality to be included in the textual database. Data relating to the earliest grazing leases, or Pastoral Runs, have been excluded due to the inconsistency of available information, specifically the location of early leaseholds.

The original maps of grazing areas show the extent of the leaseholds, somewhere within which grazing has occurred. During the construction of the GIS database it was decided that the grazing leaseholds be depicted within a matrix of 2 km grids covering the entire study area. If a lease overlapped more than 50% of a grid square the grid was marked with the attributes of that lease. Data on leases greater than 400 ha, excluding current licences which range down in size to 2 ha, were entered into the GIS for presentation at a scale of 1:100 000. Map 7 depicts the extent of current and historic grazing leases.

7.4 MINING

Gold was discovered in the study area in the early 1850s, and copper and silver-lead from the 1870s onwards. The first gold fields of the region were situated near Bendoc and Bonang, where alluvial gold, and later quartz, were mined throughout the 1850s and 1860s. In the 1880s and 1890s a new round of gold discoveries was made in the region when mining tracks were opened up, providing access to the auriferous areas. The gold fields of East Gippsland tended to be short-lived, however, yielding poor to moderate returns, and were not as geographically extensive nor productive as those of central Victoria.

Gold prospecting and extraction has occurred along many river and stream systems in the region. In the Bendoc district payable gold was eventually found in most streams flowing north from the Coast Range. In the south of the study area prospecting tended to be concentrated at the heads of the river systems. Copper and silver-lead were mined in the Deddick district in the 1870s and 1890s. Silver mining was undertaken in the Buchan area in the early years of this century. Large areas of the region have in recent decades been subject to mineral exploration licences.

Records indicate that large-scale forest clearance for mining was not commonplace in the region, though forests in the immediate vicinity of mines and associated settlements were destroyed. Mining activity was, however, very destructive of the local environment, with trees felled for fuel and building purposes, and streams and stream banks heavily disturbed in the search for alluvial gold.

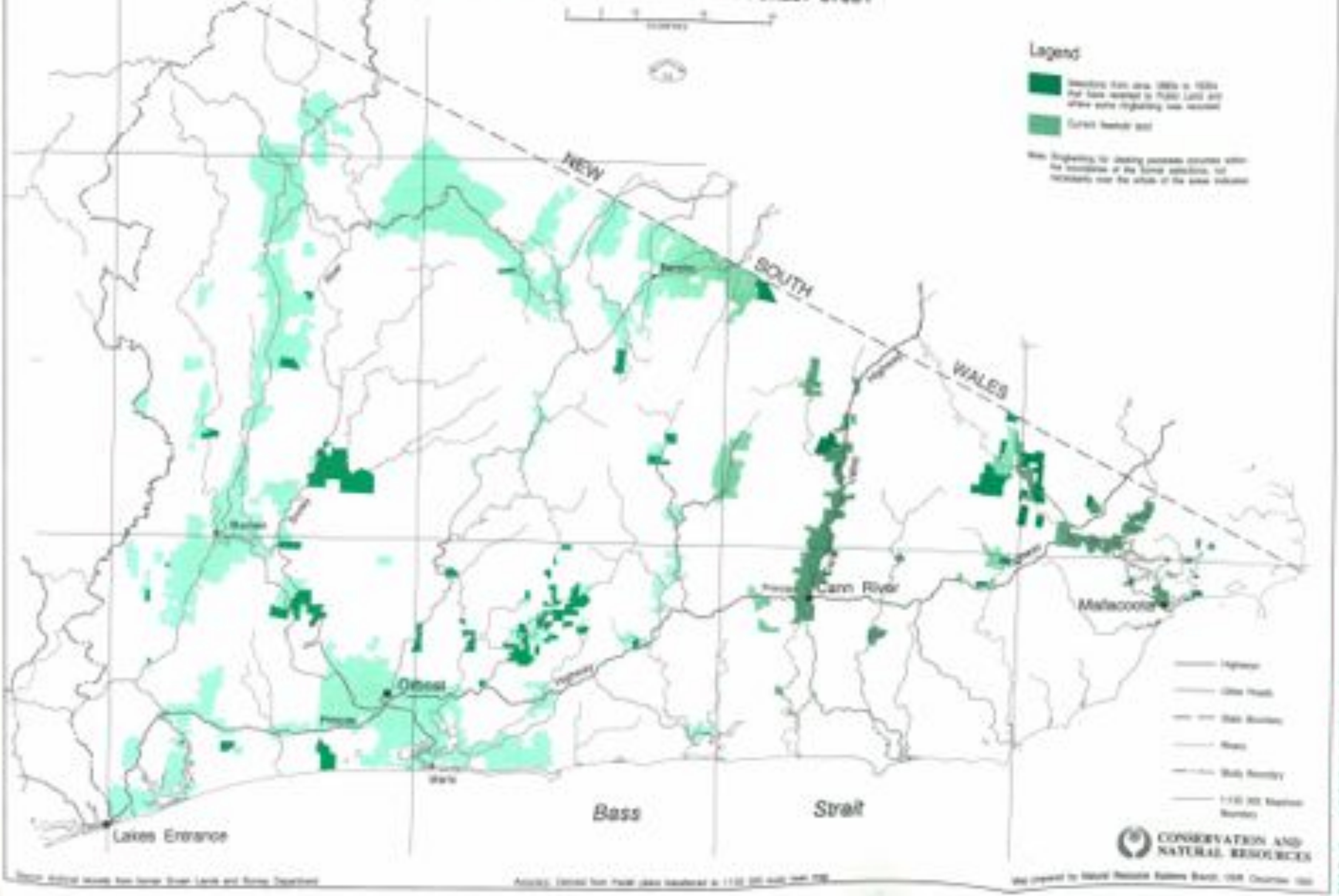
Information was obtained from the records of the Geological Survey of Victoria, reports of the former Department of Minerals and Energy, and a range of secondary sources. The significant mines and mineral extraction sites of the region were loaded into a textual database which indicates the location (AMG to 1:100 000 scale accuracy), the name, the type and the dates of operation of the mine. These data were then directly entered into the GIS with the textual attributes linked with point locations. Some historic mining access tracks have also been entered. It was not possible to determine the location of all mines and mineral extraction sites in the study area. Map 8 depicts the location of historic mining sites and tracks.

7.5 DIEBACK

The major pathogen mapped in the study area is the root rot fungus *Phytophthora cinnamomi*. This fungus has profound effects on the structure and floristics of the forest communities within which it occurs, causing large scale crown defoliation and death of plants in both the overstorey and understorey in its most severe expression. The mapping was undertaken in 1973 by the former Forests Commission of Victoria using aerial photography and field inspection. This mapping is still an accurate description of the likely extent of dieback following an epidemic event (pers. comm. Ian Smith). The origins of the disease are uncertain. Although Marks and Smith (1991) and others consider the fungus to be introduced, it is also acknowledged by Burbidge (1960), cited in Marks and Smith (1991), that there is evidence which suggests the fungus has been in Australia for many thousands of years. However for the purposes of this study, the extent and severity of dieback caused by *Phytophthora cinnamomi* was considered to be anthropogenic (Ian Smith, pers comm.). This mapping was entered into the GIS database and is depicted in Map 9.

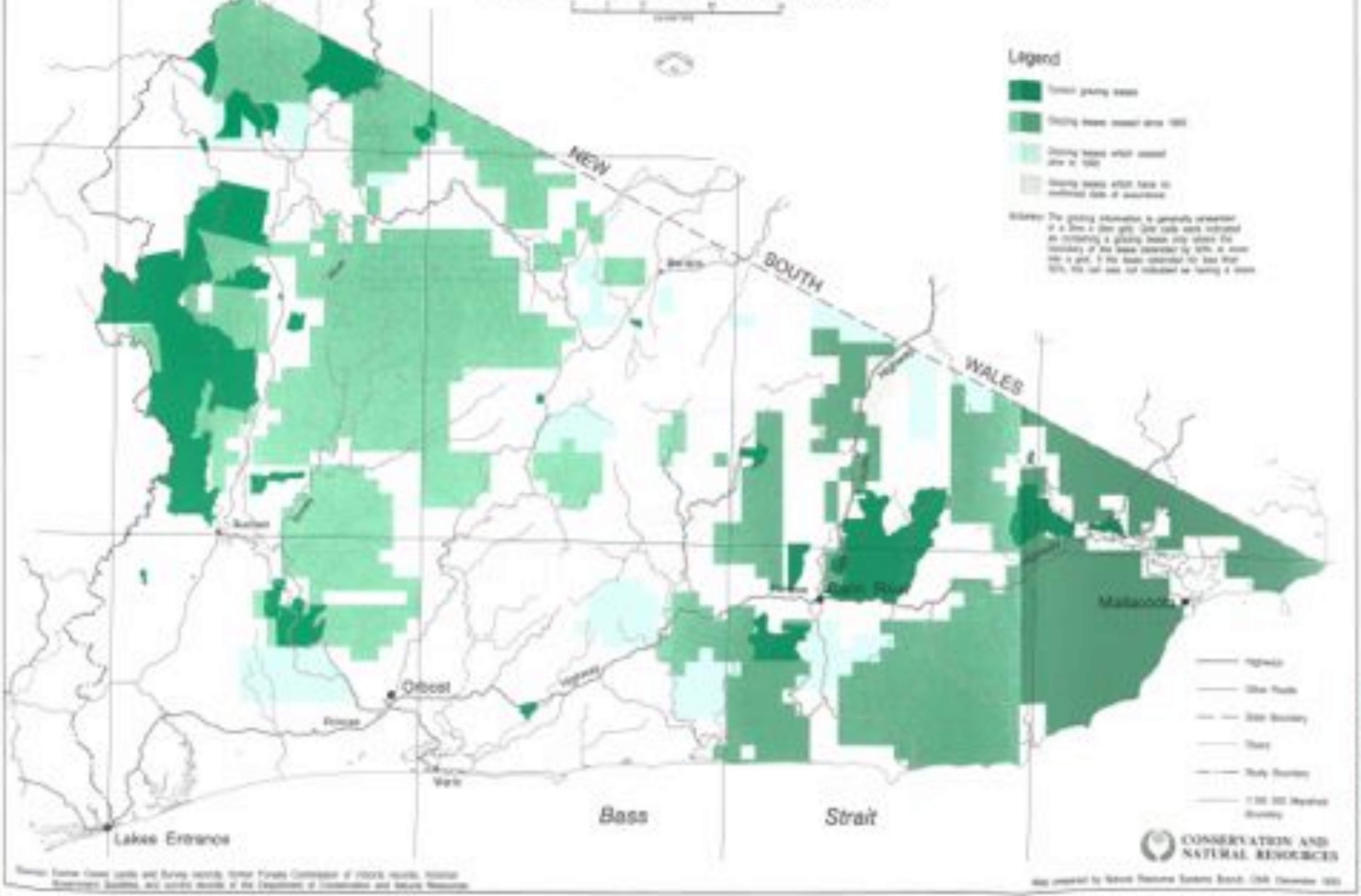
MAP 6 : AGRICULTURAL SELECTIONS

EAST GIPPSLAND OLD-GROWTH FOREST STUDY



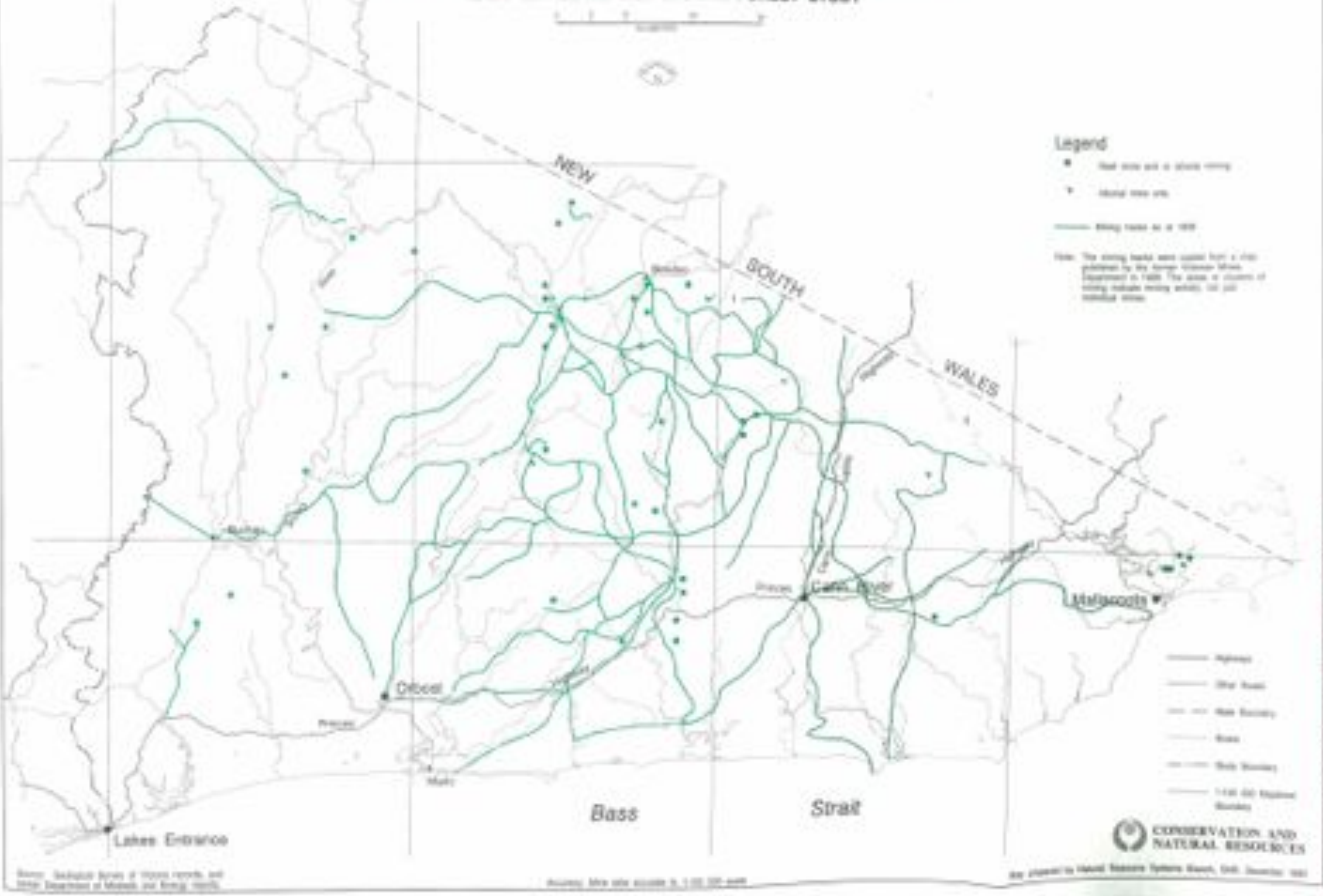
MAP 7 : GRAZING LEASES

EAST GIPPSLAND OLD-GROWTH FOREST STUDY

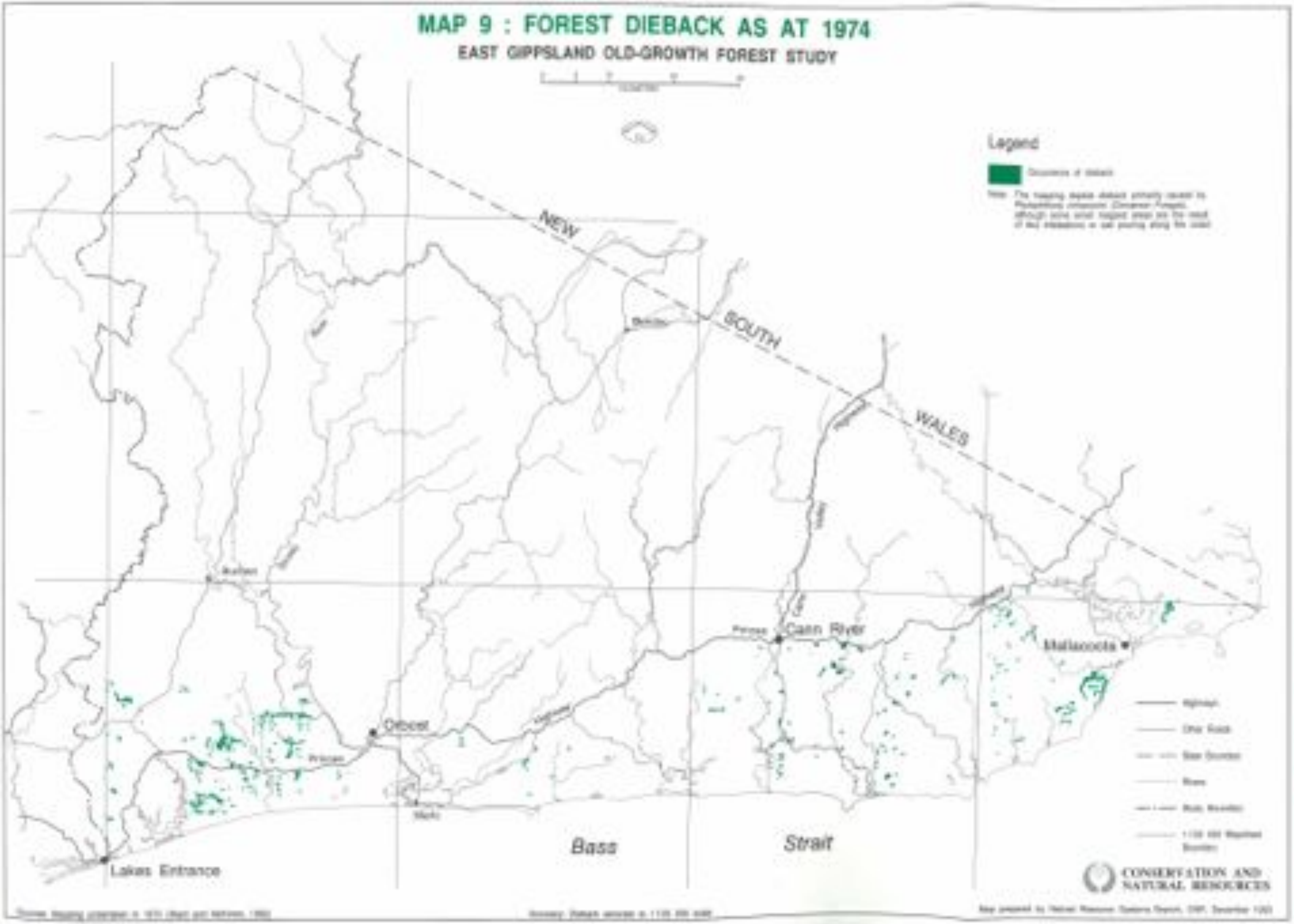


MAP 8 : HISTORIC MINING SITES AND TRACKS

EAST GIPPSLAND OLD-GROWTH FOREST STUDY



MAP 8 : HISTORIC MINING SITES AND TRACKS



MAP 9 : FOREST DIEBACK AS AT 1974

7.6 TIMBER HARVESTING

Extensive utilisation of timber has occurred throughout the forests of the study area. This begun in the 1840s with the early graziers felling trees for their immediate needs, such as huts, yards and fuel, and continued with the mining settlements of the 1850s and the agricultural settlements from the 1870s. During the 1880s and 1890s the durable timbers of the area were selectively harvested and shipped by rail or sea to markets in Melbourne. Utilisation increased after the extension of the rail head from Bairnsdale to Orbost in 1916. Hardwood railway sleepers were hewn in the study area for many decades during the 20th century, and piles, poles and beams cut and removed from the forests.

The primary customers for the durable species were the public utilities, the former Victorian Railways Department (sleepers), State Electricity Commission (light poles), the former Public Works Department (heavy construction beams) and the former Melbourne Harbour Trust (piles for piers and docks). Gippsland Grey Box was especially prized for wharf construction because of its resistance to Toredo Worm attack, whilst the abundance of Box and Red Ironbark made the Orbost district the premier sleeper hewing area for Victoria from 1920 to the early 1930s. The hewn products of the Cann River and Mallacoota districts were used by the New South Wales Railways or shipped out to New Zealand via the port at Eden in southern New South Wales.

Large scale timber harvesting began in the 1950s in response to a significant loss of resources in the Victorian Central Highlands from the 1939 bushfires and the increased demand associated with the post-war housing boom. With the merchantable forests of the coastal plain largely logged over, the attention of timber-getters moved to the foothills of the hinterlands around Buchan and to the north of Orbost and Cann River. Access to this hilly country was facilitated by the improvement in roading machinery such as bulldozers and graders during the post-war period.

Historically, timber utilisation tended to follow the easterly extension of the rail into East Gippsland, though in the era after the Second World War increased road construction assisted the expansion of the hardwood industry in the region. There was a steady increase in sawlog output throughout the 1950s and 1960s through a system of selective harvesting. A type of clearfelling system was introduced in the late 1960s and early 1970s and by 1974–75 the forests of the region were producing 40% of the state's log output. This system was a modified form of clearfelling where some trees were retained for environmental protection or conservation (DCE 1990).

During the 1970s there was a reduction in the number of mills in East Gippsland following amalgamation and take-overs with the issuing of larger individual log allocations against licences of three year duration. Hardwood log output returns for Nowa Nowa, Orbost and Cann River districts declined slightly between 1970 and 1974, then fluctuated with a trend of increased output by 1981, particularly in the Orbost forest district. Regional sustainable yield harvesting was introduced in the late 1980s following the Victorian Government's (1986) Timber Industry Strategy.

Accurate information on the areal extent of selective logging was difficult to find. Air photos (black and white, scale 1:40 000, large format) from the early 1940s were available for parts of the study area. They provided clues as to the possible location of disturbed forest but precise boundaries were difficult to derive. A few contemporary maps of these early logging activities were also found. What were available were detailed log allocation records by licence area for the period 1945 to 1970 approximately. These were reorganised to conform with current forest block and compartment boundaries and together with information on species were entered into the GIS database. It should be noted that selective harvesting within a forest compartment indicates only that this form of harvesting occurred, not its precise distribution or intensity.

A variety of forms of remote sensing and investigative techniques were employed to assist with the mapping of the clearfelling history. Landsat TM imagery (bands 3, 4 and 5) in transparency form at scale 1:1 000 000 (March 1990) and 1:250 000 (April 1992) was interpreted at scale 1:100 000 using a Kartoflex photogrammetric map revision instrument to map the clearfelling coupe boundaries from the late 1980s to the present. Landsat MSS transparencies (band 1, 3 and 4) at scale 1:1 000 000 from August 1972 to February 1987 (with scenes from August and December 1972, February 1978, October and November 1980, March 1984, January and July 1986, and January and February 1987) were also interpreted on the Kartoflex in order to map clear felling boundaries at a scale of 1:100 000 back to the early 1970s.

It was a fortunate coincidence that the advent of Landsat 1 in 1972 coincided with the shift in logging practices from selective harvesting, which is difficult to identify from either aerial photos or satellite imagery, to clearfelling and seedtree silvicultural systems in the early 1970s, which are more readily detectable from remotely sensed imagery. Nevertheless some of the early satellite images suffered from severe line striping and contrast deficiencies which significantly impaired the quality of mapping. Despite these deficiencies the mapping was comparable with local regional records that had been compiled over the years by interpretation of both small and large format aerial photos and associated field mapping. Prior to the study, the existing regional records were incomplete and were substantially up-dated as a result of the satellite image interpretation.

The extent of selective logging and clearfell harvesting are shown on Maps 10 and 11 respectively.

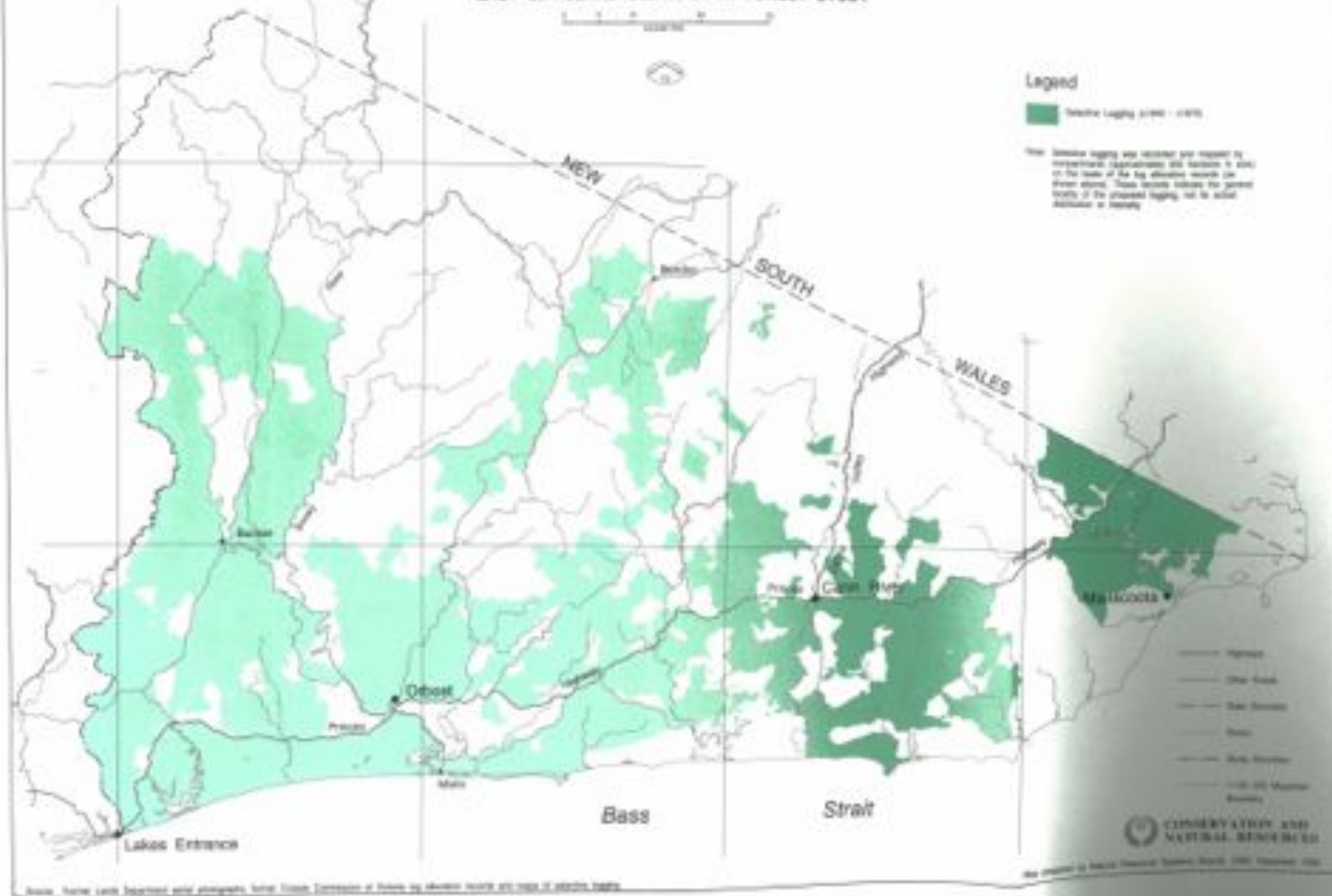
7.7 WILDFIRE

Wildfire is a particularly important disturbance to the growth stage characteristics and floristics of old-growth forest. Wildfires maintain the ecological dynamics of regeneration and decline for most eucalypt communities (Gill 1981), whilst having the potential to physically affect the morphological characteristics of growth stages. Clearly the period of time taken to recover from such a disturbance is dependent upon the fire intensity and frequency and the vegetation class involved. Since the advent of intensive wild-fire suppression techniques in recent decades, the truly 'natural' characteristics of contemporary wildfires have been questioned. Even if a wildfire has not been started by human forces, human intervention is usually used to help suppress the fire. Wildfires occur regularly in East Gippsland and major fires are known to have occurred in 1923, 1938–39, 1943–44, 1945–46, 1951–52, 1958–59, 1962–63, 1967–68, 1978–79, 1980–81, 1982–83 and 1987–88 (CFL, 1990, and Foley, 1947).

The Department of Conservation and Natural Resources (CNR) and its predecessors have routinely recorded the outer boundary of most wildfires for the last three decades on base maps for fire management planning. Prior to that only the 1952 and 1939 fire boundaries were available in map form. Unfortunately, little information on the severity of burn was available from historic records. These maps formed the basis of the fire mapping for this study. The regional base maps of wildfire history recorded by CNR (1960 to 1991) and the available historic maps (1939 and 1952 fires) were redrafted onto one complete map layer for the GIS

MAP 10 : TIMBER HARVESTING - SELECTIVE LOGGING BASED ON COMPARTMENT

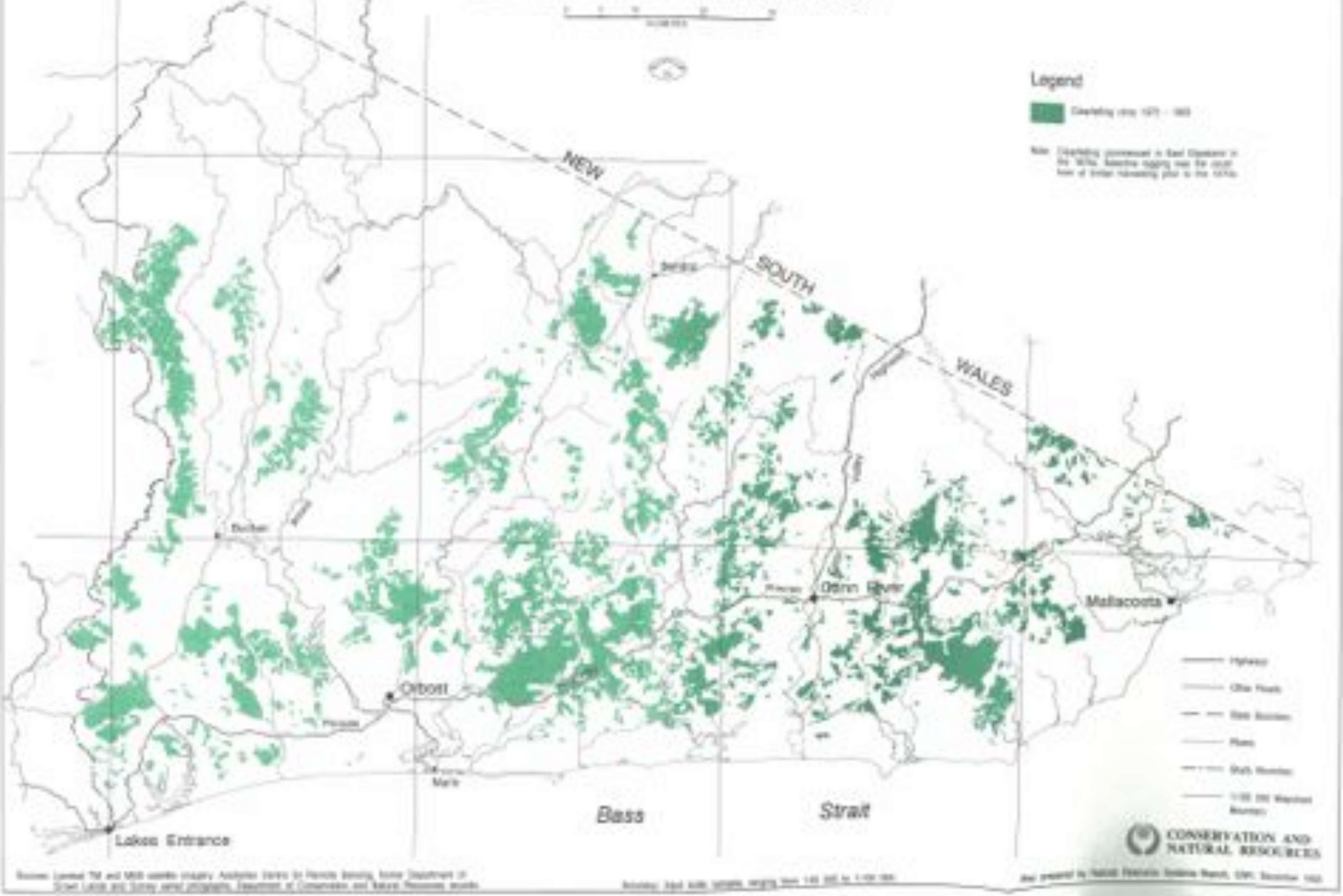
EAST GIPPSLAND OLD-GROWTH FOREST STUDY



MAP 10 : TIMBER HARVESTING - SELECTIVE LOGGING BASED ON COMPARTMENT

MAP 11 : TIMBER HARVESTING - CLEARFELL

EAST GIPPSLAND OLD-GROWTH FOREST STUDY



MAP 11 : TIMBER HARVESTING - CLEARFELL

database at a scale of 1:100 000. This information was used as an outer boundary only with further data on the effect that might have occurred to vegetation being derived directly from the growth stage and crown cover projection mapping described earlier. Map 12 depicts the distribution of known wildfires since 1939.

7.8 FUEL REDUCTION BURNING

Fuel reduction burning is the controlled use of fire to reduce the amount of flammable material on the forest floor in order to reduce the potential risk of damage from a wildfire. Fuel reduction burns normally differ quite significantly from wildfire. They are deliberately ignited on days designed to produce a cool burn thereby causing minimal damage to the crowns of trees, they may be more frequent than wildfires, occur earlier or later in the season and produce a different mosaic of burn. Fuel reduction burning of many thousands of hectares of forest has been routinely conducted in East Gippsland since the 1960s. Records of fuel reduction burning between 1970 and 1980 were kept on maps in different offices throughout the area at scales of 1:100 000 to 1:126 720. This mapping generally recorded the proposed burn areas rather than the actual area burnt. Frequently the burns cover a much smaller part of the proposed burn area. Since 1980 a percentage estimate of the area burnt has been added to the mapping. This estimate was generally derived from field reports and limited aerial observation.

In order to reconcile these two disparate data sources into a consistent map, a hard copy grid representing 2 km squares was prepared for the entire study area. Each grid square was coded with the cumulative count of the number of fuel reduction burns that were recorded as occurring in that area and the date of the most recent burn. The 2 km grid was felt to be a fair representation of the spatial accuracy of the original mapping. The greater the frequency of burning the higher the probability that some burning disturbance did take place. However, given the variable nature of fuel reduction burning, particularly with regard to intensity and area burnt and reliability of mapping, the most significant conclusion to be drawn was that areas outside those delineated as burnt would have the lowest probability of this type of disturbance. The gridded location of fuel reduction burns since the 1960s is shown in Map 13.

7.9 WEED INFESTATIONS

In an ecological context there are many classes of environmental weeds. Only severe environmental weeds are relevant to old-growth forests in the study area.

Severe environmental weeds are usually perennial and vigorous species that have the potential to rapidly occupy large areas of undisturbed native vegetation, often by vegetative spread. Those that are shade tolerant are well adapted to invading the denser and shadier vegetation classes such as Riparian Forest and Warm Temperate Rainforest. Conversely light dependent species invade more open vegetation communities such as woodlands and heaths. Their presence drastically alters the ecological processes operating within the host plant community, and may in time lead to its demise. The most significant shade-tolerant weeds of the study area are Blackberry (*Rubus fruticosus* spp. agg.), Periwinkle (*Vinca major*), Wandering Jew (*Tradescantia fluminensis*) and Bridle Vine (*Myrsiphyllum asparagoides*). Some of the more significant light-dependant weeds of the study area are Kikuyu (*Pennisetum clandestinum*) and German Ivy (*Delairea mikanioides*). This class of weeds has the most significant impact on forested vegetation communities and their potential to attain the old-growth state.

Although an extensive floristic data set exists for the study area, the collection of such data is biased to avoid areas degraded by introduced weeds. In addition the quadrat data provides little opportunity to evaluate the suitability of the habitat for the weed species involved, nor does this information provide data on the advance or decline of weeds, as each site is normally only visited once. As a consequence, no mapping of weeds or weed classes was undertaken and a weed index was not developed for this study.

7.10 ROADING AND OTHER CULTURAL FEATURES

The disturbance effect of roading is likely to be determined by the size and type of road, the date of initial construction and the degree of subsequent maintenance. At a scale of 1:100 000 primary and secondary roads are depicted in the GIS database, but minor forest access roads are not shown.

Other cultural features include the small number of urban settlements, a single railway line (the Bairnsdale to Orbost line), several fire spotting towers, communication towers, helipads, trig stations and recreation facilities including walking tracks, picnic areas and car parks. Only a selection of the more significant of these have been added to the GIS database.

The impact of roading and other cultural features on old-growth attributes was not evaluated in this study.

7.11 FREEHOLD LAND

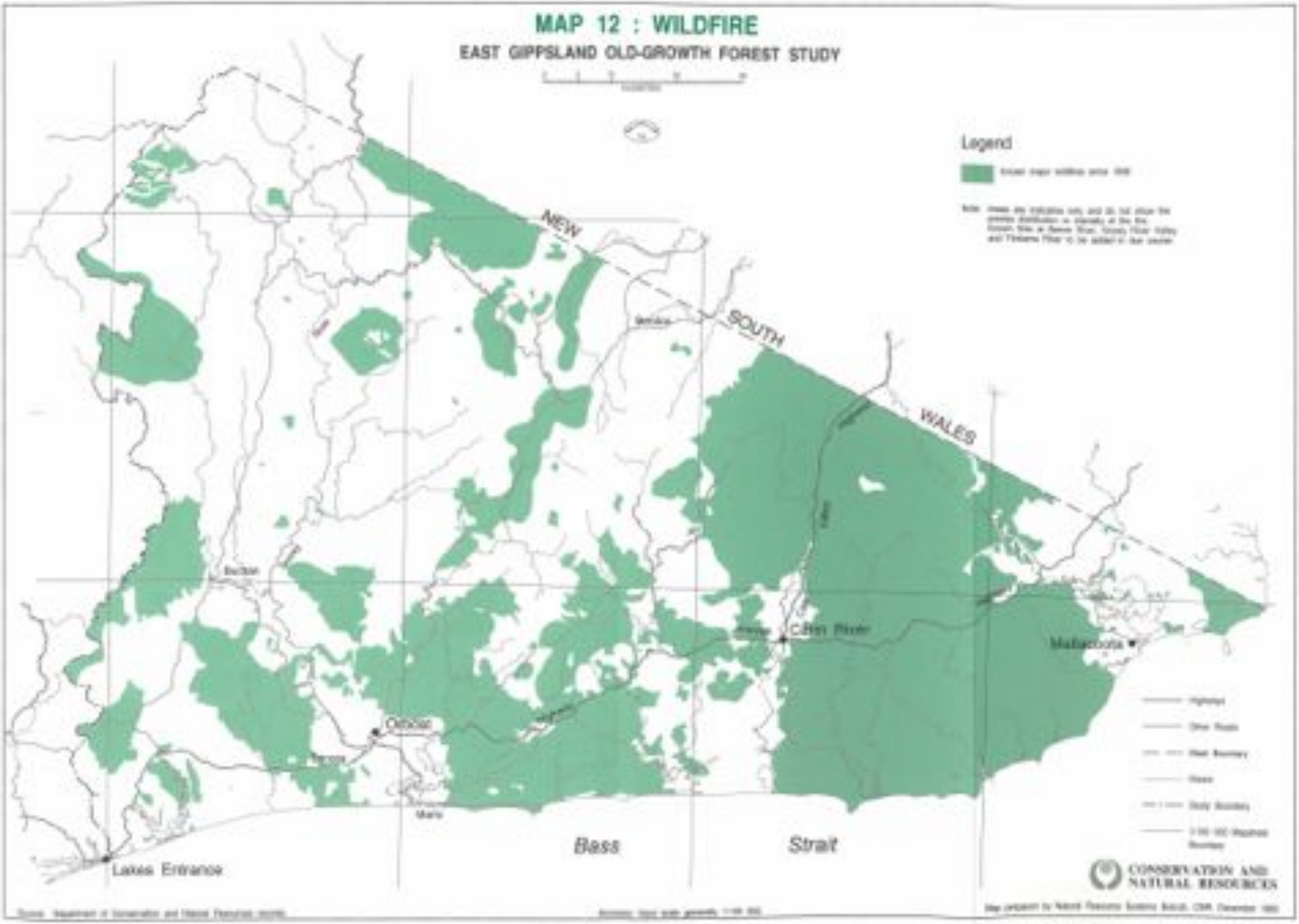
Apart from the extensive disturbance records (such as historic grazing) which were available from archives, no research into the history of land use on freehold land was undertaken for this study. It is known through clearing records and anecdotal observations that much of the freehold land has been disturbed through grazing, selective harvesting (such as post cutting) and burning. However, it was not feasible to build up a reliable picture of disturbance for the 58 969 ha (3.7% of the study area) of forest on freehold land within the time-frame of the study.

7.12 UNDISTURBED AREAS

Undisturbed areas, for the purpose of this study, were identified where no other verified form of disturbance was described. It is assumed that no area within the study area is truly undisturbed. Fire, at least, has probably affected all forests at some time in the past and weeds are also likely in many areas. It is also recognised that some areas described as undisturbed may have a contemporary un-natural disturbance that has not been recorded in the past or that was not detected by this study.

7.13 RESULTS

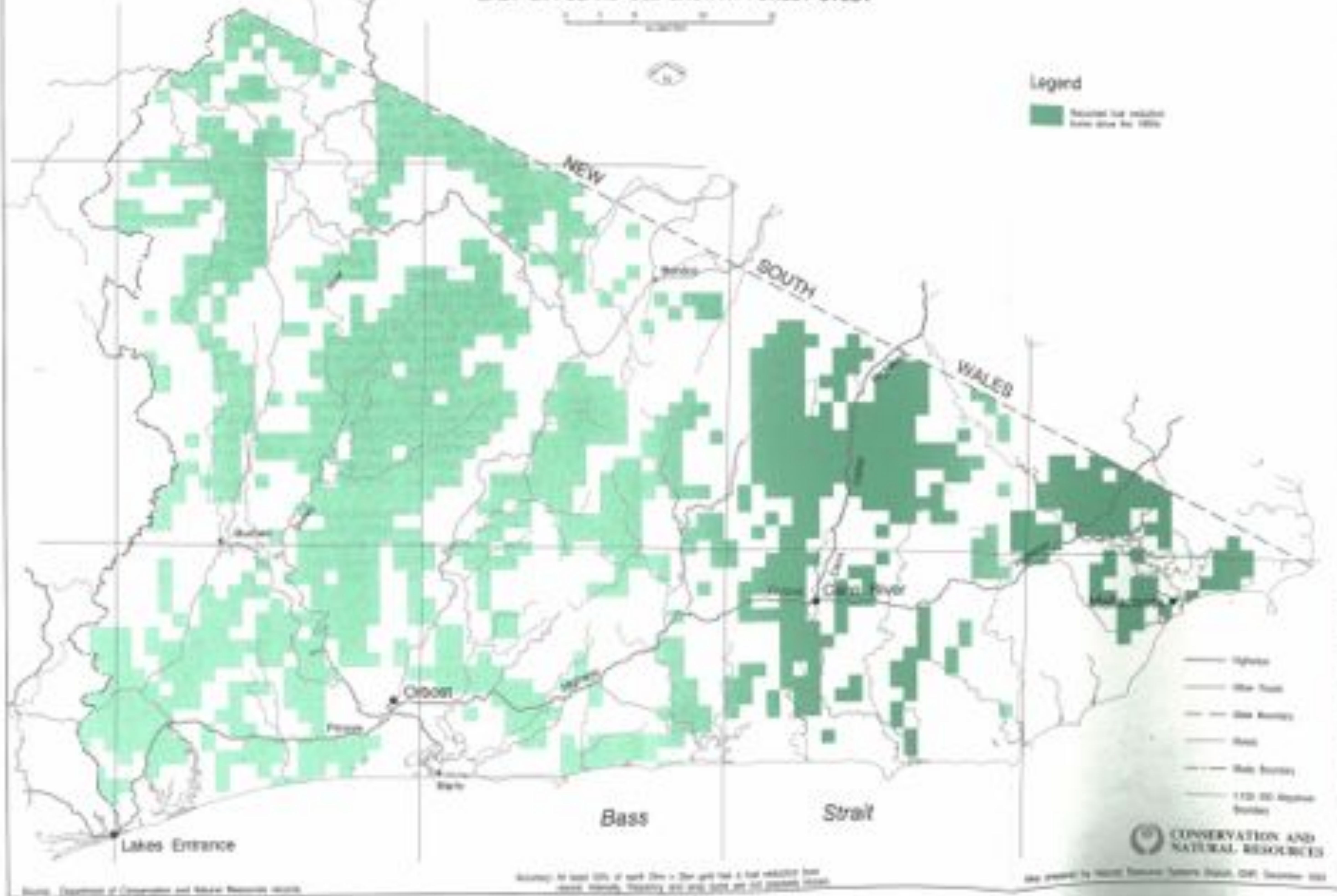
A summary of the extent of the nine mapped disturbance types by growth stages and ecological vegetation classes is given in Tables 7.1 and 7.2 respectively.



MAP 12 : WILDFIRE

MAP 13 : FUEL REDUCTION BURNING

EAST GIPPSLAND OLD-GROWTH FOREST STUDY



MAP 13 : FUEL REDUCTION BURNING

Grazing (724 709 ha), wildfire (498 327 ha), fuel reduction burning (481 055 ha) and selective logging (444 796 ha) are the most extensive disturbances recorded on public land in the study area. These figures were derived from a variety of sources, some of which have substantially over-estimated the actual extent of the disturbance. For example, the selective harvesting area includes the total area of each compartment with a known selective harvesting record, even though many compartments were only partially affected by the logging. Similarly, the grazing record includes the total area for each lease, not the area preferentially grazed. Refinements to the area actually affected by these disturbances were undertaken during the analysis of disturbances levels (Chapter 8) by reference to information on growth stages, crown cover, forest type and vegetation class.

Agricultural clearing (19 747 ha) refers only to selections which were abandoned and have subsequently reverted to Crown land. The largest areas of clearings occurred in Shrubby Dry Forest with 5786 ha (29%), Lowland Forest with 4035 ha (20%), Damp Forest with 3357 ha (17%) and Wet Forest with 1766 ha (9%).

The results for clearfelling (146 131 ha) indicate that this disturbance type is concentrated on areas of medium to high environmental site quality which produce high volumes of merchantable trees, particularly Lowland Forest with 49 281 ha (34%), Damp Forest with 41 099 ha (28%) and Wet Forest with 21 999 ha (15%). The logged areas of Shrubby Dry Forest with 17 388 ha (12%) occur on the medium environmental site quality localities where trees attain the Jacobs growth form.

Selective harvesting (444 796 ha) has occurred mainly in Lowland Forest with 150 239 ha (34%), Damp Forest with 98 069 ha (22%) and Wet Forest with 39 221 ha (9%).

Grazing has been centred on palatable vegetation classes, however the areal extent of these leases means little in terms of the grazing activity that they contained. For this reason only the figures for palatable classes are discussed. The most affected classes are Montane Grassy Woodland (93%), Montane Damp Forest (90%), Sub-alpine Woodland (90%), Grassy Dry Forest (84%), Montane Dry Woodland (81%), Rainshadow Woodland (80%), Herb-rich Forest (77%) and Montane Riparian Woodland (71%).

Fuel reduction burning has occurred in the more flammable vegetation classes that are used to provide strategic buffers to protect assets in the landscape. As a consequence 40% of the Lowland Forest area has at least one fuel reduction burn record. Other classes with fuel reduction burn records include Banksia Woodland (30%), Shrubby Dry Forest (60%), Damp Forest (54%) and Montane Dry Woodland (48%).

Table 7.1 Growth stages and disturbance type (ha) for all forested vegetation on public land within the study area.

		Disturbance Type								
Growth Stages		1	2	3	4	5	6	7	8	9
S_1	senescing only	25	364	—	2 232	11	3 577	1 660	6 093	60
S_2	senescing dominant, sparse mature, no regrowth	21	0	—	835	0	2 382	1 178	1 075	0
S_3	senescing dominant, mature subdominant, no regrowth	18	0	—	943	0	859	488	238	77
S_4	senescing dominant, sparse mature and regrowth	0	0	—	1	0	1 215	369	1 166	0
S_5	senescing and mature co-dominant, no regrowth	301	476	—	3 659	4	7 276	3 065	6 072	124
S_6	senescing and mature co-dominant, sparse regrowth	0	0	—	325	0	324	219	63	0
S_7	senescing dominant, sparse mature, regrowth subdominant	1	34	—	2 105	0	815	2 045	237	54
S_8	senescing dominant, no mature, regrowth subdominant	0	0	—	160	0	742	193	755	0
M_1	senescing subdominant, mature dominant, no regrowth	7 263	1 941	—	56 877	498	115 150	75 456	61 095	434
M_2	senescing subdominant, mature dominant, sparse regrowth	143	767	—	7 172	25	19 230	15 848	15 702	107
M_3	sparse senescing, mature dominant, no regrowth	8 342	3 882	—	88 414	679	174 769	116 691	113 453	666
M_4	sparse senescing, mature dominant, sparse regrowth	298	569	—	9 662	86	14 142	11 179	11 285	87
M_5	senescing, mature and regrowth co-dominant	1	67	—	918	2	1 077	638	463	90
M_6	senescing subdominant, mature dominant, regrowth subdominant	502	466	—	4 363	13	12 237	7 993	7 478	13
M_7	senescing subdominant, mature and regrowth co-dominant	1	0	—	301	0	972	517	671	0
M_8	sparse senescing, mature dominant, regrowth subdominant	693	1 197	—	20 530	60	23 954	18 000	19 026	297
M_9	mature only	10 293	4 092	—	96 379	531	169 501	121 063	103 905	1 928
M_{10}	no senescing, mature dominant, sparse regrowth	790	1 059	—	11 732	0	11 175	9 828	11 010	111
M_{11}	no senescing, mature dominant, regrowth subdominant	1 504	577	—	22 350	75	21 674	18 308	16 591	1 111
R_1	senescing and regrowth co-dominant, sparse regrowth	0	375	—	17	0	2 179	1 239	2 729	0
R_2	senescing and regrowth co-dominant, sparse mature	0	218	—	933	0	2 216	2 750	3 816	0
R_3	senescing and mature subdominant, regrowth dominant	153	46	—	2 600	0	4 355	2 321	3 517	20
R_4	senescing subdominant, sparse mature, regrowth dominant	2	0	—	1 043	0	2 121	1 856	2 023	241
R_5	senescing subdominant, no mature, regrowth dominant	830	26	—	278	14	3 082	2 002	3 759	9
R_6	sparse senescing, mature and regrowth co-dominant	49	490	—	3 723	49	4 919	3 829	3 536	0
R_7	sparse senescing, mature subdominant, regrowth dominant	189	356	—	9 757	46	10 764	9 984	9 866	42
R_8	sparse senescing, sparse mature, regrowth dominant	291	253	—	5 222	20	6 480	3 408	3 925	37
R_9	sparse senescing, no mature, regrowth dominant	469	191	—	3 326	0	1 567	2 004	2 347	10
R_{10}	no senescing, mature and regrowth co-dominant	113	199	—	6 074	14	9 431	4 810	7 433	9
R_{11}	no senescing, mature subdominant, regrowth dominant	568	302	—	11 988	11	8 891	8 350	9 954	275
R_{12}	no senescing, sparse mature, regrowth dominant	294	26	—	1 454	0	1 649	1 751	1 086	0
R_{13}	regrowth only	595	246	—	4 724	29	6 727	4 177	5 430	45
Unknown		4 771	1 528	—	64 699	339	77 257	27 836	62 508	761
Total All Growth Stages		38 520	19 747	146 131	444 796	2 506	724 709	481 055	498 327	6 588

Disturbance Types: 1 = Undisturbed 2 = Agricultural clearing 3 = Clearfelling 4 = Selective logging 5 = Mining 6 = Grazing 7 = Fuel reduction burn 8 = Wildfire 9 = Dieback
Disturbance types can overlap in geographic extent, for example the same forest area can be both grazed and selectively logged and therefore a total area of disturbance for each growth stage is meaningless in practical terms. Note that growth stages were not determined for all clearfelled areas. Refer to Section 10.3 for discussion on the reliability and accuracy of areas quoted in this table.

Table 7.2 Ecological vegetation classes and disturbance type (ha) for all forested vegetation on public land within the study area.

	Ecological Vegetation Class	Disturbance Type 1	2	3	4	5	6	7	8	9
1	Coastal Dune Scrub Complex	91	3	–	1 403	0	1 857	297	1 977	0
2	Coast Banksia Woodland	253	131	–	1 337	0	1 930	490	1 490	0
3	Coastal Grassy Forest	0	0	–	90	0	6	0	6	0
4	Coastal Vine-rich Forest	0	0	–	49	0	35	50	19	0
14	Banksia Woodland	372	251	1 051	16 601	0	31 117	10 979	28 953	0
15	Limestone Box Forest	195	206	430	4 619	0	18	1 604	1 064	77
16	Lowland Forest	2 425	4 035	49 281	150 239	433	155 194	98 827	173 040	5 775
17	Riparian Scrub Complex	680	129	1 455	9 178	7	12 564	5 502	13 194	304
18	Riparian Forest	481	769	769	4 724	23	8 966	5 050	8 817	15
20	Heathy Dry Forest	37	610	104	794	0	2 375	1 904	2 068	0
21	Shrubby Dry Forest	8 644	5 786	17 388	67 747	494	157 356	126 393	85 164	159
22	Grassy Dry Forest	70	830	312	7 734	0	14 264	9 655	6 870	0
23	Herb-rich Forest	226	1 243	813	4 908	0	7 584	3 958	2 934	0
24	Foothill Box Ironbark Forest	169	0	2	250	0	251	7	58	0
25	Limestone Grassy Woodland	0	97	0	384	0	188	197	39	0
26	Rain Shadow Woodland	3 765	0	–	280	105	17 853	7 138	2 049	0
27	Rocky Outcrop Scrub	328	66	42	1 017	29	2 821	2 641	2 195	0
28	Rocky Outcrop Shrubland	95	47	–	256	0	1 290	765	678	258
29	Damp Forest	6 432	3 357	41 099	98 069	807	173 534	128 892	115 517	0
30	Wet Forest	6 842	1 766	21 999	39 221	352	52 268	34 036	26 993	0
31	Cool Temperate Rainforest	618	1	496	681	14	836	662	653	0
32	Warm Temperate Rainforest	216	89	1 662	3 223	36	5 205	2 651	3 816	0
33	Cool/Warm Temperate Rainforest Overlap	4	4	48	69	0	207	70	41	0
34	Dry Rainforest	0	0	1	5	0	6	6	0	0
35	Tableland Damp Forest	1 226	127	2 227	4 915	32	1 571	724	1 028	0
36	Montane Dry Woodland	3 573	193	2 312	10 516	146	39 438	23 513	8 198	0
37	Montane Grassy Woodland	237	0	313	1 189	1	4 501	2 087	685	0
38	Montane Damp Forest	408	0	1 691	2 523	0	12 577	6 610	3 409	0
39	Montane Wet Forest	747	0	1 697	3 229	–	11 779	3 184	6 287	0
40	Montane Riparian Woodland	46	0	35	48	27	366	242	65	0
41	Montane Riparian Thicket	0	0	9	32	0	5	32	0	0
42	Sub-alpine Shrubland	0	0	26		0	201	16	0	0
43	Sub-alpine Woodland	340	7	31	353	0	6 546	2 873	1 020	0
	Other	0	0	838	9 113	0	0	0	0	0
Total		38 520	19 747	146 131	444 796	2 506	724 709	481 055	498 327	6 588

Disturbance Types: 1 = Undisturbed 2 = Agricultural clearing 3 = Clearfelling 4 = Selective logging 5 = Mining 6 = Grazing 7 = Fuel reduction burn 8 = Wildfire 9 = Dieback
Types can overlap in geographic extent; e.g. the same forest area can be both grazed and selectively logged, and so a total area of disturbance for each vegetation class is meaningless in practical terms. Also note that these disturbance areas indicate the gross extent of the paper-based (map) record and do not necessarily imply that each disturbance type has actually occurred over the whole area. This is particularly so with selective logging, grazing and fuel reduction burning. Refer to Section 10.5 for discussion on reliability and accuracy of areas quoted in this table.

8
AGE OF FORESTS IN EAST GIPPSLAND

8.1 BACKGROUND

When considering the question of old-growth forest many observers focus on the age of individual trees and/or stands. Many forest types mature at different ages, however, and the chronological age of trees is therefore not a universal and easily defined attribute of all old-growth forests. Nevertheless it is informative to define the age of trees within a particular forest type or vegetation class, to give a precise measure to the characteristic of antiquity.

Tree-ageing techniques are presently limited to ground-based measurements, which often require the destruction of the tree. Remote sensing imagery such as aerial photo interpretation or satellite imagery cannot ascertain tree ages, only growth stages as discussed earlier in Chapter 4.

The science of tree-ageing, known as dendrochronology, generally involves counting tree growth rings. The growth ring is divided into two parts, earlywood and latewood. Earlywood is formed at the beginning of each growing season. Latewood is formed later in the growing season and is generally denser and darker in colour. Normally the tree is aged by counting the latewood rings, each of which is assumed to represent one growing season or year. Many Australian tree species, however, do not produce annual growth rings that correlate with distinctive annual seasons, and it is not always possible to estimate tree age by counting growth rings in these species.

The method of the ageing involves selecting individual trees from which a sample is taken. These samples are usually obtained by one of two techniques; using an increment borer, or collecting a cross-section. An increment borer drills a small hole, usually less than one centimetre in diameter, radially from the outside of the tree to its core. The core is removed for later analysis and the tree is preserved. Collecting a cross-section involves felling a tree and cutting a full disk, or part thereof, from the stump. Although it destroys the tree this technique produces a more reliable ring count than the increment borer, particularly when the tree is large, old and solid. Unfortunately, old trees have a greater chance of being decayed, reducing the accuracy of this technique. Both techniques are slow and time-consuming and in practice permit only a very small number of samples. Increment core sampling is unsatisfactory in high density wood and this precludes non-destructive sampling for tree-ring analysis in most eucalypts.

The dendrochronology studies for this project were undertaken in two parts. The first part was reviewing existing studies of tree-ageing and their extrapolation to relevant forests within the study area. The second part involved collecting new tree ageing data through additional field sampling.

8.2 PREVIOUS TREE AGEING STUDIES

Three studies were found to provide relevant tree ageing data.

(i) Silvertop forests of East Gippsland (Incoll, 1974)

This study involved, among other forest mensuration activities, the selection and ageing of trees from 148 sites across Victoria representing the full range of growth stages from saplings to senescing stems and various ecological vegetation classes including Lowland Forest and Shrubby Dry Forest. Approximately 50 of these sites were selected from East Gippsland. Each site occurred within a stand of Silvertop Ash (*Eucalyptus sieberi*) and each tree was felled and aged by ring counting a cross-section. The oldest tree was found to be 137 years of age (47 m tall, 176 cm diameter at breast height over bark (dbhob)), and was located within the study area north-east of Orbost in an area known as Towser Ridge in Lowland Forest. The growth stages of these trees were not known.

(ii) Wet Forests of Errinundra Plateau (Piercy and Woodgate, 1984 unpubl.)

This study sought to determine the ages of both eucalypt and understorey species in representative old-growth stands at selected sites in Wet Forest and Mixed Forest on the Errinundra Plateau, well within the study area. Twenty-one trees from four sites were aged through collection of cross-sections and subsequent ring counting. At each site the oldest trees were found to be Errinundra Shining Gum (*Eucalyptus denticulata*) with ages ranging from 225 years (55 m tall, 147 cm dbhob) to 252 years (53 m tall, 231 cm dbhob). Ages of understorey species ranged from 40 years (9 m tall, 15 cm dbhob) for Elderberry Panax (*Tieghemopanax sambucifolius*) to 207 years (19 m tall, 62 cm dbhob) for Black Oliveberry (*Elaeocarpus holopetalus*) and 208 years (25 m tall, 62 cm dbhob) for Sassafras (*Atherosperma moschatum*). Again, the growth stages of these trees were not determined at the time of the study.

(iii) Wet and Dry forest types, Glenbog, NSW (Banks, 1990)

The most recent study of tree age prior to the current study was undertaken in the Glenbog State Forest of New South Wales, just north of the study area. Two sites were selected representing different forest types: Wet Forest dominated by Cut-tail (*Eucalyptus fastigata*), and Dry Forest/Lowland Forest dominated by Silvertop Ash. At each site, 18 trees were sampled from the full range of growth stages. Multi-aged stands were revealed at each site with trees ranging from 40 to 400 years in the Wet Forest and 20 to 210 years in the dry forest generally or Lowland Forest specifically. The study also provided information about fire histories and frequencies by analysing the date of occurrence of fire scars on the cross-sections. The long-term fire frequencies at the two sites were quite different, with a fire event occurring about once every 14 years in the Wet Forest and about once every eight years in the dry forest. Both sites also showed an increasing fire frequency from the 1830s and 1870s and again during this century. Only in the last two decades had fire frequency fallen to pre-European levels.

8.3 FURTHER TREE AGEING STUDIES

As part of this current study, tree ages in the Cobon block (north-west of Cann River) were assessed from recently felled individuals of Silvertop Ash in a forest stand which had been extensively studied as part of the Victorian Silvicultural Program's Value

Added Utilisation System trials. The vegetation of the stand was classified as Damp Forest dominated by Silvertop Ash with some Messmate (*E. obliqua*) and Mountain Grey Gum (*E. cypellocarpa*). The stand comprised a number of tree ages and had been unlogged until the coupe was clearfelled in April 1992. Details of the eight sampled trees are given in Table 8.1.

Tree age estimates were taken directly from radial cross sections cut from the stumps of the eight trees, based on the assumption that tree growth was seasonal. Overall the tree rings were mostly clear and distinct, with few zones of incomplete or indistinct rings; however, it is possible that rings may not have been formed during unfavourable growing years. In some of the older trees with hollow centres, age estimates were based on ring counts of the sound wood plus an estimate of the missing centre. The results from the tree ring analysis are shown in Table 8.2. A third senescing tree was also selected for sampling but was not included due to the risk involved in felling large trees with rotting centres. This tree had a diameter well in excess of 1.4 m.

Analyses of ring width increase per year indicate that trees M_1 and M_3 were in a state of accelerating growth, M_2 was experiencing constant growth, S_1 in moderate decline and S_2 in accelerating decline.

Table 8.1 Morphological characteristics of the *Eucalyptus sieberi* trees sampled for age in Cobon forest block.

Tree number	Growth stage	Height (m)	DBHOB (cm)	Crown diameter (m)
R1	Regrowth	25.8	37.5	6.5 3 6.5
R2	"	23.1	28.0	8.0 3 3.8
R3	"	25.0	33.5	5.5 3 6.5
M1	Mature	33.8	108.5	11.5 3 15.3
M2	"	31.2	100.5	12.4 3 9.4
M3	"	33.8	73.5	10.5 3 10.3
S1	Senescing	32.5	118.0	10.5 3 10.3
S2	"	31.4	134.5	20.0 3 20.0

Table 8.2 Tree age estimate for regrowth, mature and senescing trees in Cobon forest block.

Tree number	Tree ring count	Hollow centre radius (cm)	Number of missing rings	Tree age estimate
R1	47	none	0	47
R2	44	none	0	44
R3	46	none	0	46
M1	170	none	0	170
M2	169	none	0	169
M3	137	8	31–44	158–171
S1	201	15	59–75	260–277
S2	237	15	59–75	296–311

The similarity in ages of the regrowth trees and of the mature trees suggests that each of these growth stages may have been derived from a distinct regeneration episode. As Silvertop Ash is known to regenerate in response to disturbances which provide a canopy gap and a suitable seed bed, it is likely that this regeneration episode occurred after a fire. A 300 year forest fire history was derived from tree regeneration years and post-fire growth pulses indicating that 12 fires passed through the stand with a fire frequency of 22 years. There was no conclusive evidence of an increase in fire frequency since European settlement. The fires appear to have had a patchy effect on the forest stand, as not all trees were equally affected by every fire.

This work, undertaken as part of the old-growth survey, is discussed in greater detail in Appendix I.

8.4 IMPLICATIONS FOR OLD-GROWTH FOREST

Although these studies are not representative of the entire study area, they provide an interesting insight into the range of ages of each growth stage. Note that the Cobon Block study was performed in Damp Forest which is the second largest vegetation class in the study area. For the senescing growth stage, given the larger girths of unsampled trees on the site, it is likely that tree ages in excess of 311 years and up to twice the age of the trees in the mature growth stage may be found. The Cobon Block study also suggests that the mature trees are quite old, ranging from 158 to 171 years of age.

The dendrochronology work also showed that mature trees in the study forest could be expected to remain in a mature condition for another 80 years or so but this is dependent on favourable forest disturbance, fire for example, occurring at, say, 20 to 50 year intervals and the crown remaining in good condition over this period. The evidence also suggests that the transition from the mature growth stage to the senescing growth stage takes place at about 250 years. While these studies give ages for different growth stages of a small number of trees species, they are by no means conclusive or representative. More detailed and statistically rigorous work needs to be done on the question of the absolute ages of different growth stages in order to develop a comprehensive picture of the age ranges of trees within the study area for all forested vegetation classes.

9

THE BASIS FOR DEFINING OLD-GROWTH FORESTS

9.1 DEFINING OLD-GROWTH FOREST

The discussion of concepts and existing definitions (Chapter 2) demonstrates that the question of defining old-growth is not a simple one. While the characteristics of old-growth forests can be relatively easily identified, it is a more complex matter to determine at what threshold these characteristics must be present for an area to constitute old-growth forest.

Four terms are commonly used to describe old forests:

(i) OVERMATURE — in relation to the growth stage of trees and in particular eucalypts. Overmature trees are characterised by declining crown leaf area, trunk and shaping branches weakened by pathogen attack and increasing development of dead branches and bayonet limbs (Jacobs, 1955, and further discussed in Section 4.1 of this report).

(ii) SENESCING — includes overmature trees (described above) and late-mature trees which exhibit a fuller crown than overmature trees although in mild decline, and some dead branches and bayonets (adapted from Jacobs, 1955). The terms senescent and overmature are often used interchangeably. Furthermore, stands which are described in these terms are readily mapped by their morphological characteristics (refer to Chapter 4).

(iii) ECOLOGICALLY MATURE — refers to stands with a small net biomass increment, often high structural and compositional diversity and a richness of animal habitat such as hollows and dead stems (Commonwealth of Australia, 1991, Ecologically Sustainable Development Working Group–Forest Use). This term embraces a broad conceptual notion of forests that is hard to define and measure in practice although it appears to be aligned with Jacobs (1955) concept of mature, late mature and overmature growth stages.

(iv) OLD-GROWTH — is a term which describes trees or forests that are both old for their type and relatively undisturbed, and which have a number of intangible qualities. (A range of definitions is discussed in Chapter 2).

It is recognised that these terms are also difficult to define unambiguously and that they overlap considerably in scope (Figure 9.1).

The failure in the past to depict an arbitrary area for 'old-growth' forest on the growth curve (Figure 9.1) has reflected the inability of scientists to agree on thresholds for the universal characteristics that define old-growth forests. However, the objective of the current study is to establish a practical procedure for defining and delineating 'old-growth' forest for all forests in the study area. This has been achieved firstly by defining forest (Chapter 3); secondly by quantifying growth stage (Chapter 4); and thirdly by examining the impact of natural and human-induced disturbances on the structural and floristic attributes of the forests (Chapter 5, 6 and 7). The question of secondary characteristics is also discussed in this and subsequent chapters. In doing so the study has addressed all the key words in the phrase 'old-growth forest' as well as many of the common perceptions of these forests as portrayed in Figure 2.1 (Chapter 2).

Within the parameters of this study, it became evident that the most prominent old-growth characteristics were represented by stands that comprised the oldest possible growth stage (or combination of growth stages) and the least disturbed forest for a given forested vegetation class. Some old-growth characteristics, however, may also occur in younger or more disturbed stands: generally, the younger the forest, the fewer of these characteristics will be present. The point at which a particular stand no longer constitutes an old-growth forest, although subjective, can be delineated through arbitrary and dual assignment of a growth stage threshold and a disturbance level threshold. These conclusions are diagrammatically represented in Figure 9.2.

Figure 9.2 also illustrates the interaction between the structural characteristics of old-growth forests as measured by both growth stage and disturbance characteristics.

The presence, configuration and development of old-growth characteristics in a forest stand are a function of its structure, ecological vegetation class and disturbance history. The definition of old-growth forest must have ecological meaning and be based on thresholds that can be physically delineated, both on the ground and on maps, so that old-growth values can be accommodated in on-ground management of forests. This study has consequently defined old-growth forest in a way that enables these forests to be clearly delineated. This definition together with important explanatory notes is presented in Section 9.2. An important component of the definition is the proportion of the senescing growth stage that is permitted in old-growth forest. It is considered that the senescing growth stage becomes a significant influence on the ecological processes of the stand (e.g. growth of younger trees, development of hollows, nutrient cycling) when present in at least subdominant crown cover proportions, that is, approximately half the area of dominant or co-dominant growth stage(s).

Figure 9.1 A conceptual relationship between terms used to define stages of forest growth.

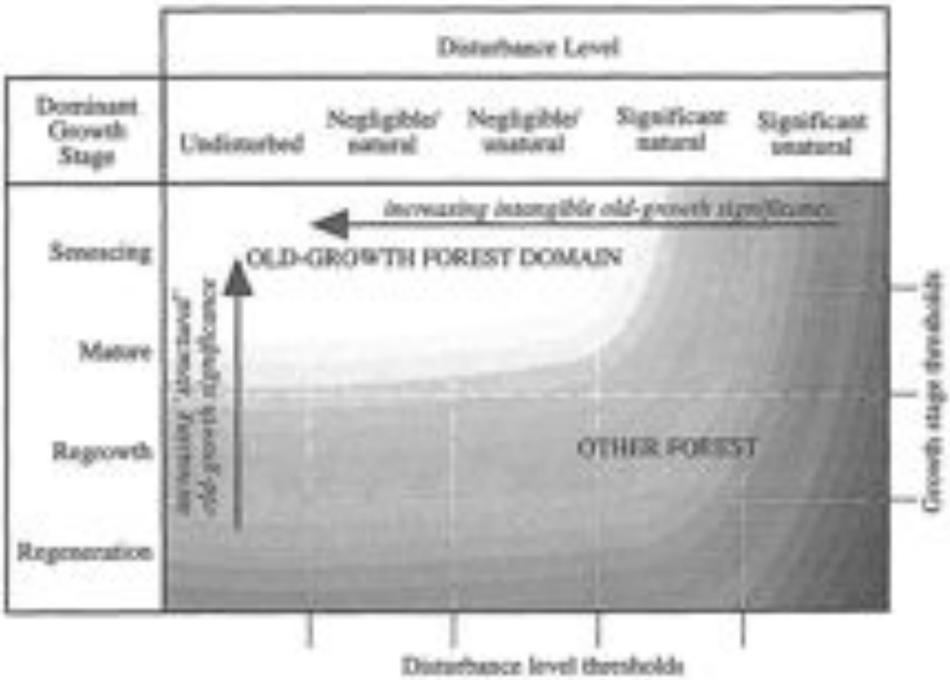


Figure 9.2 Schematic interaction between growth stage and disturbance level in defining old-growth forest.

The question of disturbance is perhaps the more difficult part of the definition to address. All forests are assumed to have been subjected to some form of disturbance. Undisturbed forest (as described in this study) is forest for which there is no record of disturbance although wildfires, for example, almost certainly have occurred in the past. Negligibly disturbed forest is forest for which a disturbance record exists, but, the disturbance is unlikely to have altered the structure (growth stage combination or crown cover) or the usual floristic composition of species for that vegetation class; or, if the alteration did occur in the past it is no longer measurable. Disturbances may be natural (e.g. wildfire) or un-natural (e.g. anthropogenic or human-induced disturbances such as agricultural clearing, logging, grazing and mining). Disturbances induced by indigenous people prior to European settlement are considered to be 'natural' in the context of this study.

Severe wildfire, the only 'significant natural' disturbance recorded in the study area, alters the structure and floristic composition of forest. As the effects of fire are often relatively short-term, once the resultant regrowth has matured, the fire-affected forest should once more be eligible for consideration as old-growth forest, provided the other elements of the definition are met. Eucalypt-dominated vegetation in the study area that depends on wildfire to facilitate regeneration and maintain ecological processes is known as fire disclimax vegetation, and most of the forested vegetation in the study area is in that category.

'Significant un-natural' disturbances, on the other hand, could cause long-term changes to forest structure and floristic composition which may preclude forest from qualifying ecologically as old-growth for several forest regeneration cycles. Even when the resultant regrowth has matured to the senescing stage in the first regeneration cycle, the forest may have only partly fulfilled the disturbance component of the old-growth definition. Other criteria, such as overstorey species ratios, floristic composition, intact ecological processes, dead standing or fallen timber, may not have returned to the pre-disturbance state. Although such forests may not fulfil the old-growth definition after one cycle of regeneration and senescence, they may do so after several cycles, provided that they have not been significantly disturbed by human influence in the meantime. The recovery of ecological processes (including structure and floristics) is likely to be linked to the ecological vegetation class involved and the type and intensity of disturbance. This could be assessed by comparing the floristic and structural attributes of the recovering stand to an undisturbed example of the same vegetation class.

However, recovery measured in terms of these ecological characteristics alone may not provide an appropriate measure of the recovery of the forest from the perspective of the intangible characteristics. Indeed there are two clearly opposing points of view that are highlighted as a result of the discussion on disturbances. The first point of view suggests that once a forest has been subjected to significant human disturbance (such as agricultural clearing or intensive timber harvesting) it can never in the foreseeable future be eligible for consideration as old-growth forest irrespective of the degree of recovery. The second point of view suggests that irrespective of the severity or type of disturbance, once a forest regains the physical and ecological characteristics of an old forest and exhibits minimal signs of human influence (e.g. absence of stumps or artefacts of settlement), it may become eligible for reconsideration as old-growth forest.

In order to satisfy the first point of view the disturbance part of the definition could read:

> 'forest ... which has been subject to either negligible un-natural disturbance at any time in the past, or natural disturbances whose physical effect (on structure and floristics) is now negligible.'

In order to satisfy the second point of view the disturbance clause could read:

> 'forest ... which has been subject to any disturbance whose physical effect (on structure and floristics) is now negligible'.

From an ecological perspective, the latter approach is preferred; that is, there is no arbitrary distinction between natural and un-natural disturbance only an assessment of the physical impact of the disturbance and the time taken for its effects to abate. This approach also recognises that the intangible characteristics, rather than an integral part of the definition, are more appropriately regarded as characteristics affecting the humanistic value of old-growth forest.

The definition presented in Section 9.2 favours the latter approach, recognising the dynamic nature of old-growth forest and allowing for forest to be recruited into, or excluded from, the old-growth domain with time. Younger forests that are naturally disturbed are a critical component of the old-growth cycle as are significantly disturbed forests in vegetation classes where little or no old-growth forest currently exists. The definition does not preclude the assessment of some old-growth characteristics in forests of the oldest growth stage that have had some form of natural or anthropogenic disturbance; nor does it preclude other pre-senescent growth stages as also having some old-growth characteristics.

9.2 DEFINITION OF OLD-GROWTH FOREST

A consideration of the foregoing guiding principles has led to the adoption of the following definition:

> **Old-growth forest is forest which contains significant amounts of its oldest growth stage in the upper stratum — usually senescing trees — and has been subjected to any disturbance, the effect of which is now negligible.**

IMPORTANT TECHNICAL REQUIREMENTS

Primary characteristics

1 The definition is based on the two primary characteristics of old-growth forest; growth stage and disturbance level. It has been developed so that old-growth can be delineated and mapped in practice.

Forest

2 Forest, for the purpose of this study, is defined as woody vegetation with a potential height generally greater than 5 m and with a crown cover projection generally greater than 10%.

Crown cover

3 Crown cover is the percentage of the site (or stand of forest) covered by the vertical projection of the periphery of the tree crowns in the upper stratum; crowns are considered to be opaque.

Growth stages

4 It is assumed that old-growth forests have attained their oldest, naturally achievable growth stage(s) combination for a particular site under a contemporary regime of 'natural' disturbance which in East Gippsland is generally fire disclimax.

5 More than one growth stage (senescing, mature or regrowth) may be present in the upper stratum. The oldest growth stage is the senescing growth stage and it must be present as a dominant, codominant or subdominant component of the stand. When present in these proportions the senescing growth stage is considered to significantly influence the ecological processes of the stand (eg growth of younger trees, development of hollows, and nutrient cycling).

6 The morphology of the senescing growth stage in many eucalypts is characterised by declining crowns and dead or dying branches, although these and other characteristics may vary between species.

7 'Dominant', 'codominant' and 'subdominant' refer to the area occupied by the crowns of a given growth stage in the upper stratum of the stand. They do not refer to the vertical structure through the profile of the crown. (They broadly occupy >60%, 30-60% and 11–60% respectively of the relative crown cover of the stand.)

8 If regrowth growth stages are present they must be 'sparse' (generally less than 10% of the crown cover) of the upper stratum for the stand to qualify as old-growth. More regrowth than this probably indicates a greater than negligible (ie. significant) disturbance.

Ecological vegetation classes and forest types

9 The morphological (physical) characteristics that identify each growth stage vary with the ecological vegetation class (floristic composition and environmental attributes) and forest type (dominant species and structure) both of which are influenced by environmental site quality. For this reason the old-growth condition manifests itself in different ways, so forest must be stratified by ecological vegetation class and forest type.

Disturbance

10 All forests are assumed to have had some form of disturbance. Undisturbed forest is forest for which there is no record of disturbance, although wildfires almost certainly occurred in the past. Negligibly disturbed forest is forest for which disturbance is known to have occurred, but, the disturbance is unlikely to have altered the structure (growth stage combination or crown cover density) or the usual floristic composition of species for that vegetation class; or, if the alteration did occur in the past it is no longer measurable. Disturbances may be natural (e.g. wildfire) or un-natural (e.g. anthropogenic or human-induced disturbances such as agricultural clearing, timber harvesting, grazing and mining). In the context of this study, and without records that enable a systematic search, disturbances induced by indigenous people before European settlement are also treated as being natural.

Intangibles

11 Old-growth forests have considerable intangible characteristics which are not directly addressed by this definition; they include grandeur, antiquity, naturalness, spirituality and aesthetics. The type of disturbance influences the intangible characteristics of forest and determines their values within the old-growth domain.

Old-growth dynamics

12 Significant anthropogenic disturbances may cause long-term changes to forest structure and floristics. Although such forests may not fulfil the old-growth definition after one cycle of regeneration and senescence, they may do so after several cycles provided they are not significantly disturbed in the meantime. The definition thus recognises the dynamic nature of old-growth and allows for forests to be recruited into, or excluded from, the old-growth domain with time.

9.3 THE NATIONAL FOREST POLICY STATEMENT

In its *Report of the Forests and Timber Inquiry* the Resource Assessment Commission (1992) concluded that old-growth forests were:

> ...forests that are both negligibly disturbed and ecologically mature and which have high conservation and intangible values.

Subsequent to the RAC findings, the Commonwealth, State and Territory Government concluded in the *National Forest Policy Statement* (Commonwealth of Australia 1992) that an old-growth forest was:

> ...forest that is ecologically mature and has been subjected to negligible unnatural disturbance such as logging, roading and clearing. The definition focuses on forest in which the upper stratum or overstorey is in the late mature to overmature growth phases.

The definition adopted by CNR for the East Gippsland study is restated as follows:

> ...forest which contains significant amounts of its oldest growth stage in the upper stratum — usually senescing trees — and has been subject to any disturbance, the effect of which is now negligible.

All three definitions are broadly consistent. They require that the forest be old ('ecologically mature', 'upper stratum or overstorey in late mature to overmature growth phases', 'significant amounts of its oldest growth stages') and little disturbed ('negligibly disturbed', 'subject to negligible unnatural disturbance', 'subject to any disturbance the effect of which is now negligible').

The National Forest Policy Statement and CNR definitions are more explicit than that of the Resource Assessment Commission on the question of age. The two former qualify their definition by reference to growth phases or stages. This is an important distinction because, unlike 'ecological maturity', growth stages or phases can be measured in a quantitative and practical way over large areas using conventional survey techniques.

On the question of disturbance, the Policy Statement and CNR definitions are also more explicit than the Commission's. The Policy Statement confines 'negligible disturbance' to un-natural causal agents only. It is silent on the question of natural forms of disturbance, although by inference it permits forest to be considered as old-growth even if its has been subject to recent significant natural disturbances such as wildfires or cyclones. The CNR definition provides for forests to be considered as old-growth that have been subject to any disturbance, natural or un-natural, provided that the effects of that disturbance are currently negligible. Thus a recent wildfire that has severely damaged the overstorey crown of a forest would remain as old-growth under the Policy Statement but would not be considered as old-growth under CNR's definition until it had recovered from the effects of the disturbance.

CNR also recognises that old-growth forests carry significant intangible characteristics (such as grandeur, antiquity and spirituality) and as these characteristics become better understood it may be possible for them to be included as factors which could help define the range of values within the old-growth forest domain.

10
ANALYSIS OF OLD-GROWTH STATUS

10.1 INTRODUCTION

The analysis procedure that was developed during the project was based on the assumption that every forest stand, irrespective of age or disturbance history, contains or potentially contains some of the characteristics used to assess old-growth forests. Having identified a core suite of characteristics (described as attributes and disturbance influences in Figure 2.1, page 12) it was then possible to assess and rank their relative significance in each forest stand.

10.2 CONSTRUCTION OF DATABASE

The growth stages, crown cover projections, vegetation classes, structural forest types and disturbances were all compiled in map form. Each map was entered into a Geographic Information System (GIS). A GIS is a computer system capable of storing maps, text and data about any point, or area, on the map. The GIS can also manipulate information, permitting any combination of information to be analysed efficiently and in a repeatable manner. For example by combining the land tenure, ecological vegetation classes and selective harvesting information in the GIS it is possible to determine the location and extent in hectares of selectively harvested areas for each vegetation class on public land and to prepare maps showing selectively harvested vegetation classes.

Data was entered into the GIS by various techniques depending primarily on the type of source data and resources available. These techniques included hand digitising or scanning of line-work, or file transfer from databases outside the GIS. Each map was registered to the appropriate 1:100 000 scale Australian Map Grid (AMG) map sheet.

The separate layers of spatial data, equivalent to maps, were overlayed on each other to produce composite maps for inquiry and analysis (Figure 10.1). The system used to digitise, register and construct the databases was ARCINFO (ESRI, California) running on a SPARC II work station (SUN computers). The layers are stored in an electronic map library within the GIS. Each is filed according to its geographic location and type of data.

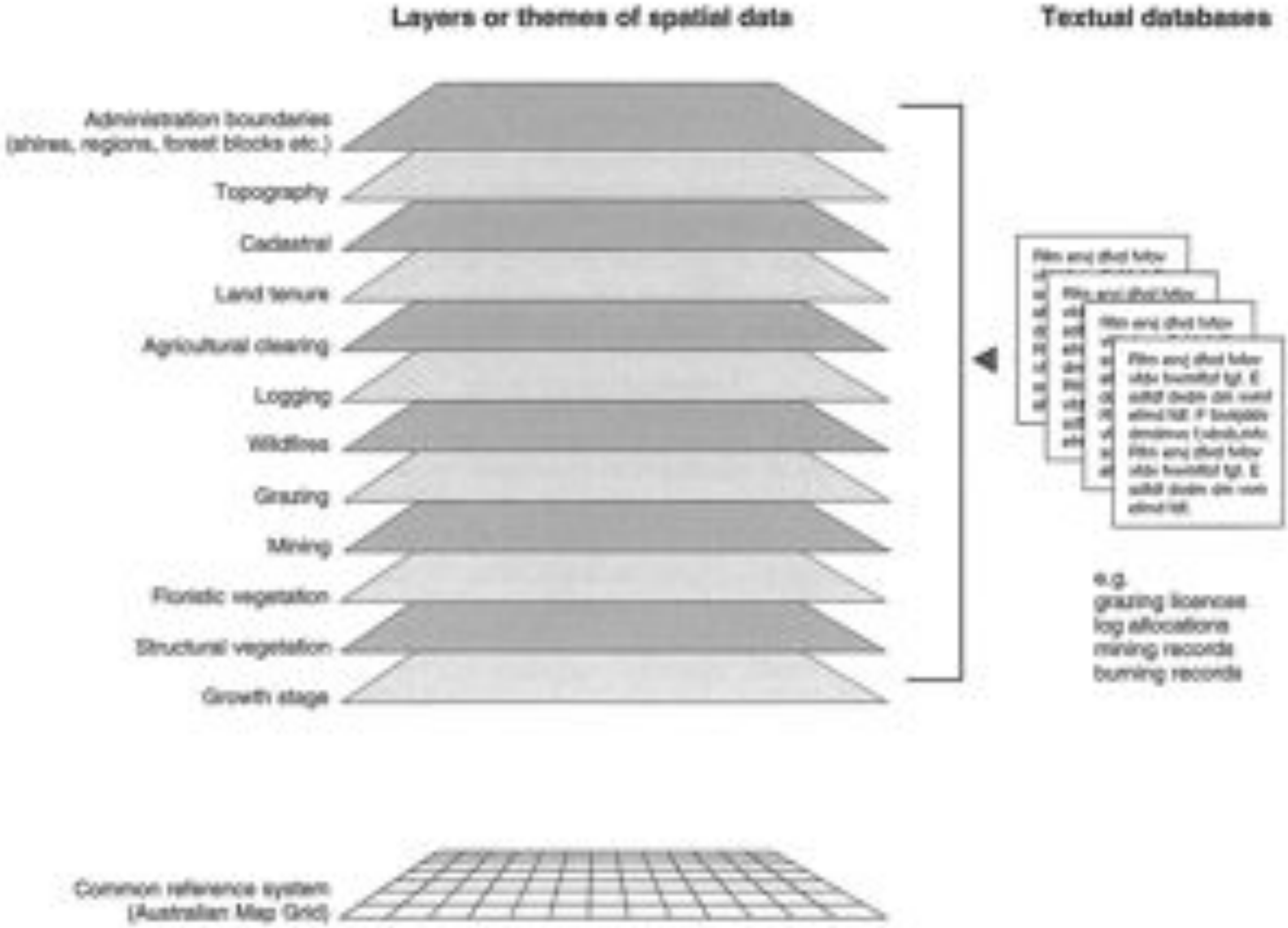


Figure 10.1 The linkage between layers in the map library of the Geographic Information System.

10.3 ANALYSIS PROCEDURE

The following steps describe the procedure used to assess, rank, classify and describe forest stands according to their level of old-growth characteristics. The procedure is summarised in Table 10.1.

Step 1: Identification of forest vegetation

The first task was to identify the total extent of terrestrial vegetation within the study area. Existing maps of vegetation classes were revised to delineate forest type and structural properties (overstorey species and height) and floristic properties (identification of ecological vegetation classes). From this work it was possible to delineate all forested ecological vegetation classes which are essentially a combination of structural and floristic vegetation data refined according to environmental attributes. Of the 44 vegetation classes identified in Table 6.2, 33 were considered to fall within the definition of forest (Section 3.2).

Table 10.1 Defining old-growth forest by structure, floristics and disturbance.

Step	Input	Action	Output
1	All structural and ecological vegetation class mapping.	Define 'forested' vegetation classes. Remove all water bodies and inlets.	OUTPUT 1 Forest areas identified by vegetation classes and forest type.
2	Crown cover projection and growth stage mapping.	Summarise mapped growth stage classes and ordered by dominance of oldest growth stages.	OUTPUT 2 All forest areas mapped according to 32 growth stage classes and ordered by dominance of oldest growth stages.
3	Disturbance mapping.	Assess type (natural or un-natural) and the level (undisturbed, negligible and significant) of disturbance.	OUTPUT 3 Growth stage classes mapped by disturbance type and level for each forested class.
4	Growth stage classes mapped by disturbance type and level for each forested vegetation class. OUTPUTS 1, 2 and 3.	Aggregate OUTPUT 3 into a single summary table for all forested classes.	OUTPUT 4 Growth stage classes ordered by dominance of oldest growth stages and by level of disturbance for each forested class. 'Old-growth' forest can then be derived.

Step 2: Review of growth stage and crown cover projection for Jacobs and non-Jacobs forested vegetation

The crown cover survey and growth stage mapping resulted in a large and complex array of combinations describing the individually mapped forest stands. Combining groups of similar growth stage classifications resulted in a reduction from 218 to 32 distinct combinations of crown cover projection and growth stage classifications (refer to Table 4.5, page 30).

The growth stages in Table 4.5 are ranked in descending order of relative proportions of oldest growth stages. The relative proportion of growth stages within a forest stand has also been used to assist in the ranking. Although not undertaken in this analysis the crown cover projection factor for each polygon could be used to further organise the ranking of individual forest stands within each growth stage class. More complex assumptions could be applied to specific growth stage combinations within each vegetation class when better relationships between crown cover and old-growth values are developed through further field based research. Map 14 depicts the extent of forest growth stage groupings.

The aerial photo interpretation growth stage classes M_3, M_4, M_9 and M_{10} actually contain non-Jacobs stands, which, although mapped through aerial photo interpretation as mature dominated, are senescing dominated in practice. These stands occur on sites of low environmental quality and their senescing components were identified through their forest type and height class following strategic field checking. The statement of GIS analysis stages (Appendix G) used to derive old-growth forest indicated the procedure used to reclassify these stands into their correct senescing class. This reclassification was undertaken in Step 4.

Step 3: Assignment of disturbance levels

The effect of disturbances can vary from one vegetation class to another, and consequently uniform and robust assumptions about the distribution and degree of impact of disturbances which are mapped on a broad hectare basis can only be made for each vegetation class. For example, grazing is unlikely to have an appreciable effect on unpalatable vegetation classes, even if records indicate that the licensed grazing area included these classes. Additionally, disturbance records were verified by aerial photograph interpretation; for example, parts of historic agricultural selections which currently contain dense old trees were unlikely to have been cleared even if historical records indicated that clearing occurred at that selection. Thus, it was necessary to evaluate the impact of recorded disturbances according to the vegetation class, the forest type and the growth stage and crown cover projection present at each site.

This process resulted in the development of a series of disturbance levels, based on the effects of disturbances on forest stand structure and floristics. On the whole, unless a recorded disturbance was correlated with an observed change in growth stage ratios, crown cover or floristic composition, it was considered to be negligible. In the absence of flora quadrat data or ground knowledge of significant floristic degradation, the presence of significant structural disturbance was considered a reliable indication of floristic alteration from the undisturbed state for that vegetation class. Ecological vegetation classes that are favoured for grazing by domestic stock and which had a grazing lease which post-dates 1960 were considered to be significantly disturbed. The disturbances have been described by three criteria:

- type and year or period of occurrence
- nature — natural or un-natural (human-induced)
- intensity — undisturbed, negligible disturbance, significant disturbance.

A summary statement of the area of each disturbance type is given in Table 7.1 for growth stages and in Table 7.2 for ecological vegetation classes. Having examined the type of disturbance for each vegetation class it was then possible, using a combination of known responses, to determine the significance of each disturbance in terms of the structure and floristics. This resulted in three disturbance levels being described in Table 10.2 and depicted in Map 15.

The following discussion provides a more detailed description of each disturbance level. Details of the steps used to determine the disturbance level based on disturbance type, ecological vegetation class, forest type, growth stage and crown cover are given in Appendix G.

Disturbance Level 1

Areas with no recorded disturbance history were described as UNDISTURBED, even though some environmental weed species may be present and wildfires have almost certainly occurred at some time in the past.

Disturbance Level 2

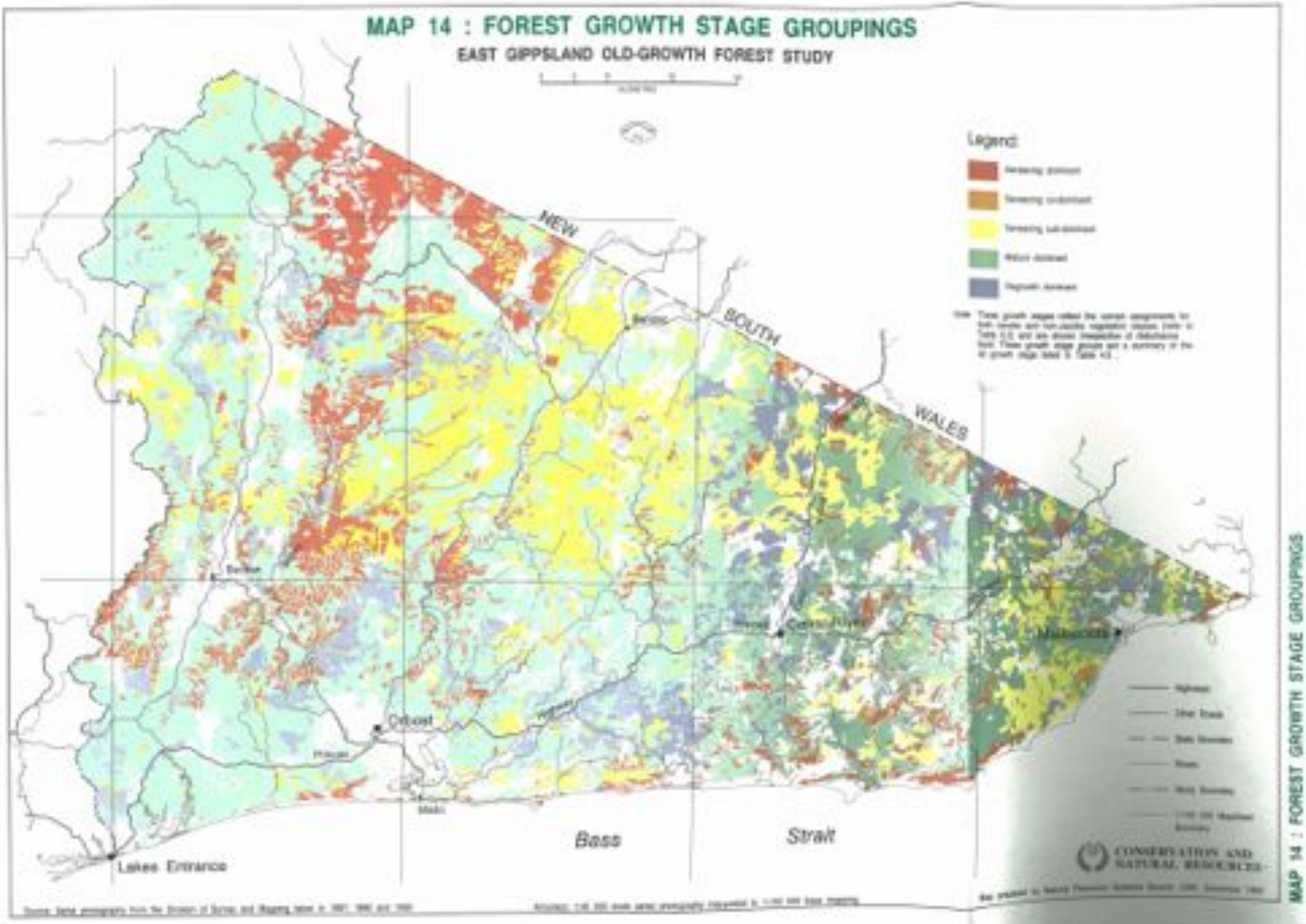
A NEGLIGIBLE disturbance was defined as:

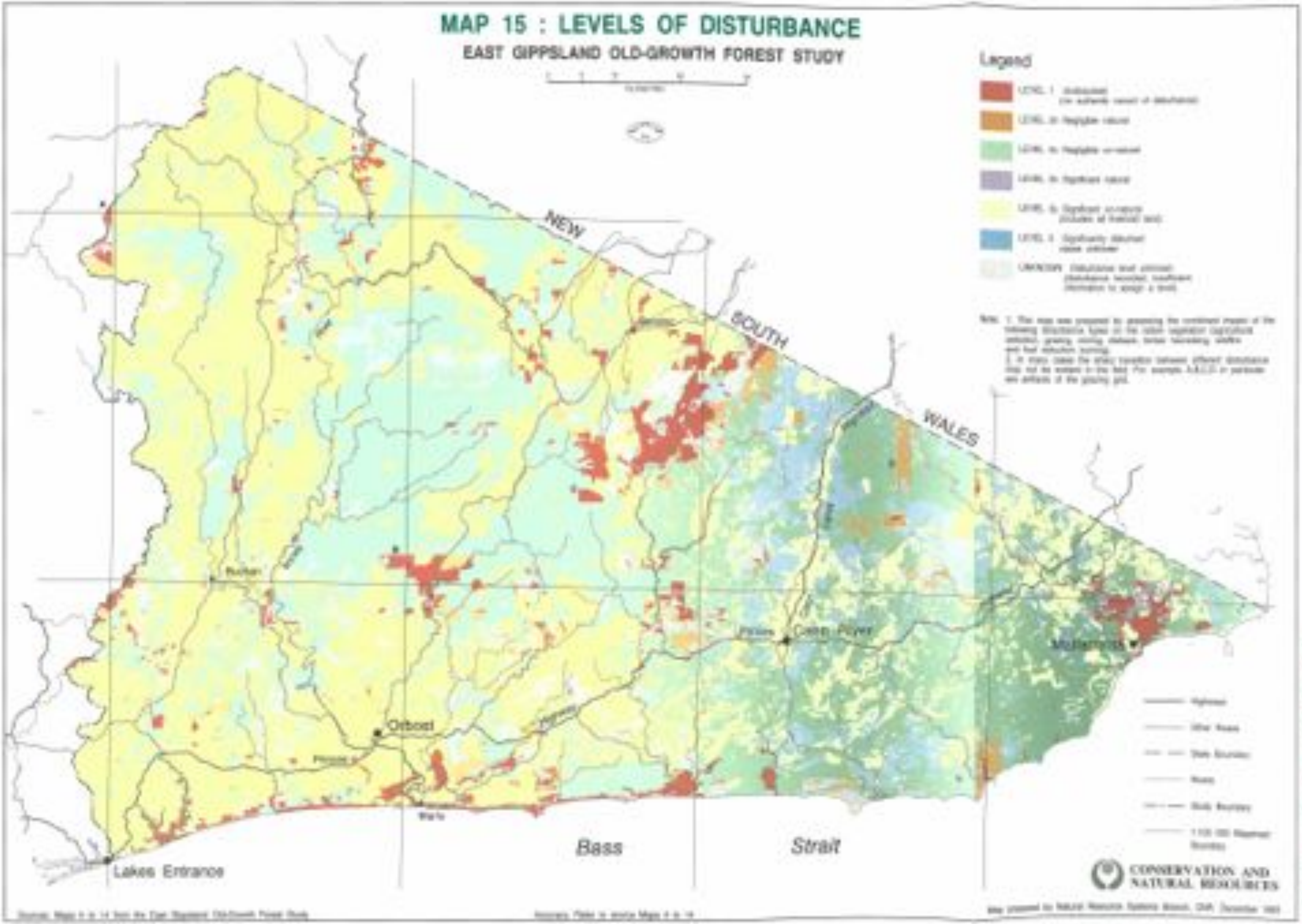
> a disturbance for which there is an authentic record and which is unlikely to have altered the structure (growth stage ratios or crown cover projection) or the usual floristic composition of species for that ecological vegetation class; or if a disturbance did occur in the past the effect is no longer significant.

Areas with negligible disturbances were further identified according to whether the disturbance records were natural (level 2n) or un-natural (level 2u). Areas with negligible natural disturbances were considered to be structurally and floristically intact. Such cases involved ground or crown fires whose effect in the canopy had declined to undetectable levels. Areas with negligible un-natural disturbances were considered to be structurally and floristically intact although slight and reversible floristic changes associated with such disturbances may have occurred. An assignment of a negligible un-natural disturbance level (2u) may fall into one of several categories which is dependent upon the disturbance type and in some cases the ecological vegetation class involved.

Table 10.2 Classification of disturbance levels for forested vegetation.

Disturbance level	Explanation of disturbance level
1 Undisturbed	*Disturbance recorded:* None *Notes:* Comprised areas with no record of disturbance and no disturbance indicated by aerial photo interpretation, or non-flammable vegetation classes with a fuel reduction burn record, and water-bodies.
2n Negligible 'natural' disturbance	*Disturbance recorded:* Wildfire *Notes:* Wildfire was recorded, but no growth stage or canopy damage was evident. Comprised areas where the aerial photo interpretation cannot confirm the presence of the fire. This implies that either the record was incorrect, or the fire only affected the understorey, or that the forest canopy had recovered from the wildfire.
2u Negligible 'un-natural' disturbance	*Disturbance recorded:* Clearfell logging, selective logging, agricultural clearing, fuel reduction burning, grazing *Notes:* Comprised areas where an un-natural disturbance was recorded however examination of the crown cover and growth stage mapping, together with the vegetation class mapping suggested the disturbance was negligible or perhaps even non-existent.
3n Significant 'natural' disturbance	*Disturbance recorded:* Wildfire *Notes:* Comprised areas where a wildfire was recorded and the growth stage mapping confirmed a significant growth stage or canopy disturbance had taken place. This indicated that a 'recent' crown or mid-canopy fire had taken place.
3u Significant 'un-natural' disturbance	*Disturbance recorded:* Clearfell logging, selective logging, agricultural clearing, grazing, mining, pathogens *Notes:* Comprised areas where these disturbances had been individually or collectively recorded and a significant un-natural disturbance was confirmed by the crown cover or growth stage mapping.
3 Significant disturbance, type unknown	*Disturbance recorded:* None *Notes:* Comprised areas where a significant disturbance level was confirmed by the aerial photo interpretation, however no authentic disturbance record was available to assign the type of disturbance.
Unknown disturbance recorded, level unknown	*Disturbance recorded:* Clearfell logging, selective logging, agricultural clearing, grazing, wildfire *Notes:* A disturbance record was available but its level could not be confirmed by the aerial photo interpretation or through other sources.


MAP 14 : FOREST GROWTH STAGE GROUPINGS
EAST GIPPSLAND OLD-GROWTH FOREST STUDY
Legend
NEW
SOUTH
WALES
Cribbast
Lakes Entrance
Bass
Strait
CONSERVATION AND NATURAL RESOURCES
MAP 14 : FOREST GROWTH STAGE GROUPINGS


MAP 15 : LEVELS OF DISTURBANCE
EAST GIPPSLAND OLD-GROWTH FOREST STUDY
Legend
NEW
SOUTH
WALES
Buchan
Orbost
Cann River
Mallacoota
Lakes Entrance
Bass
Strait
CONSERVATION AND NATURAL RESOURCES

Some of these disturbance records are spatially imprecise. For example, when the disturbance type is recorded as clearfell logging, agricultural clearing or selective logging but the growth stage mapping shows no evidence of disturbance, disturbance level 2u is assigned. This indicates that an un-natural disturbance is recorded but is unlikely to have occurred. In the case of fuel reduction burning 2u is assigned because of inadequate and unreliable mapping records of this disturbance type. This notation indicates that fuel reduction burning is recorded for some part of the polygon, however whether it ever occurred, how frequently, or over what area is not known. It is known with certainty that large areas that were recorded as having been fuel reduced, have definitely not been burnt or only burnt once. In such cases the forest is considered to be negligibly disturbed (level 2u). In the case of vegetation classes with high year-round moisture levels, such as Wet Forest or Cool Temperate Rainforest, a fuel-reduction burn record is considered erroneous and the disturbance level becomes undisturbed (level 1).

A disturbance level of 2u may also be assigned where a grazing lease is recorded. Grazing lease records are extensive data sets that have variable occupation and stocking densities. Where an ecological vegetation class is not palatable to domestic stock the disturbance level is assigned as negligible even when the grazing lease is still current (provided the growth stage does not indicate a disturbance has occurred). In palatable ecological vegetation classes, an arbitrary time period of thirty years free from grazing is considered to be necessary to permit recovery from the disturbance, but only where the attendant grazing and associated burning practices have not altered the growth stage is the stand considered to be negligibly disturbed (level 2u).

Disturbance Level 3

A SIGNIFICANT disturbance was defined as:

> a disturbance which is likely to have altered the growth stage ratios, crown cover projection and the usual floristic composition of that vegetation class and which is detectable at the time of the survey, or is indicated in an existing and authentic record.

Areas with significant disturbances were further identified according to whether the disturbances were natural (level 3n) or un-natural (level 3u). The different levels recognise different disturbance intensities. Whilst significant natural disturbances (major wildfires) can cause significant structural and floristic changes, the impact of significant un-natural disturbances was considered to be greater and longer-lasting. The only significant natural disturbance identified and mappable was wildfire. In contrast, other significant disturbances such as storm damage and landslides are known to have occurred in the study area but were too small to map.

The emphasis in these definitions is on the detectability of the disturbance in terms of stand structure and floristics. Both growth stage and crown cover projection are defined in terms of a class, with upper and lower limits. In practice a disturbance may have occurred, but if it does not result in a measurable change of growth stage proportions, crown cover or floristic composition then it is considered to be negligible. A significant disturbance is always indicated when the proportion of regrowth in any stand is greater than 10% of the crown cover of the upper stratum.

In areas with significant un-natural disturbances, structure, floristic composition (or both) will be markedly altered. These sites may contain some old-growth attributes such as tree hollows, whilst other attributes are significantly compromised or lost entirely. Weed invasion can be serious and may contain a high proportion of severe environmental weed species; however, sites that have low levels of weeds may ultimately recover and return to the undisturbed state after several cycles of regeneration, maturation and senescence. Examples of this class of disturbance include grazing in Riparian Forest and Montane Dry Woodland, detectable levels of selective logging, recent grazing and forest dieback, agricultural clearance, clearfell logging and slashed air fields that are surrounded by bushland. Normal ecological processes are significantly disrupted for many years following these disturbances but the structural and floristic composition may ultimately recover after several cycles of regeneration, maturation and senescence.

Note that multiple disturbances were possible on any one site. For example, an area could be grazed, selectively logged and burnt by wildfire. Where this has occurred the disturbance level was assigned on the basis of the most significant disturbance type.

Step 4: Assignment of old-growth status

Stands of old-growth forest were identified according to the definition formulated in Chapter 9; that is, stands with negligible disturbances (disturbance levels of 1, 2n and 2u) which contained senescing trees present in dominant, codominant and subdominant proportions (growth stages S_{1-6} and M_{1-2} for Jacob's forest vegetation classes, or growth stages S_{1-6} and M_{1-4}, M_{9-10} for selected non-Jacob's forest vegetation classes). Thus for Jacobs forest vegetation classes (identified in Table 6.2) the following growth stage classes as mapped through air photo interpretation (Table 4.5) qualified for old-growth status:

- senescing dominant (S_1–S_4)
- senescing and mature co-dominant (S_5–S_6)
- senescing subdominant and mature dominant (M_1–M_2)

For non-Jacobs forest vegetation (Table 6.2) the growth-stage mapping from air photo interpretation (Table 4.5) was unable to adequately detect the senescing growth stages. Field inspection confirmed that this non-Jacobs growth form was common on poorer sites (forest usually less than 28 m in height). The forest type mapping, in combination with certain vegetation classes, identified those forest types that usually contained non-Jacobs growth form stands. They were:

- S_4, S_5, Y, P_4, Ac, B, Ca, O, Po, Rh, W (Table 5.1) with vegetation classes 1–2, 14, 17, 20–21, 24, 27–28 and 40–42 (Table 6.2)
- for mature dominant/senescing subdominant or sparse/no regrowth stages derived from API (M_3 and M_9). Therefore those became an actual growth stage of senescing only (S_1)
- the mature dominant/senescing sparse or absent/sparse regrowth (M_4 and M_{10}) became senescing dominant/sparse mature and regrowth (S_4)
- and the same suite of actual growth stages (S_1–S_4, S_5–S_6 and M_1–M_2) as for Jacobs forest vegetation classes, above, then qualified for old-growth status.

It is recognised that the assignment of M_3 and M_9 to S_1 could equally have been to S_2 or S_3 and may be revised in future as better techniques are developed to distinguish the differences between non-Jacobs senescing and mature. However, for the purposes of identifying old-growth forest there is no significant difference between S_1, S_2 and S_3. It is also recognised that the non-Jacobs mature components of other API-derived growth stage classes (including M_1 and M_2) could be reviewed to assess the actual components of senescing stands. However, this would also have no impact on the determination of old-growth status. Any other forest stands with no or negligible disturbances were identified as negligibly disturbed' forest provided the regrowth component was less than 10% of the crown cover of the upper stratum of the stand. All remaining stands were identified as 'significantly disturbed forest'. Further sub-divisions were made to identify natural and un-natural disturbances for both negligibly and significantly disturbed forest.

10.4 RESULTS

The extent of disturbance levels by growth stages on forested public land is given in Table 10.3. Only 3.5% (32 584 ha) of all forest (918 833 ha) was found to be undisturbed, 47% (431 665 ha) was negligibly disturbed, and 49.5% (454 584 ha) was significantly disturbed.

The extent of old-growth forest growth stages for each vegetation class on public land is given in Table 10.4. Old-growth forest totals 224 364 ha and is found in eight growth stage classes. Senescing dominant growth stage classes (S_1 to S_4) total 108 360 ha, senescing codominant (S_5 and S_6) 3572 ha and senescing subdominant (M_1 and M_2) 112 432 ha, or 48%, 2% and 50% respectively of all old-growth forest. Two growth stage classes, senescing dominant forest (99 555 ha) and senescing subdominant/mature dominant (102 761 ha) account for 90% of the area of old-growth forest. Senescing dominant Shrubby Dry Forest (74 243 ha) alone accounts for 33% of all old-growth forest.

The extent of old-growth forest and other forest of varying disturbance levels for each vegetation class is summarised in Table 10.5. Old-growth forest was found in 26 of the 33 forested ecological vegetation classes. Shrubby Dry Forest (88 013 ha), Damp Forest (42 749 ha) and Wet Forest (36 585 ha) together account for 75% of all old-growth forest. Other negligibly disturbed forest (204 330 ha) was found in 19% of forested public land in the study area.

Of the seven forested ecological vegetation classes that did not contain old-growth forest, four were rainforest, two were very small in total area (Sub-alpine Shrubland (202 ha) and Coastal Grassy Forest (90 ha)) and one, Montane Grassy Woodland, had 95% (4573 ha) affected by significant un-natural disturbances. Several ecological vegetation classes have been substantially affected by significant un-natural disturbances, including Limestone Box Forest (80%), Riparian Forest (72%), Grassy Dry Forest (87%), Herb-rich Forest (86%), Rainshadow Woodland (63%), Montane Dry Woodland (83%), Montane Grassy Woodland (95%), Montane Damp Forest (90%), Montane Riparian Woodland (84%), Montane Riparian Thicket (89%), Sub-alpine Woodland (86%), Lowland Forest (45%) and Tableland Damp Forest (52%).

The extent of old-growth forest and other forest of varying disturbance levels for each structural forest type on public land is given in Table 10.6. Stringybark B (15 m to 28 m) with 48 560 ha, Messmate-Gum B (28 m to 40 m) with 35 486 ha and Red Stringybark – Yertchuk (15 m to 28 m) with 34 991 ha together comprise 53% of the old-growth forest. The other 26 forest types account for the remainder of the old-growth forest.

A summary statement of the proportion of old-growth forest for each ecological vegetation class on public land is given in Table 10.7. Vegetation classes that still retain a substantial proportion of old-growth forest include Foothill Box Ironbark Forest (63%), Rocky Outcrop Scrub (52%), Banksia Woodland (49%), Rocky Outcrop Shrubland (44%), Shrubby Dry Forest (42%), Wet Forest (41%), Coast Banksia Woodland (32%) and Tableland Damp Forest (31%). Old-growth forest comprises 21.8% of all forested ecological vegetation classes and comprises 21.2% of all public land in the study area. No old-growth forest was mapped on freehold land due to the assumed high levels of disturbance. Finally, over 7000 stands of old-

Table 10.3 Growth stages and disturbance level (ha) for all forested vegetation on public land within the study area

Growth	Stages	Disturbance Type and Level (ha)						
		1	2A	2B	3A	3B	3	Total
S_1	senescing only	415	37	3 197	1 083	2 214	0	6 946
S_2	senescing dominant, sparse mature, no regrowth	21	37	1 684	26	829	0	2 597
S_3	senescing dominant, mature subdominant, no regrowth	31	0	797	53	477	0	1 358
S_4	senescing dominant, sparse mature and regrowth	0	0	1 032	0	183	0	1 215
S_5	senescing and mature co-dominant, no regrowth	982	31	4 657	1 036	2 725	0	9 431
S_6	senescing and mature co-dominant, sparse regrowth	31	6	65	0	259	0	361
S_7	senescing dominant, sparse mature, regrowth subdominant	0	0	0	971	1 386	0	2 357
S_8	senescing dominant, no mature, regrowth subdominant	0	0	0	461	293	0	754
M_1	senescing subdominant, mature dominant, no regrowth	9 992	4 086	104 310	2 374	35 959	0	156 721
M_2	senescing subdominant, mature dominant, sparse regrowth	224	640	10 730	7 407	4 401	0	23 402
M_3	sparse senescing, mature dominant, no regrowth[2]	9 931	8 651	133 945	4 775	78 168	0	235 470
M_4	sparse senescing, mature dominant, sparse regrowth[3]	753	981	11 886	50	6 652	0	20 322
M_5	senescing, mature and regrowth co-dominant	0	0	0	411	826	100	1 337
M_6	senescing subdominant, mature dominant, regrowth subdominant	0	0	0	6 802	7 051	679	14 532
M_7	senescing subdominant, mature and regrowth co-dominant	0	0	0	575	418	2	995
M_8	sparse senescing, mature dominant, regrowth subdominant	0	0	0	10 785	24 021	1 172	35 978
M_9	mature only[2]	9 474	6 752	129 889	1 952	96 023	0	244 090
M_{10}	no senescing, mature dominant, sparse regrowth[3]	730	718	7 534	190	10 120	0	19 292
M_{11}	no senescing, mature dominant, regrowth subdominant	0	0	0	6 247	31 143	1 930	39 320

Table 10.3 (continued)

Growth Stages		Disturbance Type and Level (ha) 1	2n	2u	3n	3u	3	Total
R_1	senescing and regrowth co-dominant, no mature	0	0	0	2 207	537	0	2 744
R_2	senescing and regrowth co-dominant, sparse mature	0	0	0	3 166	1 286	42	4 494
R_3	senescing and mature subdominant, regrowth dominant	0	0	0	2 671	2 528	182	5 381
R_4	senescing subdominant, sparse mature, regrowth dominant	0	0	0	1 163	1 678	0	2 841
R_5	senescing subdominant, no mature, regrowth dominant	0	0	0	4 203	805	1	5 009
R_6	sparse senescing, mature and regrowth co-dominant	0	0	0	2 438	4 366	199	7 003
R_7	sparse senescing, mature subdominant, regrowth dominant	0	0	0	6 425	9 571	656	16 652
R_8	sparse senescing, sparse mature, regrowth dominant	0	0	0	2 576	5 533	906	9 015
R_9	sparse senescing, no mature, regrowth dominant	0	0	0	877	3 464	395	4 736
R_{10}	no senescing, mature and regrowth co-dominant	0	0	0	3 545	8 695	119	12 359
R_{11}	no senescing, mature subdominant, regrowth dominant	0	0	0	3 753	13 302	547	17 602
R_{12}	no senescing, sparse mature, regrowth dominant	0	0	0	457	2 630	295	3 382
R_{13}	regrowth only	0	0	0	3 674	6 852	611	11 137
Total All Growth Stages		32 584	21 939	409 726	82 353	364 395	7 836	918 833

Disturbance Levels:

Level 1: Undisturbed
Level 2n: Negligible natural disturbance
Level 2u: Negligible un-natural disturbance
Level 3: Significant, type unknown
Level 3n: Significant natural disturbance
Level 3u: Significant un-natural disturbance (floristically disturbed)

Notes:
These growth stage areas are for forested vegetation classes only. The growth stages are those derived from aerial photo interpretation (Table 4.6, Chapter 4). They exclude all low crown cover class 1 (<10 percent) stands. Growth stages M_3 and M_4, M_9 and M_{10} contain some non-Jacobs stands which are senescing-dominated in practice, although only detected as mature dominated by the aerial photo interpretation. These were re-classified to senescing dominated classes (see Steps 3 and 4, Section 9.3 and Appendix G) for the determination of old-growth forest status. Areas are considered reliable to approximately the nearest 10 ha.

Table 10.4 Old-growth forest growth stages (ha) for each forested ecological vegetation class on public land within the study area[1,2].

	Stands containing senescing growth stages											
	Dominant					Co-dominant			Subdominant			Total
Ecological Vegetation Class	S_1	S_2	S_3	S_4	Subtotal	S_1	S_4	Subtotal	M_1	M_2	Subtotal	
1 Coastal Dune Scrub Complex	305	0	0	0	305	0	0	0	0	0	0	305
2 Coast Banksia Woodland	1 063	0	0	0	1 063	0	0	0	24	0	24	1 087
3 Coastal Grassy Forest	0	0	0	0	0	0	0	0	0	0	0	0
4 Coastal Vine-rich Forest	0	0	0	0	0	0	0	0	22	0	22	22
14 Banksia Woodland	14 079	0	102	887	15 068	0	0	0	2 595	365	2 960	18 028
15 Limestone Box Forest	0	0	0	0	0	0	0	0	270	53	323	323
16 Lowland Forest	589	126	150	0	865	905	0	905	11 245	3 472	14 717	16 487
17 Riparian Scrub Complex	2 891	0	19	280	3 190	191	0	191	808	202	1 010	4 391
18 Riparian Forest	0	13	0	5	18	32	0	32	404	67	471	521
20 Heathy Dry Forest	518	0	0	78	596	0	0	0	47	124	171	767
21 Shrubby Dry Forest	74 243	159	21	4 710	79 133	95	30	125	7 625	1 130	8 755	88 013
22 Grassy Dry Forest	0	0	0	0	0	0	0	0	55	0	55	55
23 Herb-rich Forest	0	0	0	0	0	1	0	1	136	4	140	141
24 Foothill Box Ironbark Forest	312	0	0	0	312	0	0	0	65	0	65	377
25 Limestone Grassy Woodland	0	0	0	0	0	3	0	3	5	0	5	8
26 Rain Shadow Woodland	2 188	0	0	204	2 392	0	0	0	0	0	0	2 392
27 Rocky Outcrop Scrub	2 397	30	0	55	2 482	0	0	0	149	8	157	2 639
28 Rocky Outcrop Shrubland	484	0	0	129	613	2	0	2	88	13	101	716
29 Damp Forest	187	747	174	389	1 497	558	26	584	37 506	3 162	40 668	42 749
30 Wet Forest	256	70	92	200	618	1 028	1	1 029	34 107	831	34 938	36 585
31 Cool Temperate Rainforest	0	0	0	0	0	0	0	0	0	0	0	0
32 Warm Temperate Rainforest	0	0	0	0	0	0	0	0	0	0	0	0
33 Cool/Warm Temperate Rainforest Overlap	0	0	0	0	0	0	0	0	0	0	0	0
34 Dry Rainforest	0	0	0	0	0	0	0	0	0	0	0	0
35 Tableland Damp Forest	17	0	0	0	17	21	0	21	2 141	0	2 141	2 179
36 Montane Dry Woodland	2	101	0	0	103	0	0	0	2 783	0	2 783	2 886
37 Montane Grassy Woodland	0	0	0	0	0	0	0	0	0	0	0	0
38 Montane Damp Forest	0	3	0	0	3	0	0	0	273	0	273	276
39 Montane Wet Forest	22	56	5	0	83	668	0	668	2 337	240	2 577	3 328
40 Montane Riparian Woodland	0	0	0	0	0	0	0	0	31	0	31	31
41 Montane Riparian Thicket	2	0	0	0	2	0	0	0	1	0	1	3
42 Sub-alpine Shrubland	0	0	0	0	0		0	0	0	0	0	0
43 Sub-alpine Woodland	0	0	0	0	0	11	0	11	44	0	44	55
Total	99 555	1 305	563	6 937	108 360	3 515	57	3 572	102 761	9 671	112 432	224 364

1 Includes all stands identified as containing old-growth forest (including both Jacobs and non-Jacobs growth form forests). 2 Areas considered accurate to nearest 10 ha.

Table 10.5 Old-growth forest area (ha) by forested ecological vegetation class for public land in the study area.[1,2]

Ecological vegetation class		Old-growth forest	Other negligibly disturbed forest	Significantly disturbed forest: Natural	Significantly disturbed forest: Un-natural	Unknown	Total
1	Coastal Dune Scrub Complex	305	40	0	1	2 763	3 109
2	Coast Banksia Woodland	1087	78	42	26	2 164	3 397
3	Coastal Grassy Forest	0	1	0	0	89	90
4	Coastal Vine-rich Forest	22	20	0	41	39	122
14	Banksia Woodland	18 028	4 191	3 308	3 411	8 042	36 980
15	Limestone Box Forest	323	231	31	3 710	363	4 658
16	Lowland Forest	16 487	61 719	27 187	110 712	29 026	245 131
17	Riparian Scrub Complex	4 391	1 845	1 865	1 445	8 118	17 664
18	Riparian Forest	521	1 279	396	9 057	1 403	12 656
20	Heathy Dry Forest	767	135	1 110	915	62	2 989
21	Shrubby Dry Forest	88 013	34 681	16 095	53 270	17 923	209 982
22	Grassy Dry Forest	55	1 150	132	14 753	813	16 903
23	Herb-rich Forest	141	520	133	8 327	608	9 724
24	Foothill Box Ironbark Forest	377	53	0	125	40	595
25	Limestone Grassy Woodland	8	58	0	213	192	471
26	Rain Shadow Woodland	2 392	93	0	14 013	5 681	22 179
27	Rocky Outcrop Scrub	2 639	586	57	505	1 265	5 052
28	Rocky Outcrop Shrubland	716	141	68	159	522	1 606
29	Damp Forest	42 749	75 029	21 750	88 478	10 282	238 288
30	Wet Forest	36 585	13 803	3 287	30 380	6 033	90 288
31	Cool Temperate Rainforest	0	0	0	290	2 273	2 563
32	Warm Temperate Rainforest	0	0	0	539	6 238	6 777
33	Cool/Warm Temperate Rainforest Overlap	0	0	0	4	264	268
34	Dry Rainforest	0	0	0	0	11	11
35	Tableland Damp Forest	2 179	696	97	3 674	354	7 000
36	Montane Dry Woodland	2 886	2 670	110	40 209	2 642	48 517
37	Montane Grassy Woodland	0	108	0	4 573	144	4 825
38	Montane Damp Forest	276	821	5	12 618	242	13 962
39	Montane Wet Forest	3 328	3 821	2 110	4 008	239	13 506
40	Montane Riparian Woodland	31	9	0	436	40	516
41	Montane Riparian Thicket	3	1	0	32	0	36
42	Sub-alpine Shrubland	0	162	0	27	13	202
43	Sub-alpine Woodland	55	389	0	6 321	545	7 310
	Other	0	0	0	0	30 383	30 383
Total		224 364	204 330	77 783	412 472	138 811	1 057 760

1 The areas of all disturbance classes other than old-growth forest include the low crown cover density stands (crown cover class 1, < 10%). The Unknown areas include areas for which no growth stage mapping was undertaken because forest was not apparent from the aerial photographs.
2 Areas considered reliable to approximately the nearest 10 ha.

growth forest were found on public land within the study. These ranged in size from just a few hectares to over 10 000 ha. The extent of old-growth forest is depicted by growth stages in Map 16, and by disturbance levels in Map 17.

10.5 DISCUSSION ON ANALYSIS, ACCURACY AND VERIFICATION

The following sections deal with the most obvious results of this study, provide a framework for those who will have to use the large datasets which have been generated, and provide guidance on how to interpret the results as well as suggesting a mechanism for systematically reviewing this work as new data becomes available.

Old-growth analysis

The analysis program that was developed to derive old-growth forests for the study area thoroughly reviewed all data before assigning disturbance levels (Appendix G). This was particularly important with respect to the un-natural disturbance types of timber harvesting, grazing and agricultural clearance. Anecdotal evidence indicates that a majority of the old-growth mapped during this study has not been significantly disturbed by fuel reduction burning, even though contemporary records are insufficient to verify this beyond doubt.

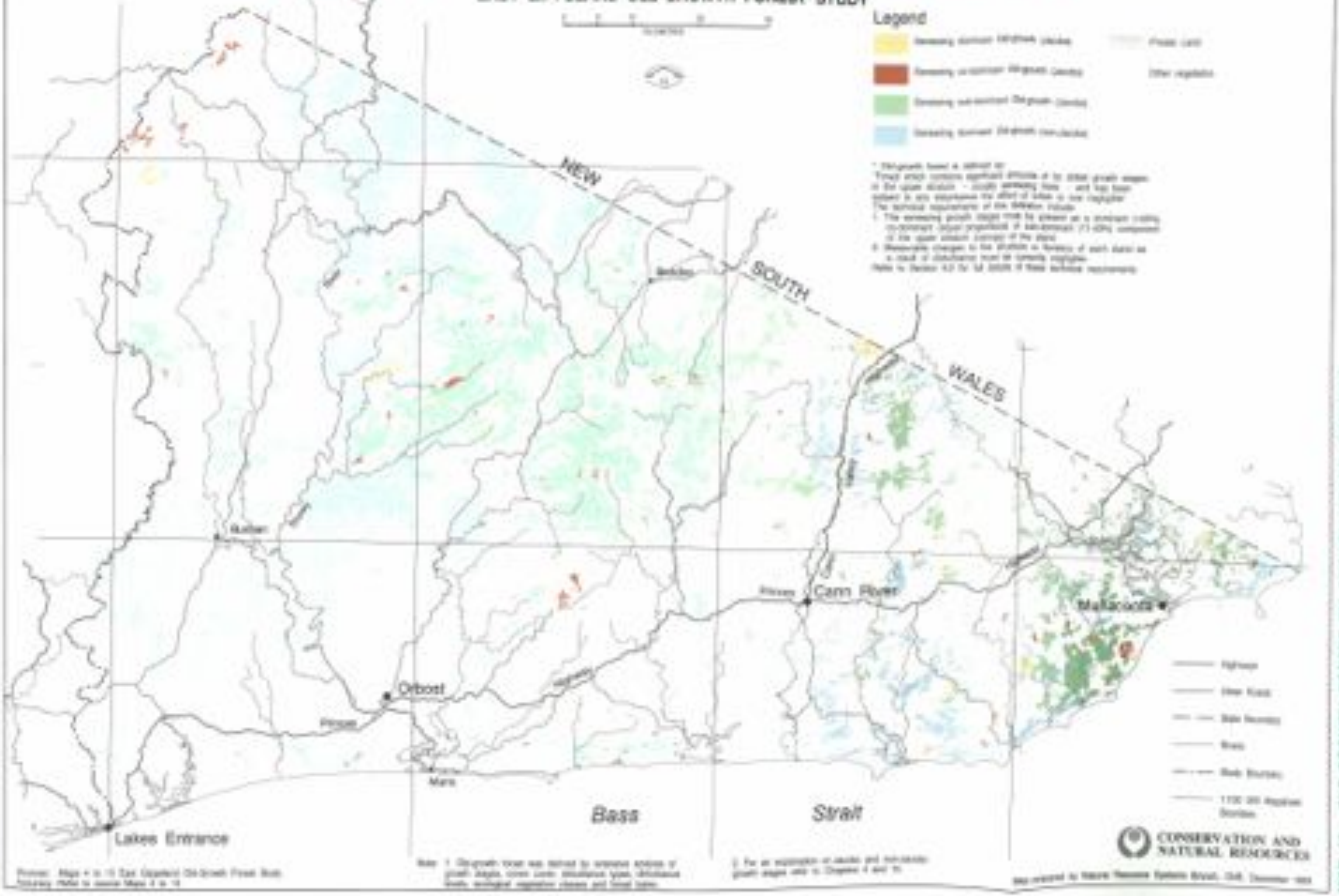
In general a precautionary principle of favouring the growth stage and crown cover mapping over less reliable records was applied. For example, where a paper record indicated clearfelling and the growth stage mapping indicated dense, old trees the paper record was rejected; similarly for logging and wildfires. This approach should ensure that most stands identified as old-growth forest on public land are actually old-growth. The number of times these contradictions recurred were far too numerous to check in the field for the entire study area and it does mean that comprehensive field verification of these anomalies in particular should be undertaken to confirm or revise the mapping.

It is possible that some areas of older forests that have been assigned a significant un-natural disturbance record may not be significantly disturbed. If this is so, such forest stands could qualify as old-growth. For example, areas of damp and wet forests that have either a selective logging or agricultural clearance record and a crown cover class of three or less were assigned a significant un-natural disturbance level on the basis that the crown cover was less dense as a result of the disturbance. Work by Ashton (1976) in Wet Forests of Victoria's Central Highlands indicates that such stands thin naturally to a crown cover of three or less as they senesce. In addition, vegetation classes that are sensitive to grazing and have a grazing record which post-dates 1960 have been assigned a significant un-natural disturbance level. The spatially imprecise nature of these records and the vagaries of grazing leasehold utilisation would indicate that some areas of these forests could be negligibly rather than significantly disturbed. Such areas may therefore qualify as old-growth forest, subject to the appropriate growth stage combinations.

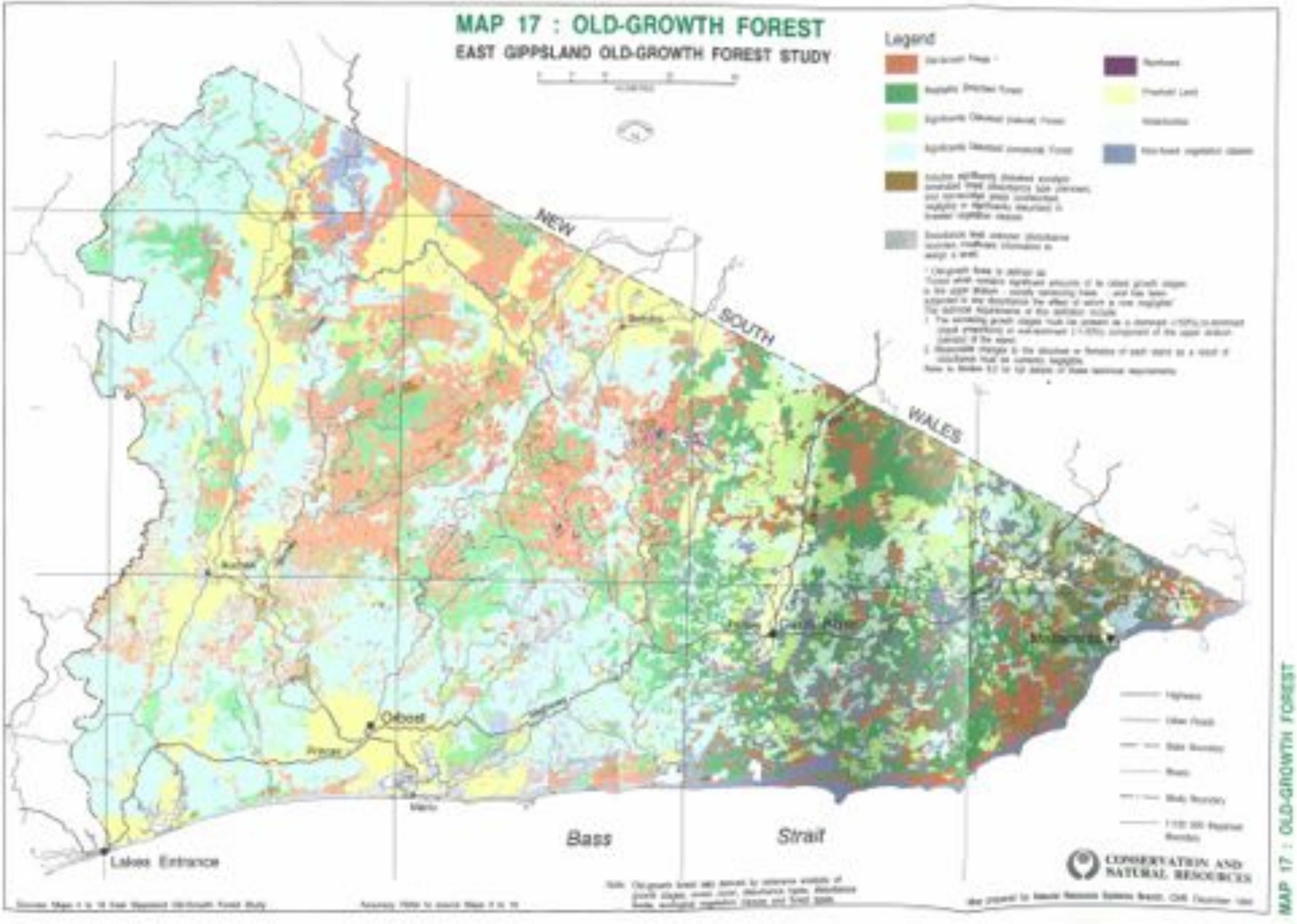
The analysis also excluded two other classes of vegetation: non-forested ecological vegetation classes, and low crown cover areas (crown cover less than 10%) in forested vegetation classes which do not conform to this study's definition of forest. Non-forested vegetation classes such as Clay Heathland sometimes have a sparse overstorey of Swamp Stringybark (*Eucalyptus conspicua*), whilst the Sub-alpine Wet Heaths of the Treeless Sub-alpine Complex can have a scattered overstorey of Mountain Swamp Gum (*E. camphora*) or Black Sallee (*E. stellulata*). Sub-alpine Woodland and Montane Dry Woodland have low crown cover and this may be the normal

MAP 16 : OLD-GROWTH FOREST BY GROWTH STAGE GROUPING

EAST GIPPSLAND OLD-GROWTH FOREST STUDY



MAP 16 : OLD-GROWTH FOREST BY GROWTH STAGE GROUPING



MAP 17 : OLD-GROWTH FOREST
EAST GIPPSLAND OLD-GROWTH FOREST STUDY
Legend
NEW
SOUTH
WALES
Orbost
Lakes Entrance
Bass
Strait
CONSERVATION AND NATURAL RESOURCES
MAP 17 : OLD-GROWTH FOREST

Table 10.6 Old-growth forest area (ha) on public land by forest type in the study area[7].

Forest Type: mature height	Forest Type: Principal species	Code ALP[1]	Code GLH[2]	Code EG[3]	LCC Code EG[4]	Old-growth forest	Negligibly disturbed forest	Significantly disturbed forest: Natural	Significantly disturbed forest: Un-natural	Unknown	Total
>40 m	Shining Gum, Mountain Ash	4a		Ni	2a	2 632	351	16	3 301	558	6 858
	Mountain Ash			A	2b	1 921	880	0	74	141	3 016
	Alpine Ash	3a		Wb	2c	2 778	1 450	1 872	2 069	232	8 401
	Cut-tail			F	2d	19 272	9 495	5 884	15 834	6 113	56 598
	Messmate-Gum A		M_{II}	M_2, M_2	2e	16 790	9 787	2 558	15 643	5 134	49 912
>28 m	Alpine Ash	3b				1 081	2 535	198	3 604	122	7 540
(not	Shining Gum, Mountain Ash[5]	4b				357	0	0	811	29	1 197
necessarily	Messmate–Gum B	5a	M_{III}	M_3	3a	35 486	60 651	16 235	106 447	12 397	231 216
<40 m)	Peppermint–Gum A			P_3	3b	2 622	1 654	41	5 486	849	10 652
	Silvertop			As	3c	3 567	13 612	4 920	22 998	6 695	51 792
	Stringybark A		S_{III}	S_3	3d	12 407	68 973	24 104	126 895	25 805	258 184
	Silvertop–Bloodwood			Rb_3	3e	7 474	6 019	1 433	1 939	764	17 629
	Box			B	3f						
<28 m	Box			B	4b	10 144	444	59	16 016	5 620	[6]32 283
(usually	Box	6			6b						
> 15 m)	Peppermint–Gum B			P_4	4a	8 552	837	891	3 362	472	14 114
	Stringybark B	5b	S_{IV}	S_4	4b	48 560	12 214	10 586	39 726	12 055	123 141
	Red Stringybark–Yertchuk		Y	Y	4c	34 991	3 653	5 526	6 724	6 305	57 199
	Bloodwood–Angophora		Rb		4c	2 583	2 187	672	1 750	3 930	11 122
	Snow Gum Candlebark	2b				278	1 626	41	20 348	1 063	23 356
<15 m	Brittle Gum, Red	5c				7 567	646	349	7 835	1 405	17 802
(generally	Stringybark										
> 8 m)	Swamp Stringybark		S5			12	1	1	35	32	81
	Snow Gum	2a	S_v	SnG	5	75	401	0	4 759	499	5 734
	Callitris			Ca	6a	758	0	0	815	1 671	3 244
	Podocarpus			Po		0	1	0	0	56	57
	Wattle		W	Ac		1 333	262	33	205	1 276	3 109
	Open	5d		O		3 122	266	639	672	8 556	13 255
Various	Alpine Wet Heath	1				0	65	1	49	14	129
	Closed Forest			Hatched	1a, 1b						–
	Other					2	6 320	1 724	5 075	37 018	50 139
Total						224 364	204 330	77 783	412 472	138 811	1 057 760

Notes:

1. Former FCV CODE ALP = Alpine study area mapping
2. Former FCV CODE GLH = Gippsland Lakes Hinterland study area mapping
3. Former FCV CODE EG = East Gippsland study area mapping
4. LCC CODE EG = East Gippsland study area mapping
5. Regrowth.
6. Combined area statement for Box classes 3f, 4b and 6b.
7. Areas considered reliable to approx. 10 ha.

Table 10.7 Summary statement of proportion of old-growth forest for each ecological vegetation class (EVC) on public land in the study area. All values are percentages.

Forested ecological vegetation class		Area as % of EVC	Area as % of old-growth	Area as % of total public forest
1	Coastal Dune Scrub Complex	10	<1	<1
2	Coast Banksia Woodland	32	<1	<1
3	Coastal Grassy Forest	0	0	0
4	Coastal Vine-rich Forest	18	<1	<1
14	Banksia Woodland	49	8	1.7
15	Limestone Box Forest	7	<1	<1
16	Lowland Forest	7	7	1.6
17	Riparian Scrub Complex	25	2	<1
18	Riparian Forest	4	<1	<1
20	Heathy Dry Forest	26	<1	<1
21	Shrubby Dry Forest	42	39	8.5
22	Grassy Dry Forest	<1	<1	<1
23	Herb-rich Forest	1	<1	<1
24	Foothill Box Ironbark Forest	63	<1	<1
25	Limestone Grassy Woodland	2	<1	<1
26	Rainshadow Woodland	11	1	<1
27	Rocky Outcrop Scrub	52	1	<1
28	Rocky Outcrop Shrubland	44	<1	<1
29	Damp Forest	18	19	4
30	Wet Forest	41	16	3.5
31	Cool Temperate Rainforest[1]	–	–	0
32	Warm Temperate Rainforest[1]	–	–	0
33	Cool/Warm Temperate Rainforest Overlap[1]	–	–	0
34	Dry Rainforest[1]	–	–	0
35	Tableland Damp Forest	31	1	<1
36	Montane Dry Woodland	6	1	<1
37	Montane Grassy Woodland	0	0	0
38	Montane Damp Forest	2	<1	<1
39	Montane Wet Forest	25	1	<1
40	Montane Riparian Woodland	6	<1	<1
41	Montane Riparian Thicket	8	<1	<1
42	Sub-alpine Shrubland	0	0	0
43	Sub-alpine Woodland	<1	<1	<1
Total		21.8[2]	100	21.2[3]

Notes:
1 The old-growth status of rainforest was not considered in this study (see explanation, Section 12.2).
2 Old-growth forest as a percentage of all forested vegetation in the study area.
3 Old-growth forest as a percentage of all public land in the study area.

undisturbed condition. In these situations old woody vegetation may therefore qualify as old-growth woodlands, crown cover notwithstanding.

Mapping accuracy

The spatial and attribute mapping accuracy of the old-growth maps generated by this study are directly related to the reliability of the data used in their compilation. The most reliable and up-to-date information was the crown cover and growth stage mapping (derived from 1:40 000 scale air photos) and the forest type mapping (existing 1:63 360 scale mapping). Although the ecological vegetation class mapping (1:100 000 scale) was more general it too was considered to be reliable at the scale at which it was collected. However, the disturbance records vary greatly in quality and reliability.

The clearfelling (1:25 000 and 1:100 000 scale), dieback (1:100 000 scale) and mining (point sources at 1:100 000 scale) records were considered to be the more reliable, although the spatial extent of the mining records was depicted by an arbitrary buffer indicating their likely area of influence. The compartment-based logging allocation records (scale 1:100 000) were indicative of the general locality of proposed selective logging (to the nearest few hundred hectares) and likely logging intensities. The historical records of agricultural clearance (from Parish plans) were also broad in nature, providing indicative evidence of likely clearing or ring-barking. The wildfire mapping (generally 1:100 000 scale) probably gave a good outer boundary of the fire but provided no information on intensity. The grazing and fuel reduction records were both 2 km × 2 km grids (at scale 1:100 000) and are the least spatially precise records. The grazing records gave little useful information about stocking rates and numbers, while the fuel reduction records had no information on burning intensities and gave limited reliable information on the actual extent of the burns.

These differences in accuracy are intuitively well understood and were taken into account through a series of validation steps in which the datasets were cross-referenced. If evidence from a high accuracy dataset contradicted that of a lower accuracy dataset, the former was taken. Comprehensive descriptions of the data are given in the GIS records of the Department of Conservation and Natural Resources.

The variable quality of the datasets also affects the precision of the area statements. It would be desirable to quote confidence limits for each of the subtotals and totals for primary datasets (e.g. growth stage, forest type) and to accumulate these confidence limits for the derived datasets (e.g. disturbance levels, old-growth forest). Unfortunately, the complex series of assumptions that were used to prepare the derived datasets (Appendix G) make it difficult to determine the actual precision of these derived figures in each case. Thus for simplicity all datasets have been quoted to the nearest whole hectare with primary datasets considered reliable to the nearest 5 hectares (Tables 4.6, 5.2 and 6.2) and the derived datasets (Tables 10.3–10.6) considered reliable to the nearest 10 hectares. However, specific areas may be more or less accurate and the users of this information should consider all variables.

In summary, the mapping of old-growth forest (Maps 16 and 17) is intended for use at scales from 1:100 000 to 1:250 000.

Roads and other cultural features

Roads, interpretation facilities, camping and picnic grounds and other cultural features can occur in old-growth forest stands. Because of their small size they were not mapped during this study, but they clearly have a significant un-natural impact on the immediate area of the old-growth forest stand in which they occur. This effect depends on the area occupied by the feature, the maintenance it receives and the structural and floristic disturbance these factors have on the adjacent forest. General assumptions can be made as to these effects, but there has been no attempt to determine their impact on the old-growth forest identified by this study. The impacts may be better assessed by wilderness-type analyses conducted at an appropriate scale.

Rainforest
The old-growth status of rainforest was not determined during this study. The reason for this was the lack of specific growth stages descriptions for rainforest species. Developing these descriptions would have been time consuming and not warranted as rainforest occupies less than 1% (9619 ha) of all forest in the study area.

Freehold land
All freehold land was considered to be affected by significant un-natural disturbances. This assumption was made on the basis that the lack of evidence to the contrary would have necessitated a comprehensive and impractical on-ground checking program.

Verification of mapping
Comprehensive verification of the maps derived as a result of the old-growth analysis was not possible over such a large area although substantial field work was undertaken during the mapping of primary data (e.g. growth stages, ecological vegetation classes and forests types). The refinement of these maps is an on-going task for public land managers, particularly with respect to the on-ground disturbance characteristics of the old-growth stands.

This study has expended considerable effort in collating and organising a large array of disparate datasets. Many of these are routinely required for Departmental activities, irrespective of the issue of old-growth forests. In order for this information to maintain its currency to assist with reviews of the old-growth forest mapping presented in this study, and generally in the interests of efficiency, a set of master maps at scales of 1:100 000 (e.g. vegetation growth staging) and 1:25 000 (e.g. clearfelling) should be maintained at the major CNR work centres, so that authentic changes and updates can be made onto those masters. New data should then be added systematically to the GIS and related textual databases for permanent storage and reference. Much of this updating will be usefully undertaken as part of Victoria's State-wide Forest Resource Inventory, which will be undertaken from 1993 to 1996.

Field inspection should concentrate on the following areas of old-growth forest:

1 Those old-growth stands with a selective logging or clearfelling record where the forest type exceeds 28 m in height. Stumps, logging tracks, landings and other evidence of logging activity should be sufficient to indicate a change in crown cover, growth stage or floristic composition over at least a 10 hectare area before a change to the mapping is warranted.
2 The old-growth stands with a wildfire record from about the last 20 years, or at least two fuel-reduction burns in about the last 10 years. Evidence of disturbance to crown cover (recent epicormics), growth stage (presence of stags, regeneration or regrowth in the lower crown stratum) or floristic composition (presence of some obligate seeders and post-fire colonising herbs and forbs) should be sought. In particular, some obligate seeders such as wattles present as vigorous understorey species in dry forests are good indicators of recent fire.
3 Areas of old-growth forest within one kilometre of private property. These areas may be significantly unnaturally disturbed.

as well as the following areas of forest not currently shown as old-growth:

4 Areas of Riparian Forests, Moist Forests, Tableland Damp Forest and Montane Moist Forests with a crown cover of 3 or less in riverine situations with a grazing record or on steep slopes that have a record of selective logging or agricultural clearance. These areas are currently shown as significantly disturbed because of their lower crown cover, but they might be negligibly disturbed and thus qualify as old-growth.

In addition, it will be important to review the assumptions made in Appendix G in calculating the disturbance levels. As a better understanding of the complex interactions between disturbance types and vegetation classes is gained it will be necessary to reanalyse the datasets in order to improve the mapping of old-growth forests.

Relative ages of old-growth forest stands

The eight growth stage classes (S_1 to S_6 and M_1 to M_2) that characterise the old-growth forest domain do not necessarily demonstrate a progression of increasing relative age from M_2 to S_1. This suggests that all stands from all vegetation classes do not always logically progress through these growth stages classes as they age. Disturbance influences, particularly wildfire, have a profound effect on the growth stage composition. At any one point in time, given the largely unpredictable occurrence of wildfire in any given stand, certain growth stages may be more extensive than at other times. For these reason it may be more advisable to examine the broader groups of senescing dominant (S_1 to S_4), senescing codominant (S_5 and S_6) and senescing subdominant (M_1 and M_2) growth stage classes when considering issues of structural representation.

11

ECOLOGICALLY SUSTAINABLE FOREST MANAGEMENT AND CONSIDERATIONS FOR OLD-GROWTH FORESTS

11.1 INTRODUCTION

This study has delineated the current extent of old-growth forests in East Gippsland. The results represent a snap-shot in time. These forests are a dynamic entity and their distribution and composition will change as a result of both the forces of nature and human management. One of the basic elements of the National Forest Policy Statement on old-growth forests is that relevant management agencies will develop management plans to appropriately protect old-growth forests. This management will require an understanding of the range of conservation and intangible forest values within the broader old-growth forest domain identified and quantified in Chapter 10.

11.2 THE CONCEPT OF OLD-GROWTH FOREST VALUES

The definition of old-growth forest is based on the premise that two primary characteristics of old-growth forests, growth stage and disturbance level, are universally pre-eminent in delineating these forests. This approach dictates that consideration of other characteristics such as fauna, biomass, biodiversity, and naturalness will not alter the delineation of the old-growth forest domain, although these characteristics may also be seen as old-growth forest values.

For management purposes it may be desirable to delineate, within the old-growth forest domain, the best expression of the area of old-growth forest for a whole range of old-growth forest values including fauna, flora, forest age, growth stage, height and density, biomass, biodiversity, timber and water production, naturalness, spirituality and grandeur. This list is not exhaustive. The optimum or peak expression of some of these values, such as growth stage, height, density and some species of flora and fauna, in old-growth forest may be currently identified in East Gippsland. For others, however, further analysis, survey work and research is still required before the extent of the many values can be determined with confidence. In this context the full domain of old-growth forest provides the framework for seeking and describing the extent and spatial arrangement of the value. Several examples of the relationship between these values and their optimum, best or peak expression within the old-growth forest domain are given in Table 11.1, while the concept is depicted in Figure 11.1.

VALUE A

Highest proportion of senescing growth stages in old-growth Wet Forest

Illustrates the site specific nature and rarity in East Gippsland of stands which are only known from the wet climate refuges of the Errinundra Plateau and Rodger River.

VALUE B

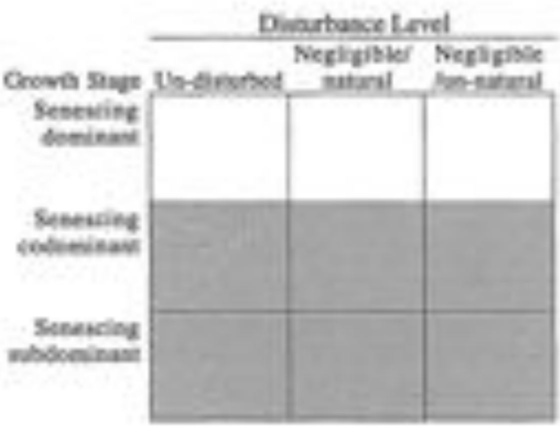
Undisturbed (no un-natural disturbance recorded) old-growth forest

Illustrates natural forests, from the perspective of intangible values

VALUE C

Peak wood production for old-growth Damp Forest

Illustrates likely peak wood production in old-growth Damp Forest under a variable regime of negligible disturbances



VALUE D

Likely optimum habitat for a given fauna species in old-growth Wet Forest

Illustrates the highest value habitat for an old-growth dependent species of fauna which relies upon abundant hollows and a range of growth stages and understorey species that only result from disturbance.

Figure 11.1 The concept of optimum or peak areas (illustrated by the darker tones) for particular old-growth forest values within the old-growth forest domain.

Table 11.1 Examples of the relationship between some of the values of old-growth forests and their peak or optimum expression.

Value	Peak or optimum expression
Primary	
age	peak age (oldest forest)
growth stage	most advanced growth stage
naturalness	undisturbed (no un-natural disturbance)
Secondary	
habitat	optimum habitat for a given species of fauna
bio diversity	most abundant suite of species
biomass	maximum quantity of biotic material
wood production	maximum quantity of merchantable wood
water production	maximum potable water yield

The terms peak, best expression, highest value and so on are meant to convey the notion that a diverse range of old-growth forest values can exist within the old-growth domain. For example peak may be used where the development of the value can be determined by a linear measure such as age, or height. In contrast the term optimum is invoked where the value concerned is determined from a more complex array of old-growth forest characteristics, such as the optimum habitat for a particular species.

Figure 11.1 suggests that the peak or optimum area may vary from value to value. For example, the optimum habitat area for a species of old-growth dependent fauna may differ from the peak area for wood production. This is not surprising given the specific requirements in each case.

It should be noted that, almost without exception, the area for any one of these values will be a subset of the full old-growth forest domain. More-over some of these values will have equal or greater expression outside the old-growth forest domain. In these instances they become broader forest values and not simply old-growth forest values.

11.3 FAUNA VALUES

One of the principal reasons for the perceived importance of old-growth forest ecosystems is that certain fauna may be completely or substantially dependent on them. These species are generally more abundant in old-growth forests, although they are not usually restricted to them. The relationship between fauna and the forests in which they live is most easily understood in terms of the reliance of the fauna on particular attributes which are usually most abundant in older forests. Although for many species these attributes are most common in old-growth forests, like the fauna that rely on them they are not restricted to such forests.

It was beyond the brief of this study to map the secondary attributes that link fauna to old-growth forests. Most secondary attributes are difficult to map by remote sensing methods, such as satellite imagery and aerial photo interpretation. However the old-growth forests described, delineated and mapped by this project provide the ideal stratification for undertaking studies of the relationship between fauna and old growth forest; indeed, this mapping is an invaluable aid to these studies. Further research is required to map secondary attributes within and between vegetation classes and to determine their importance to the old-growth forest dependent fauna of the study area.

A literature review of the fauna of the study area with respect to old-growth forest was undertaken and is detailed in Appendix H. This knowledge, coupled with the information contained in this study, permits the development of conceptual models to better describe the relationship between old-growth forest and fauna. These relationships, based on the two primary characteristics of old-growth forest, growth stage and disturbance level, can be used to better determine the likely extent of specific fauna within the old-growth forest domain.

11.4 CONTEXTUAL VALUES (NATURALNESS)

Old-growth forest stands identified by this study exist in a landscape or neighbourhood which has been subject to various levels of disturbance. These disturbance levels may be seen as indicators of the 'naturalness' of the neighbourhood surrounding old-growth forests. Consequently it is possible to consider the level of context of old-growth stands based on the degree of naturalness of their neighbourhood. Such considerations will be important in the development of prescriptions in management plans. However, before a naturalness analysis of an old-growth neighbourhood can be of substantial use to land managers, the following questions need to be addressed:

- Do old-growth stands retain their complement of biota irrespective of the size of the stand, the shape of the stand or the severity of the edge effect?
- Do old-growth stands retain their complement of biota irrespective of the disturbance level of their neighbourhood? Is this dependent on the structure or floristics of the stand?
- Are the neighbourhoods of old-growth forest stands likely to isolate the populations of old-growth dependent species if these stands are separated through significant disturbance?
- What is the minimum distance between separate stands of old-growth which would facilitate gene flow for old-growth dependent biota?

Furthermore, in any analysis of naturalness the following factors need to be considered:

- scale of the analysis; strategic (regional) scales such as the full study area (over one million hectares), or operational (local) scales where only a few stands are considered;
- overall size of an old-growth forest stand and its tendency to create its own context;
- convoluted boundaries of individual stands;
- shape of stands, irrespective of whether they are narrow or broad;
- proximity of nearby stands, whether they are contiguous or not;
- unequal effect of different disturbance types which may have been given the same disturbance level rating (see analysis Step 3 Chapter 10);
- disproportionate effect created by stands of very large size; and
- radius or area of consideration adjacent to the stand.

It should be recognised that the context analysis is likely to be dependent on the old-growth value under consideration.

Analysis procedures that consider these factors begin to address the important issues of forest connectivity, proximity and viability. Intuitively, the lower the level of disturbance in the neighbourhood surrounding the old-growth stand the more viable that stand and its suite of values is likely to be. Nevertheless, given the dearth of data on old-growth forest in particular and its neighbourhood interactions in general, naturalness analyses such as that suggested here require a considerable amount of research.

11.5 INTANGIBLE VALUES

Old-growth forests embrace a range of characteristics that are not easily quantified by scientific formulae. Intangible and humanistic values such as antiquity, grandeur, naturalness, spirituality and aesthetics, were not measured in any quantitative way in this study. Rather they can be portrayed by description. Four ecological vegetation classes were chosen in order to illustrate and contrast these characteristics in a range of old-growth forests. These descriptions were intended to be expansive, broadening the stereotyped perception that all old-growth forests consist of very large old trees, thereby giving equal consideration to the forests of lower biomass or with other characteristics.

Wet Forest

These forests invoke the classic images of old-growth forests. They are frequently shrouded in mist, which lends an air of mystery to their antiquity and grandeur; they contain the tallest flowering plants in the world, sometimes rising to over 80 m, and they are usually cool and moist. Animal life is cryptic in these forests being hidden by the dense vegetation or by the height of the canopy. The physical dimensions of the dominant trees humble the observer, who is left with the impression that time moves more slowly within this cathedral-like atmosphere.

Coast Banksia Woodland

These woodlands are diminutive by comparison with the other forests of East Gippsland. The old-growth Saw Banksias and Nadgee Stringybarks rise in twisted and gnarled forms to only 5 m or 10 m, their canopies pruned by the salt-laden gales which periodically sweep in off Bass Strait. In the lee of the dunes their dense structure provides a respite from the wind-swept beaches only metres away. The crops of flowers produced by these woodlands attract huge flocks of lorikeets which feed noisily in the low canopy.

Rocky Outcrop Scrub

Clinging to steep rocky slopes, this form of old-growth forest has a structure which contradicts and challenges our perceptions of old forests. The overstorey of mallee-form River Peppermints with their sapling-like trunks belies the antiquity of their enormous mallee roots. The understorey is dense with Red Wattle and Blackthorn, producing a closed canopy that traps moisture and restricts the senses of the human visitor. The soils are rich, and beneath the canopy where light is dim, the redolence of the earth, Red Wattles and Blackthorn is overpowering. Colours are muted greens and brown broken only by the golden mantle of wattle blossom in spring and the flocks of Crimson Rosellas and King Parrots feeding in the Blackthorn of late summer.

Shrubby Dry Forest
Steep northern aspects are clothed in Shrubby Dry Forest where the soils have barely progressed beyond the rocks from which they are derived. The trees whose small girth and height would seem to the casual observer to have been only recently reforested, are proof of a harsh existence on some of nature's poorest soils. Nothing is lush in this forest, fire is frequent and the sunlight is unrelenting as it beats through the thin tree crowns onto the swards of blue-leaved bitter-peas below. Though light is plentiful, colours are subdued except for brief periods in spring when the wattles and peas are in flower. On the forest floor the dappled mosaic of dry leaf litter crunches beneath the walker's feet in this old, but to most, unremarkable forest.

Descriptions such as these begin to address some of the qualities that are more highly valued by a part of the community. These forests are managed for the community good and measures of intangible characteristics need to be developed in order to permit their use in describing the full range of values within old-growth forest. The development of such measures may involve social scientists seeking public opinions.

11.6 THE DYNAMIC NATURE OF OLD-GROWTH FOREST

As with all forest, there are dynamic and cyclic properties to old-growth forests. This study has considered a number of the influences that are constantly at work shaping and re-shaping the extent and characteristics of these forests. Some of these influences can be manipulated by forest managers. This manipulation will occur on the basis of the perceived or known values of old-growth forest, and to the extent that this is possible the following considerations will be important for the development of management prescriptions for old-growth forests:

- representing old-growth forest within each ecological vegetation class;
- representing younger forest which is currently negligibly disturbed (this has the potential to be old-growth forest some time in the future);
- recognising that senescing dominated stands in significantly disturbed forest may also be important, particularly where they belong to an ecological vegetation class which has a relatively small amount of extant old-growth forest;
- ensuring that negligibly disturbed vegetation classes, present in the overall mosaic of forest, are used to enhance the naturalness of the neighbourhood old-growth forest stands; and
- determining the adequacy and comprehensiveness of protection measures for old-growth forest on a biogeographic basis.

A rigid management system based on today's 'old-growth' stands that fails to recognise these considerations strongly runs the risk of becoming less useful at some future time. Moreover the small suite of mappable characteristics that scientists will use over the next few years to delineate old-growth forest provide no certain measure of the many secondary characteristics (such as faunal attributes, functional process and intangible values) that may well warrant consideration as important management values. It is these factors that underline the need to have an active and responsive approach to the long-term delineation and management of these forests in the context of all forest values.

12
CONCLUSIONS

12.1 THE DEFINITION OF OLD-GROWTH FOREST

This study of the forests of East Gippsland has produced a working definition of old-growth forests which encompasses the most important features of these forests. This working definition is accompanied by an expanded series of technical explanatory notes to ensure that these forests can be practically described and delineated. The definition is based on the premise that two characteristics, growth stage and disturbance level, are pre-eminent in defining old-growth forests.

12.2 GENERAL CONCLUSIONS

Effects of early European settlement and utilisation

Determining the history of disturbance in the study area was a major part of the study. The proportion of East Gippsland that was old-growth forest prior to European settlement remains unknown. The new technologies and attitudes of the Europeans have had a profound effect on the forests of the study area. The extent and impact of their imposed disturbance regime on these forests has been a function of the value of the forest resources and their accessibility.

European impact on the East Gippsland landscape began with grazing from the Monaro Tablelands of New South Wales via the Snowy River valley during the 1830s and 1840s. Large areas of Rainshadow Woodland, Montane Dry Woodland, Montane Grassy Woodland and Montane Damp Forest were taken up for grazing leases. In all 724 709 ha (69%) of public land in the study area has been subject to grazing leases. The related burning practices, combined with grazing and rabbit plagues, caused significantly altered the structure and floristics of the vegetation. Today, about 20% of the area of these vegetation classes are old-growth forests.

The pastoralists opened up the country and agricultural selection followed in the 1830s and 1840s. Initially the most fertile ecological vegetation classes such as Rainshadow Woodland, Montane Grassy Woodland, Limestone Grassy Woodland, Grassy Dry Forest and Herb-rich Forest were selected and cleared.

The relatively small remaining areas of these vegetation classes were adjacent to farmland; their durable species were selectively logged for fencing and construction, while the vegetation itself continued to be grazed. As a consequence of these activities, the area of old-growth forest which remains in these vegetation classes is very low and ranges from being non-existent for Montane Grassy Woodland to 2392 ha for Rainshadow Woodland. A total 19 747 ha of former agricultural selections were found on public land, with a further 158 925 ha remaining as freehold today.

From the 1850s to the 1860s gold discoveries in East Gippsland led to an increased population and the establishment of a large mining community. Timber was cut for both housing and mining during that period. However, only 2506 ha of the study area was assumed to be directly affected by mining disturbances.

The next major wave of development began on the coastal plain where the rail head was extended from Bairnsdale to Orbost in 1916 and the artificial entrance at Lakes Entrance was opened in 1889. Various public utilities became primary customers for the region's durable species. In the 1920s and early 1930s the Orbost district was Victoria's primary sleeper supply area.

Effects of modern settlement and utilisation

By the 1940s durable species were scarce and the public utilities were forced to accept other species from the area such as White Stringybark and Mahogany, which continues to be milled from the Lowland and Limestone Box Forests to the present day. In all, 444 796 ha of public land was found to be covered by some form of selective harvesting record. At the time of this study, 7% of Limestone Box Forest was found to be old-growth forest. Lowland Forest is the largest ecological vegetation class in the study area (representing 24% or 245 131 ha of the public land forest), but only 7% (16 487 ha) exists as old-growth forest. Most of these stands are in the more remote coastal country west of Mallacoota where durable species are not a feature of the vegetation class.

By the early 1950s the demand for housing construction timber began to accelerate due to increasing affluence, home ownership, and post-war migration. With the merchantable forests of the coastal plain largely logged over, the attention of timber-getters moved to the foothills of the hinterland around Buchan and to the north of Orbost and Cann River. Access to hilly country was facilitated by the improvement in road-building machinery after World War 2. The extensive stands of Damp Forest provided the high timber volumes from trees with good form necessary to supply the newly emerging markets. By 1974–75 the forests of the region were producing 40% of the State's log output. Damp Forest is the second largest ecological vegetation class (23% of the public land forest estate), and 18% of its area has been classified as old-growth forest. This is in contrast to the old-growth figures for the Wet Forests of the study area, which although occupying only 9% of the public forest area, sees 41% classified as old-growth forest. This may be partly a reflection of the respective fire histories and seasonal restrictions on access to Wet Forests.

Several forested vegetation classes have a relatively high proportion of their area as old-growth forest despite being near to access and settlement: Coast Banksia Woodland (32%), Shrubby Dry Forest (42%), Banksia Woodland (49%), and Foothill Box–Ironbark Forest (63%). These stands have probably survived as old-growth because on the whole they lack durable species, have poor form, are not sought after for grazing or have restricted distributions.

Old-growth forest was identified on 21.2% (224 364 ha) of public land, occurring in 26 of the 33 forested ecological vegetation classes. About 75% of the identified old-growth forest occurred in three ecological vegetation classes: Shrubby Dry Forest (88 013 ha), Damp Forest (42 749 ha) and Wet Forest (36 585 ha). Only 3.5% of all forest on public land was found to be undisturbed, 47% negligibly disturbed and 49.5% significantly disturbed. Old-growth forest was not mapped on freehold land due to the assumed high levels of disturbance.

Limitations to the study

With over a million hectares of native vegetation, over one fifth of which is considered to be old-growth forest, it was not possible to field-check all of this area and ongoing verification is required. While the growth stage, forest type and ecological vegetation class mapping were considered reliable, the existing records of disturbance were less accurate, particularly for selective logging, grazing and fuel reduction burning. Wildfire is also a disturbance that requires more research. It has a profound effect on the extent, growth stage distribution and floristics of most vegetation types in the study area and its influence on old-growth forest characteristics is particularly important.

This study has acknowledged that old-growth forests contain significant intangible characteristics such as antiquity, grandeur, naturalness and spirituality. However, these characteristics have not been specifically used to delineate the old-growth forests of the study area, but rather have been more generally applied in describing the qualitative values of old-growth forest. Better measures of intangible characteristics need to be developed before they can be consistently applied to the assessment of the various values within the domain of old-growth forest stands.

The importance of the information obtained from this study

The results of this study are a snapshot in time. Old-growth forests are a dynamic entity subject to both the forces of nature and human management. This study has established the present location and context of all forests in the study area, including the old-growth forests. It has considered some of the more important old-growth forest values that need to be examined in the preparation of management prescriptions. Importantly, the survey has provided a comprehensive information base for the East Gippsland forests to enable the Department of Conservation and Natural Resources to meet its commitments under the National Forest Policy Statement.

G. Gillespie

Plate 1 Old-growth Damp Forest two kilometres south of Malinns, on the Bonang Highway at Martins Creek. Note the mixed age classes and fallen tree. Many of the senescing trees in this locality were densely clothed in mistletoe.

G. Gillespie

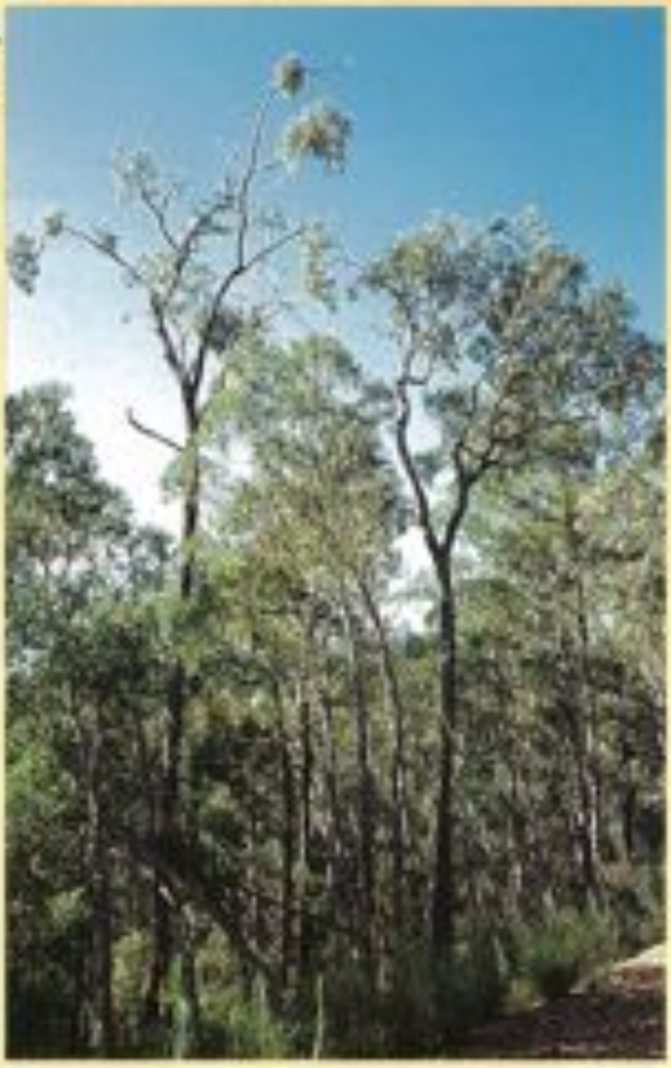
Plate 2 Saw Banksia (*Banksia serrata*) in Old-growth Coast Banksia Woodland on the Pearl Point Road, four kilometres south-west of Bemm River township.

G. Gillespie

Plate 3 This overmature (Jacobs 1955) senescing (in the sense used in this study) Mountain Gum (*Eucalyptus dalrympleana*) shows classic crown decline, bayonets, hollows and burls. This tree grows in Montane Dry Woodland at the Delegate River crossing on the Bendoc–Bonang Road.

A. Rule

Plate 4 Late mature (Jacobs 1955) senescing (in the sense used in this study) Silvertop (*Eucalyptus sieberi*) in Lowland Forest on the Tower Ridge Road, east of Murrungowar. This area of old-growth Lowland Forest was the site for Incoll's dendrochronology work.



G. Gillespie

Plate 5 Old-growth Shrubby Dry Forest on the River Road, one kilometre north-east of the junction between the Tambo and Timbarra Rivers. This non-Jacobs forest has Red Ironbark (*Eucalyptus tricarpa*) which is senescing with a non-Jacobs morphology.

G. Gillespie

Plate 6 Old-growth Coast Banksia Woodland on the Pearl Point Road, four kilometres south-west of Bemm River township. This non-Jacobs forest has salt-pruned Gippsland Stringybark (*Eucalyptus* sp.aff. *globoidea* East Gippsland) which show Jacobs senescing morphology.

Plate 7 Sleeper hewer at work in the Orbost district in the 1930s. (Courtesy of Ron Anderson, taken from *The Cann R Collection, Volume 1*, published by the Snowy River Mail, Orbost, 1985.)

Plate 8 Ostler's Mill, near Orbost, in the 1920s. (Department of Conservation & Natural Resources collection)

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Appendix A
PROJECT BRIEF
WITH SCHEDULE AND BUDGET

PROJECT TITLE:
CLASSIFICATION AND ASSESSMENT OF OLD GROWTH FORESTS IN EAST GIPPSLAND
DATE: JUNE 1991

1 BACKGROUND

Continuing debate about forest issues in East Gippsland often revolves around the question of old growth forest. Perceptions of old growth are as varied as they are numerous. Useful and scientifically defensible debate cannot take place until more is understood about the character of old growth forest and in particular, its location, extent, composition and significance.

Implementation of management practices to protect, maintain or enhance the values of old growth forest, requires a greater understanding of the character of old growth forest and importantly, changes in this character over time. The old growth study was initiated as one of nine projects approved for funding by the Commonwealth Government to seek prudent and feasible alternatives to logging of National Estate forests in the East Gippsland Forest Management Area (EGFMA).

Further relevant background is the agreement between DCE and the Australian Heritage Commission which makes reference to an objective study of the National Estate in the EGFMA. The first stage of the study will identify the national estate values and report on the extent of representation of those values in both National Parks and State Forests. The agreement provides for a second stage of the project which initially will be a survey of old growth forests and a survey/review of historic, archaeological and Aboriginal site data. This new information will be integrated with other data in DCE's Geographic Information System as part of a systematic study of national estate values.

In parallel with this project a submission for a survey of old growth forests has been accepted for funding (to the extent of $70 000) by the National Forest Inventory (Bureau of Rural Resources).

It should also be noted that the State Conservation Strategy for Victoria, under the heading of 'protecting the forests', gives a commitment to locate, map and identify the age classes of ecologically mature forests. The project outlined below will also be a significant step towards meeting this commitment.

2 AIM

The primary purpose of the study is to construct an objective and scientifically credible array of spatially co-ordinated and integrated data describing the characteristics and values of the range of age classes in forests of East Gippsland with a major focus on the older age classes.

3 OBJECTIVES

i Undertake a field survey, using aerial photographs and satellite imagery and data obtained from other sources, to determine the nature and extent of older forests on all classes of land in the EGFMA. Gaps in the existing data bases will be identified as a precursor to this study.

ii Undertake research into, and analysis of, historical data located within lands and forests archival resources.

iii Define a set of age classes of forest that are ecologically significant and will facilitate modelling of spatial and temporal changes in forest age structure for management and research purposes.

iv Assess and map the nature and degree of human-induced disturbances and their impact on the environment using quantitative measures such as weed indexes and dendrochronology.

v From this information, erect a digital database and integrate with other data layers in the GIS including topography, logging and fire history, forest type, floristic vegetation, land systems, land tenure and land use.

vi Using overlay analysis techniques, identify and describe the natural and cultural values of older forests in the study area.

4 RELATED PROJECTS

The old growth study is linked to other projects, including some of those under the National Estate Forest Agreement between the Victorian and Commonwealth Governments. This study will be the first of its kind on old growth forests in Victoria. Consideration will given during the project design phase to the need to ensure compatibility with future studies on old growth forests elsewhere in the state. The key related projects are:

- East Gippsland Forest Management Plan, and specifically the preparation of a digital data base and Resources Statement.
- Expansion of biological surveys (Commonwealth/State Agreement).
- Surveys of historical, archaeological and Aboriginal cultural significance (Commonwealth/State Agreement).
- National Forest Inventory — establishment of regional databases
- Environmental monitoring studies under the VAUS and SSP projects.

5 OTHER CONSIDERATIONS

Project Management

Co-ordination and oversight of the project is provided by the DCE Reference Committee set up under the Steering Committee for the joint DCE–AHC review of the representation of National Estate in Parks and in State Forest of East Gippsland.

A Technical Advisory Committee provides scientific and technical advice on all aspects of the study including the question of definitions. The Advisory Committee includes representatives (as either members or observers) from the Natural Resources Systems Division, Flora and Fauna Division, Regions, National Parks and Public Land Division, Forest Products Management Division, Victorian Archaeological Survey and other representatives as required. The Advisory Committee also includes a representative of the Australian Heritage Commission (observer status) and the National Forest Inventory Project Team (observer status). The Advisory Committee provides technical guidance for the Project Team.

The Project Team comprises a project manager (SCI 4), a team leader (SCI 3), two scientists (SCI 2 and SCI 1), a technical officer and an historian.

BUDGET, OLD GROWTH FOREST PROJECT

		National Estate		NFI
Budgets		90/91	91/92	91/92
Salaries				
• Project Manager (SCI 4) 20%		—	8 445	—
• Team Leader (SCI 3) 100%		10 734	38 414	—
• Biologist (SCI 2) 100%		—	—	33 705
• Scientist (SCI 1) 100%		—	—	24 750
• Technical Officer (TO II) 100%		8 568	29 555	—
• Historic Studies (ADM 5) 50%		—	20 000	—
• GIS Analyst		—	10 000	—
• On Costs	LL/PT/WC 11.65%	2 248	8 901	6 809
	LSL 2.8%	482	1 910	—
	Super	2 895	12 010	—
	Admin 13.57%	2 620	10 368	—
	Wage Case 2.5%	—	1 910	1 460
Subtotal		27 547	141 513	66 724
Vehicle And Expenses				
Vehicle Hire		722	23 300	—
• Travelling Expenses		2 603	7 800	—
• Accommodation		—	5 000	—
Subtotal		3 325	36 100	—
Materials And Equipment				
• Equipment		—	7 902	—
• Map Consumables		313	4 300	—
• GIS Work Station (50%)		12 000	—	—
• Map Scanning		—	10 000	—
Subtotal		12 313	22 202	
Consultancies		—	—	3 276
Subtotal		—	—	3 276
Total		43 185	199 815	70 000

Timing
Recruitment of the Project Team will be completed as a matter of priority and will be fully operational by 1 July 1991. It is proposed that all field work, analysis and mapping will be completed by 30 June 1992.

Attachments
Attachment 1 Budget
Attachment 2 Work Targets
Attachment 3 Survey Methodology
Attachment 4 References

These budgets and work estimates permitted the completion of the report to draft stage. Following comment on the draft the following additional commitments were made to complete the report to publication stage:

- Project Manager (SCI 4) 5 months
- Biologist (SCI 2) 5 months
- Remote Sensing Scientist (SCI 1) 3 months
- GIS analyst (SCI 2) 3 months

This considerable additional effort involved a substantial review of the analysis procedures for old-growth characteristics, checking and extending the primary data set as new data sources were revealed, devising new GIS analysis procedures, editing the final manuscript and preparing the final maps. After allowing for publication costs it was estimated that an additional $80 000 was spent on the project.

OLD GROWTH SURVEY — WORK TARGETS

SURVEY METHODOLOGY

1 PROCEDURE

Whilst a considerable body of relevant information already exists in various data bases, the lack of information on tree and stand age, fire and logging, grazing and farming history will require extensive field survey in conjunction with document based research. The survey procedure will be as follows:

1.1 Review the key parameters required for a comprehensive assessment and classification of young, mature and old growth forest.
1.2 Undertake primary document based research to determine nature and extent of human induced disturbance.
1.3 Review data sources and existing maps.
1.4 Determine those areas where further mapping is required either as up-dating or new mapping. Review satellite imagery and aerial photography to determine the optimum approach to further mapping. Prepare preliminary map of available information.
1.5 Review existing data bases and determine those areas and parameters which require further ground survey.
1.6 Undertake aerial photo interpretation and design the ground survey to complement the initial stratification.
1.7 Establish and measure ground sample plots. Parameters recorded above are to be measured from a common sampling point, wherever possible.
1.8 Dendrochronology studies will be undertaken from exposed stumps on recent logging coupes and elsewhere where appropriate.
1.9 Undertake primary data analysis by appropriate information systems. Input results to the GIS database.
2.0 By applying ground truth to remotely sensed data, prepare data layers for the key parameters. These maps will be prepared for presentation at a scale of 1:100 000 (i.e. the standard GIS regional scale) with overview maps at a scale of 1:250 000. The minimum size of map units (or polygons) at this scale will be about 5 hectares.

2 SPATIAL DATA

The key parameters to be presented as discrete map layers in GIS will be:
- stand age/ages
- forest type (overstorey species and growth phase)
- floristic vegetation
- crown cover
- stand height (absolute or relative)
- weed index
- fire type, frequency, time since burn and extent
- grazing intensity, duration and extent
- clearing from agricultural purposes, period and extent
- mining type, intensity and extent
- timber harvesting type, intensity, year of origin and extent.

Additional information for consideration during the final analysis will include:

- soils
- topography (aspect, elevation and drainage)
- climate (temperature and rainfall)
- land tenure and land use
- tree size, stand density – diameter distribution
- frequency of stag headed trees (with hollow frequency index).

Note that the study will examine all old growth values, irrespective of land tenure.

3 ANALYSIS AND OUTPUTS

A list of criteria that categorises old growth forest will be prepared. It is unlikely that all of these criteria will be capable of measurement through field survey or archival examination, in the life of this project. The key parameters collected during the project will be the practical measures of these criteria. Evaluation of these criteria may be undertaken through a simple 'threshold' approach or by assigning 'levels of significance' within a criterion. For example, one criterion may be that the age of the forest overstorey must be greater than 100 years for it to be considered old growth. Subject to meeting other 'thresholds' / 'levels of significance' in the list of criteria, this forest area can be then classed as one of the categories of old growth forest.

Data will also be collected on the size, shape and connectivity of both the existing and future patches of old growth forest to facilitate any future analysis to determine the significance of areas of younger age classes. This information will be most valuable for planning and management of old growth forests and recognises the dynamic nature of forest ecosystems. The Department's GIS will be used extensively for data analysis and map production.

A report of the study with maps will describe and quantify the growth stage, condition and land-use status of old growth forests in East Gippsland.

4 LIMITATIONS TO THE STUDY

As a first priority the Project Team will review existing data sources. It is recognised that expansion of the survey will be constrained by the limited time and resources available for the study. The implications of these limitations will be a primary consideration for the Technical Advisory Committee.

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Appendix B

FIELD TECHNIQUE FOR ASSESSING CROWN COVER PROJECTION

Adapted from Method of Walker and Hopkins (1990), in K.C. McDonald *et al.* (eds). Australian Soil and Land Survey : Field Handbook. 2nd edn.

1. Sample crowns of similar stratum (height) along a zig-zag transect.

a Lay out a tape in straight line as the basis for the transect.

b Measure from one tree to another by selecting the closest tree in the direction of the transect line. Remember to select a tree in the direction of the transect (from start to finish). The selected tree can be toward or across the transect line.

2. Measure the width of crowns and gaps between the crowns.

a Crown widths are measured as the width parallel to the transect line. For ovoid crowns average the longest and shortest widths.

b The crown gaps are measured in the line from one trunk to the other trunk.

c Twelve measurements of each is sufficient.

d In cases where crowns overlap, the crown gap has a negative value. The greater the overlap the greater the negative value.

e In cases where crowns are conspicuously clumped, the clumps can be considered as a large crown, and the crown gap becomes the distance between clumps.

3. Crown separation

$$\text{Crown separation ratio C} = \frac{\text{mean gap}}{\text{mean width}}$$

then

$$\text{Crown cover\%} = \frac{k}{(1+C)^2}$$

where k = 80.6

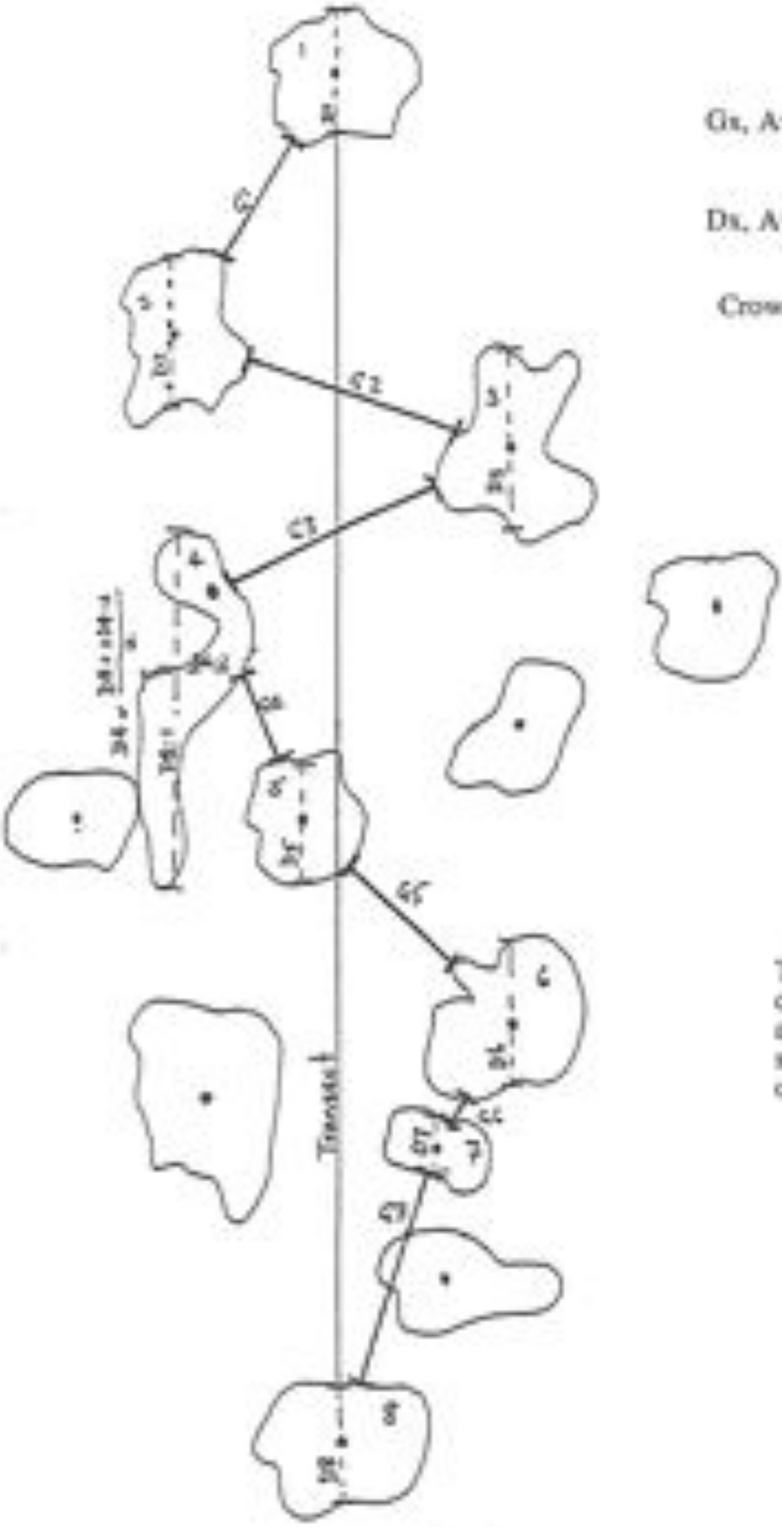
Note:

1 Always record the individual diameters and gaps on standard field sheet.

2 Accurately locate the transect position on the aerial photograph and mark on the transparency overlay.

Aerial view of transect line for field estimation of crown cover projection

Start



$$\text{Gx, Average Gap} = \frac{\sum G1 \ldots n}{n}$$

$$\text{Dx, Average Gap} = \frac{\sum D1 \ldots n}{n}$$

$$\text{Crown gap ratio} = \frac{Gx}{Dx}$$

Trees with ovoid crowns like No. 4, average the longest and shortest diameter to obtain crown diameter.

Finish

Appendix C
DESCRIPTION OF FOREST TYPE CLASSES

The descriptions in this appendix are taken largely from Buntine 1974 (unpubl). This study was undertaken to determine the location and quality of timber resources, so the descriptions of forest type classes do not elaborate on their other values (such as faunal, floristic and intangible attributes).

(N_1) Shining Gum

The typical forest type of the Errinundra plateau where *E. nitens* occurs as a pure species often in excess of 60 m height. The understorey is commonly of a dense 'jungle' type containing many of the Closed Forest species. Included in this class are some of the higher elevation forests where *E. nitens* occurs in mixture with other species such as *E. fastigata* and *E. delegatensis*. This mixture of species is found more commonly away from the Plateau in the dissected upper headwaters of the Ada, Errinundra, Bendoc, Delegate and Rodger Rivers.

The forests appear to be even-aged, apparently having resulted from a catastrophic fire over 200 years ago. Normally the understorey vegetation remains damp, especially in the gullies, thus excluding natural fires during all but exceptionally dry periods.

This is a most important commercial class of forest that is currently being utilised by the Bendoc and Orbost sawmillers. The timber is valued for all grades of scantling and is quite suitable for seasoning quality. The logging season is restricted to the drier months of the year, being hindered at other times by snow fall and wet roads. Major access roads have to be of a high standard to allow logging to be continued for as long as possible.

Very little detailed information is available on the fauna and flora of these forests however representative samples of the vegetation are included in the reserves of the Errinundra Plateau.

(A) Mountain Ash

These are not extensive forests in the Orbost Shire, being restricted to two regions. One is the upper headwaters of the Errinundra and Combienbar Rivers, and the other is in the upper Rodger and Yalmy Rivers. The dominant species is *E. regnans* which can grow to over 75 m in height. This species does not occur at the higher elevations and is found in protected gullies bordering *E. nitens* and *E. delegatensis*, associated with the typical wet sclerophyll type understorey of the higher foothill forests. Fires are very infrequent but play a most important part in the natural regeneration of these forests.

Because of the difficulties of access, utilisation has so far been restricted to the portion of these forests in the upper Combienbar River. This type is not specifically reserved anywhere in the Orbost Shire.

(Wb) Alpine Ash

The dominant species is *E. delegatensis*, normally occurring as pure stands on or near the Errinundra Plateau, and in the upper portion of the Yalmy River. At the highest elevation on exposed sites around Monkey Top, the Bowen Range and Mt Tingaringy, *E. delegatensis* assumes a stunted form and often adjoins areas of *E. pauciflora*. For simplicity sake this stunted form has been included in this class.

Alpine Ash is an important commercial species and is currently being logged on the Errinundra Plateau in association with *E. nitens*. Regeneration in the natural state is very dependent on severe fires, apparently occurring slightly more frequently than in the Shining Gum forests, and results in forests that are even aged.

(F) Cut-tail

This is an extensive forest type of the foothill and mountain forests the major species being *E. fastigata*. Although *E. fastigata* occurs extensively in pure stands in the catchments of the Delegate, Bendoc and Ada Rivers, and the Mt Tennyson locality, it also mixes with many other species, the most common of which are *E. nitens*, *E. cypellocarpa* and *E. obliqua*. *E. fastigata* covers a wide range in elevation from a small near-coastal occurrence at Wingan Inlet, then extensively throughout the wetter foothill forests to the forests of the Errinundra Plateau. Although preferring the sheltered slopes in the foothill zones, it extends onto the northern aspects around Bendoc and Mt Tennyson.

The understorey varies considerably depending on locality, containing many of the Closed Forest species on or near the Errinundra Plateau but becoming very similar to that of the Messmate Gum forests at lower elevations.

Severe fires are very infrequent with ring counts showing that much of the higher elevation forests of this type were probably regenerated at about the same time as the Shining Gum forests. In the foothill zone, some evidence of past fire damage is often present.

It is a most important commercial forest type and represents a considerable portion of the harvestable timber of the foothill and mountain forests. It has only been extensively utilised in a few locations, mainly at Bendoc, Murrungowar, Club Terrace and Combienbar but forms the bulk of the sawlog resource of a number of the allocated logging units.

Areas of *E. fastigata* are reserved in the Mount Alfred National Park.

(M_1, M_2, M_3) Messmate–Gum A and B

A very extensive forest type that occurs throughout the Orbost Shire, this forest type is present in most land systems ranging from the gullies of the coastal plains to extensive stands in the foothill and mountain zones. It has been subdivided by height into two classes, those stands that are known to be greater than 40 m (M_1, M_2) being separated from the rest (M_3).

E. cypellocarpa is normally present to various degrees with a wide range of other species, the most common being *E. obliqua*. Other common species are *E. viminalis*, *E. fastigata*, *E. pseudoglobulus*, *E. botryoides*, *E. muelleriana* and *E. elata*. In the Howe Range *E. fraxinoides* can be common, being the only occurrence of this species in Victoria. The actual species present in any particular area differ considerably, *E. muelleriana* and *E. pseudoglobulus* preferring drier sites, *E. fastigata* the moist protected gullies, while *E. elata* and *E. botryoides* are more common in stream-side environments. The understorey varies considerably depending on location.

This is a very valuable commercial forest type wherever it occurs. All of the species are of value for sawlog timber and for a range of other types of produce including poles and sleepers. At its best development tree height may exceed 60 m as on the western slopes of the Ellery Ridge where merchantable volumes can be correspondingly high. It has been utilised for many years in the foothill forests around Orbost, Murrungowar, Bemm River, Cann River, Wingan Inlet and Genoa, and also to a more limited extent at higher elevations near Bonang and Bendoc.

Roading developments in more recent years have now extended logging operation into the more inaccessible areas around Combienbar and the catchments of the Goolengook and Thurra Rivers. Even so huge virgin areas of this type still exist around Mt Kaye, Ellery Creek and west of the Bonang highway. At higher elevations in the Delegate and Bendoc River catchments, this forest type often occurs on the northerly slopes in association with *E. fastigata* and *E. nitens* on the protected southerly slopes.

The frequency and the severity of wildfire varies greatly depending on locality. At lower elevations where it is commonly in association with the Stringybark forests, fires are relatively frequent, all stands showing some degree of fire damage. At higher elevations with higher rainfall and a less inflammable understorey fire is less frequent. Most of the species of this forest type are relatively resistant to fire and consequently a range of age classes is usually present.

(P_3) Peppermint Gum A

This is a restricted forest type of the Bendoc–Bonang region with *E. radiata* and *E. rubida* being the dominant species. Other species that may be present are *E. dalrympleana*, *E. camphora* and *E. obliqua*. The value of this type for hardwood sawlog production is dependent on the quantity of *E. obliqua* present and the quality of the *E. radiata* which is capable of producing high quality scantling timber. In some localities suffers severely from rot and ant defect. *E. radiata* at its best development commonly exceeds 50 m in heights (e.g. along the Delegate River).

The understorey is generally open with a scattering of sclerophyll shrubs and grasses. Fires are consequently usually mild and in the past, have been encouraged to promote grass growth for forest grazing. Natural regeneration is spasmodic resulting in an uneven aged forest.

(As) Silvertop

This forest type consists of all of the areas of pure *E. sieberi* that could be identified during the study. Further areas that could not be identified will have been included in the Stringybark type.

At its best development for hardwood sawlog production, *E. sieberi* occurs as pure stands in which tree heights exceed 60 m. These stands have an appearance similar to that of the other related ash eucalypt species and are best represented on the ridges around Murrungowar, Genoa, Mount Ellery and Mount Future. Very high volumes per hectares are obtainable from such stands. Silvertop is an unusual species compared to the forest types already described, as it grows to its best development on ridge tops and exposed northern and western slopes. In such locations it attains greater heights and straighter form than other species. On the drier and more exposed slopes, the tree height is much less but the species still usually occurs in pure stands except at the limit of its range where it borders on the Red Stringybark forests.

These stands are normally even aged and are slightly more fire resistant than stands of the other ash species. Fire susceptibility is high during the summer months due to the light ground fuels which dry out readily and are very inflammable. Fire damage is common even after mild fires, and allows access for rot and termites. Intense fires are particularly damaging, often causing tree death; however, Silvertop is naturally a heavy seeding species and usually regenerates prolifically following fire.

E. sieberi produces valuable sawlog timber that has been utilised from the coastal and foothill forests from Nowa Nowa to Cann River for many years. Currently considerable volumes are being removed from stands in the Murrungowar–Combienbar–Bemm River areas. Other high quality stands in the Harrisons Creek catchment are being utilised.

(S_3) Stringybark A

This is an extensive forest type of the lower foothill forests and coastal plains. A large range of species are recorded from this type but the dominant ones are always Silvertop and/or one or more of the Stringybark group e.g. *E. globoidea*, *E. baxteri*, *E. agglomerata*, *E. muelleriana*. Other species include *E. botryoides* (uncommon), *E. bridgesiana*, *E. cypellocarpa* (scattered), *E. consideniana*, *E. polyanthemos* (rare), *E. mannifera* (rare), *E. sideroxylon* (rare) and *E. bosistoana* (rare). These forests all become very dry and inflammable during summer and are very prone to severe wild fires which can cause extensive damage to the standing trees. In the absence of fire the fuel build-up in the understorey can be very high and further increases the severity and likelihood of fires. Most of the species present are, however, very resistant to fire and in the event of intense fire are capable of re-shooting from lignotubers and dormant buds in the stems.

The stands are usually either uneven aged or have a very uneven size distribution. This has resulted both from the effects of fire and the effects of past selective utilisation. Most of the species are highly valuable for sawlogs, with many being also suitable for sleepers, poles and honey production. The huge extent of these forests plus their ease of access and location in relation to existing conversion centres, make them very valuable for both present and future timber supplies. If correctly managed, relatively high volumes of timber per hectare can be obtained.

These forests were the main source of timber supplies for the early development around Nowa Nowa and Orbost, utilisation of the coastal forests now having extended as far east as the Wingan River. Early sleeper cutting of selected species such as *E. sideroxylon* and *E. bosistoana* in these forests near Nowa Nowa, has now resulted in these two species being virtually eliminated from this forest type. Current operations around Orbost have concentrated on re-logging through cut-over areas but large areas of virgin stands are still located in the Genoa area.

(Rh_3) Silvertop–Bloodwood

This forest type is restricted to the country east of the Wingan River and south of the Princes Highway. It is probably a variant of the Stringybark type with the *E. gummifera* taking the place of the Stringybark species to form a mixture with *E. sieberi*. Apart from these two major species, *E. cypellocarpa*, *E. consideniana* and *E. globoidea* are occasionally common. Fires have not been as common as in the rest of the Stringybark forests, probably because of the lack of agricultural development in the immediate surrounds.

These forests have not been utilised but contain considerable volumes of virgin *E. sieberi* and *E. globoidea* that is suitable for sawlogs. The volumes of sawlog timber available, however, are only a small portion of the total amount of wood available. The stands tend to be of a mature–overmature type with an understorey typical of the coastal Stringybark and Silvertop forests.

(P_4) Peppermint Gum B

This is the forest type that normally adjoins Snow Gum areas either on the open tableland country around Bonang and Dellicknora or at higher elevations on the Bowen Ranges, Mt Tingaringy and the Monument Range. Tree heights are typically less than 28 m and may even be as low as 15 m on the very exposed slopes. At lower elevations this type has, to a certain degree, been cleared for agriculture where topography is suitable.

The dominant species is *E. dives*, usually in mixture with *E. rubida*. Other species that may also be present include *E. camphora* (wetter areas), *E. viminalis* (gullies), *E. stellulata* (lower elevations), *E. macrorhyncha*, *E. bridgesiana*, *E. gunnii* (rare) and *E. pauciflora* (on the margins of the type).

The understorey is usually sparse, open and often grassy, making it susceptible to fire as it dries off readily during the summer months. Lightning fires are common at higher elevations, especially in the Tubbut region.

These forests currently have no commercial value although some of the lower elevation areas may have some future for softwood conversion for other adjacent forest types which may be susceptible to fire damage.

(S_4) Stringybark B

This subdivision includes a number of forest types that have been grouped together for simplicity. It is meant to represent the lower height class areas of the stringybark forests but the coastal belt also includes large areas of stunted *E. botryoides*. The major species are the stringybarks, predominantly *E. globoidea* with some patches of stunted *E. sieberi*. East of the Wingan River *E. muellerana* can also be quite common.

The most extensive areas are the low stringybark forests north of Orbost on the fall into the Snowy River and in the drier areas of the Cann and Genoa Rivers. The type is either non-commercial or of a low value for timber production depending on its location in relation to more productive stands. Some areas could be quite highly productive of pulpwood. These forests are very prone to fire, but recover quickly and are very valuable protection forests.

(Y) Red Stringybark–Yertchuk

This classification includes two forest types that have been grouped together for simplicity, each of which have little, if any, commercial value.

Type (a) This is the *E. consideniana* – *E. cephalocarpa* forest of the coastal belt. The understorey is typically very similar to the heaths, the type in fact usually being in the zone between heaths and the coastal stringybark forests.

Type (b) This is the bulk of the land that has been mapped under this classification and includes most of the protection forests of the drier, more exposed slopes of the Snowy, Deddick and Genoa Rivers. The dominant species is *E. macrorhyncha*, but numerous other species may also be present and can form a wide variety of mixtures. They include *E. goniocalyx* (Deddick River,), *E. consideniana* (lower Snowy Valley), *E. gunnii* (Bowen Ranges), *E. sideroxylon* (rare), *E. bridgesiana*, *E. polyanthemos*, *E. mannifera* (rare), *E. cypellocarpa* (stunted), *E. dives* (higher elevations) and *E. pseudoglobulus* (rare).

The understorey is usually low and relatively open. It becomes very inflammable during the summer months and in conjunction with the low tree height, often less than 15 m, can pose a major fire hazard. Lightning fires are common, the steep slopes and limited access making control very difficult and hazardous. The species are however, extremely fire resistant and important for erosion control and water catchment purposes.

(Rb_4) Bloodwood–Angophora

This is an interesting and restricted coastal forest type of the Genoa region. The two major species, *E. gummifera* and *Angophora floribunda*, either occur pure, in mixtures with each other or other species such as *E. globoidea*. *Angophora floribunda* is common in the coastal forests of southern New South Wales but is restricted in Victoria to the Mallacoota region. Along the coast between Lake Barracoota and Wingan Inlet, *Angophora* is absent, the dominant species being a very stunted form of *E. gummifera*.

Tree heights rarely exceed 28 m and may be as low as 10 m adjacent to the coast. The type is largely uncommercial but could supply minor produce depending on the species present. Near the coast the understorey contains many of the heath species typical of the coastal stringybark forest elsewhere. Fuel build-up can be quite high in the absence of fire.

(SnG) Snow Gum

Snow Gum (*E. pauciflora*) has only limited occurrences in the Orbost Shire but occurs in two quite different sites. The first is as one of the dominant species of the tableland country around Bendoc and Bonang where severe frosts have probably excluded other species, and the second is on the upper portions of the dominant mountain peaks of the Shire at elevations over 1 200 m.

Most of the plateau occurrences have been cleared for agriculture and only scattered remnants remain at the edges of clearings and along the Delegate and Bendoc Rivers. *E. stellulata* and *E. camphora* are common associated species. At the higher elevation Snow Gum is more stunted and grows on extremely exposed situations. Here it adjoins areas of stunted *E. delegatensis*. *E. perriniana* forms a mixture with *E. pauciflora* on parts of the Bowen Ranges, but occurs pure at one location near Tower Bowen. Other occurrences of *E. pauciflora* are on the Monument Range, Monkey Top, Mt Tingaringy and at Delegate Hill.

The understorey is usually very grassy and poses little hazard for fires.

(B) Box

This type includes all areas that were recognised as being dominated by one of the box species. The most common are *E. bosistoana*, *E. mellidora*, *E. polyanthemos* and *E. albens*.

E. bosistoana is a most important species that has been sought after for many years for sleepers, beams and poles. It is now restricted to a few limited areas near Nowa Nowa (Lake Tyers), Orbost (Snowy River, Raymond Creek), Noorinbee and Genoa (Genoa and Wallagaraugh Rivers). Large areas have been cleared for agriculture in the early parts of the century. At its best development it can exceed 70 m (Jones Creek).

The other major occurrence of Box are the White Box (*E. albens*) forests of the upper Snowy River. This species is restricted to this rain shadow area and occurs nowhere else in the Shire. Although the timber is of high quality, tree height is usually not very great (20 m), growth slow and form poor. It is utilised to a limited extent for local farm timbers and honey production. The understorey is very open and grassy but can be hazardous for fire protection because of the tendency for fires to stay alight in roots and stumps underground. In the McKillops Bridge region the species often forms a mixture with *Callitris collumellaris* and at higher elevations may mix with *E. goniocalyx* or *E. macrorhyncha*. The upper limit of *E. albens* is about 600 m.

(Ca) Callitris

These forests only occur in the upper Snowy River area of the Orbost Shire. The dominant species is *Callitris collumellaris*, which although often as pure stands along the Snowy River, always either adjoins or grows in mixture with *E. albens*.

Callitris produces very valuable timber but is slow growing and does not thin itself, resulting in dense stands of trees. Most of this type in the study area is thought to be relatively even aged, probably resulting from a past wild fire. *Callitris* does regenerate naturally if the seasonal conditions are suitable. Grazing can prevent the establishment of regeneration.

(Po) Podocarpus

Podocarpus lawrencei, Mountain Plum Pine, occurs in the Goonmirk Range area of the Errinundra Plateau where it grows atypically in tree form rather than as a scrambling low shrub. An investigation was carried out by Forester J. Nankervis (File No. 65/3218) to delineate the limits of this species in this locality, the result of which led to the increase in the size of the Goonmirk Rocks Scenic Reserve. The areas that were delineated at that time have been included as a separate forest type.

(Ac) Wattle

This forest type includes all areas of pure wattle. The most significant are the *Acacia dealbata* stands of the Errinundra Plateau region, and the *Acacia mearnsii* areas on the exposed slopes of the Deddick River valley. At this latter locality the vegetation height is often less than 6 m, with a number of other species, including *Leptospermum*, *Goodenia* and *Westringia* growing in close association and resulting in a dense, low, shrubby vegetation.

(O) Open

All natural treeless areas have been mapped as this forest type, including swamps, coastal sands, tea-tree areas and the extensive coastal heaths which make up the bulk of the type. These heaths are very extensive throughout the complete coastal zone from Lake Tyers to Cape Howe. They contain an abundance of plant species and support a wide range of animal and bird life. Fire has been an important factor in maintaining a diverse range of species and is a common feature of this environment. Fire has often been induced by man to increase the potential of this forest type for grazing purposes.

Closed Forest

These are the non-eucalypt forest associations that are often referred to by the common names of 'rainforests', 'jungles' or 'gully forests'. Closed forests of this type are restricted in Victoria to east of the Mitchell River with the best and most extensive examples being located in the Orbost Shire. They are very rich in ferns, epiphytes, and climbers, very sensitive to fire and, especially the lowland type, need the protection of the surrounding forest to survive.

Type (a) The higher elevation montane variety of the Errinundra Plateau, which occurs both as an understorey to *E. nitens* and *E. fastigata* and as pure stands, where it appears to have displaced the eucalypts over a long period of fire exclusion. The identifying species of this association are *Atherosperma moschatum* (Sassafras), *Elaeocarpus reticulatus* (Blue Oliveberry), *Podocarpus lawrencei* (Mountain Plum Pine), *Drimys lanceolata* (Mountain Pepper) and many ferns and epiphytes.

This variety occurs quite extensively in the Coast Range locality where it appears to be a linking variety between the sub-tropical forests of New South Wales and the temperate forests of Tasmania. *Acacia dealbata* usually occurs within or adjoining these areas.

Type (b) Commonly referred to as the lowland variety and in contrast is restricted to the deep sheltered gullies of the foothill forests. It occurs throughout the foothill forests of the Orbost Shire but in only a few places, notably Mt Drummer and Jones Creek, does it cover large areas as a pure type.

The main representative species are *Eugenia smithii* (Lilly-pilly), *Tristania laurina* (Kanooka), *Pittosporum undulatum* (Sweet Pittosporum), *Eucryphia moorei* (Eastern Leather-wood), *Bedfordia arborescens* (Blanket Leaf), plus many climbers, creepers, ferns and epiphytes that do not occur at higher elevations.

Note: For those other forest types listed in Appendix D, only summary descriptions are available from map legends or LCC reports.

Appendix D
RELATIONSHIP BETWEEN FOREST TYPE MAPPING AND ECOLOGICAL VEGETATION CLASS MAPPING
(Buntine, 1974; LCC, 1974, 1977, 1982)

Notes for this appendix:

1 * indicates species added to the dominant tree species of each forest type as a refinement needed to map more restricted ecological vegetation classes during this study.

2 'Mixed Forest' refers to Warm or Cool Temperate Rainforest with a eucalypt overstorey. This structural form of those ecological vegetation classes was not mapped during the study.

Appendix D:1

FOREST TYPE AND HEIGHT CLASS	DOMINANT TREE SPECIES[1]		RAINFALL (mm) ELEV. (m)	LANDFORM & GEOLOGY	ECOLOGICAL VEGETATION CLASS (and number)		
	USUAL	OCCASIONAL			USUAL	OCCASIONAL	RARE
2a (EG) 4a (ALP) 5b (EG) >40 m, 4b (ALP) (regrowth 28–40 m)	*E. nitens*	*E. cypellocarpa** *E. fastigata**	800–1000 700–900	Montane: Devonian granitoids	30. Wet Forest	29. Damp Forest	—
	E. denticulata	*E. fastigata**	1400–2000 900–1200	Montane, plateau, intermontane basin: Ordovician sediments Devonian Snowy River Volcanics	30. Wet Forest	31. Cool Temperate Rainforest, Mixed Forest	—
A (EG) >40 m	*E. regnans*	*E. fastigata** *E. obliqua**	1400–2000 800–1100	Intermontane basins, plateau, dissected montane: Ordovician sediments, Devonian Snowy River Volcanics	30. Wet Forest	31. Cool Temperate Rainforest, Mixed Forest	—
8b, (ALP) 0a, >40 m, 5b (regrowth 28–40 m)	*E. delegatensis*	*E. regnans* *E. obliqua*	1000–1400 1000–1200	Montane plateau, dissected montane: Devonian granitoids, Silurian sediments, Ordovician sediments	39. Montane Wet Forest	38. Montane Damp Forest	36. Montane Dry Woodland
	E. delegatensis	*Leptospermum grandifolium**	1000–1400 1000–1200	Montane creeks: Quaternary alluvium	41. Montane Riparian Thicket	—	—
F >40 m	*E. fastigata* *E. denticulata* *E. nitens*	*E. cypellocarpa** *E. obliqua**	400–1400	Dissected foothills, plateau: Ordovician sediments, Devonian granitoids	30. Wet Forest	29. Damp Forest, 31. Cool Temperate Rainforest, Mixed Forest[2]	32. Warm Temperate Rainforest, Mixed Forest[2]
M_S (GLP) M_1,M_2 >40 m	*E. cypellocarpa* *E. fastigata* *E. obliqua*	*E. globulus* ssp. *pseudoglobulus** *E. viminalis**	1200–2000 400–1000	Dissected foothills, intermontane basins, plateaux: Devonian, Snowy River Volcanics and granodiorites, Ordovician sediments	30. Wet Forest	31. Cool Temperate Rainforest, Mixed Forest[2]	—
5a 28–40 m	*E. croajingolensis** *E. obliqua*	*E. delegatensis**	900–1200 900–1200	Dissected montane: Ordovician sediments, Devonian granitoids	38. Montane Damp Forest	36. Montane Dry Woodland	—
	*E. croajingolensis** *E. viminalis**	—	900–1000	Dissected foothills, plateau: Tertiary basalts	23. Herb-rich Forest	—	—
M_3 (M_{SD}) 28–40 m	*E. cypellocarpa* *E. muelleriana* *E. obliqua* *E. viminalis*	*E. globulus* ssp. *pseudoglobulus** *E. sieberi** *E. fastigata**	1000–1200 10–100	Dissected foothills in gullies, intermontane basins, tablelands and ridge tops of mountain ranges: Ordovician granitoids Devonian Snowy River Volcanics	29. Damp Forest	32. Warm Temperate Rainforest, Mixed Forest[2]	31. Cool/Warm Temperate Rainforest Overlap
			1200–2000 100–1000	" "	—	30. Wet Forest	31. Cool Temperate Rainforest, Mixed Forest[2]
	*E. bauerana** *E. bosistoana** *E. tricarpa**	*E. globoidea** *E. globulus* ssp. *pseudoglobulus** *E. viminalis*	700–900 0–100	Rocky river valley slopes, shores of submerged river valleys: Tertiary limestones and marls	13. Limestone Box Forest	—	34. Dry Rainforest
	*E. croajingolensis** *E. elata** *E. botryoides** *E. viminalis** *Tristaniopsis laurina**	*E. ovata**	750–1200 5–800	River and creek flats: Quaternary alluvium	18. Riparian Forest	32. Warm Temperate Rainforest	19. Riparian Shrubland

Appendix D:2

FOREST TYPE AND HEIGHT CLASS	DOMINANT TREE SPECIES[1]		RAINFALL (mm) ELEV. (m)	LANDFORM & GEOLOGY	ECOLOGICAL VEGETATION CLASS (and number)		
	USUAL	OCCASIONAL			USUAL	OCCASIONAL	RARE
P₁, P₁₁ 28–40 m	*E. pauciflora** *E. rubida / dalrympleana* *E. viminalis**	*E. ovata**	900–1000 850–1100	Dissected montane on broad ridges and slopes: Devonian granodiorites, Tertiary basalts	37. Montane Grassy Woodland	—	—
P₂, P₂₂ 28–40 m	*E. croajingolensis** *E. dalrympleana**	*E. obliqua*	1100–1300 850–1200	Montane tableland: Ordovician sediments	35. Tableland Damp Forest	35. Montane Dry Woodland	29. Damp Forest
	*E. mannifera** *E. radiata*		800–1000 900–1700	Dissected montane: Ordovician sediments	36. Montane Dry Woodland	—	—
Ax 28–40 m	*E. sieberi*	*E. consideniana**	800–1000 100–800	Dissected foothills and coastal hills: Ordovician sediments	21. Shrubby Dry Forest	16. Lowland Forest	—
		*E. globoidea**	900–1200 10–500	Coastal hills: Ordovician sediments	16. Lowland Forest	—	21. Shrubby Dry Forest
		E. cypellocarpa *E. muelleriana*	1000–1100 700–900	Dissected foothills: Ordovician sediments	—	29. Damp Forest	—
S₂ (S₂₂) 28–40 m	*E. consideniana* *E. globoidea* *E. sieberi*	*E. baxteri* *E. [illegible]**	900–1200 80–500	Coastal hills: Ordovician sediments	21. Shrubby Dry Forest	—	16. Lowland Forest
		*E. mannifera** *E. tricarpa**	600–900 200–300	Coastal hills: Ordovician sediments	21. Shrubby Dry Forest	—	—
		*E. muelleriana** *E. obliqua**	1100–1200 800–1100	Intermontane basin: Devonian Snowy River Volcanics	29. Damp Forest	—	—
		*E. tricarpa** *E. polyanthemos**	600–800 20–250	Ridge tops: Ordovician sediments	24. Box Ironbark Forest	—	—
	*E. pryoriana**	*Acacia mearnsii** *Banksia integrifolia** *Banksia serrata**	750–900 3–20	Tertiary dunes: Quaternary aeolian sands	3. Coastal Grassy Forest	—	—
Rh³ 28–40 m	*E. gummifera* *E. sieberi* *E. globoidea*	*Angophora floribunda*	900–1200	Coastal plains and hills: Devonian adamellites and granites Ordovician sediments	16. Lowland Forest	—	—
	E. botryoides *E. gummifera*	*Angophora floribunda*	1000–1200	Lower slopes around coastal embayments: Quaternary colluvium	4. Coastal Vine-rich Forest	—	—
B Various	*E. baueriana** *E. bosistoana* *E. tricarpa**	*E. globulus* ssp. *pseudoglobulus** *E. viminalis**	700–900 0–100	Shores of submerged river valleys: Tertiary limestones and marls	15. Limestone Box Forest	—	34. Dry Rainforest (peninsulas with north west and east aspects)
	E. melliodora *E. viminalis**	*Acacia caerulescens,** *A. implexa,** *A. melanoxylon** *Allocasuarina verticillata** *Banksia marginata** *E. rubida**	700–800 250–400	Dissected foothill karst: Devonian limestone	25. Limestone Grassy Woodland (ridges, north, east and west aspects)	23. Herb-rich Forest (south aspects) —	34. Dry Rainforest (rocky slopes with north aspects)

Appendix D:3

FOREST TYPE AND HEIGHT CLASS	DOMINANT TREE SPECIES[1]		RAINFALL (mm) ELEV. (m)	LANDFORM & GEOLOGY	ECOLOGICAL VEGETATION CLASS (and number)		
	USUAL	OCCASIONAL			USUAL	OCCASIONAL	RARE
B Various	*E. albens*	*Allocasuarina verticillata**	750–900 600–900	Upper dissected slopes at foothills: Devonian granodiorites	20. Heathy Dry Forest (north aspect)	—	—
	*E. nortonii**	—	750 600–900	Upper dissected slopes at foothills: Devonian granodiorites	22. Grassy Dry Forest (south aspect)	—	—
	*E. bridgesiana**	*E. polyanthemos**	750–850 200–400	Dissected foothills: Devonian granodiorites	22. Grassy Dry Forest (upper slopes)	—	—
B, S, Cn, Various	*Callitris glaucophylla** *C. endlicheri** *E. albens*	*E. blakelyi* *E. melliodora*	650–750 100–600	Dissected foothills: Devonian granodiorites	26. Rainshadow Woodland	—	—
	E. albens	*Callitris endlicheri** *C. glaucophylla**	650–750 100–600	Dissected foothills: Ordovician sediments	21. Shrubby Dry Forest	—	—
B Various	*E. melliodora* *E. tricarpa**	*Acacia silvestris** *Eriostemon trachyphyllus**	760–800 40–150	River gorges: Devonian Snowy River Volcanics, Ordovician sediments	27. Rocky Outcrop Scrub (north aspects)	—	34. Dry Rainforest (south aspects)
P_4 15–28 m	*E. dives* *E. rubida*	*E. mannifera**	800–1000 900–1200	Dissected montane: Ordovician sediments	36. Montane Dry Woodland	21. Shrubby Dry Forest	—
S_4 ($S_{(y)}$) 15–28 m < 15 m	*E. polyanthemos* *E. tricarpa*	—	700–800 10–900	Dissected foothills: Ordovician sediments	24. Box Ironbark Forest	—	—
	E. tricarpa	*E. smithii* *E. macrorhyncha*	700–800 100–900	Dissected foothills: Ordovician sediments and hornfels	27. Rocky Outcrop Scrub (north or west aspects)	—	—
S_4 ($S_{(y)}$), Sh 15–28 m	*E. globoidea* *E. sieberi* *E. botryoides*	*Allocasuarina littoralis**	700–900 10–900	Dissected foothills: Devonian Snowy River Volcanics, Ordovician sediments	21. Shrubby Dry Forest	22. Grassy Dry Forest	16. Lowland Forest
			700–1200 10–250	Coastal plains: Tertiary outwash alluvium	16. Lowland Forest	—	—
	E. botryoides	*E. sieberi*	900–1200 5–150	Coastal plains: Quaternary aeolian sands	14. Banksia Woodland	16. Lowland Forest	—
	*Banksia integrifolia** *E.* spp. aff. *globoidea** *Leptospermum laevigatum**	*Banksia serrata**	900–1100 10–250	Coastal dunes: Quaternary aeolian sands	2. Coast Banksia Woodland	3. Coastal Sand Heathland	14. Banksia Woodland
	*E. conspicua**	—	800–900 10–100	Coastal plains: Tertiary outwash alluvium	7. Clay Heathland	8. Wet Heathland	—
	E. consideniana *E. macrorhyncha*	—	600–700 250–900	Dissected foothills: Devonian Snowy River Volcanics	28. Rocky Outcrop Shrubland	27. Rocky Outcrop Scrub	—
Y 15–28 m	*E. consideniana* *E. macrorhyncha*	*E. polyanthemos*	700–900 100–900	Dissected foothills: Devonian Snowy River Volcanics, Ordovician sediments	21. Shrubby Dry Forest	—	—
Y < 15 m	*E. consideniana*	*E. conspicua**	800–1000 10–80	Coastal plains: Quaternary alluvium	7. Clay Heathland	—	—
	Melaleuca squarrosa	*E. ovata**	800–1000 0–150	Lowland creeks: Quaternary alluvium	17. Riparian Scrub Complex	—	—
	E. consideniana	*E. globoidea**	800–1000 10–250	Coastal plains: Tertiary outwash alluvium	16. Lowland Forest	14. Banksia Woodland	—
	E. consideniana	*E. sieberi**	800–900 10–100	Coastal plains: Tertiary outwash alluvium	14. Banksia Woodland	16. Lowland Forest	—

Appendix D:4

FOREST TYPE AND HEIGHT CLASS	DOMINANT TREE SPECIES[1]		RAINFALL (mm) ELEV. (m)	LANDFORM & GEOLOGY	ECOLOGICAL VEGETATION CLASS (and number)		
	USUAL	OCCASIONAL			USUAL	OCCASIONAL	RARE
Rb 15–28m	*Angophora floribunda* *E. gummifera*		900–1000 5—200	Coastal plain: Tertiary outwash alluvium	16. Lowland Forest	7. Clay Heathland	21. Shrubby Dry Forest
	E. sieberi	*E. gummifera*	900–1000 5—100	Coastal plain: Quaternary aeolian sands	14. Banksia Woodland	2. Coast Banksia woodland	—
2b (ALP) < 15 m	*E. glaucescens** *E. kybeanensis**	*E. delegatensis** *E. pauciflora**	900–1100 1100–1200	Montane ridges : Silurian sediments	42. Sub-alpine Shrubland	—	—
2b (ALP) 15–28 m	*E. radiata* *E. rubida/dalrympleana*	*E. pauciflora*	900–1200 900–1200	Dissected montane, montane Plateau: Devonian granites and Snowy River Volcanics	36. Montane Dry Woodland	—	—
Sc, < 15 m	*E. camphora** *E. croajingolensis**	*E. stellulata**	900–1000 900–1200	Montane river and creek flats: Quaternary alluvium	40. Montane Riparian Woodland	—	—
	E. dives, *E. mannifera*	*E. radiata* *E. macrorhyncha*	900–1000 900–1000	Dissected montane: Silurian sediments, Devonian Snowy River Volcanics, Ordovician sediments	36. Montane Dry Woodland	21. Shrubby Dry Forest 22. Grassy Dry Forest	20. Heathy Dry Forest
S_1 (S_2) <15 m	*E. conspicua*		700–800 10–100	Coastal plains: Tertiary outwash alluvium	7. Clay Heathland	8. Wet Heathland	—
Bn(G), 2a (EG), S_2 8–15 m	*E. pauciflora*	*E. dalrympleana** *E. perriniana* *E. rubida**	900–1400 1200–1400	Sub—alpine peaks: Ordovician sediments, Devonian Snowy River Volcanics	43. Sub-alpine Woodland	44. Treeless Sub—alpine Complex	—
Pc Various	*Podocarpus lawrencei*	*Tasmannia spp.*	1400–2000 1120–1200	Montane slopes: Devonian granodiorites	31. Cool Temperate Rainforest (thickets)	—	—
Ac, W Various	*Acacia silvestris** *Eriostemon trachyphyllus**	*E. smithii** *E. polyanthemos**	650–900 200–1000	Dissected north and west aspects on upper slopes of river gorges: Devonian Snowy River Volcanics, Ordovician and Silurian hornfels	27. Rocky Outcrop Scrub	—	—
	Acacia dealbata	*Dicksonia antarctica**	1200–2000	Montane plateau: Ordovician sediments, Devonian Snowy River Volcanics	30. Wet Forest	—	11. Cool Temperate Rainforest
G, T, M Various	*Banksia marginata* *Bossiaea ensata* *Epacris impressa* *Lepidosperma concavum* *Ricinocarpos pinifolius*	*E. botryoides* *E. spp. aff. globoidea*	900–1000 10–20	Tertiary Dunes: Quaternary aeolian sands	3. Coastal Sand Heathland	—	—
	Leptospermum laevigatum *Myoporum insulare* *Spinifex hirsutus*	*Banksia integrifolia*	700–1000 5—100	Primary Dunes: Quaternary aeolian sands	1. Coastal Dune Complex	2. Coast Banksia Woodland	—
	E. macrorhyncha *E. consideniana*	*Leptospermum brevipes* *Ozothamnus conditus*	700–900 200–1000m	Ordovician sediments and Devonian granitoid outcrops	28. Rocky Outcrop Shrubland	—	—

Appendix D:5

FOREST TYPE AND HEIGHT CLASS	DOMINANT TREE SPECIES[2]		RAINFALL (mm) ELEV. (m)	LANDFORM & GEOLOGY	ECOLOGICAL VEGETATION CLASS (and number)		
	USUAL	OCCASIONAL			USUAL	OCCASIONAL	RARE
Open (O), (–) < 2 m	*Juncus kraussii* *Mimulus repens* *Sarcocornia quinqueflora* *Suaeda australis* *Triglochin striata*	*Melaleuca ericifolia*, *Phragmites australis*	900-1000 -0.25—0.75	Saline peat flats adjacent to estuaries: Quaternary peats	9. Coastal Salt Marsh	—	—
	Bolboschoenus caldwellii *Juncus kraussii* *Lycopus australis*	*Melaleuca ericifolia*	800-1000 0-0.4	Estuarine mud terraces: Quaternary alluvium and peats	10. Estuarine Wetland	—	—
Open (O), (–) < 2 m	*Cladium procerum* *Baumea articulata* *B. rubiginosa* *Phragmites australis*	*Melaleuca squarrosa* *Gahnia clarkei* *Gleichenia microphylla*	900-1000 -0.5—0.0	Coastal lagoons: Quaternary aeolian sand and peats	11. Coastal Lagoon Wetland	—	—
	Pseudoraphis paradoxa *Baumea rubiginosa* *Hydrocotyl sibthorpioides* *Asperula subsimplex*	*Leptospermum lanigerum* *Melaleuca ericifolia*	700-800 -0.5—0.0	Coastal dune swales: Quaternary aeolian sands and peats	12. Wet Swale Herbland	—	—
	Baumea juncea *Leptocarpus brownii*	*Melaleuca armillaris*	900-1000 0.0—0.5	Coastal embayment infill: Quaternary aeolian sands and peats	13. Brackish Sedgeland	—	—
Open (O), (–) < 2 m	*Leptospermum lanigerum* *Melaleuca squarrosa* *M. ericifolia*	*E. ovata* *Gleichenia microphylla*	750-1200 5—150	Lowland Creeks: Quaternary alluvium	17. Riparian Scrub Complex	—	—
	Allocasuarina paludosa *Epacris obtusifolia* *Leptospermum continentale* *Melaleuca squarrosa* *Xanthorrhoea resinosa*	*E. conspicua*	800-1100 10-150	Lowland river & creek terraces: Tertiary outwash alluvium and Quaternary alluvium	8. Wet Heathland	—	—
	Allocasuarina paludosa *Leptospermum continentale* *Tetrarrhena turfosa*	*E. sieberi* *Angophora floribunda*	900-1000 10-20	Near coastal plain: clayey Ordovician sediments and Tertiary outwash alluvium	7. Clay Heathland	—	—
	*E. nitida** *Banksia marginata**	*Xanthorrhoea australis*	750-800	New coastal plain: sandy Tertiary outwash alluvium	—	—	6. Sand Heathland
I <2 m	—	*E. camphora* *E. stellulata*	850-1300 800-1200	Quaternary alluvium and peats, on perched soaks and stream side flats	44. Sub-alpine Complex	—	—
		Kunzea ericifolia *Podocarpus lawrencei*	850-1300 800-1200	Rock screes of Devonian Snowy River Volcanics or Ordovician sediments			

Appendix E

DESCRIPTIONS OF ECOLOGICAL VEGETATION CLASSES IN EAST GIPPSLAND

VEGETATION DESCRIPTION

For ease of description the ecological vegetation classes of the study area are presented in groups that reflect broad landscape zones based on elevation and landform. Many name changes have occurred since the original floristic mapping. The original or equivalent names are noted in the descriptions as synonyms. The nomenclature follows the *Census of Victoria's Plant Communities* (CNR, in prep). Brief summaries are given of climate, soils, elevation range and floristics for each vegetation class (* indicates introduced species). The area statements are for public land only.

COASTAL VEGETATION

The vegetation of this landscape zone is confined to the Quaternary dunes of the coast, coastal embayments, lakes and inlets. These occur between Lakes Entrance and the New South Wales border. Geology is predominantly Quaternary aeolian calcareous (coastal) and siliceous (sub-coastal) sands. These often form extensive dune fields. Minor outcrops of Devonian granitoids and Ordovician marine sediments form cliffs and headlands in the east of the study area. The geology of the lakes and embayments is a variety of Quaternary alluviums, colluviums and peats.

Ecological vegetation class 1. Coastal Dune Scrub Complex
Synonym: Primary Dune Scrub (Forbes *et al.* 1981)
Area: 3109 ha

This complex covers the vegetation succession from the grasses and the halophytes on the foredune to the closed scrubs of Coast Tea Tree *Leptospermum laevigatum* on the secondary dunes along the ocean beaches and lake shores of the study area. This class is therefore widespread but restricted to the coast in the study area. The soils are aeolian calcareous sands that have very low humus contents. Rainfall is in the range of 760–1000 mm with elevation being between 5 and 100 m.

The most conspicuous plants of the foredune are the grasses Hairy Spinifex *Spinifex sericeus* and Marram Grass **Ammophila arenaria*, the herb Coast Sow-thistle *Actites megalocarpa*. The shrub Cushion Bush *Leucophyta brownii* is also common. The halophytes most often present are Sea Rocket **Cakile maritima* and Karkalla *Carpobrotus rossi*. In the lee of the primary dune the shrubby species Coast Wattle *Acacia sophorae* and Coast Tea-tree *Leptospermum laevigatum* become dominant.

Coast Daisy-bush *Olearia axillaris*, Common Boobialla *Myoporum insulare* and Coast Everlasting *Ozothamnus turbinatus* are also ubiquitous.

Examples: Ninety-mile Beach at Lake Bunga, Point Ricardo and Wingan Inlet.

Ecological vegetation Class: 2. Coast Banksia Woodland
Synonym: Coastal Banksia Woodland (Forbes *et al.* 1981)
Area: 3397 ha

Coast Banksia Woodland is restricted to near coastal localities on secondary or tertiary dunes behind Primary Dune Scrub complex on calcareous sand. This class is not common in the study area. The upper levels of the soil profile show some evidence of iron and calcium leaching (being noticeably paler than lower levels in the profile). The humus content of the soil profile is higher than for the soils of Coastal Dune Scrub Complex. Annual rainfall is 800–1100 mm per annum. The elevation ranges from 10–250 m with the class occurring up to 5 km inland.

The dominant tree is Coast Banksia *Banksia integrifolia* with Bangalay *Eucalyptus botryoides* becoming more conspicuous further east in the study area. The understorey comprises a tall shrub layer of Coast Tea-tree *Leptospermum laevigatum* of varying density. Where Coast Tea-tree does not predominate several shrub species frequently occur. These include Coast Beard-heath *Leucopogon parviflorus*, Sea Box *Alyxia buxifolia*, Large-leaf Bush-pea *Pultenaea daphnoides* and Tree Broom-heath *Monotoca elliptica*. Coast Sword-sedge *Lepidosperma gladiatum* may be a prominent feature of the ground layer of this class. Scrambling life forms are common with Bower Spinach *Tetragonia implexicoma*, Climbing Lignum *Muehlenbeckia adpressa* and Seaberry Saltbush *Rhagodia candolleana* being the most prominent.

Examples: Corringle Slips south of Orbost, the camping area on the Thurra River east of Point Hicks.

Ecological Vegetation Class 3. Coastal Grassy Forest
Synonym: Part of Coastal Sclerophyll Forest (Forbes *et al.* 1981)
Area: 90 ha

This class grows on the most inland aeolian dunes in the west of the study area where rainfall is less than 900 mm and is very restricted in the study area. The upper part of the profile is moderately high in humus content and low in iron and calcium which has been leached to lower levels. This class grows on tertiary dunes within 2 km of the coast. The elevation is from 5–15 m above sea level. This class is at its eastern limit in Victoria. Further east in the study area where rainfall exceeds 1000 mm it is replaced by Banksia Woodland on the same geology.

Coastal Grassy Forest is a woodland or open forest in structure. The dominant tree is Coast Manna Gum *Eucalyptus pryoriana*; Saw Banksia *Banksia serrata*, Coast Banksia *Banksia integrifolia*, Black Wattle *Acacia mearnsii* and Cherry Ballart *Exocarpos cupressiformis* are less common canopy or sub-canopy species. The groundlayer is rich in herbs and grasses, and orchids (especially greenhoods *Pterostylis* spp.) and Helmet Orchids *Corybas* spp. which arte a feature of this class. The prominent grasses are Common Tussock Grass *Poa labillardieri* and Blady Grass *Imperata cylindrica*, and the fireweeds *Senecio* spp. are the most obvious herbs.

Examples: Lake Bunga Foreshore Reserve between the Lakes Entrance golf course and Lake Bunga, a small occurrence at the end of Lake Tyers House Road and the area surrounding the car parks immediately to the north of Sailors Grave on East Cape at Cape Conran. These are the only sites known in the study area.

Ecological Vegetation Class 4. Coastal Vine-rich Forest
Synonym: Part of Coastal Sclerophyll Forest (Forbes *et al.* 1981)
Area: 122 ha

Coastal Vine-rich Forest is an example of an ecological vegetation class at the end of its biogeographic range in Victoria, being more common and better developed in southern coastal New South Wales. This class develops either on sandy aeolian or colluvial soils and is restricted in Victoria to the study area. The colluvial soils develop at the foot of slopes (often in shallow coastal gullies) which spill out onto coastal inlets or on aeolian sands on the seaward side of coastal hills which have a damp southern aspect. Soils maintain their high moisture levels throughout the year either because of the vegetation's aspect or its proximity to gullies and their attendant water tables. Rainfall is in the range of 900–1000 mm. This vegetation class grows from sea level to 40 m elevation.

The overstorey is most commonly dominated by Bangalay *Eucalyptus botryoides* with Rough-barked Apple *Angophora floribunda* whilst Red Bloodwood *Eucalyptus gummifera* may be more prevalent east of Wingan Inlet. The understorey has a scattered tall shrub layer of Black Wattle *Acacia mearnsii* and Blue Olive berry *Elaeocarpus reticulatus*. These understorey shrubs are festooned with a diverse array of rainforest lianes such as Forest Clematis *Clematis glycinoides*, Mountain Clematis *C. aristata*, Jungle Grape *Cissus hypoglauca*, Wombat Berry *Eustrephus latifolius* and Bearded Tylophora *Tylophora barbata*. The liane diversity may approach that of Warm Temperate Rainforest. The groundlayer is dominated by Bracken *Pteridium esculentum*, tussock grasses and a wide array of herbs. This vegetation is very species rich and may have in excess of 100 species in a 30 × 30 m area.

In coastal New South Wales this class ultimately develops into littoral rainforest in the absence of fire. In Victoria the ingress of what are often low intensity ground fires prevents this plant community from developing into littoral rainforest.

Examples: The northern shores of Lake Barracouta, areas adjacent and just north of Howe Flat, Peach Tree Camp on Peach Tree Creek Tamboon Inlet and the gully to the east of the Point Hicks Road crossing of the Thurra River mouth, several gullies in around the Mallacoota township and the slope of the eastern shore near the mouth of Wingan Inlet where there is a fire protected south facing slope.

Ecological Vegetation Class 5. Coastal Sand Heathland
Synonym: Coastal Heathland (Forbes *et al.* 1981, LCC 1991)
Area: 681 ha

The Coastal Sand Heathlands are restricted to the upper third of Quaternary aeolian dunes slopes or their ridges generally within 500 m of the sea. They are relatively uncommon in Victoria. The soils are well drained siliceous sands low in organic material. The elevation is from 10–20 m.

Coastal Sand Heathland is dominated by a diverse shrub layer with such species as Common Heath *Epacris impressa*, Silver Banksia *Banksia marginata*, Wedding Bush *Ricinocarpos pinifolius*, Common Aotus *Aotus ericoides*, Sword Bossiaea *Bossiaea ensata* and Blue Dampiera *Dampiera stricta* being the most common. This class has a substantial representation of sedges, lilies and grasses. The sedges which are typical are Zig-zag Bog-sedge *Schoenus brevifolius*, Sandhill Sword-sedge *Lepidosperma concavum* and Slender Twine-rush *Leptocarpus tenax*. The lilies Spiny-headed Mat Lily *Lomandra longifolia* and Milkmaids *Burchardia umbellata* are often encountered whilst Kangaroo Grass *Themeda triandra* occurs sporadically in this class.

Examples: West Cape Road, Cape Conran

Ecological Vegetation Class 6. Sand Heathland
Synonym: Not previously mapped *Leptospermum myrsinoides* Heathland (Forbes *et al.* 1981), Sand Heathland (LCC 1991)
Area: 44 ha

Sand Heathland grows at only one locality in the study area on a broad slope with leached siliceous sands derived from Tertiary outwash alluviums about 40 km from the coast. The rainfall is about 800 mm per annum and the elevation is 120 m. This is in contrast to the bulk of its range where it is near coastal vegetation growing on Quaternary aeolian sands.

The ecological vegetation class is an open low woodland of Shining Peppermint *Eucalyptus willisii*, with an understorey dominated by Austral Bracken *Pteridium esculentum* and Heath Tea-tree *Leptospermum myrsinoides*. The low shrubby ground layer of Common Aotus *Aotus ericoides*, Silver Banksia *Banksia marginata* and Prickly Broom-heath *Monotoca scoparia* occupies the gaps between the Bracken.

Examples: Quire Track just east of its crossing of Boggy Creek. Outside of the study area good examples occur nearby at Old Mill Road just west of its crossing with Boggy Creek several kilometres south of Quire Track or on the Loch Sport-Golden Beach Road.

Ecological Vegetation Class 7. Clay Heathland
Synonym: Coastal Heathland (Forbes *et al.* 1981)
Area: 1781 ha

There are clearly two entities within this ecological vegetation class. The first, 'Seacliff Clay Heathland', is restricted to the windswept salt spray drenched cliff tops of the far eastern coast of the study area. This sub-coastal entity is restricted in the study area to within 500 m of the coast between Sandpatch Point and Mallacoota. The soils vary from shallow sand veneers over heavy sandy clays to pure sandy clays. The source geologies for this community are Tertiary gravelly clays on a low coastal peneplain overlying Ordovician marine sediments. The soils are frequently water-logged as a result of the underlying geology although they may dry out significantly over summer. Annual rainfall is in the order of 900–1000 mm. This vegetation class grows at an elevation of about 20 m above sea level but may be as high as 40 m in New South Wales.

This vegetation is, at a small scale, one of the richest heathland communities on Earth (Parsons & Cameron 1974) and is well represented farther north along the south coast of New South Wales in the Nadgee Nature Reserve. It is dominated by the shrubs Scrub Sheoke *Allocasuarina paludosa*, Heath Milkwort *Comesperma ericinum*, Hops Goodenia *Goodenia ovata*, Tangled Guinea-flower *Hibbertia empetrifolia*, Slender Platysace *Platysace heterophylla*, Shrubby Platysace *P. lanceolata* and Prickly Tea-tree *Leptospermum continentale*. Beneath these shrubs a rich suite of grasses, sedges and lilies grow. The grasses most often encountered include Peaty Rice-grass *Tetrarrhena turfosa*, Kangaroo Grass *Themeda triandra*, Velvet Wallaby Grass *Danthonia pilosa*, Bordered Panic *Entolasia marginata*, Veined Spear-grass *Stipa rudis* and Fibrous Spear-grass *Stipa semibarbata*. Common sedges indicative of impeded drainage include Stiff Rapier-sedge *Lepidosperma neesii*, Zig-zag Bog-sedge *Schoenus brevifolius*, Slender Bog-sedge *S. tenuissimus*, Sheath Sedge *Cyathochaeta diandra* and Spreading Rope-rush *Empodisma minus*. Common lilies such as Milkmaids *Burchardia umbellata* and Blue Squill *Chamaescilla corymbosa* are also present.

Examples: the coastal cliff tops between Sandpatch Point and Mallacoota within 500 m of the coast.

The second entity, 'Lowland Clay Heathland' is widespread geographically, but uncommon within the study area. Characteristically it occurs on sites with impeded drainage derived from Tertiary outwash alluviums. The soil profile is usually a duplex with the upper horizon having a pale bone colour, being a silty or clayey sand which overlies mottled yellow sandy clays. The soils have a water impeding layer which often leads to the soil profile being sodden during winter and spring. Topographically this community occupies broad slopes or ridges with gently gradients or occasionally shallow basins. The rainfall ranges from 800–100 mm per annum.

Like the first entity described in this ecological vegetation class, this vegetation can be very species rich. Swamp Stringy Bark *Eucalyptus conspicua* is usually present as a sparse low woodland overstorey although this species also occurs in Wet Heathland. Yertchuk *E. consideniana* may be present on the more elevated margins of these heaths. The understorey is variably shrubby. Tall shrubs include Bushy Hakea *Hakea* sp. (*H. sericea sens lat.*), Scrub Sheoke *Allocasuarina paludosa*, Crimson Bottlebrush *Callistemon citrinus*, Silver Banksia *Banksia marginata*, Burgan *Kunzea ericoides* and Prickly Tea-tree *Leptospermum continentale*. Small shrubs which are common include Common Heath *Epacris impressa*, Swamp Heath *Epacris paludosa* and Tangled Guinea Flower *Hibbertia empetrifolia*. The ground layer is dense and diverse with a variety of life forms commonly represented. These include the sedges Thatch saw-sedge *Gahnia radula* and commonly Rapier-sedge *Lepidosperma filiforme*. Unlike Wet Heathland the common grass-tree of these heathlands is the Small Grass-tree *Xanthorrhoea minor*. The orchid flora can also be diverse with species such as Twisted Sun-orchid *Thelymitra flexuosa*, Salmon Sun-orchid *T. rubra*, Wax-lip Orchid *Glossodia major*, Small Wax-lip Orchid *G. minor*, Parsons Bands *Eriochilus cucullatus* and Large Tongue-orchid *Cryptostylis subulata* commonly represented in these heathlands. The seasonally wet nature of these sites is exemplified by the abundance of the diminutive Screw Fern *Lindsaea linearis* as part of the ground layer in this plant community.

Examples: Jones Creek Flora Reserve, Moresford Track north of Orbost, the Bruthen-Buchan Road at Kanni Creek near the Kanni Creek Racecourse and south of the Buchan–Nowa Nowa Road intersection of the Bruthen–Buchan Road.

Ecological Vegetation Class 8. Wet Heathland
Synonym: Coastal Heathland (Forbes *et al.* 1981); Lowland Heathland (Bramwells *et al.* in prep)
Area: 9 514 ha

The swales between the coastal dunes and the margins of many small creeks are the favoured sites for this ecological vegetation class. Wet Heathland is a common community within 50 km of the coast in the study area. Drainage is poor, with the water table at or near the surface for most of the year. The soils often have a peaty surface layer overlying leached siliceous sands. Annual rainfall is around 900 mm.

Along the coast Wet Heathland occupies the niche between Coast Sand Heathland and the Riparian Scrub of drainage lines whereas further inland this vegetation class occupies the zone between Banksia Woodland and the adjacent Riparian Scrub. The community has a lower species diversity than Coastal Sand Heathland and is dominated by the trunkless Spear Grass-tree *Xanthorrhoea resinosa* giving rise to the vernacular 'Grass tree plain'. Several shrub species which include Scented Paperbark *Melaleuca squarrosa*, Scrub Sheoke *Allocasuarina paludosa*, Prickly Tea-tree *Leptospermum continentale* and Blunt-leaf Heath *Epacris obtusifolia* are usually present. The sedge Spreading Rope-rush *Empodisma minus* is a feature of this class.

Examples: common throughout the lowland country within 40 km of the coast; easily viewed sites include the Wingan River on the Princes Highway, along the Point Hicks-Cann River Road and many other areas in East Gippsland.

Ecological Vegetation Class 9. Coastal Saltmarsh
Synonym: Saltmarsh (Forbes *et al.* 1981)
Area: 904 ha

Coastal Saltmarsh is restricted within the study area. It grows on the sheltered saline flats of coastal estuaries where its very specific niche requirements of twice daily inundation with saline water can be fulfilled. Rainfall is generally less than 1000 mm per annum. As this community is tide affected the elevation ranges from 0.25 m below sea level to 0.75 m above sea level.

Coastal Saltmarsh comprise several zones. The lowest and most frequently inundated zones adjacent to the lake or inlet are dominated by Beaded Glasswort *Sarcocornia quinqueflora* and Streaked Arrow-grass *Triglochin striata*. The next most landward zone is taller herbs represented by Austral Sea-blite *Suaeda australis*, Beaded Glasswort, Creeping Monkey Flower *Mimulus repens*, Rounded Noon-flower *Disphyma crassifolium* and Creeping Brookweed *Samolus repens*. The most landward zone is dominated by Sea Rush *Juncus kraussi*, with Common Reed *Phragmites australis* occasionally present where freshwater infiltration occurs from surrounding land forms.

Examples: Lake Corringle south-east of Orbost, Frenchs Narrows west of Marlo and the lake shores of Sydenam, Tamboon and Mallacoota Inlets near their seaward entrances.

Ecological Vegetation Class 10. Estuarine Wetland
Synonym: Not previously recognised therefore not mapped (Frood, in prep.)
Area: 795 ha

This class occurs throughout the study area between the lower saline reaches and the upstream freshwater zones of coastal embayments. Here the inundating waters are usually salty, sometimes brackish and occasionally fresh over the period of a year depending upon river flooding regimes. The class is restricted in the study area to a short length of narrow lake shores where the correct salinity and inundation regimes exist. Estuarine Wetland is therefore restricted within the study area. Inundation may last for many months whilst the coastal inlet is blocked before flooding breaks the coastal barrier. Once the barrier is breached inundation occurs twice daily as a result of exposure to tides. The community grows on anaerobic peat rich muds. Rainfall is generally between 800–1000 mm per annum. Elevation is 0–0.75 m above sea level.

Estuarine Wetland is dominated by graminoids such as Sea Rush *Juncus kraussii* and Sea Club-sedge *Bolboschoenus caldwellii*, with the herbs Sea Celery *Apium prostratum*, Fat Hen **Chenopodium album* and Glaucous Goosefoot *C. glaucum* common in the gaps between the sedges. The common Reed *Phragmites australis*, Australian Gypsywort *Lycopus australis* and Swamp Paperbark *Melaleuca ericifolia* occur at the landward edge of this plant community.

Examples: the vicinity of Burnt Bridge on Toorloo Arm Lake Tyers, Lake Wat Wat west of Marlo, the upper reaches of Tamboon Inlet north of Peach Tree Creek, and the upper reaches of Wingan Inlet.

Ecological Vegetation Class 11. Coastal Lagoon Wetland
Synonym: Not previously recognised therefore not mapped (Frood, in prep.)
Area: 718 ha

Coastal Lagoon Wetland occupies the margins of coastal freshwater lagoons that have formed behind the coastal dune barrier and the adjacent hills. This geomorphological feature is uncommon and small in extent within the study area so that the class is likewise uncommon. Soils are humus rich sands and silts which remain inundated for most of the year, occasionally becoming exposed over summer. Rainfall is between 900–1000 mm with the elevation being at or around sea level.

This class has several zones dependant upon water depth and persistence of inundation. Within the lagoon itself where exposure is rare, the dominant species are Soft Twig-rush *Baumea rubiginosa* and Water Ribbons *Triglochin procera*. On the more frequently exposed lagoon margin the species diversity increases and may include such species as Jointed Twig-rush *Baumea articulata*, Leafy Twig-rush *Cladium procerum*, Running Marsh-flower *Villarsia reniformis*, Swamp Club-sedge *Isolepis inundata*, and Common Reed *Phragmites australis*. On the lagoon margin the vegetation begins to merge into Riparian Scrub Complex as indicated by the presence of Swamp Paperbark *Melaleuca ericifolia*, Scented Paperbark *M. squarrosa*, Tall Saw-sedge *Gahnia clarkei* and Forest Bindweed *Calystegia marginata*. Scrambling Coral-fern *Gleichenia microphylla* often scrambles through this scrub.

Examples: Lake Barracoota, Lake Wau Wauka east of Mallacoota and the lagoons south of the Marlo Aerodrome, as well as the swamps of the lower Snowy River and Brodribb River flats for example south of Lake Curlip.

Ecological Vegetation Class 12. Wet Swale Herbland
Synonym: Not previously recognised therefore not mapped (Frood, in prep.)
Area: 789 ha

Wet Swale Herbland occupies the swale which has formed between the coastal dune barrier and the hinterland hills which extends from Lake Tyers in the west to the beginning of Corringle Creek in the east. This particular class is not known to occur outside the study area (Frood pers comm.). The landform is an old coastal lagoon that has been infilled as organic deposits from wetlands accumulated over the millennia (McCrae and Williams 1981). The soils are therefore predominantly deep peats with aeolian sand lenses occurring on the southern margin of the marsh where dune blowouts have ingressed in the past. Inundation can be complete and may last for many months, however most of the marsh dries out over late summer. Rainfall is around 760 mm per annum and the elevation is 0-0.5 m above sea level.

The vegetation varies according to elevation and therefore the frequency of inundation as well as the substrate. On more elevated peat soils the dominant species are the endangered Slender Mud-grass *Pseudoraphis paradoxa*, Mat Grass *Hemarthria uncinata*, Soft Twig-sedge *Baumea rubiginosa* and a thick carpet of herbs dominated by Shining Pennywort *Hydrocotyl sibthorpioides*, Water Woodruff *Asperula subsimplex*, and the small sedge Floating Club-sedge *Isolepus fluitans*. On elevated aeolian sand lenses Slender Mud-grass *P. paradoxa* is dominant along with the introduced herbs Hairy Hawkbit **Leontodon taraxicoides*, Couch **Cynodon dactylon* and the native herbs Shining Pennywort *H. sibthorpioides* and Centella *Centella cordifolia*. Floating Club-sedge *I. fluitans* may also be common. More frequently inundated lower elevation sites within the marsh are dominated by Tall Spike-sedge *Eleocharis sphacelata* and Slender Mud-grass *P. paradoxa*.

Examples: Ewings Marsh.

Ecological Vegetation Class 13. Brackish Sedgeland
Synonym: Not previously recognised therefore not mapped (Frood, in prep.)
Area: 195 ha

The habitat of this vegetation class is restricted to Howe Flat, which is between Lake Barracoota to the east (freshwater) and Lake Mallacoota to the west (saline). The flat is a mosaic of aeolian and sand lenses and lacustrine-derived peats that are subject to intermittent and variable levels of inundation from the overflow of Lake Barracoota and the backup of Lake Mallacoota. Rainfall is 900–1000 mm per annum and the elevation is between 0 and 2 m ASL.

Structurally, the most dominant species are moisture-dependent sedges: Bare Twig-sedge *Baumea juncea*, Coarse Twine-rush *Leptocarpus brownii*, Common Bog-sedge *Schoenus apogon* and Shiny Bog-sedge *S. nitens*. Moisture-dependent grasses and herbs are well represented, but tend not to be dominant at a species level. They include Common Blown Grass *Agrostis avenacea*, Centella *Centella cordifolia*, Heath Wallaby-grass *Danthonia semiannularis*, Heath Bent-grass *Deyeuxia densa*, Tiny Sundew *Drosera pygmaea*, Creeping Raspwort *Gonocarpus micranthus*, Mat Grass *Hemarthria uncinata*, Angled Lobelia *Lobelia alata* and Swamp Selaginella *Selaginella uliginosa*. There are scattered copses of the tall shrub Bracelet Paperbark *Melaleuca armillaris* along with other salt-tolerant species such as Bare Twig-sedge *Baumea juncea*, Knobby Club-sedge *Isolepus nodosa*, Sea Rush *Juncus kraussii*, Creeping Brookweed *Samolus repens*, Shining Bog-sedge *Schoenus nitens*, Beaded Glasswort *Sarcocornia quinqueflora* and Shiny Swamp-mat *Selliera radicans*, which together attest to the brackish nature of the habitat of this ecological vegetation class.

Example: Howe Flat.

COASTAL PLAINS VEGETATION

The coastal plains of East Gippsland are a low relief landform consisting of plains and low hills (20-100 m) between Lakes Entrance and the New South Wales border.

Precipitation varies from 760 mm in the west to 1100 mm in the east. Winds are frequently gale force during autumn, winter and spring. The wind has profound impacts upon the composition and structure of vegetation within 500 m of the coast. The geology is mostly Tertiary outwash alluviums with small areas of low hills of Ordovician marine sediments and Devonian granitoids. Quaternary aeolian sand sheets may extend as a thin veneer over the Tertiary sediments many kilometres inland. A thin band of Tertiary Limestone outcrops around the coastal streams and lakes between Lakes Entrance and Orbost.

Ecological Vegetation Class 14. Banksia Woodland
Synonym: Banksia Woodland (Forbes *et al.* 1981)
Area: 36 980 ha

Two floristic entities of Banksia Woodland are provisionally recognised in the study area. The first grows on the oldest Quaternary aeolian dunes in the study area where rainfall exceeds 900 mm. Below the 800 mm isohyet it also grows on the sandiest lenses of Tertiary outwash alluvium away from the coast in the west of the study area. Soils are invariably sandy loams which have been leached of iron and calcium in the upper horizons which are free draining. Humic pans may develop at one to several metres below the soil surface on old dunes (as can be seen on many of the road cuttings on the Marlo Cape Conran Road). The elevation is in the order of 5–160 m. The community is generally an open woodland at maturity.

The overstorey is usually dominated by Saw Banksia *Banksia serrata* with one of several eucalypts sporadically present; Bangalay *Eucalyptus botryoides*, Yertchuk *E. consideniana*, Nadgee Stringybark *E.* sp. aff. *globoidea*, Silvertop Ash *E. sieberi* or Red Bloodwood *E. gummifera*. The understorey is usually shrub rich although on frequently burnt sites Austral Bracken *Pteridium esculentum* may predominate. Common shrubs include Wedding Bush *Ricinocarpos pinifolius*, Common Heath *Epacris impressa*, Broom Spurge *Amperea xiphoclada*, Sunshine Wattle *Acacia terminalis*, Sweet Wattle *A. suaveolens*, Handsome Flat-pea *Platylobium formosum*, Common Aotus *Aotus ericoides* and Common Correa *Correa reflexa*. The ground-layer is dominated by Sand-hill Sword-sedge *Lepidosperma concavum* (which appears to replace the Coast Sword-sedge *L. gladiatum* of Coast Banksia Woodland). Oat Spear-grass *Anisopogon avenaceus* may be common with Swamp Selaginella *Selaginella uliginosa* a feature of damp spots in this vegetation.

Examples: Cape Conran Road between Frenchs Narrows and Cape Conran

The second floristic entity grows on Tertiary sands which occur east of the Yeerung River on the coastal plains generally south of the Princes Highway. It characteristically occurs near creeks between Wet Heathland (down slope) and the surrounding Lowland Forest (up slope) and is visually very distinctive. It is relatively widespread in the study area. Soils are coarse sands derived from Tertiary outwash alluviums. They are very well drained, leached of iron and are very low in organic matter in marked contrast to the adjacent plant communities. Wet Heathland has poorly drained peaty sands or silts whilst the adjacent Lowland Forest has a variety of loams richer in clays and iron than the soils of the Banksia Woodland. The vegetation's structure ranges from open scrub to open woodland. Rainfall is between 900–1100 mm per annum. The elevation range is 40–220 m.

The dominant overstorey species is Saw Banksia *Banksia serrata* with Yertchuk *Eucalyptus consideniana* generally present. The understorey characteristically has a tall shrub layer of Paperbark Teatree *Leptospermum trinervium* and a dense medium shrub layer of *Acacia terminalis* and other wattles, Handsome Flat-pea *Platylobium formosum* and Wedding Bush *Ricinocarpos pinifolius*. The groundlayer has such common shrubs as Common Heath *Epacris impressa* and Common Correa *Correa reflexa*. One of the prominent species that grows in Banksia Woodland on Tertiary sands which distinguishes it from those which grow on Quaternary sands is Thick Twist-rush *Caustis pentandra*, which is often present. Other species which are distinctive include Silvertop Ash *Eucalyptus sieberi*, Prickly Geebung *Persoonia juniperina*, Bundled Guinea-flower *Hibbertia prostrata*, Dagger Wattle *A. oxycedrus* and *Lycopodium deuterodensum*. Species generally absent from this floristic entity that are present in the other which grows on Quaternary sands are Bangalay *Eucalyptus botryoides* and Oat Spear-grass *Anisopogon avenaceus*.

Examples: In the vicinity of Jones Creek Track and its intersection with Bens Track, around the junction of the Drummer Road and Horseshoe trail (both north of the Princes Highway) and many locations along the Point Hicks Road to the south of the Princes Highway.

Ecological Vegetation Class 15. Limestone Box Forest
Synonym: Part of Coastal Sclerophyll Forest (Forbes *et al.* 1981)
Area: 4 658 ha

The Tertiary limestones that outcrop around the coastal streams, gullies and lakes from Metung to Orbost are the locations for this very distinctive forested vegetation class, which is the only known example of this vegetation in the state. Because such outcrops are only exposed along the lower slopes of gullies west of the Snowy River mouth, this class is restricted in the study area. The soils are generally well developed terra rossas. The rainfall is about 760 mm per annum and the elevation is 1–30 m.

This tall open forest is dominated by Coast Grey Box *Eucalyptus bosistoana*, Blue Box *E. bauerana* and Red Ironbark *E. tricarpa*. The understorey generally has a tall shrub-layer of Hazel Pomaderris *Pomaderris aspera*, *Hakea eriantha* the vulnerable tree Limestone Blue Wattle *Acacia caerulescens*, Snowy Daisy-bush *Olearia lirata*, Bootlace Bush *Pimelea axiflora*, Cherry Ballart *Exocarpos cuppressiformis* and Sweet Pittosporum *Pittosporum undulatum*. The ground-layer is generally grass and herb rich on sheltered aspects but may be almost completely bare on drier aspects. Herbs which are common in this vegetation class include Hairy Sheep's Burr *Acaena agnipila*, Bidgee-widgee *A. novae-zelandiae*, Forest Buttercup *Ranunculus plebius*, Slender Mint *Mentha diemenica*, Shade Plantain, *Plantago debilis*, Forest Nightshade *Solanum prinophyllum*, Fireweed Groundsel *Senecio linearifolius*, Dwarf Skull-cap *Scutellaria humilis* and Slender Dock *Rumex brownii*. The Variable Sword-sedge *Lepidosperma laterale* and the grasses Common Tussock Grass *Poa labillardieri* and Common Wheat-grass *Elymus scabrus* are also common and widespread in this vegetation class. The abundance of herbs and grasses indicates this class occupies moderate to high site quality localities. This is consistent with its distribution on limestone derived soils with a moderately low rainfall regime. This class often grows adjacent to the Warm Temperate Rainforests of nearby gully systems or sometimes abuts the rare, Limestone Pomaderris Shrubland community (not mapped) of Lake shores in the Lake Tyers area.

Examples: Trident Arm and Burnt Bridge in Lake Tyers State Park and Partellis Crossing Hartland River north of the Princes Highway between Nowa Nowa and Orbost.

Ecological Vegetation Class 16. Lowland Forest
Synonym: Lowland Sclerophyll Forest (Forbes *et al.* 1981)
Area: 245 131 ha

The lowland plains and coastal hills are the province of Lowland Forest although it does sometimes extend up onto the dissected hinterland. The geology is predominantly Tertiary. This is a variable lithology that ranges from conglomerate and coarse sands (river catchment deposits) to clays (levee deposits ephemeral wetlands or flood plains) and produces a wide range of soils from free draining infertile sands over clays to more fertile deeper gradational clays. This ecological vegetation class also grows on a wide range of Devonian granitic geology (ademellites and granites which produce free draining sandy loams) and Ordovician marine sediments which produce sandy clay loams. Rainfall is 760–1200 mm per annum. The elevation ranges from 10–500 m although the bulk of the Lowland Forest distribution is below 250 m elevation.

The overstorey is dominated by a great diversity of eucalypts with differing environmental affinities. Probably the most widespread species is Silvertop Ash *Eucalyptus sieberi* which occurs on the heavier clay soils and sub-soils and prospers where logging disturbance has occurred. Other species on heavier soils in the lower rainfall zones are Red Ironbark *E. tricarpa* (also on granitic geology), and Mountain Grey Gum *Eucalyptus cypellocarpa*. Gippsland Peppermint *E. croajingolensis* grows in higher rainfall areas on heavy soils, as does Bloodwood *E. gummifera* further east where rainfall exceeds 900 mm. Trees that are dominant in Lowland Forest on sandier sites include Nadgee Stringybark *E.* sp. aff. *globoidea*, White Stringybark *E. globoidea*, Yertchuk *E. consideniana* and Rough-barked Apple *Angophora floribunda*. These sandier sites often have an understorey of Saw Banksia *Banksia serrata*.

The understorey is usually dense with a medium and low shrub layer well represented. Shrubs which are common in Lowland Forest are Holly Lomatia *Lomatia ilicifolia*, Blue Dampiera *Dampiera stricta*, Shrubby Platysace *Platysace lanceolata*, Broom Spurge *Amperea xiphoclada*, Hairy Pink-bells *Tetratheca pilosa*, Hairpin Banksia *Banksia spinulosa*, Silver Banksia *B. marginata*, Bushy Hakea *Hakea* sp. (*Hakea sericea s. l.*), Sallow Wattle *Acacia longifolia*, Sunshine Wattle *A. terminalis*, and Myrtle Wattle *A. myrtifolia*. Sedges and lilies are common life forms on heavier clay soils where Thatch Saw-sedge *Gahnia radula*, Red-fruit Saw-sedge *Gahnia sieberiana*, Curly-wig *Caustis flexuosa*, Spiny-headed Mat-lily *Lomandra longifolia*, Wattle Mat-lily *L. filiformis*, Small Grass-tree *Xanthorrhoea minor* and the irid Leafy Purple-flag *Patersonia glabrata* often present. Ferns are low in diversity, however Austral Bracken *Pteridium esculentum* may be dominant on sandy soils and where fire frequency is high. The diversity and abundance of grasses is low, except where recent disturbance has occurred. Such sites may have a high cover of Forest Wire-grass *Tetrarrhena juncea*.

Herbs are low in diversity but are sometimes common. Such species include Hairy Fan-flower *Scaevola ramosissima*, Stinking Pennywort *Hydrocotyle laxiflora*, Common Lagenifera *Lagenifera stipitata* and Ivy-leaved Violet *Viola hederacea*. Vines are generally absent.

Examples: This class occurs extensively along the Princes Highway between Lakes Entrance and the New South Wales border.

Ecological Vegetation Class 17. Riparian Scrub Complex
Synonym: Not previously recognised therefore not mapped (LCC 1991).
Area: 17 664 ha

There are two ecological vegetation classes mapped as one in this complex. The first of these are the Riparian Scrubs that occur along gullies and creeks on the lowland plains and low hills where the streams are small, semi-permanent or permanently flowing and the gradient is gentle. This community is ubiquitous at low elevations east of Orbost where the surrounding topography offers no protection from fire. Soils are generally silty or sandy, low in clay content, variable in organic content (but often high) and eutrophic in fertility. The class structure is generally an impenetrable thicket of shrubs and ferns with a eucalypt overstorey being rare.

The dominant shrubs are Scented Paperbark *Melaleuca squarrosa*, Woolly Tea-tree *Leptospermum lanigerum* or Smooth Tea-tree *L. glabrescens*. In more saline margins of this environment the class may be dominated by Swamp Paperbark *M. ericifolia*. Beneath the dense shrub canopy Scrambling Coral Fern *Gleichenia microphylla* grows rampantly with Tall Saw-sedge *Gahnia clarkei* occurring throughout. On the margins of such thickets, the shrub Rusty Velvet-bush *Lasiopetalum macrophyllum* is common. Because the overstorey is so dense the ground-layer only becomes diverse and evident after fire.

Examples: Newtons Creek, Princes Highway, Stony Creek crossing of Old Colquhoun Road west of Nowa Nowa, Stoney Creek crossing west of Red Knob on the Bruthen Nowa Nowa Road and the Smokey Creek crossing of the Princes Highway east of Bellbird.

The second ecological vegetation class mapped under this complex is referred to by Moorrees (1991) as Swampy Riparian Forest. This community usually occupies the swampy areas of Quaternary alluviums on flood plains which are remote from the more elevated river levees occupied by Riparian Forest. This ecological vegetation class also occurs where billabongs have gradually been infilled by silt and rotting vegetation. This class is likely to have been more extensive in the past, especially on the margins of the Riparian Scrubs of the Lower Snowy and Brodribb River plains.

Riparian Swampy Forest is dominated by Swamp Paperbark Melaleuca ericifolia, with an intermittent overstorey of Swamp Gum *Eucalyptus ovata* or Manna Gum *E. viminalis*. The understorey has a diverse array of species that include Tree Everlasting *Ozothamnus ferrugineus*, Common Reed *Phragmites australis*, Australian Gypsy Wort *Lycopus australis*, Water Pepper *Persicaria* spp. and Fishbone Ferns *Blechnum* spp.

Examples: West of the Cabbage Tree Palms Reserve picnic area and the northern end of the Lake Curlip Wildlife Reserve west of the Tabbera Road.

Ecological Vegetation Class 18. Riparian Forest
Synonym: Riparian Forest (Forbes *et al.* 1981)
Area: 12 656 ha

Undisturbed Riparian Forest is now uncommon in the study area as a result of agricultural clearance. Much of what remains is severely weed infested particularly along the watercourses. This class grows along the larger creeks and river flats where soils are usually Quaternary alluviums of various grades (sandy to silty), high in clay content but somewhat variable in organic content. The soils are generally deep and moderately well drained. Rainfall is of the order of 900–1200 mm with the elevation in the range 5–600 m.

The overstorey is usually dominated by eucalypts where fire has occurred in the past. Common species include: Gippsland Peppermint *Eucalyptus croajingolensis*, Manna Gum *E. viminalis*, River Peppermint *E. elata*, and Bangalay *E. botryoides*. The following species were once more common especially in the Cann and Genoa River Valleys but have now been largely cleared; Blue Box *E. bauerana* and Coast Grey Box *E. bosistoana*. Where fire is less frequent or severe the understorey contain several non-eucalypt species such as Kanooka *Tristaniopsis laurina*, Lilly Pilly *Acmena smithii* or Muttonwood *Rapanea howittiana*. These species may develop into rainforest patches if fire frequency is sufficiently low. Riparian Forest generally has a well developed secondary tree-layer which is indicative of high site quality. Blackwood *Acacia melanoxylon*, Black Wattle *A. mearnsii*, Silver Wattle *A. dealbata* and Burgan *Kunzea ericoides* are some of the more ubiquitous species. The tall shrub layer is also well developed with Victorian Christmas-bush *Prostanthera lasianthos*, Sweet Bursaria *Bursaria spinosa*, Hazel Pomaderris *Pomaderris aspera* and Woolly Teatree *Leptospermum lanigerum* common. The groundlayer is generally rich in herbs, grasses and ferns. The most common ferns are Fishbone Water-fern *Blechnum nudum*, Downy Ground-fern *Hypolepis glandulifera*, Rough Tree-fern *Cyathea australis* and Common Maidenhair Fern *Adiantum aethiopicum*. Common grasses include Weeping Grass *Microlaena stipoides* and Basket Grass *Oplismenus hirtella*. The most common and seriously invasive weeds of this community are White Willow **Salix alba*, Blackberry **Rubus fruticosus* spp. agg. and Kikuyu **Pennisetum clandestinum*.

Examples: Cann River Bushland Reserve, the river flats of the Brodribb, Errinundra, Combienbar and Queensborough rivers.

DISSECTED FOOTHILLS AND INTERMONTANE BASIN VEGETATION

This land unit forms the bulk of the dissected country in the study area. The elevation ranges between 100 to 1000 m. Rainfall varies considerably and is in the range of 650–1700 mm. Snowfalls are rare and do not persist for more than a couple of days at lower elevations but may persist for several weeks above 900 m. At elevations above 700 m the influence of cloud cover and fog drip significantly augments the moisture available to vegetation growing there. This results in an expansion of more mesic communities such as Damp and Wet forests out of protected gullies onto ridges and northern and western slopes above these elevations.

Geologies are predominantly Ordovician marine sediments, and a wide variety of Ordovician and Devonian granitoids. Smaller areas of Devonian geology consisting of terrestrial sediments, Snowy River Volcanics and Buchan Limestone as well as Tertiary basalts occur mostly in the west of the study area.

Ecological Vegetation Class 19. Riparian Shrubland
Synonym: Not previously recognised therefore not mapped
Area: 659 ha

The river beds of the major streams of the study area are the favoured habitat for this ecological vegetation class. The soils are generally infertile coarse sands and the environment remains in a state of periodic and severe disturbance as a result of frequent floods. Adult eucalypts only inhabit the margins of this vegetation although saplings may be transitory in the river beds.

The overstorey is dominated by a diverse array of shrubs able to withstand frequent flooding or those able to regenerate rapidly after such disturbance. Ubiquitous species include: Burgan *Kunzea ericoides*, Black Wattle *Acacia mearnsii*, White Sallow Wattle *A. floribunda*, Silver Wattle *A. dealbata*, River Bottlebrush *Callistemon sieberi*, Kanooka *Tristaniopsis laurina* and the common weed White Willow **Salix alba*. In the gaps on the bare sand a plethora of native and introduced herbs and grasses grow. Genera commonly represented are Knotweeds *Persicaria* spp., Love-grasses *Eragrostis* spp., Thorn-apple **Datura* spp. and thistles of many genera.

Examples: Snowy River at McKillops Bridge, Genoa River in the Genoa River Gorge and Cann Valley Highway at the Cann River Crossing.

Ecological Vegetation Class 20. Heathy Dry Forest
Synonym: Not previously recognised therefore not mapped (LCC 1991)
Area: 2 989 ha

This forested ecological vegetation class grows on exposed aspects and ridge-tops with free-draining soils derived from fertile Silurian or Devonian granitoids. Soils are, however, relatively infertile due to leaching, poor colluvial soil development and low organic matter levels compared with down slope sites of the same geology which support the more fertility-dependent classes such as Herb-rich Forest. Rainfall is generally less than 1000 mm per annum.

The overstorey is generally low (8–15 m) but may reach 30 m in higher rainfall areas. Characteristic species include Yertchuk *Eucalyptus consideniana*, Broad-leaved Peppermint *E. dives* and Red Stringybark *E. macrorhyncha*. The understorey is nearly always low in height with Prickly Broom-heath *Monotoca scoparia*, Daphne Heath *Brachyloma daphnoides*, Urn Heath *Melichrus urceolatus* and Peach Heath *Lissanthe strigosa* usually represented. Grasses are often present at low levels of cover with Kangaroo Grass *Themeda triandra* being one of the more consistently represented species.

Examples: Diggers Hole Track between Bald Hills and the Buchan River to the north.

Ecological Vegetation Class 21. Shrubby Dry Forest
Synonym: Not previously recognised therefore not mapped (LCC 1991)
Area: 209 982 ha

This is the most widespread of the dry forest ecological vegetation classes. Shrubby Dry Forest is generally found on ridges and western or northern slopes in high rainfall zones, but may extend onto eastern and southern aspects and gullies in the lower rainfall zones. There is a considerable variation in height of the overstorey: between 8 and 45 m (even within species). This reflects the huge differences in rainfall between the driest (<700 mm) and the wettest sites (1000 mm). However most stands in this vegetation class are less than 28 m high.

The geologies are low to moderately fertile Devonian Snowy River Volcanics and terrestrial sediments, with Silurian or Ordovician marine sediments also common. The generally low rainfall in the major site quality limitation for this vegetation. Soils are skeletal sandy clay loams that are well drained as a result of the steep landforms upon which Shrubby Dry Forests grows. Fire is a frequent and often intense plant selection factor in this class.

The most common tree species are Red Stringybark *Eucalyptus macrorhyncha*, Yertchuk *E. consideniana*, Red Box *E. polyanthemos*, Brittle Gum *E. mannifera*, Silvertop Ash *E. sieberi* and White Stringybark *E. globoidea*. The understorey lacks a secondary tree layer (a reflection of low site quality). There is a medium to low shrub layer that is characteristically low in diversity. Shining Cassinia *Cassinia longifolia*, Pale Hickory Wattle *Acacia falciformis*, Sunshine Wattle *A. terminalis*, Cluster-flower Geebung *Persoonia confertiflora*, Hop Bitter-pea *Daviesia latifolia*, Gorse Bitter-pea *D. ulicifolia* and Common Heath *Epacris impressa* are the most frequent understorey shrubs. Herbs are uncommon; the drought and fire tolerant lilies Cluster-headed Mat-lily *Lomandra longifolia* ssp *exilis* and Wattle Mat-lily *L. filiformis* are frequently present.

Examples: Yalmy Road north of Raymond Creek to the junction of Pinnak Road, the Buchan to Gelantipy Road north of the Murrindal River to W Tree Falls, along the Bonang Highway on exposed western aspects and ridges north of Goongerah to Mount Little Bill Track and along the Buldah Gap Road west of Buldah Gap.

Ecological Vegetation Class 22. Grassy Dry Forest
Synonym: Not previously recognised therefore not mapped (LCC 1991)
Area: 16 903

Grassy Dry Forests grow under low to moderate rainfall regimes (700–1000 mm). This vegetation class is usually restricted to ridges and upper slopes except on northern and western aspects or where rainfall is at the lower end of the range where it may be more extensive on all aspects. Parent geologies are quite variable but are united by the fact that the soils that develop from them are moderately fertile and usually relatively low in organic matter. For example, this vegetation class grows on Ordovician mudstones along Border Track north-east of Genoa, on Devonian feldspar ignimbrites (rhyodacites), on Balley Hooley Road east of Buchan, as well as Tara Range Track immediately to the south, and on Devonian granodiorites west of Gelantipy in the Buchan River valley along the Glenmore Road. Within the study area the limited extent of such growing conditions means that this vegetation is not common. Grassy Dry Forest usually grades into Herb-rich Forest on moister aspects and in major gullies whilst in drier areas this class grades into Heathy Dry Forest higher up slope on the same geology. The resulting soils are generally well developed, leached, moderately deep and structureless coarse and sandy or gravels overlying clay loams.

The organic content is generally low reflecting the limited colluvial development possible for soils which generally occur on ridges under low rainfall regimes. Grassy Dry Forest is generally low in stature and at times becomes an open woodland.

The dominant overstorey trees vary according to elevation and the geology particularly the granitoid plutons involved. In the Buchan River Valley the overstorey trees are Gippsland Blue Gum *Eucalyptus globulus* ssp *pseudoglobulus* (indicative of the moderately high soil fertility), But But *E. bridgesiana*, Yertchuk *E. consideniana* and Brittle Gum *E. mannifera*. In the Deddick Valley the dominant species is But But. In the Upper Snowy valley at elevations in the order of 650–800 m the dominant overstorey species is Silver Bundy *E. nortonii*, But But and Yertchuk. The understorey usually has a low diversity medium shrub-layer of Shining Cassinia *Cassinia longifolia*, Prickly Broom-heath *Monotoca scoparia* and Curved Rice-flower *Pimelea* *curviflora*. The groundlayer is dominated by drought tolerant herbs such as Variable Plantain *Plantago varia*, Stinking Pennywort *Hydrocotyl laxiflora*, Hairy Sheep's Burr *Acaena agnipila*, Slender Tick-trefoil *Desmodium varians*, Common Raspwort *Gonocarpus tetragynus*. The most frequently encountered grasses which give this class its name include Kangaroo Grass *Themeda triandra*, Weeping Grass *Microlaena stipoides*, Wallaby Grasses *Danthonia* spp. and Plume Grasses *Dichelacne* spp.

Examples: Glenmore Road between Blackfellows Creek and the Buchan River, the Deddick River Valley between Tubbut and Warm Corners.

Ecological Vegetation Class 23. Herb-rich Forest
Synonym: Not previously recognised therefore not mapped (LCC 1991)
Area: 9724

Very fertile well drained colluvial soils derived from Silurian and Devonian granodiorites, tonalites and Tertiary basalts in low to moderate rainfall zones form the hub of this vegetation's distribution within the study area. Because of the fertile soils and the grassy open understorey of this plant community it has suffered a disproportionate loss to agricultural clearing and is now rare within the study area in comparison to its original extent.

With the exception of ridge-top occurrences on the basalt derived soils, Herb-rich Forest grows on lower slopes and in gullies. This is because of the better soil development on lower slopes which is partly the result of the colluvial movement of organic matter from up slope and leaching of nutrients from the ridges which support such communities as Grassy Dry Forest and Heathy Dry Forest. Hence soils for this community are well developed and gradational, generally brown in colour, rich in humus and range in texture from friable loams to cracking clays, depending upon the source geology. Rainfall is often relatively low for the study area and is generally between 800–1000 mm.

The overstoreys of this class always have at least one of several box species which may include Yellow Box *Eucalyptus melliodora*, Apple-top Box *E. angophoroides* or Coast Grey Box *E. bosistoana*. Often a good indicator species is Gippsland Blue-gum *Eucalyptus globulus* ssp. *pseudoglobulus* with a variety of other eucalypts present but not indicative of this plant community. Understorey trees are not common but are usually represented by a wattle such as Blackwood *Acacia melanoxylon*, Lightwood *A. implexa* or Black Wattle *A. mearnsii*.

The understorey may be shrubby when recently disturbed, however the species diversity for these life forms is usually low, with one to several of the following represented; Common Cassinia *Cassinia longifolia*, Burgan *Kunzea ericoides* or Austral Indigo *Indigofera australis*. The understorey has a high cover of grasses but is more notable for its great diversity of herbs which gives rise to the name of this class. The grasses (a ubiquitous life form) may include such well known species as Common Tussock Grass *Poa labillardieri*, Soft Tussock Grass *P. morrisii*, Grey Tussock Grass *P. sieberiana*, Weeping Grass *Microlaena stipoides* and Common Wheat Grass *Elymus scabrus*.

Common herbs include Austral Bear's-ears *Cymbonotus preissianus*, Solengyne *Solengyne gunnii*, Trailing Speedwell *Veronica plebia*, Variable Plantain *Plantago varia*, Shade Plantain *P. debilis*, Yellow Rush-lily *Tricoryne elatior*, Slender Tick-treefoil *Desmodium varians*, Twining Glycine *Glycine clandestina*, Crane's-bill *Geranium homeanum* and Coarse Lagenifera *Lagenifera stipitata*. Several grass-like sedges are usually present with Short-stemmed Sedge *Carex breviculmis* and Common

Sedge *C. inversa* frequent, with Bergalia Sedge *C. longebrachiata* often encountered in damper locations The small epacrids Cranberry Heath *Astroloma humifusum* and Honeypots *Acrotriche serrulata* are usually also present.

Examples: the junction of Glenmore Road and the Murrindal Gelantipy roads, Cemetery Track 3 km north of the Princes Highway north-east of Cann River and south of Goongerah to Ironbark Creek on the Bonang Highway.

Ecological Vegetation Class 24. Foothill Box Ironbark Forest
Synonym: Box Ironbark Woodland (Forbes *et al.* 1981)
Area: 595 ha

The actual distribution and status of Foothill Box Ironbark Forest in East Gippsland has been poorly understood in the past. The floristic composition of this class was originally described by Forbes *et al.* (1981). Subsequent mapping of the community at 1:250,000 by Parkes *et al.* (1984), was not strictly on the basis of the community as described by Forbes *et al.* (1981). This has for example, resulted in the mapping of Shrubby Dry Forest with Ironbark present in it as Box Ironbark Woodland. Red Ironbark occurs sporadically over a wide area in East Gippsland occur within a number of other communities which include; Shrubby Dry Forest, Lowland Forest and Limestone Box Forest. This has lead to the perception by the wider community that the presence of Ironbark automatically denotes the presence of the ecological vegetation class Foothill Box Ironbark Forest. In this project Foothill Box Ironbark has been remapped strictly on the basis of the plant community as originally delineated by Forbes *et al.* (1981).

Dry north and west facing slopes are the favoured locality for this unusual and very restricted plant community. There are two disjunct occurrences of this vegetation class within the study area. The most restricted occurs on Tertiary limestone cliffs around Lake Tyers and Lake Bunga, whilst the more extensive (but still restricted) occurrence is around Martins Creek on Ordovician marine sediments. The Tertiary limestone type was too small to map at the scale of this study. The vegetation class structure varies from woodland to open forest.

The dominant overstorey trees are Red Box *Eucalyptus polyanthemos* and Red Ironbark *E. tricarpa*, which usually grow together. There is often a well-developed understorey tree layer with Red Wattle *Acacia silvestris* occasional, and Cherry Ballart *Exocarpos cupressiformis* scattered throughout. A tall shrub layer is usually present with Dusty Daisy-bush *Olearia phlogopappa*, Shiny Cassinia *Cassinia longifolia*, Pale Hickory Wattle *Acacia falciformis*, Large Mock-olive *Notelaea venosa* and Sticky Hop-bush *Dodonaea viscosa* the most usual. The understorey groundlayer consists of low shrubs and herbs. The characteristic shrubs are Hop Goodenia *Goodenia ovata* and Common Correa *Correa reflexa*.

The vegetation class growing around Lake Tyres and Lake Bunga has a similar structure and species complement, with interesting species substitutions. The Box is Gippsland Grey Box *Eucalyptus bosistoana*, and the wattles are Limestone Blue Wattle *Acacia caerulescens*, Lightwood *A. implexa* and Golden Wattle *A. pycnantha*. The Foothill Box Ironbark Forest growing on the limestones usually have a suite of halophytes or coastal species also present. These include Sea-box *Alyxia buxifolia* and Sea-berry Saltbush *Rhagodia candoleana*.

Examples: Scanlons Creek Track several hundred metres north of Paradise Ridge Road (southern junction), cliffs on lake shores around Lake Tyers and Lake Bunga.

Ecological Vegetation Class 25. Limestone Grassy Woodland
Synonym: Grassy Woodland (Robinson 1991)
Area: 471 ha

This class is restricted to the Devonian limestones of the Buchan and Murrindal river valleys. The structure of the vegetation varies from an open woodland to open forest. Limestone Grassy Woodland occurs on fertile terra rossa soils and has been largely cleared for agricultural development and grazing (Robinson 1990). The remaining intact vegetation is now restricted to small areas on caves reserves around Buchan and Murrindal. The largest single occurrence is at the southern end of Gillingal Station which is private land.

The dominant trees on ridges are Yellow Box *Eucalyptus melliodora* and Manna Gum *E. viminalis*. Candle Bark *E. rubida* may be co-dominant in the valleys. The understorey is characterised by a scattered tall shrub layer of low diversity with such species as Blackwood *Acacia melanoxylon*, Lightwood *A. implexa*, Limestone Blue Wattle *A. caerulescens*, Tree Violet *Hymenanthera dentata*, Sweet Bursaria *Bursaria spinosa* and Drooping Sheoke *Allocasuarina verticillata* being typical. The groundlayer is dominated by grasses with Kangaroo Grass *Themeda australis* being the most common and Red-leg grass *Bothriochloa macra*, Common Tussock Grass *Poa labillardieri*, soft Tussock Grass *P. morrisii* and Blady Grass *Imperata cylindrica* also represented. A wide variety of herbs may also be present and commonly include Cinquefoil *Geranium potentilloides*, Bidgee-widgee *Acaena novae-zelandiae*, Sheep's Burr *A. echinata*, Solenogyne *Solenogyne gunnii*, Small-leaf Bramble *Rubus parvifolius*, Kidney Weed *Dichondra repens*, Grassland Wood-sorrel *Oxalis perennans* and Maori Bedstraw *Galium propinquum*.

Examples: The Pyramids, Murrindal, and Wyatts Reserve.

Ecological Vegetation Class 26. Rainshadow Woodland
Synonym: Rainshadow Woodland (Forbes *et al.* 1981)
Area: 22 179 ha

Rainshadow Woodland is a very distinctive ecological vegetation class which is restricted to Silurian granodiorites around Campbells Knob on the Snowy River and further north on the upper Snowy and lower Deddick and Suggan Buggan rivers. The class is restricted to elevations below 650 m in the rain shadow country where rainfall is generally less than 700 mm per annum. Above this (on the same geology) Grassy Dry Forest begins to establish. Soils are coarse sandy to gravelly loams that are structureless and usually orange in colour and low in humus content.

The dominant tree is White Box *Eucalyptus albens* on all but the most exposed aspects. On the steeper drier aspects White Cypress-pine *Callitris glaucophylla* and Black Cypress-pine *Callitris endlicheri* form pure stands or occasionally mixed stands with White Box. The understorey consists of a range of shrubs which include the Peach Heath *Lissanthe strigosa*, Narrow-leaf Hop-bush *Dodonaea* ssp. *angustifolia*, Sticky Everlasting *Ozothamnus thyrsoideus* and Urn Heath *Melichrus urceolatus*. The understorey is very rich in herbs and grasses such as Small-leaf Glycine *Glycine microphylla*, Large Tick-treefoil *Desmodium brachypodum*, Centuary **Centaurium* spp., Fuzzy New Holland Daisy *Vittadinia cuneata*, Saloop Saltbush *Enardia hastata*, Nodding Saltbush *Enardia nutans*, Prickly Starwort *Stellaria pungens* and Kidney Weed *Dichondra repens*. The grasses are numerous and include Kangaroo Grass *Themeda triandra*, Common Wheat-grass *Elymus scabrus*, Barbwire Grass

Cymbopogan refractus Silky Blue-grass *Dichanthium sericeum* and Nigger-heads *Enneapogan nigricans*. The vine Small-leaved Clematis *Clematis microphylla* var *leptoneura* and the Purple Coral-pea *Hardenbergia violacea* are also common.

Examples: Along Deddick Road between Wheelers Saddle and Tubbut and Suggan Buggan Road between Ballantyne Gap and the NSW border on the Snowy River.

Ecological vegetation class 27. Rocky Outcrop Scrub
Synonym: Rocky Outcrop Open-shrubland (Forbes *et al.* 1981)
Area: 5052 ha

The northern and western slopes of mountains and valleys of the Murrindal, Snowy, Suggan Buggan, Deddick and Brodribb Rivers are the favoured localities of this unusual class. Soils are skeletal brown earths derived from a variety of geologies including Devonian Snowy River Volcanics and Ordovician marine sediments. The class is conspicuously absent from sites of granitic geology. It is however often associated with the contact metamorphic (hornfels) zone which mark the granitic pluton boundary with that of the adjacent sedimentary geology.

The overstorey is nearly always dominated by Red Wattle *Acacia silvestris*, with Rock Wax-flower *Eriostemon trachyphyllus* being either subordinate, codominant or dominant depending upon their age and fire history. Another variant of this community has mallee-form River Peppermint *E. elata* and Gully Gum *E. smithii* as the dominant overstorey trees. When the overstorey is dense, the understorey is sparse with only the occasional herbs such as Bedstraw *Galium migrans* and Saloop Saltbush *Enardia hastata* or the rare grass Feathery Wheat-grass *Australopyrum retrofractum* occurring in the ground layer. When the overstorey is more open the understorey has several shrubs which include Slender Tea-tree *Leptospermum brevipes*, Wallaby-bush *Beyeria lasiocarpa* Dusty Daisy-bush *Olearia phlogopappa* and Shrubby Velvet-bush *Lasiopetalum macrophyllum* often present. Where this community grows close to rivers the tall shrub layer often has Sweet Bursaria *Bursaria spinosa*, Snowy Daisy-bush *Olearia lirata* and Tall Baeckea *Baeckea virgata* represented. Frequently the seedlings of adjacent communities such as Warm Temperate Rainforest like Wonga Vine *Pandorea pandorana* and Sweet Pittosporum *Pittosporum undulatum* germinate beneath the closed canopy but rarely seem to develop although the drought tolerant White Milk-vine *Marsdenia rostrata* sometimes does.

Examples: Mt Bulla Bulla, Gorge Road South of Mt Nowa Nowa, North of Moonkan Track opposite its intersection with the Rodger River Track and many remote localities along the Snowy River Valley.

Ecological Vegetation Class 28. Rocky Outcrop Shrubland
Synonym: Rocky Outcrop Open-shrubland (Forbes *et al.* 1981)
Area: 1606 ha

The geologies upon which this class grow are variable and range from Devonian Snowy Volcanics to Ordovician hornfels and granitic intrusions. Snowy River Volcanics carry the majority of Rocky Outcrop Shrubland and the plant community's distribution is centred on the upper Snowy, Suggan Buggan and lower Deddick rivers and is usually associated with tableland escarpments and river gorges. Rocky Outcrop Shrubland on granitoids are rare in the study area, however one example does occur on the Buchan River at Mount Stewart and several others in the far east around Mount Kaye and Genoa. Soils are always shallow and usually skeletal sandy clay loams (Snowy River Volcanics) or sandy loams (granodiorites). There is a moderate level of soil organic matter, perhaps due to the infrequency of fire. Fire is probably uncommon in larger patches of this vegetation because of the discontinuous distribution of fuels and the considerable areas of bare rock and ground that characterises the open shrubland structure of Rocky Outcrop Shrubland. Rainfall is low and ranges between 700–900 mm and is usually less than 800 mm. Dry northern and western aspects are important in maintaining the dry habitat of this community. The elevation ranges from 100–1000 m.

Eucalypts may or may not be present in this ecological vegetation class. Common species include Yertchuk *Eucalyptus consideniana*, Red Stringybark *E. macrorhyncha*, and occasionally Hill Red Gum *E. blakelyi* on the upper Snowy River. Some species such as Tingaringy Gum *E. glaucescens* and some ecotypes which have mallee growth forms such as Silvertop Ash *E. sieberi* and River Peppermint *E. elata* seem especially adapted to these environments. The most notable feature of this vegetation is the diverse shrub layer. Species that are rocky outcrop specialists include Pepper Everlasting *Ozothamnus conditum*, Nunniong Everlasting *O. rogersianius*, Grey Everlasting, *O. obcordatum*, Violet Daisy-bush *Olearia iodochroa*, Twiggy Lignum *Muehlenbeckia declina*, Wedge-leaf Hop-bush *Dodonaea viscosa* ssp. *cuneata*, Sticky Boronia *Boronia anemonifolia*, Slender Tea-tree *Leptospermum brevipes*, Heath Platysace *Platysace ericoides*, Spiked Mint-bush *Prostanthera phylicifolia*, Burgan *Kunzea ericoides* Birch Pomaderris *Pomaderris betulina*, and Striped Pomaderris *P. pilifera*. Red Wattle *Acacia silvestris* may be present but is not as dominant as it is in Rocky Outcrop Scrub. Groundlayer plants are low in diversity and are generally uncommon where soils are shallow.

Where soils are better developed such as on Snowy River Volcanics, Shining Everlasting *Helichrysum viscosum* and Tall Raspwort *Gonocarpus elatus*, Long-leaf Wallaby Grass *Danthonia longifolia*, Dense Spear-grass *Stipa densiflora*, Nodding Saltbush *Enardia nutans* and Saloop Saltbush *E. hastata* may be locally common. On granodioritic outcrops such as on Mount Stewart the shrub species diversity drops considerably with Black Wattle *Acacia mearnsii* and Common Fringe Myrtle *Calytrix tetragona* the dominant shrubs whilst Nodding Blue-lily *Stypandra glauca* is also abundant. The very well drained sandy loams probably contribute to the greater diversity of seasonal geophytes on this rock type than is the case for similar environments for this vegetation class growing elsewhere on Snowy River Volcanics.

The typical floristics of this class when growing on granites in the far east of the study area are for the overstorey to be sparse with Silvertop Ash *Eucalyptus sieberi* and Mallee-form Gully Gum *E. smithii* and Blue-leaved Stringybark *E. agglomerata* present. The shrub layer is dominated by White Kunzea *Kunzea ambigua*, Rusty Pomaderris *Pomaderris lannigera*, Tangled Pseudanthus *Pseudanthus divaricatissimus* and Sticky Hop-bush *Dodonaea viscosa*. Small shrubs include Common Correa *Correa reflexa*, Myrtle Wattle *Acacia myrtifolia* and Blunt Bush-pea *Pultenaea retusa*. The groundlayer is sparse but typically has wallaby grasses *Danthonia* spp. present, Black-anther Flax-lily *Dianella revoluta* and Variable Sword-sedge *Lepidosperma laterale* also represented.

Examples: Mt Stewart, Mt Bulla Bulla, Maramingo Hill, Genoa Peak, Mt Kaye.

Ecological Vegetation Class 29. Damp Forest

Synonym: Not previously mapped. Damp Sclerophyll Forest (Forbes *et al.* 1981)
Area: 238 288 ha

Damp Forest is very widespread across the study area, favouring gullies or eastern and southern slopes in the lowlands and dissected country below 700 m. Above 700 m and in higher rainfall zones the effect of cloud cover at ground level and the subsequent fog drip permits this class to expand out of the gullies onto broad ridges and northern and western aspects. This ecological vegetation class forms an important ecotone with Warm Temperate Rainforest, helping to maintain moisture differentials that protect the latter plant community in the event of frequent or severe wildfire. The class grows on a very wide range of geologies which include Tertiary basalts and outwash alluviums, Devonian Snowy River Volcanics and terrestrial sediments and Ordovician and Silurian granitoids and marine sediments. At least one floristic community Basaltic Damp Sclerophyll Forest (Peacock *et al.* in press) has to date been recognised as restricted to one geology. The common features of the soils are that they are usually colluvial, deep and well structured with moderate to high levels of humus in the upper soil horizons. Rainfall ranges from 760–1400 mm annually. Snow falls are uncommon at lower altitudes but may be a yearly event around 1000 m although they do not usually persist for more than a couple of days. The elevation range is 2–1000 m. Damp Forest is structurally a tall open forest.

There are many eucalypts that can dominate this ecological vegetation class and their presence or absence is probably a function of rainfall, altitude and biogeography. The very common species of lower elevations in gully occurrences where rainfall is less than 1000 mm are; Mountain Grey Gum *Eucalyptus cypellocarpa*, Messmate *E. obliqua*, and Yellow Stringybark *E. muelleriana*. At moderate elevations for this class Gippsland Peppermint *E. croajingolensis* is common along with Silvertop Ash *E. sieberi* and Messmate on more exposed ridges. At higher elevations with greater rainfall Cuttail *E. fastigata* predominates along with Messmate. In the far east of the state White Ash *E. fraxinoides* is a feature of this vegetation. On more fertile geologies such as Tertiary limestones, basalts and Ordovician granodiorites Gippsland Blue Gum *E. globulus* ssp. *pseudoglobulus* is characteristic.

There may be a small tree layer of Blackwood *Acacia melanoxylon*, with Frosted Wattle *A. frigescens* often present at elevations above 900 m. On wetter sites there is usually a scattering of wiry vines such as Wait-a-while *Smilax australis* and Wombat Berry *Eustrephus latifolius* present along with a tall shrub layer of Blanket-leaf *Bedfordia arborescens*, Musk Daisy-bush *Olearia argophylla* and Hazel Pomaderris *Pomaderris aspera*. There is usually a dense groundlayer of ferns. The most common tree-fern is Rough Tree-fern *Cyathea australis* with False Bracken *Calcita dubia* and Gristle Fern *Blechnum cartilageneum* being the most abundant ground fern. Where there is an adjacent stand of Warm Temperate Rainforest elements from this ecological vegetation class may invade Damp Forest in the absence of fire. The rampant Forest Wire-grass *Tetrarrhena juncea* is diagnostic in most forms of this plant community.

Herbs may be common where bare ground occurs with the ubiquitous species including Shade Raspwort *Gonocarpus humilis* and Native Violet *Viola hederacea*. In drier forms of this vegetation the structure and species composition changes so that there are no tree-ferns. Under such conditions Austral Bracken *Pteridium esculentum* may be the only fern present and the understorey is dominated by a medium shrublayer. Shrubs in this form of the class include Narrow-leaf Wattle *Acacia mucronata*, Wedge-leaf Everlasting *Helichrysum cuneifolium*, Hop Goodenia *Goodenia ovata* and Elderberry Panax *Polyscias sambucifolia*. The dominant groundlayer species is usually Cane Holy Grass *Hierochloe rariflora* and the herb Shade Raspwort *Gonocarpus teucrioides*.

Examples: Gullies and protected slopes on the Bonang Highway north of Gooongerah south of Gap Road, Lind National Park and the slopes and low hills of the Deddick Trail between Rodger River and Moonkan Track.

A well known floristic vegetation community of this ecological vegetation class is Basaltic Damp Forest which is extremely restricted in the study area. It is known with certainty from only two small outcrops of Tertiary olivine basalt on Paradise Ridge Road north of Orbost. The community is a tall open forest with a dense shrublayer of broad-leaved shrubs and a herb rich groundlayer. This floristic community grows on basalt caps on a ridge. The soils are well structured (if somewhat skeletal), friable silty clay loams rich in organic material. These soils are very fertile. The elevation is between 440 and 460 m. The rainfall is around 1000 mm per annum.

Basaltic Damp Forest is dominated by Gippsland Blue Gum *Eucalyptus globulus* ssp. *pseudoglobulus* and Yellow Stringybark *E. muellerana*. The understorey has a tall shrub layer of Blanket-leaf *Bedfordia arborescens*, Sweet Pittosporum *Pittosporum undulatum*, Banyalla *P. bicolor* and a medium shrublayer composed of Prickly Coprosma *Coprosma quadrifida*, Fireweed Groundsel *Senecio linearifolius*, Shiny Cassinia *Cassinia longifolia* and Hop Bush *Goodenia ovata*. The groundlayer consisted of a variety of herbs and ferns. These included such species as Common Maidenhair *Adiantum aethiopicum*, Southern Tick-trefoil *Desmodium gunni*, Ivy-leaf Violet *Viola hederacea* and Forest Starwort *Stellaria flaccida*. Several rainforest lianes are prominent and include Austral Sarsparilla *Smilax australis* and Forest Clematis *Clematis glycinoides*.

Ecological Vegetation Class 30. Wet Forest
Synonym: Wet Sclerophyll Forest (Forbes *et al.* 1981)
Area: 90 288 ha

This is the tallest class in the study area and may attain heights of 80 m. Wet Forest is relatively common at mid elevations in the study area and is characterised by a tall eucalypt overstorey, a tall broad-leaved shrubby understorey and a fern rich ground layer that is usually dominated by tree-ferns. Wet Forest grows on a variety of landforms; gullies, south facing slopes, coastal ranges, escarpments, intermontane basins and plateaus where rainfall is high and cloud cover at ground level is frequent. This floristically cool temperate vegetation forms an important ecotonal buffer with Cool Temperate Rainforest, helping to maintain moisture differentials that can prevent direct incursion by fire into the adjacent rainforest. The geologies upon which Wet Forest grows are diverse and include Devonian Snowy River Volcanics, Devonian terrestrial sediments, Silurian granodiorites and Ordovician marine sediments. Soils are deep gradational clay or sandy clay loams rich in organic matter. The rainfall is high 900–2000 mm per annum with the elevational range 300–1100 m but mostly between 600–1000 m.

The dominant overstorey trees are Errinundra Shining Gum *Eucalyptus denticulata*, Cuttail *E. fastigata*, Messmate *E. obliqua*, Mountain Ash *E. regnans* and Manna Gum *E. viminalis*. There is usually an understorey of small trees such as Silver Wattle *Acacia dealbata*, Blackwood *A. melanoxylon* and Frosted Wattle *A. frigescens*. Beneath this, the tall shrublayer is dominated Austral Mulberry *Hedycarya angustifolia*, Musk Daisy-bush *Olearia argophylla*, Mountain Correa *Correa lawrenciana*, Hazel Pomaderris *Pomaderris aspera* and Blanket Leaf *Bedfordia arborescens*. Beneath these shrubs there is nearly always a dense layer of Soft Tree-ferns *Dicksonia antarctica*.

The groundlayer is dominated by ferns, with Hard Water Fern *Blechnum wattsii*, Mother Shield Fern *Polystichum proliferum*, Mother Spleenwort *Asplenium bulbiferum* and Bat's Wing Fern *Histiopteris incisa* the most usual. There may be a scattering of herbs where light can penetrate to the forest floor. Herbs which are representative are Native Violet *Viola hederacea*, Shade Nettle *Australina muelleri* and Pretty Grass-flag *Libbertia pulchella* on wetter sites near streams. The species described thus far are common in undisturbed forests. After disturbance such as fire, roading or logging a thick profusion of pioneer species clothe the groundlayer. These species grow and reproduce quickly, then die out. Such species include the shrubs Common Cassinia *Cassinia aculeata*, Victorian Christmas-bush *Prostanthera lasianthos*, the herbs Golden Everlasting *Bracteantha bracteata*, Fireweed Groundsel *Senecio linearifolius* and Shade Raspwort *Gonocarpus humilis*.

Where Cool Temperate Rainforest occurs in adjacent gullies the canopy species of this class will invade Wet Forest by germinating on the trunks of Soft Tree-ferns.

Examples: Nunnet Road on the Nunniong Plateau, Coast Range Road in the Errinundra National Park, Gap Road between the Bonang Highway and Result Creek to the east.

Ecological Vegetation Class 31. Cool Temperate Rainforest
Synonym: Cool Temperate Rainforest (Forbes *et al.* 1981)
Area: 2563 ha

Cool Temperate Rainforest grows on Devonian Snowy River Volcanics and granodiorites as well as Ordovician marine sediments and is generally restricted to deeply incised gullies and gully-heads with southern aspects. On the Errinundra Plateau one stand extends beyond the gully habitat to cover several ridges. Soils are well developed gradational clay or sandy clay loams high in humus content. Rainfall is high and is in the order of 1000–2000 mm a year. Structurally this class is a closed forest.

The most common canopy species are Southern Sassafras *Atherosperma moschatum*, Black Oliveberry *Elaeocarpus holopetalus*, whilst the subsidiary species are Gippsland Waratah *Telopea oreades* and Privet Mock-olive *Notelaea ligustrina*. The understorey shrublayer is poorly developed with Prickly Coprosma *Coprosma quadrifida* being the only commonly occurring species. The understorey is dominated by Soft Tree-fern *Dicksonia antarctica* and a dense sward of ground ferns. Common ground ferns in Cool Temperate Rainforest are Mother Spleenwort *Asplenium bulbiferum*, Mother Shield Fern *Polystichum proliferum*, and Bat's wing Fern *Histiopteris incisa*. The latter is especially common in canopy gaps. Herbs may be common in places and include Shade Nettle *Australina muelleri*, Common Nettle *Urtica incisa* whilst the lily Pretty Grass-flag *Libbertia pulchella* is frequent in well lit gaps along streams. The vine flora is low in diversity and cover. Epiphytes particularly ferns and germinating canopy species are very common on tree-ferns, whilst this vegetation class hosts the greatest diversity of bryophytes for any vegetation class in the state. Bryophyte diversity commonly exceeds forty species in a 30 m by 30 m area.

Examples: Coast Range Road Errinundra National Park, north of Gap Road running along Result Creek.

Ecological Vegetation Class 32. Warm Temperate Rainforest
Synonym: Warm Temperate Rainforest (Forbes *et al.* 1981)
Area: 6777 ha

Warm Temperate Rainforest is the most extensive of the three rainforest classes found in the study area. It grows on a wide range of geologies in fire protected niches such as gullies, south facing slopes and less commonly on seacliffs and islands. Once extensive stands which grew on lowland river flats are now rare as the result of agricultural clearing. Soils are usually colluvial, occasionally alluvial and usually well developed with high levels of organic matter. Rainfall is between 630-1200 mm per annum. Structurally this community is a closed forest.

The dominant canopy species is Lilly-pilly *Acmena smithii*, with as many as five other trees being codominant or subdominant; Sweet Pittosporum *Pittosporum undulatum*, Muttonwood *Rapanea howittiana*, Yellow-wood *Acronychia oblongifolia*, Kanooka *Tristaniopsis laurina* or Eastern Leatherwood *Eucryphia moorei*. Blackwood *Acacia melanoxylon* is often an emergent above the closed canopy. This dense overstorey is festooned with up to fifteen species of lianes. Common woody liane species include Jungle Grape *Cissus hypoglauca*, Forest Clematis *Clematis glycinoides*, Milk-vine *Marsdenia rostrata*, and Jasmine Morinda *Morinda jasminoides*.

The understorey may have a low to medium shrublayer of Prickly Coprosma *Coprosma quadrifida* and Large Mock-olive *Notelaea venosa*. There are generally also sub-canopy, wiry climbing vines such as Wait-a-while *Smilax australis* and Wombat-berry *Eustrephus latifolius* present. The groundlayer is dominated by ferns which include tree-ferns such as Soft Tree-fern *Dicksonia antarctica* and Rough Tree-fern *Cyathea australis* as well as up to fourteen ground ferns. Some of the more common ground ferns are Shiny Shield-fern *Lastreopsis acuminata*, Jungle Brake *Pteris umbrosa*, Downy Ground-fern *Hypolepis glandulifera* and Mother Shield Fern *Polystichum proliferum*. Vascular epiphytes including ferns, orchids and germinating canopy species on tree-ferns may be common.

Examples: Princes Highway immediately south of Toorloo Arm and the Brodribb River at its crossing with the Princes Highway.

Ecological vegetation class 33. Cool/Warm Temperate Rainforest Overlap
Synonym: (not previously recognised or mapped)
Area: 268 ha

The primary determinants for the development of this vegetation class are elevation, rainfall and topographic protection from fire. This vegetation is restricted to deeply incised gullies and river valleys below the Errinundra Plateau the Howe Range and the Murrungowar Range. This vegetation has a restricted elevational range and has thus far only been recorded between 400-800 m.

Cool/Warm Temperate Rainforest Overlap is transitional in nature. This is reflected by the species complement which is shared between Cool Temperate and Warm Temperate Rainforest. Canopy species include Southern Sassafras *Atherosperma moschatum*, Lilly Pilly *Acmena smithii*, Leatherwood *Eucryphia moorei* (in the Howe Range), Blackwood *Acacia melanoxylon* and Frosted Wattle *Acacia frigescens*. Liane diversity is usually between that of Cool and Warm Temperate Rainforest with White Milk-vine *Marsdenia rostrata* and Mountain Clematis *Clematis aristata* frequently present. Other species which are occasionally present are Black Olive-berry *Elaeocarpus reticulatus*, Mountain Pepper *Tasmannia lanceolata* and Gippsland

Waratah *Telopea oreodes*. Fern diversity like that of the lianes is also more diverse than Cool Temperate Rainforest but less diverse than that of Warm Temperate Rainforest.

Examples: Glen Arte Road Murrungowar, Errinundra River East Branch on the Errinundra Plateau escarpment, the headwaters of the Big River, Goolengook and Little Goolengook Rivers and in the Howe Range.

Ecological Vegetation Class 34. Dry Rainforest
Synonym: Dry Rainforest (Cameron 1992, Robinson 1991)
Area: 11 ha

Although an apparent contradiction in terms, Dry Rainforest has many structural and floristic characteristics of rainforest despite growing in very dry situations. This ecological vegetation class has a closed canopy of drought tolerant rainforest trees and lianes. In Victoria this plant community is highly restricted, being confined to East Gippsland in Victoria. Dry Rainforest is more common further north in New South Wales and can therefore be considered in Victoria to be at its southern biogeographic limit in Australia. It occurs in warm rain shadow river valleys at elevations of 80–400 m (Cameron 1992). The parent geology within the study area varies from Devonian Limestones in the Murrindal River Valley to Devonian Snowy River Volcanics on the Snowy River to granitoids on the Genoa River. Soils are skeletal and well drained. Rainfall is 700–900 mm per annum. The overriding feature dictating the distribution of Dry Rainforest seems to be the nearly complete absence of fire for very long periods of time.

Dry Rainforest is unusual in that there is an almost complete absence of eucalypts. The overstorey is usually dominated by Sweet Pittosporum *Pittosporum undulatum*, with Lilly Pilly *Acmena smithii* also present at some sites. The understorey may have spiney shrubs such as Prickly Coprosma *Coprosma quadrifida* but is generally poorly developed. Ferns are notably low in cover and diversity with drought tolerant species such as Sickle Fern *Pellaea falcata* and Necklace Fern *Asplenium flabellifolium* representative. Vine diversity is high (9–12 species) with woody and wiry types most common DCE (1991). Typical vines are Wonga Vine *Pandorea pandorana* and Mountain Clematis *Clematis aristata*. The groundlayer is dominated by drought tolerant species such as *Danthonia longifolia* Long-leaved Wallaby-grass and Cockspur Flower *Plectranthus parviflorus*.

Examples: Anticline on the Murrindal River, Murrindal and at the Pyramids further south on the Murrindal River, various localities along the mid-reaches of the Snowy River between Campbells Knob and the confluence with the Buchan River and on Lonely Bay at Toorloo Arm Lake Tyers.

DISSECTED MONTANE AND MONTANE TABLELAND VEGETATION

The vegetation of these land units occurs between 900 and 1200 m. The landforms are the lower slopes of higher peaks and large (predominantly cleared) montane tablelands. Localities where these vegetation types occur include the Wulgulmerang, Gelantipy, and Monaro Tablelands and their surrounding hills. Precipitation ranges from 800–1000 mm. Snow falls every year and although heavy at times, rarely persists for longer than two months. The effect of cold air drainage from surrounding elevated landforms onto the tablelands at the lower elevations is important in maintaining a persistently cold environment especially at night. By contrast the dissected country of similar altitude to the tablelands does not support such vegetation because the pooled cold air drained from surrounding elevated areas is quickly dissipated. Isolated peaks that support this vegetation are several hundred metres higher than the plateaus whose similar vegetation is maintained by cold air drainage. Geology ranges from Ordovician marine sediments through to Devonian Snowy River Volcanics. Granitoids are not a common feature of this landscape in the study area.

Ecological Vegetation Class 35. Tableland Damp Forest
Synonym: Montane Damp Sclerophyll Forest BRO 3.1 Chesterfield *et al.* (1988)
Area: 7000 ha

Tableland Damp Forest is an extremely picturesque ecological vegetation class that has developed on the southern most extension of the Monaro Tablelands in Victoria and is not known from New South Wales (Austin pers. comm.). It occupies the niche between Wet Forest and Dry Montane Woodland which may be characterised by a temperature and moisture regime that is intermediate between these two classes. It is restricted to the Errinundra Plateau and the adjacent Cottonwood Range and is thus restricted within the study area. This class occurs at elevations between 850 to 1200 m. The topography is low in relief, the geology is marine sediments of Ordovician age and the precipitation is between 1000 and 1400 mm annually. Frosts are frequent and snowfalls are a yearly event although these do not generally persist for more than a few weeks at a time.

The overstorey is characteristically tall with Gippsland Peppermint *Eucalyptus croajingolensis* dominant with Mountain Gum *E. dalrympleana* and Errinundra Shining Gum *E. denticulata* being codominant or occasionally dominant. The understorey is very distinctive and is dominated by a tall but patchy shrub layer of broad-leaved shrubs and heaths. Species most common include; Gippsland Waratah *Telopea oreades*, Forest Geebung *Persoonia silvatica*, Errinundra Pepper *Tasmannia* sp.(Errinundra Plateau), Mountain Pepper *T. lanceolata*, Blackwood *Acacia melanoxylon*, Subalpine Beard-heath *Leucopogon maccraei* and Mountain Beard-heath *L. hookeri*. The ground layer is dominated by a diverse assemblage of herbs such as Mountain Cotula *Leptinella filicula*, Rough Laganifera *Laganifera stipitata* Ivy-leaf Violet *Viola hederaceae*, Matted Pratia *Pratia pedunculata* and Tasman Flax-lily *Dianella tasmanica* being the most conspicuous. The Mother Shield-fern *Polystichum proliferum* occurs sporadically.

Examples: From the junction of Gap Road and Gunmark Road to the intersection with Coast Range Road, west and south west of Bendoc, and the Playgrounds Track north of its intersection with Gap Road.

Ecological Vegetation Class 36. Montane Dry Woodland
Synonym: Montane Sclerophyll Woodland (Forbes *et al.* 1981)
Area: 48 517 ha

The driest and most exposed ranges and montane tablelands host this very widespread ecological vegetation class within the study area. Geologies are predominantly Devonian Snowy River volcanics although there are also extensive areas of Silurian and Ordovician marine sediments. The community grows on soils of varying development from very skeletal on spurs and northern aspects to quite deep at such localities as the Wulgulmerang and Monaro Tablelands. Precipitation is in the order of 800–1000 mm a year with substantial amounts of this falling as snow which may persist for several months at a time. The altitude range is 900–1300 m. This class is an open woodland structure to an open forest where disturbance by fire is frequent.

The overstorey trees vary considerably according to altitude and precipitation. At higher altitudes with lower precipitation Snow Gum *Eucalyptus pauciflora* and Candlebark *E. rubida* predominate whereas Broad-leaved Peppermint *E. dives* and Brittle Gum *E. mannifera* occur at lower altitudes under similar rainfall regimes. On better watered lower altitude sites Narrow-leaved peppermint *E. radiata* and Mountain Gum *E. dalrympleana* are more common. The understorey varies considerably according to fertility and elevation and should be the subject of further floristic analysis. Generally though, the lower rainfall, less fertile geologies (Snowy River volcanics and the marine sediments) have shrubby understoreys with a low overall species diversity (around 30 species). Typically the shrub understorey consists of Prickly Bush-pea *Pultenaea juniperina*, Gorse Bitter-pea *Daviesia ulicifolia*, Prickly Broom-heath *Monotoca scoparia*, Rough Coprosma *Coprosma hirtella* and Grey Guinea-flower *Hibbertia obtusifolia*. Tussock grasses *Poa* sp. are the ubiquitous grasses of this vegetation.

Examples: Wulgulmerang on the Black Mountain Benambra Road and west of Bendoc.

Ecological Vegetation Class 37. Montane Grassy Woodland
Synonym: Not previously recognised therefore not mapped
Area: 4825 ha

Two distinctive floristic entities occur within the study area. The first is restricted to the granodiorites that at lower elevations and rainfall give rise to Rainshadow Woodland. These occur on rounded dissected ranges on all aspects. The geology is Silurian granodiorites which are moderately fertile. The resulting soils are relatively deep, structureless, coarse sandy loams high in organic matter. The precipitation is in the order of 900–1000 mm annually. Snowfalls are common and may persist for many months. The elevation range is about 850–1100 m.

The dominant eucalypts in this structurally simple class are Snow Gum *Eucalyptus pauciflora* and Candlebark *E. rubida* – Mountain Gum *E. dalrympleana*, whilst at lower elevations Manna Gum *E. viminalis* can be the most prominent species. The understorey has a very sparse shrublayer of Blackwood *Acacia melanoxylon*, Pale Hickory Wattle *A. falciformis*, Shiny Cassinia *Cassinia longifolia*, and Pale-fruit Ballart *Exocarpos strictus*. The groundlayer is dominated by many species of herbs and grasses. Some of the more common species are Kangaroo Grass *Themeda triandra*, Large Tussock Grass *Poa labillardieri*, *P. labillardieri* (Blue Form), Grey Tussock Grass *Poa sieberiana*, Common Wheat-grass *Elymus scabrus*, Twin Flower Knawel *Scleranthus biflorus*, Showy Violet *Viola betonicifolia*, Branching Daisy *Brachyscome aculeata*, Grass Trigger Plant *Stylidium graminifolium*, Austral Bear's Ear *Cymbonotus preissianus*, Bidgee-widgee *Acaena novae-zelandiae*, Hairy Sheep's Burr *A. agnipila*, Rough Bedstraw *Galium gaudichaudiana*, Common Raspwort *Gonocarpus tetragynus*, Hairy Speedwell *Veronica calycina* and Prickly Starwort *Stellaria pungens*. Austral Bracken *Pteridium esculentum* may be sporadically present.

Examples: Suggan Buggan Road on the slopes of Mount Hamilton (at the head of the escarpment above Buchan Creek), the Ingeegoodbee Track beginning 3 km north of its intersection with McFarlane Flat Track to the Victorian border.

The second floristic entity is restricted to the few remaining areas of basaltic lithogy that have survived agricultural clearing. This geologically specific floristic form of Montane Grassy Woodland is thus very restricted within the study area. Soils are well developed clay loams with occasional out-cropping basalt on the ridges. They are poorly drained and very wet in winter and spring although they may dry out considerably over summer. Precipitation is 800–900 mm per year. The elevation range is 800–850 m.

The overstorey is dominated by Manna Gum *Eucalyptus viminalis*, Snow Gum *E. pauciflora*, and Swamp Gum *E. ovata*. The understorey shrublayer is dominated by the tall shrubs Silver Wattle *Acacia dealbata* and on wetter sites Lemon Bottlebrush *Callistemon pallidus*. The low shrublayer has several heaths with Common Heath *Epacris impressa*, Cranberry Heath *Astroloma humifusum*, Honey Pots *Acrotriche serrulata* and Coral Heath *Epacris microphylla* present. The shrubs Prickly Teatree *Leptospermum continentale* and the rare Dusky Bush-pea *Pultenaea polifolia* also represented.

Typically the grassy understoreys are dominated by Kangaroo Grass *Themeda triandra*, Mat Grass *Hemarthria uncinata*, Spiny-headed Mat-lily *Lomandra longifolia* and many herbs such as Yam-daisy *Microseris lanceolata*, Self Heal **Prunella vulgaris*, Kidney-weed *Dichondra repens*, Austral Bear's Ear *Cymbonotus preissianus*, Yellow Bulbine-lily *Bulbine bulbosa*, Alpine Woodruff *Asperula pusilla*, Common Woodruff *A. conferta*, Austral Carraway *Oreomyrrhis eriopoda* and Showy Violet *Viola betonicafolia*. Several moisture loving sedges Common Bog-sedge *Schoenus apogon* and Finger Rush *Juncus subsecundus* attest to the seasonally wet nature of the soils in this form of Montane Grassy Woodland.

Examples: The Honeysuckle Range immediately east of the farmland on the Tubbut-Bonang Road.

Ecological Vegetation Class 38. Montane Damp Forest
Synonym: Not previously recognised therefore not mapped (LCC 1991)
Area: 13 962 ha

Montane Damp Forest occurs on Devonian Snowy River volcanics. It grows on sheltered slopes and in gully heads where cold air drainage has not had a chance to pool and depress minimum temperatures for substantial periods. This class is not common in the study area. Soils are reasonably well formed sandy clay loams that have a moderate organic content. The elevation is in the range 900–1100 m. Precipitation is the range of 900–100 mm per annum. Structurally this vegetation class is a tall open forest.

The flora of Montane Damp Forest reflects both the moist nature of the sites upon which it grows as well as its elevation. The overstorey is dominated by Gippsland Peppermint *Eucalyptus croajingolensis*, Alpine Ash *E. delegatensis* and Messmate *E. obliqua*. The understorey often has a small tree-layer of Silver Wattle *Acacia dealbata* and Blackwood *A. melanoxylon*. Below this a well developed medium shrub-layer of Rough Coprosma *Coprosma hirtella*, White Elderberry *Sambucus gaudichaudiana*, Dusty Daisy-bush *Olearia phlogopappa*, Derwent Speedwell *Parahebe derwentiana*, Common Cassinia *Cassinia aculeata*, Bootlace Bush *Pimelea* *axiflora* and River Lomatia *Lomatia myricoides*.

The ground layer is dominated by grasses, herbs and ferns. The common grasses are Tall Tussock-grass *Poa helmsii* and Sword Tussock-grass *P. ensiformis*. Some of the ubiquitous herbs include Bidgee-widgee *Acaena novae-zelandiae*, Forest Starwort *Stellaria flaccida*, Mountain Buttercup *Ranunculus scapiger* and Mountain Cotula *Leptinella filicula*. The most abundant fern is Mother Shield-fern *Polystichum proliferum*. Sometimes Tasman Flax-lily *Dianella tasmanica* is also a prominent feature of the groundlayer.

Examples: The Seldom Seen Track east of the fire tower.

Ecological Vegetation Class 39. Montane Wet Forest
Synonym: Montane Forest (Forbes *et al.* 1981)
Area: 13 506 ha

The Montane Wet Forests of the study area grow on the most sheltered wet sites such as gully heads and south facing slopes at montane elevations (900–1200 m). Intact examples of this forested ecological vegetation class are now uncommon in the production forests of the study area, especially on the Nunniong Plateau. Overall the class is not common within the study area. Precipitation exceeds 1200 mm a year and snow falls may be common in winter but generally do not persist for more than several months at a time. This vegetation grows on Devonian Snowy River volcanics and Ordovician granodiorites. The resultant krasnozemic soils are very deep, structureless clay loams that are characteristically a deep brick red in colour. Structurally this vegetation class is a tall open forest.

The dominant overstorey tree is Alpine Ash *Eucalyptus delegatensis*, with a small subsidiary tree-layer of Frosted Wattle *Acacia frigescens* and Silver Wattle *Acacia dealbata*. The understorey is dominated by a dense layer of Soft Tree-fern *Dicksonia antarctica*, and Mother Shield Fern *Polystichum proliferum*, Bats-wing Fern *Histiopteris incisa* and Hard Water-fern *Blechnum wattsii*.

Examples: The eastern and southern fall of the Gelantipy Plateau and the Nunniong Plateau.

Ecological Vegetation Class 40. Montane Riparian Woodland
Synonym: Montane Wet Forest (Mueck and Peacock 1992), Alpine Wet Heathland EG 1.1 Forbes *et al.* (1981)
Area: 516 ha

Montane Riparian Woodland is associated with the meandering streams which flow through the Montane Dry Woodlands of the Wulgulmerang and Monaro Tablelands. The re-naming of the class reflects its structure, environment and altitudinal occurrence. Within the study area this class is uncommon because of agricultural clearing. The geology is Quaternary alluviums. Soils are peat rich silts and clays. Precipitation is above 1000 mm per annum. Structurally this vegetation is an open woodland on smaller creeks but may be largely un-treed on the larger streams such as the Buchan River near its crossing with the Benambra Black Mountain Road.

Associated trees are Black Sallee *Eucalyptus stellulata*, Narrow-leaf Peppermint *E. radiata* and Mountain Swamp Gum *E. camphora*. Beneath this open canopy a dense sward of grasses, herbs and shrubs proliferate. The dominant grasses are Large Tussock *Poa labillardieri*, Common Wheat-grass *Elymus scabrus* and the introduced

Yorkshire Fog **Holcus lanatus*. The common sedges Tall Sedge *Carex appressa* and Fen Sedge *Carex gaudichaudiana* add to the grassy park-like appearance of this vegetation. This plant has a high diversity of herbs, a majority or which are cosmopolitan riparian species such as Self Heal **Prunella vulgaris*, Matted St. John's Wort *Hypericum japonicum*, Gunn's Willow-herb *Epilobium gunnianum*, Brooklime *Gratiola peruviana*, and Australian Buttercup *Ranunculus lapaceous* as are the common ferns Alpine Water-fern *Blechnum pennamarina* and Soft Water-fern *Blechnum minus*.

Example: Boundary Creek and Pack Bullock Creek on the Gelantipy Wulgulmerang Road, the upper Buchan River catchment and Swede Creek upstream of its crossing with Hepburn Road on the Monaro Tablelands east of Bendoc.

Ecological Vegetation Class 41. Montane Riparian Thicket
Synonym: Montane Riparian Forest (Forbes *et al.* 1981)
Area: 36 ha

Montane Riparian Thicket is found along the riparian zones in Montane Wet Forest. The restricted nature of habitat of this class means that it has a restricted occurrence within the study area. The soils are colluviums or alluviums and are generally silty clay loams rich in organic matter which are generally waterlogged. Streams although small, are generally permanent. The elevation range is 900–1500 m. Rainfall is in excess of 1200 mm per annum. Structurally this vegetation is a thicket.

The overstorey trees (which are seldom rooted in this narrow vegetation class but usually overhang it) are Alpine Ash *Eucalyptus delegatensis* and Candlebark *E. rubida*. The thicket component of the understorey is dominated by Mountain Tea-tree *Leptospermum grandifolium*. The understorey is frequently shaded and many of the species which flourish there are shade tolerant. Such species include Tall Sedge *Carex appressa*, Mountain Cotula *Leptinella filicula* and Forest Mint *Mentha laxiflora* are some good examples. In the canopy gaps moisture loving shrubs grow with such species as Wax-berry *Gaultheria appressa*, Dusty Daisy-bush *Olearia phlogopappa* and Mountain Pepper *Tasmannia lanceolata* being common. Along the stream flats ferns are the common life form with Alpine Water-fern *Blechnum pennamarina*, Fishbone Water-fern *B. nudum*, Soft Water-fern *B. minus* and Mother Shield Fern *Polystichum proliferum* the most commonly encountered.

Examples: The headwaters of Mia Mia Creek upstream of its crossing with Mellick Munje Track and the headwaters of Omeo Creek north of the Black Mountain Benambra Road.

SUB-ALPINE VEGETATION

This vegetation occurs on the mountain peaks and high ranges of the Great Divide (above 1200 m) and occasionally as low as 800 m along streams where cold air drainage maintains sub-zero temperatures for extended periods. The landforms are rounded peaks with occasional periglacial features such as rock rivers on the Wombargo Range. Localities include Mounts Tingaringy, Cobberas and Wombargo. The environment is characterised by high precipitation (generally 1000–1400 mm), a large proportion of which falls as snow. Snow cover is persistent and usually lasts for four to five months. Cold air drainage along gullies may extend the range of these vegetation classes below 1200 m in some cases. Winds are frequently gale force during autumn, winter and spring. Geology varies considerably. Silurian andesites, Ordovician marine sediments, Ordovician/Devonian granitoids to Devonian acid volcanics of the Snowy River Volcanic Group are represented. The soils derived from the sub-alpine environment and their divergent lithologies are correspondingly diverse. They range from rock screes, through skeletal clay loams low in organic matter to the high organic content peats of the Treeless Sub-alpine Complexes.

Ecological Vegetation Class 42. Sub-alpine Shrubland
Synonym: Alpine Mallee Shrubland (Walsh *et al.* 1984)
Area: 202 ha

This class grows exclusively on Silurian sediments that have been folded so that the bedding layers are perpendicular to the horizontal and running at right angles to the ridge lines. This unusual juxtaposition of geology and bedding orientation has a very limited occurrence and the class is likewise restricted within the study area. Soils are skeletal and shallow sandy clay loams. The rainfall is around 900 mm a year. The altitude range for this vegetation class is 1200–1400 m.

The Mallee-form eucalypts of Sub-alpine Shrubland are Mallee Ash *Eucalyptus kybeanensis*, Black Sallee *E. stellulata*, Tingaringy Gum *E. glaucescens* and Brumby Point Sallee *E. elaephloia*. These species show a marked height difference according to aspect, ranging from 0.5–2.0 m on northern aspects to 3–6 m on southern aspects. The dominant feature of this vegetation are the shrubs. The understorey also varies in height according to aspect. The dominant understorey shrubs are Mountain Banksia *Banksia canei* and Leafy *Bossiaea bossiaea foliosa*. Tall Parsnip *Trachymene anisocarpa* and Grass Trigger plant *Stylidium graminifolium* common shrubs include, Heath Platysace *Platysace ericoides*, Woolly-bear Wattle *Acacia lucasii*, Alpine boronia *Boronia algida*, Sticky Boronia *Boronia anemonifolia*, Daphne Heath *Brachyloma daphnoides*, Dwarf Sour-bush *Choretrum pauciflorum*, Lemon Bottle-brush *Callistemon pallidus*, Rough Coprosma *Coprosma hirtella*, Nunniong Everlasting *Ozothamnus rogersianus*, Slender Tea-tree *Leptospermum brevipes*, Drooping Beard-heath *Leucopogon gelidus*, Trailing Broom-heath *Monotoca rotundifolia*, Violet Daisy-bush *Olearia iodochroa*, Leafless Sour-bush *Omphacomeria acerba* Alpine Oxylobium *Oxylobium alpestre*. Herbs and grasses are uncommon or absent.

Example: Brumby Point at the eastern end of Brumby Point Track and along Reedy Track several kilometres to the southeast. These are the only known localities for this vegetation community.

Ecological Vegetation Class 43. Sub-alpine Woodland
Synonym: Snow Gum Woodland (Forbes *et al.* 1981)
Area: 7310 ha

Sub-alpine Woodland grows on a wide range of geologies within the study area at elevations in excess of 1300 m above sea level. Because such elevations are uncommon in the study area this ecological vegetation class is likewise uncommon. Soils are generally skeletal sandy clay loams that have rich humus layer at or near the soil surface in most instances (although this may be reduced on exposed ridges and northern or western aspects). Structurally this class is a woodland except where burning is frequent.

The overstorey is dominated by Snow Gum *Eucalyptus pauciflora*, with an understorey of low shrubs over a groundlayer of grasses and herbs. Shrub species commonly present are Mountain Heath *Leucopogon hookeri*, Prickly Bush-pea *Pultenaea juniperina*, Gorse Bitter-pea *Daviesia ulicifolia* and less commonly Alpine Oxylobium *Oxylobium alpestre*. The diverse herb flora are represented by Prickly Starwort *Stellaria pungens*, Common Billy-buttons *Craspedia glauca*, Branching Daisy *Brachyscome aculeata*, Alpine Woodruff *Asperula scoparia*, Showy Violet *Viola betonicifolia*, Variable Willow-herb *Epilobium billardierianum* ssp *cinereum*, Bidgee-widgee *Acaena novae-zlandiae*, Pale Vanilla Lily *Arthropodium milliflorum*, Variable Groundsel *Senecio lautus* and Grass Trigger-plant *Stylidium graminifolium*.

Examples: Mount Wombargo on the Black Mountain Benambra Road, Diggers Hole Spur, Diggers Hole Track between Reedy Track and Brumby Point Track.

Ecological Vegetation Class 44. Treeless Sub-alpine Complex
Synonym: (in part) Alpine Wet Heathland (Forbes et al. 1981)
Area: 1071 ha

This complex consists of a number of floristic entities which are often closely associated with the alluvial flats of many larger streams at sub-alpine levels as well as on the sub-alpine plains where cold air drainage is a regular occurrence and drainage is poor. Such habitats are very restricted and the area of these communities is therefore also restricted. The geology is diverse and ranges from Quaternary alluviums to Devonian Snowy River Volcanics. The soils are consequently also diverse, ranging from peats or peat-rich silts and clay loams to rock screes. The elevation range is 870–1500 m.

There are five ecological vegetation classes represented in this complex within the study area and their description is taken from the Alpine Vegetation of Victoria (Walsh *et al.* 1983). Two additional classes occur in the study area, however, Podocarpus Heathland ALP 1.1 and Sparse Rocky Alpine Heathland ALP 3.3 (Walsh *et. al.* 1984) are very small in area and are restricted to the Mt Cobberas area and were not mapped. The other five, Alpine Heathland ALP 6.4, Alpine Grassland ALP 7.3, Wet Alpine Heathland ALP 9.3, ALP 9.5 and Damp Alpine Heathland ALP 10.3 were mapped during the study. Of these Alpine Heathland ALP 6.3, Alpine Grassland ALP 7.3 and Damp Alpine Heathland ALP 10.3 occupy the greatest proportion of the area mapped as Treeless Sub-alpine complex. As a consequence only the latter vegetation classes are described. Alpine Heathland APL 6.3 is widespread in the Eastern Highlands and within the study area. It grows on dry shallow soils derived from varied geologies which include igneous and sedimentary types. It occurs between 1160–1760 m.

Alpine Heathland is dominated by a wide array of grasses and herbs. The dominance of these life forms has resulted from grazing pressure and the associated grazier burning practices which have depleted the shrub layer. Areas within the study area which are not burnt (such as the eastern plains of the Nunniong Plateau) are dominated by Clustered Bush-pea *Pultenaea fasciculata*. Elsewhere the low shrub Alpine Rusty-pods *Hovea montana* may also be common. Frequently encountered herbs in this community are Twin-flowered Knawel *Scleranthus biflorus*, Scaly Buttons *Leptorhynchus squamatus*, Austral Bugle *Ajuga australis*, Spoon Daisy *Brachyscome spathulata* and Alpine Yam-daisy *Microseris* aff. *lanceolata* (Alps).

Examples: Nunniong High Plains and the Cobberas.

Alpine Grassland ALP 7.3 is extensively disturbed by grazing and has many introduced species as a result. It occurs on dry granite derived soils on flat or gently sloping sites and grows in the altitude range of 1200–1620 m. Alpine Grassland ALP 7.3 is a grassland or sedgeland dominated by Soft Tussock Grass *Poa hiemata* which is otherwise species poor and weedy as a consequence of grazing. Common weeds include White Clover **Trifolium repens* and Sheep Sorrel **Acetosella vulgaris*.

Examples: Nunniong High Plains, Emu Flat.

Damp Alpine Heathland ALP 10.3 is dominated by a range of shrubs and a diverse assortment of herbs. The paucity of shrubs at many sites within the study area in this heathland vegetation is attributable to repeated autumn burning by graziers. This vegetation class grows on broad shallow drainage lines and seepage platforms on hillsides. Soils are derived from basalts on the Nunniong Plateau and Snowy River Volcanics around the Cobberas.

Species usually represented in Damp Alpine Heathland include the shrubs Coral Heath *Epacris microphylla*, Small-fruit Hakea *Hakea microcarpa* Drumstick Heath *Epacris breviflora*, the grasses Prickly Tussock Grass *Poa costiniana*, Hookers Fescue *Austrofestuca hookeriana*, Thick Bent Grass *Deyeuxia crassiuscula* the graminoids Spreading Rope-rush *Empodisma minus*, Mountain Cord-rush *Restio australis*, Bog Woodrush *Luzula australasica*, Common Bog-sedge *Schoenus apogon*, Fen Sedge *Carex gaudichaudiana* and the herbs Mountain Woodruff *Asperula gunnii*, Creeping Raspwort *Gonocarpus micranthus*, Matted St. John's Wort *Hypericum japonicum*, Mountain Velleia *Velleia montana*, Grass Trigger-plant *Stylidium graminifolium*, Alpine Cotula *Cotula alpina* and Fringed Carraway *Oreomyrrhis ciliata*.

Examples: Native Dog Flat and Mundys Plain.

Appendix F
HISTORY OF LAND USE IN EAST GIPPSLAND

AGRICULTURAL CLEARING

Agriculture currently represents less than 15% of land use by area in East Gippsland. In comparison with other regions in Victoria agriculture has largely failed to make a lasting impression on the landscape, and in some instances has been little more than a temporary incursion into the forests.

Agricultural communities are concentrated in the fertile land of the west around Buchan, extending north to the plateau country and basalt derived soils of Gelantipy and Wulgulmerang; on the fertile limestones, river flats, coastal plains and adjoining cleared foothills around Orbost; in the north near Bendoc, Bonang and Tubbut; and in the far east at Cann River, Mallacoota and along the Genoa River valley.

The first settlements in the region were established in the 1840s, around Delegate and Dellicknora, and in the south eastern corner near Mallacoota, Genoa and Wangarabell. These were outlying stations of the southern New South Wales pastoral industry and were among the first white communities in Victoria. Leases for pastoral runs in this period were administered by the colonial Government of New South Wales.

The Snowy River flats were settled in the 1870s, with the first township blocks sold in Orbost in 1881. Crown land selection — the process of sub-division, forest clearance and closer settlement which began in Victoria in the 1860s — made little impact on East Gippsland until the 1880s. Then in the relatively short period before the end of the century the best farm land in the region was taken up — around Orbost and Buchan, in the north at Bendoc and Bonang, along the Cann River valley and in small fertile pockets scattered throughout the region.

All that remained after the first flurry of selection was marginal forested country, 'potential' agricultural land that eventually proved unsuited to farming. Turn of the century Crown land sub-divisions in the marginal districts of Murrungowar, Kuark were remote from markets and poorly served with roads. Despite the best efforts of the selectors, these settlements failed and were later abandoned. Many are now located within State Forests or National Parks.

The former Victorian Department of Crown Lands and Survey persevered with attempts to settle the marginal forested areas of East Gippsland right up until the 1930s, and sometimes beyond this, despite an increasing number of forfeitures. The Forests Commission eventually claimed most of these areas for future timber production, though a history of ringbarking, grazing or crop cultivation sometimes led to weed infestation, coppicing of trees and disturbed vegetation communities.

Selection of Crown land in the forests of East Gippsland generally took place between 1880 and 1930. The Land Act of 1884 introduced the concept of leasing Crown Lands for agricultural purposes, including land of marginal quality in areas not previously opened up for settlement. The East Gippsland forests tended to fall into this category. The 1884 Act also provided for classification of lands according to their perceived productive capability, and rents were aligned to this. In forested areas of East Gippsland agricultural allotments were generally deemed third class.

Selection blocks in forested districts were typically 120–160 ha, with portions of hilly land and river flats. Fertile stretches along river courses were more keenly sought by settlers. In the rough and difficult country of the region's hinterland, selectors found the remote and inaccessible blocks almost impossible to farm successfully. The majority of allotments surveyed and set aside in forest areas by the Lands Department were never taken up, much less attempted and later abandoned.

The Lands Department created correspondence files to administer the sale and leasing of Crown lands under the requirements of various land acts, dating back to the 1860s. For selection allotments in East Gippsland which later reverted to the Crown, more than 300 files have been retrieved and examined to determine the extent and period of forest clearance. Less than half contained evidence of ringbarking. Valuable and detailed descriptions of the local environment, for the period immediately prior to leasing or farming, can be found in some files.

Selectors in forested areas, as elsewhere in the state, were required to make 'improvements' to their blocks, and clearing for pasture or crops was the most time-consuming and back-breaking task. Ringbarking (or 'ringing') trees was the preferred method, usually done in spring when the sap had risen. A strip of bark was cut from around the circumference of the trunk, and the tree left to die. Eventually the branches dropped off, and the tree was cut, burnt or pulled down, and the stump dug out ('grubbed') and burnt. The undergrowth and scrub were cleared or pushed over, and burnt off with the remains of the ringbarked trees. Selectors toiled to clear blocks with shovels, axes, saws, bullocks, horses and fire. Pasture grasses were sown onto the cleared, but not always ploughed fields. Clearing was a near constant occupation in some districts, where bracken and suckers quickly returned.

Hundreds of miles of post and rail, chock and log, barbed wire and netting fences were built in East Gippsland forests. The Lands Department considered the fencing of boundaries and paddocks to be an essential part of the settlement process. It represented the mark of the settler, and a commitment to working the property. Selectors in East Gippsland sometimes complained that this task was impossible on their allotments, where boundaries passed through impenetrable 'jungle', or over steep terrain.

Most settlers grazed cattle or sheep, and kept a few pigs. Some cultivated maize, an important crop in East Gippsland, though it was not extensively grown in forest areas where agriculture eventually failed. Oats were also planted, vegetable and house gardens were common, and the more industrious settlers established small orchards. Fruit trees were regarded as an improvement by the Department, and added to the net value of the selector's input. Dairy farming was also attempted in coastal districts.

Huts, outbuildings, pens and stock-yards, and dwellings of three to four rooms, plus verandah, were built by the more able or successful selectors. Local timber was used for these purposes — it was plentiful and cheap.

When allotments were given up and abandoned, sometimes after occupation of three or four years, but in some instances after 15–20 years, reversion to natural conditions was surprisingly quick. Fires moved through and destroyed the settlers' improvements. Forfeited blocks were sometimes taken up by another selector, and the process of clearing and building began again. In the present Murrungowar State Forest, the first selections of the late 1880s and 1890s were followed by another phase of clearing and farming in the 1910s and 1920s. Very few freehold allotments remain in this district.

Data relating to agricultural clearing has been collated into a textual database, which contains information on the location, extent and period of clearing (ringbarking) within a given Crown land allotment, and authenticated by historical records. Where clearing was undertaken on a portion of the allotment area, the percentage is based upon data provided by Crown Land Bailiffs and contained within selection files. Parish plans have been used to situate allotments within the EGFMA, and to facilitate incorporation into the GIS.

Primary sources

1 Public Records Office : Series 440, 444 and 5357, 'Crown Lands and Survey Files' for selection, occupation, survey data and general correspondence.
2 Central Plan Office, Survey and Mapping Division, Department of Finance : parish, township and county 'Record Plans' and 'Historical Plans'.

GRAZING

The first cattle were depastured in the forests of East Gippsland by graziers from southern New South Wales, driven into the region by a run of dry seasons in the 1830s and 1840s. They started a tradition in the region which continues today, where cattle are depastured in State forests and on unoccupied public land, usually by local farmers in need of extra pasture. Their licences are administered by the Department of Conservation and Natural Resources.

This project has identified five categories of grazing licences/leases in East Gippsland. The categories do not represent different types of forest grazing, rather alternate forms of administration which generated discrete record collections. There is a deal of chronological overlap between the categories of grazing. Information about stock numbers is variable, unreliable in the early period and not consistently available in recent records. The size of leases, and the boundaries, have also varied considerably over time. The five categories are:

1 Pastoral Runs, administered by the colonial governments of New South Wales and Victoria, date range 1838–1883.
2 Grazing leases/licences, administered by the former Victorian Department of Crown Lands and Survey under various Land Acts, date range 1875–1978.
3 Grazing Blocks, administered by the former Department of Crown Lands and Survey, category 121 and 130 leases, date range 1920–1988.
4 Forests Commission grazing licences, c1908–1983.
5 Current licences, administered by the Department of Conservation and Natural Resources, earliest date 1886.

Records relating to pastoral runs generally provide information on the names of runs and run holders, date and size of holdings, grazing capacity and sometimes the number of stock depastured. The large size of some early runs (e.g. Yieldersley–Tildesley, 38 880 ha) and subsequent confusion over names (inconsistent spelling, duplication between parish and run names) can result in the incorrect identification and placement of runs. Leases were also subject to frequent changes of ownership and temporary transfers (Wakefield, 1969). They were often relinquished in good seasons, and taken up again later. Run holders in remote areas could easily avoid paying rents, and escape the official net. The extent of grazing in East Gippsland is likely to be under-represented in the official record for this period.

Cattle runs were first established on the Monaro Plains of south-eastern New South Wales in the 1820s and 1830s, though depasturing licences were not officially issued until 1837. As the industry expanded and stock numbers increased a run of dry seasons set in and the squatters of Monaro turned south in their search for new land on which to establish out stations. What is now East Gippsland became an integral part of the 'Squattage District' of Monaro, where future state boundaries were of little consequence (Hancock, 1972).

In the period up to mid-century, runs were opened in the Snowy River district at Suggan Buggan, Wulgulmerang and Orbost, and in the east at Wangrabelle, Genoa, Maramingo and Mallacoota. From 1847 run holders were required to obtain their leases from the then Victorian Lands Department.

The end of the squatting era had its genesis in the campaign to 'unlock the lands', which began in the gold rush period in Victoria. The campaign was aimed at curbing the growing political power of the squatters, and settling the thriving population of Victoria on the land. The Land Act of 1862 (Duffy Act) introduced the system of annual licensing for pastoral runs, and heralded the end of squatting tenure. Large grazing runs continued to be licensed and occupied after this period, though by the 1880s their number had halved in Victoria, and the area of pastoral occupation reduced by two-thirds.

The Land Act of 1884 identified grazing areas which could be made available under lease. Subsequent land acts continued to make provision for grazing on unoccupied Crown land. In East Gippsland, where extensive forest areas were available for grazing, the Lands Department administered leases right up until the early 1980s when it was amalgamated with the new Department of Conservation, Forests and Lands. The Forests Commission and its predecessor in the Lands Department have also administered annual licences or seven year leases in reserved forest areas in the region since 1908. CFL assumed responsibility for the administration of all grazing areas on public land in 1983, and licences are currently issued through the Land Information Management Systems Branch of the Department of Conservation and Natural Resources.

In 1946 a Royal Commission into Forest Grazing investigated the fire lighting practices of graziers. The custom of deliberate burning was considered to have been widespread prior to the 1920s, but had declined in the post-1939 period because of increased fire restrictions. Graziers reluctantly accepted the curtailment of the custom, though many continued to light fires in summer to provide autumn and winter herbage, and in autumn to ensure access for the next season. In 1945/46, 34% of all forest outbreaks in Victoria occurred east of the Snowy River, with 24% east of the Bemm River. Many of these were started by graziers (Stretton, 1946).

Graziers traditionally burnt large tracts of their leaseholds to encourage the growth of sweeter pasture, to keep the forest open and 'clean', and to provide a measure of safety against wildfires. Fires were started along ridge lines, with low-level flames moving down into gullies. Tussocks and bracken on the forest floor were burnt off in an attempt to generate more succulent, but not necessarily nutritious herbage. Stringybark ridges have a particularly low carrying capacity for cattle (Hamlyn, 1985).

Two to three years after burning, palatable feed became scarce and graziers set fire to another section of forest. Successful firing usually required several years accumulation of debris and forest litter. Graziers worked different sections of their leaseholds on a rotating basis. Repeated burning caused chaotic regeneration, coppicing, overstocking and competition within vegetation communities. These conditions also led to increased disease and pest susceptibility (McKinty, 1969).

Introduced grazing animals browse trees and shrubs, herbs and grasses. Their hooves compact soils and damage vegetation, whilst the spread of weeds is accelerated by the voiding of viable seed in their dung. They eat young seedlings and new shoots. Sheep are particularly close croppers and if allowed they will graze ground cover to the roots and cause soil erosion. Grazing animals are selective feeders, preferring succulents to unpalatable or spiky plants. Where both palatable and unpalatable plants occur in a locality, selective grazing changes the relative abundance of these two groups of species. This process may take many decades. Other adverse ecological effects of grazing include stream bank erosion and increased stream siltation (Resource Assessment Commission, 1992).

Rabbits were in plague proportions in East Gippsland in the first decades of this century, and drove many selectors from their blocks. They crop closely, eating even the roots of herbage, and inhibit tree regeneration. Their burrowing and grazing erodes soils and reduces soil fertility. Many hundreds of miles of wire netting was strung around farms in East Gippsland forests in attempts to stop the spread of the rabbit. Pockets of high rabbit infestation in the region today can be found around Deddick and Tubbut, in dry country near McKillops Bridge, and on the Marlo Plains.

Information on grazing leases has been compiled into a textual database which holds information on the extent, period of grazing and gridded location of the leasehold. Pastoral runs have been excluded due to the inconsistency of available data, specifically the location of early leaseholds. The four remaining categories of grazing records have been combined, and incorporated into the GIS. Leases were taken up irregularly and generally not held continuously over a given period. Only large grazing tracts in forest areas have been included, the minimum being approximately 1200 ha.

Primary sources

1 Public Records Office: Series 5920 Pastoral Run papers (microfiche, plus Index), Series 6467 'Depasturing Licences, Correspondence', and Series 440 and 5357'Crown Lands and Survey Files' for grazing leases and correspondence.
2 Central Plan Office : 'Put Away' and 'Historical Plans' GB (grazing Blocks) and PR (Pre-emptive Rights).
3 Department of Conservation and Natural Resources: Forests Commission County Plans 'Grazing Leases', Lands Department Plans 'Grazing Blocks', Forests Commission grazing licences/leases, Lands Department category 121 and 130 grazing licences/leases (file index), and current LIMS licences.
4 Victorian Government Gazettes.

MINING

W.B. Clarke, clergyman and geologist, discovered gold bearing rocks at Bendoc and Omeo in the early 1850s. The first claim was registered at Bendoc in 1855, by East Gippsland pioneers Hamilton Reed and John Lock. In an attempt to stimulate more gold discoveries, the colonial Government sent prospecting parties into Gippsland in 1860, and C.W. Nicholson's group succeeded in finding gold in streams near Bonang and Bendoc. By 1864, 200 Chinese diggers were reported to be active in the Bendoc–Delegate–Haydens Bog area, where fields remained busy throughout the 1860s and

1870s. Diggers were encouraged by the success of these operations to seek gold in other districts of East Gippsland.

In the 1880s and 1890s mining tracks were opened up throughout the region. Improved access brought a round of new discoveries and mining revivals. The Bendoc and Bonang fields were active again. Other busy fields during these years were Club Terrace, Clarkeville, McKenzie River, Combienbar and Delegate River. In the later 1890s diggers flocked to the fields at Brodribb River, B.A. Creek, Cabbage Tree Creek, Errinundra River and Boulder Creek.

Gold prospecting and extraction has occurred along many river and stream systems in East Gippsland. In the Bendoc district payable gold was eventually found in most streams flowing north from the Coast Range (Griffin, 1962). In the south of the region prospecting tended to concentrate on the heads of the river systems.

Small mining revivals took place on some East Gippsland fields in the economically depressed 1930s, including Bendoc, Club Terrace and McKenzie River. From the middle of this century large areas of the region have been subject to mineral exploration licences. Investigations have been made into gold deposits in the Bendoc–Bonang district, silver-lead in Lower Devonian beds at Errinundra and Deddick, and copper in the west of the region. The Accommodation Creek copper mine has been worked in recent decades.

Gold mining and mineral exploration and extraction are traditionally associated with despoliation of the local environment, though related disturbance tended to be intensive rather than extensive. Trees in the locality of mines were felled for fuel and building purposes, and streams and stream banks suffered greatly from the search for alluvial gold. Prospecting was a destructive forest activity which frequently involved the deliberate burning of the understorey to improve the digger's view of the terrain for his assessment of the local geology.

The gold fields of East Gippsland tended to be short lived, and yielded poor to moderate returns for the efforts of the miners. They were not as geographically extensive nor financially rewarding as those of Central Victoria, where the scale of gold extraction devastated the environment and changed the surface of the landscape. The extent of forest clearance, so remarked on by mid-nineteenth century visitors to the fields of Bendigo, Ballarat and Daylesford, and evident in the pictorial record of this period, appears not to have been widespread in East Gippsland. There are few anecdotal accounts or supporting records to indicate that large-scale forest clearance was associated with mining in this region, though forests in the vicinity of mines and mining settlements were destroyed. Forest west of the Bonang Highway, between the Gap and Rising Sun roads, still shows evidence of mining related disturbance (pers. comm. David Ingram).

Alluvial mining

On the early alluvial gold fields of Victoria mining claims were generally 2.5 to 3.5 m square. Diggers removed the topsoil first to get at the alluvial gravel or clay, which may have been from 15 cm to 9 m beneath the surface. Water was used to separate the gold from the dirt, either through panning by the stream side, or by sluicing or repeated washing. A variety of sluice boxes could be seen on the alluvial fields.

Where alluvial gold occurred at the deeper levels, mining required timbered shafts and winches to bring up the 'paydirt'. Horses were sometimes used to drive the more elaborate whims, which raised and lowered buckets at deeper mines. The animals wore a circular track around the head of the mine shaft. A similar effect could be observed at sites where horse-powered puddling machines were used to separate greater quantities of gold from dirt. Puddlers were circular constructions, with iron or wooden laths lining the sides and base. A perpendicular shaft with harrows attached was dragged through the water and alluvial dirt, as the horse moved around and around the machine. After repeated washings the gold settled on the bottom of the puddler.

Water was an essential element of gold mining operations. In mountainous country elaborate earthworks were constructed to carry water from elevated streams or man-made dams to the mines. Shallow races followed the contours of the landscape to sluicing operations. Where water was taken over gullies or ravines, bush carpenters built some spectacular flumes.

Most alluvial mining occurred along natural water-courses. Sink holes were dug in the banks of streams in the search for alluvial gold. Neat piles of rocks and stones can indicate where creek workings have occurred, placed there by prospectors in their search for gold-bearing gravel. When creeks yielded good returns, miners built channels and dams to divert streams to get at the rich creek beds.

Hydraulic sluicing was employed at mines where the water supply and gradient permitted a build-up of pressure. The water was conducted into large hoses made of canvas or duck, often banded with metal rings for extra strength, which were powerful tools and difficult to control. Two men were sometimes required to direct the hose at the terraced alluvial banks of gold-bearing creeks and streams. Miners could more easily dislodge huge quantities of clay, which was then washed repeatedly in large sluicing boxes or ground sluicing operations. Tailings, or left over dirt, was washed away into gullies or tipped back into creeks.

On many fields in Central Victoria, the first phase of alluvial mining was followed by the more capital intensive but financially rewarding quartz reef mining. This pattern was repeated in East Gippsland, though on a smaller scale. While reef mining apparently ushered in the decline of the individual digger, it would be a mistake to believe that small-scale alluvial prospecting and mining died out. Itinerant diggers were still common on the gold fields of Victoria until the 1930s and beyond. Very often farmers on Crown land selections in auriferous areas, including those of East Gippsland, tried to supplement incomes through prospecting.

Quartz-reef mining in Victoria

Mining companies were formed all over Victoria to exploit the wealth of the underground reefs, very often as public share companies. Huge capital investment and large engineering works were required to mine the deep lodes. Refining techniques were also improved, as the companies endeavoured to extract ever finer quantities of gold.

Excess water and foul air were just some of the hazards faced by miners in the deeper shafts. Where quartz outcropped at the surface, open-cut mining methods were used. Horizontal tunnels, or adits, were also driven into hillsides below the cut in search of the quartz bearing rock.

The relics of reef mining, such as crusher and boiler remains, can still be found on abandoned fields all over Victoria. Quartz crushing batteries were driven by wood-fired boilers, which absorbed huge quantities of local timber. Others used hydro power, provided by water-wheels at the site and fed by races connected to elevated water storage areas. Water-wheels were more common at mountain sites. Batteries were often located near creeks where tailings could be washed away. Small mines tended not to operate their own batteries, but carted ore to another site for crushing. Aspen's Battery was located at the end of the track of the same name in the present Errinundra National Park, and was used by miners from the nearby Bonang field.

Innovations associated with quartz reef mining in Victoria in the 1870s and 1880s included the development of more efficient drills, safety cages, and the use of dynamite for breaking up the ore. Cyanide processing was introduced at some mines, to extract finer quantities of gold after the crushing process was completed. Circular corrugated iron (or later concrete) tanks were constructed at sites where a combination of potassium cyanide and zinc shavings was used to precipitate minute particles of gold from the crushed quartz.

East Gippsland gold fields

Bendoc was an alluvial and quartz reef gold field, where alluvial workings of the mid-1850s were followed by the discovery of the main reefs in the years after 1866. The township of Wagra (later Bendoc) developed around the mine workings in the 1860s. Much alluvial prospecting took place in streams around Wagra at this time.

Reefs were eventually worked for approximately four kilometres to the north, and ten kilometres south of Bendoc (to Clarkeville). Prospectors found the reefs were small but rich, though sometimes difficult to mine because of the depth of the loam. Alfred Howitt, the Police Magistrate at Bairnsdale, visited the Bendoc field in 1868. He found a battery in operation, crushing quartz for the local mines, and powered by a sixteen-feet iron overshot wheel. It was supplied by a race from the Bendoc River (Brough Smyth, 1979/80).

The Eclipse Mine opened in 1869. A primitive wooden-head battery and water-wheel was installed at the site, fed by a race two and a half kilometres long. The Come Love claim near Bendoc had a main shaft 170 feet deep (Griffin, 1962).

Back Creek alluvial field was active in the late 1850s, and again in the 1870s and 1880s with puddling and sluicing operations. It was reworked in the 1930s with hydraulic sluicing. Craigie Bog Creek was also heavily prospected in the 1860s and 1880s, when hydraulic sluicing was used to extract gold from the alluvial terraces. By the late 1880s nearly all the lower portion of the Queensborough River had been prospected for gold, with Chinese diggers prominent on the field. In the 1890s adits were driven into Delegate Hill in the search for quartz reefs.

The Victoria Star reef gold mine did not open until 1911 but proved to be the highest yielding mine in East Gippsland. Reefs were worked down to 300 feet, and a crusher, boiler and cyanide processing tanks were associated with the operation. The mine was still active in the 1930s though rising water levels eventually led to its closure (Griffin, 1962).

Hydraulic sluicing was again used at the Craigie Bog and Little Bog fields in the 1930s, and at Black Forest Creek. The disturbance is still evident at these sites (pers comm Keith Twyford).

The Clarkeville reef gold field was opened up in 1889, with a flurry of reef discoveries and claims. Mines followed the long line of reef stretching south from the present Little River Road, through branches of the Bendoc River and Sassafras Creek to where Aspens Battery Track crossed the parish border. Several crushers and a water-wheel were brought onto the field. The quartz was removed through surface work and shafts sent down to 300 feet (Butler, 1985).

Situated some 12 km south of Bendoc, on the divide between the north-south flowing streams, Clarkeville was a difficult field to work, and snow bound in winter. By 1899 reefs had been worked north from Clarkeville for approximately 10–12 kilometres, many of them to water level. The field was very busy for most of the next decade, and a sizeable township developed around the workings. Clarkeville's population of 200 was serviced with a school, hotel, post office, stores and other facilities (Griffin, 1962). By 1910 the field was deserted. In the 1930s there was some renewed activity, at the New North Discovery and New South Discovery mines.

Gold was taken from creeks in the Bonang area in the early 1860s. The Dick Turpin–Blackfellows Creek alluvial field was active in the 1870s. Alluvial claims ranging from three to fourteen feet deep were worked for one and a half miles along Blackfellows Creek from the Bonang River. Dick Turpins Gully was similarly worked for half a mile from the Bonang River in 1889 (Butler, 1985).

Quartz reefs were discovered on the Bonang field after the alluvial phase declined, leading to a revival in the 1880s and 1890s. Many well-known Bonang claims and mines date from this period. Reefs were mostly worked to water level on the field, where the Bonanza and Pioneer reef mines were important local operations. Claims followed a line of reef known as the 'East Blue' which crossed the state border between Delegate River and Mount Tingaringy (Butler, 1985). A battery at the Bonanza mine and another crusher at Aspen's Battery served the miners on this field for many years.

In 1869 the Marriott brothers discovered a reef while prospecting for alluvial gold at the head of the Rising Sun Creek. Their claim was situated about one and a quarter miles south-west of Bonang. Alfred Howitt visited the Rising Sun mine, and thought its prospects were good (Brough Smyth, 1979/80), but due to the difficult terrain the mine was not developed at this time. It was re-opened in the late 1880s and became the second richest reef in East Gippsland, yielding 60,000 pounds worth of gold (Griffin, 1962). Shafts were sunk to 500 feet and 90 chains of tramway installed to carry the ore from the shafts to a battery on the Bonang River. The crusher was powered by a water-wheel 20 feet in diameter.

Alluvial mining was taking place in the Delegate River area in the 1860s, when an officer of the Geological Survey visited the district and reported that the vegetation on Delegate Hill had been cleared (Gell and Stuart, 1989). This may have been to facilitate prospecting. Police Magistrate Howitt also visited the Upper Delegate River field in this period. He found a party of Chinese diggers '...had constructed a flood-race of considerable length, calculated to carry all the Delegate River.' Howitt noted further prospecting activity in the Goongerah Creek locality (Brough Smyth, 1979/80).

In the 1880s there was hydraulic sluicing on the Delegate field, and hole sinking for quartz reef exploration. Boland's workings were extensive at this time, and included the construction of water races. The field remained active into the 1890s. Most of the alluvial mining was undertaken within five kilometres of the source of the river.

Numerous auriferous reefs were discovered on the Club Terrace field, many of which paid good returns. Gold was first found here in 1895, and by 1896 five kilometres of gold-bearing reefs had been recorded, including the famous Ace of Clubs reef. Two reefs were worked by the Ace of Clubs mining operation, including one for 150 feet along the surface (Aust. Mining Standard, 23 April 1896). Hillside alluvial terraces were also profitably worked in the Pyramid Creek area. Another wave of prospecting, including the building of tunnels and shafts, occurred in the Club Terrace district in the 1930s, in the Millionaire Gully–Euchre Creek locality (Kenny, 1937). More workings took place in 1948, but were largely unproductive.

The alluvial terraces of the Errinundra district supported one of the richest reefs in East Gippsland in the 1890s, operated by the Gippsland Boulder Mine. The mine opened in 1898 on the Bola Creek and proved to be the third richest in the region. After working the quartz at the surface, tunnels were driven into the hillside in the area above the creek, and the ore was taken to Club Terrace for crushing. Alluvial mining on the Errinundra River about the turn of the century also yielded payable results (Dunn, 1907).

B.A. Creek alluvial field was opened after gold was discovered in 1872, attracting predominantly Chinese diggers to the area. Miners diverted watercourses and sank shallow tunnels and shafts to get at the alluvial dirt. Some reef mining was also undertaken, with two crushers located at each end of the creek valley. Another rush in the 1890s brought 400 diggers to B.A. Creek (Butler, 1985).

Panning around the shores of Mallacoota Inlet in 1894 led to a rush of claims in the following year. Shallow excavations were made at the lake edge, and quartz lodes were worked down to depths of 100 feet in places. The Spotted Dog mine was the most famous in the Mallacoota district, with several shafts driven into a reef approximately 100 m long. The claim covered 90 acres and was worked steadily in 1896–97. Other reef mines were dotted around the Inlet, and featured deep and shallow shafts, with some tunnelling into hillsides.

Small rushes and periods of gold mining occurred elsewhere in East Gippsland. On the Combienbar River alluvial and quartz workings of the 1870s were followed by new discoveries in 1888, and more local activity in the 1890s. Tributaries of the river, including the Cobon, Farquhar and Boulder Creeks, also yielded some gold (Flett, 1970).

Gold was discovered in the upper Bemm River as early as 1859, but prospecting activity was concentrated in reefs along the lower reaches of the stream in the 1890s. Poddy Creek was another comparatively low yielding reef field, where adits were driven into the hillside overlooking the stream. To the south-east of the hill surface workings, of up to 1.5 m deep, were made along a ridge for 30–40 m (Butler, 1985). The reefs were payable only over short distances.

Alluvial workings on the McKenzie River and nearby creeks brought a short-lived rush to the field in the late 1880s. It was reworked in the 1930s. Reef gold was known to exist in Genoa as early as 1859, but most workings on this small field also took place in the late 1880s. Jones gold mine was located north of the town, 200 m from the Genoa River. Some small shafts were associated with this operation.

Gold reefs were opened up at Mt Tara in 1896, and were worked through to the 1900s. Alluvial gold in the bed and side washes of the Brodribb River was taken out in 1888, and again in the 1890s. Small quantities of alluvial gold were won from the Cabbage Tree Creek in the late 1890s.

Other minerals

Copper sinking was undertaken in the Deddick district in 1872, followed by a busy period of silver-lead prospecting in the 1890s. By 1897 mining syndicates had applied for leases covering 25 square miles, and were digging pot-holes, shallow open-cuts, shafts and hillside tunnels, all over the field. Most lodes were located on the eastern bank of the Snowy River. Much of this prospecting proved to be fruitless, however, though lodes were believed to carry lead, silver, copper and gold. A settlement reputedly developed in association with the mining, but its location is unknown.

H.S. Whitelaw, of the Geological Survey, visited Mt Deddick in 1917 and found mining in operation again, but like the earlier rush, success was hampered by transport and access difficulties (Whitelaw, 1917). Silver mining was popular in the Buchan district in the first decades of this century. The Glen Shiel silver mine was situated between Butchers Creek and the Snowy River, east of the Buchan–Gelantipy Rd. In 1905 the mine featured shafts and an open cut 14 feet deep (Dunn, 1907). Lead ore has also been extracted from limestone at Murrindal.

While still in the region, Whitelaw visited some 'old workings' of a silver lode at Back Creek, four miles east-south-east of Buchan. He also noted new workings of the same lode nearby, from which more than eight tons of ore had been removed. The Buchan Prospecting Syndicate formed in this period to exploit a lode originally known as the 'Tara Crown', five miles south-east of Buchan. The syndicate drove a southerly tunnel for 325 feet, opened an easterly cross-cut, erected a ten-head battery on the creek bank below the workings, and installed a balanced incline tramway to transport the ore for crushing. Further shafts and tunnels were built, and about 400 tons of ore was extracted by 1917. Both gold and silver were won from this mine, but profits were negligible (Whitelaw, 1917).

Accommodation Creek copper mine was the site of silver-lead mining in the 1900s, and copper extraction in the 1930s and after. Another copper mine was operating at Cambell Knob about the turn of the century, with an associated settlement. Further mineral extraction in the region included a wolfram (tungsten) mine at Mt Bendoc in 1914–18. Manganese was known to exist in two outcrops near Jacksons Crossing on the Snowy River in the first decades of this century, but no report of mining was associated with the finds at this time (Kenny, 1917).

Mining and mineral extraction sites have been incorporated into the GIS via a textual database, and should be interpreted in conjunction with the above information to estimate the nature and extent of related disturbance. It has not been possible to spatially locate all mining sites in East Gippsland.

Primary sources

1 Records and Progress Reports of the Geological Survey of Victoria.

2 Department of Minerals and Energy: Mining Registrars' Quarterly Reports, Progress Reports and Unpublished Reports.

TIMBER UTILISATION

For most of the 19th century in Victoria any person holding tenure over Crown land, including a Miners Right, pastoral run, selection purchase lease or a licence to split or mill timber, could cut down trees virtually unhindered and unsupervised. Forests in proximity to settlements were subjected to the greatest devastation.

The first legislative power enabling the Government to reserve forest areas to protect the timber resource was granted under the *Amending Land Act* of 1865. At this time a Commission of Inquiry recommended the establishment of forest reserves, though none were set aside in East Gippsland. Another *Land Act* of 1869 gave the Governor the power to reserve from sale any Crown lands required for public purposes, including those needed for the growth and preservation of timber. In 1871 local boards were set up to oversee the management of the reserves. They were followed shortly after by a Central Forest Board, but it too lacked the legislative authority to control forest utilisation and management across the State. Timber reserves differed from State forests in that they were intended for the temporary supply of fuel and fencing for nearby settlements.

A series of Forest Acts were brought unsuccessfully before the colonial Government in the years leading up to the turn of the century. Beginning with the 1879 Forest Bill, and followed by subsequent attempts in 1881 and 1887, concerned members of Parliament tried to introduce some constraint over the forest industry in Victoria, as well as the extension of the forest reserve system. The 1887 Bill was especially advanced for the period, recommending the establishment of fixed rates and charges for timber products, and trained foresters to supervise the operations of timber fellers.

The *Land Act* of 1884 (later embodied in an Act of 1890) eventually provided the legislative power to forbid the alienation (for settlement) of State forests or timber reserves, though the provision was undermined by the Governor-in-Council's power to alter the area of the reserves in question. Permanent State forest reserves were eventually set aside in the county of Croajingolong in May 1896 (Carver, n.d., vol. E). The *Forest Act* of 1907 also resulted in the reservation of more than 370,000 acres in the region for forest purposes (McKinty, 1969).

G.S. Perrin was appointed the first Conservator of Forests in 1888, in the Forests Branch of the Victorian Department of Crown Lands and Survey. In this period before the creation of a properly funded and independent Forests Department, Perrin could exercise only restricted power over utilisation of the total forest resource, though he was responsible for the management of existing reserves. His first report in 1890 stressed the need for trained foresters to oversee timber utilisation, and the enforcement of stricter fire prevention regulations. The Government did not to act on these recommendations at the time (Carron, 1985).

The *Forests Act* of 1907 led to the establishment of a State Forests Department in 1908, extending the jurisdiction of the Conservator to plantations and Government nurseries as well as forest reserves. The jurisdiction of the new Department was still restricted to limited regulation of commercial timber extraction, and silvicultural work in regrowth forests which had been cut out under early utilisation.

Management of Victorian forests in the modern sense did not begin until after 1918, when the Forests Department was empowered to frame and enforce planning controls for management and utilisation of the resource. The Forests Commission was eventually established in 1921, with adequate funding for replanting and forest supervision. Three forest districts were set up in East Gippsland, with offices at Nowa Nowa, Orbost and Noorinbee (for the Cann Valley–Mallacoota district). In this early period Commission staff were mostly concerned with silvicultural operations. Until 1925 improvement work was carried out in the forests of more durable species, such as box, ironbark and red gum, which had suffered heavily under early, indiscriminate selective cutting operations. Mapping and inventory of forests across the State were also early priorities.

Pre-1920

Trees have been felled and timber removed from the forests of East Gippsland since the first settlers spread out across the landscape in the middle of last century. Graziers, cattlemen and shepherds used locally available timber for their immediate needs, such as huts and yards. When people came seeking gold in the north of the region in the 1850s and 1860s, local pit sawmills supplied the demand for building and mining timbers. In the early days of settlement in Bendoc, palings were split and saplings cut down for studs from forest in the Delegate River locality (Griffin, 1962).

Timber splitters worked relatively unhindered in forests in this early period. For the payment of a licence fee to a local official or police constable, their splitting and halving operations went unsupervised, and few restrictions were placed on species, size or quantity. Sawmillers competed with splitters in forests, taking only the prime parts of sound trees in their haste to get to the next tree (Shillinglaw, 1951). Sawmills could be erected on Crown land for the payment of an annual licence fee, but no limit was placed on the quantities of logs obtained and the fee was not related to the volume extracted. This was changed in 1893 when royalty rates for red gum sawlogs were restructured from an 'area' to a 'volume' system. The new system was gradually extended to all sawlogs and other forest products by 1905 (Moulds, 1991).

Agricultural settlers moved into the region from the 1870s, selecting and leasing forested Crown land allotments from the Lands Department on which they attempted to establish farms. The selectors cleared extensive areas of forest and were heavy consumers of timber for fuel, building and fencing purposes. Settlements in the Cann and Genoa River districts in the 1880s made good use of local timbers for construction purposes. Ringbarked timber, the result of their extensive clearing, was generally wasted.

The coastal forests of East Gippsland have been exploited for timber since settlement began in the region. The Lake Tyers district was noted for many years for the quality of its Grey Box timber. Forest produce was taken to Melbourne by rail after the line was extended to Bairnsdale in 1888, or by schooner from the ports at Marlo and on the Gippsland Lakes. Barges carried timber across the lakes, and down the Snowy River in the 1880s and 1890s. Gippsland Grey Box was used extensively for engineering purposes in the city, as pylons for the port of Melbourne, and for street paving blocks (Moulds, 1991).

Timber extraction in the late nineteenth century was boosted by the artificial opening at Lakes Entrance in 1889. Local eucalypt species, including Red Ironbark, Grey Box, Forest Red Gum and Red Box, were sought after construction timbers. The nearest and best trees were cut down under this kind of utilisation. Grey Box and ironbark logs were taken out of forest on the eastern side of the Nowa Nowa Arm of Lake Tyers about the turn of the century. In the same period the Colquhoun forest east of the lower Tambo River was extensively logged (Carver, n.d., vol. C). Forests in the far east of the region escaped similar logging at this time because they were 'practically inaccessible' (Royal Commission, 1899–1900).

The spread of the railway network generated increased demand for sleeper timbers, especially the hardwoods preferred by railway engineers — Red Ironbark, Gippsland Grey Box and red gum. Sleeper and beam hewers worked to meet the demand in forests to the west of Lake Tyers and through to the Colquhoun area in the period before 1900. Sleeper hewing was a very wasteful forest operation. Often only one or two sleepers were cut from a tree and the remaining timber left to rot. Hewers used axes, broad axes, mauls and wedges to finish the sleepers in the forest (Frawley, 1990). The rail was extended to Orbost in 1916, and local logging and sleeper hewing expanded along the line. In the Colquhoun forest a network of tramways was established to deliver timber to the Colquhoun railway siding (pers. comm. Peter Evans).

Forests were administered by the Lands Department up until 1919. After this period the Department and the Forests Commission were sometimes in dispute over Crown land alienation in East Gippsland. As the rate of failed and forfeited selections increased in forested areas, it became obvious that extensive tracts originally set aside for agricultural settlement were more suited to timber production. Many such areas were eventually taken over by the Forests Commission, as timber reserves or permanent forests. Minor adjustments were subsequently made to reserved forest boundaries on a regular basis, not only to expand the areas but also to excise sections for agricultural settlement. From 1930 to 1969 approximately 10,500 acres of reserved forest in East Gippsland were relinquished, removing areas of recognised low timber production potential (McKinty, 1969).

In Victoria in 1962 'timber reserves' and 'permanent forests' became 'reserved forest'; that is, forest reserved for forestry purposes. 'Protected forest' was chiefly unalienated Crown land, and not set aside for timber production. The two categories of reserved and protected forest are now combined under the term 'State forest' (Carron, 1985). Since 1983 however, State forest, as defined by the Land Conservation Council, includes both public land in timber production areas and uncommitted public land (LCC, 1986). Commercial timber is extracted from both timber production areas and uncommitted land within State forests. Two thirds of all public land in East Gippsland today is designated State Forest.

1920–1945

Timber utilisation in East Gippsland in these years was dominated by sleeper and beam hewing, with piles, poles and mill logs accounting for the remaining timber production. Public bodies in Melbourne were the chief consumers of East Gippsland timber products, namely the Public Works and Victorian Railways Departments, State Electricity Commission and Melbourne Harbour Trust. Gippsland Grey Box was especially prized by the Harbour Trust for its resistance to attack by the marine Toredo Worm. The Forests Commission also undertook widespread silvicultural treatment of forests in these years, particularly in the 1930s when gangs of unemployed men were deployed in the region. The annual reports of the three forest districts in East Gippsland, as well as the Forests Commission, are the primary sources for much of the following information.

Native hardwoods began to be used more extensively for building from the 1920s. Advances in seasoning techniques, including kiln drying, reconditioning of ash species, and improved preparation and grading of timber, brought about a decline in the reliance on imported timbers. During the war the Government (via the Commonwealth Timber Controller) oversaw forest utilisation and timber production, and where necessary directed supplies to defence operations (Moulds, 1991).

Sleeper and beam hewing continued to be important local industries in East Gippsland. The Victorian Railways Department sought hardwood sleepers from the Nowa Nowa and Orbost forest districts, the latter being the premier sleeper hewing area in the State in this period. In the Cann Valley–Mallacoota district, sleepers were cut for the railways departments of New South Wales and New Zealand.

Forest areas in the Nowa Nowa district containing suitable timbers and within reasonable distance of the rail were cut-out before the Second World War. By the mid-1930s accessible ironbark and box timber had become scarce, though hewers were working in forests throughout the southern portion of the Nowa Nowa district, in the west near the Tambo River, and in the north and north-west. In 1934 hewers moved into the Lake Tyers Aboriginal Reserve, from where they removed 16,418 sleepers in 22 months (Nowa Nowa Annual Reports, 1935–37).

Shortages of suitable sleeper timbers led to pressure on the Railways Department to accept other species. By the end of the decade hewers were working in mahogany gum and white stringybark stands, in the Tildesley, Boggy Creek, Stoney Creek and Hospital Creek blocks. Sleepers continued to be an important forest product in Nowa Nowa throughout the war years.

Sleeper and beam trees in the Orbost district were also heavily utilised in forest areas close to the rail. In 1932–33, 90% of the district's revenue came from sleeper production for the Railways Department. By the mid-1930s hewn timbers were being taken from reserved forest in all parishes surrounding Orbost, in coastal districts and inland as far as Club Terrace. New cutting areas were opened up each year from 1931 to 1938, but accessible timbers were nearly exhausted by the end of the decade.

Forests Commission officers were concerned with the wasteful operations of the hewers, who were very selective of the trees they felled. Sleeper production areas were more often 'cut over' than 'cut out'. Logs were dragged to a 'sleeper landing' (cleared and levelled section of forest), cut into nine feet lengths, and squared with a broad axe. Hewers branded their sleepers, for later inspection and reimbursement, and waste timber was generally left in the bush.

The industry was also under scrutiny for the hewers' practice of carting their own sleepers to the rail, encouraging them to work in accessible areas only. The Commission believed that professional carters were better equipped to bring sleepers in from more difficult locations. Sleepers were taken to the stations at Orbost, Bairnsdale or Nowa Nowa, where the Railways Department 'passer' checked their quality. Rejected sleepers were cast off or sold for less than their real value — a terrible waste of hardwood timbers. In an attempt to better control the industry, Commission staff began marking trees for sleeper and beam production in July 1939.

In 1938 the sleeper quota was reduced to 66 sleepers per hewer per month. This had the immediate effect of driving men out of the industry, and forcing others to supplement meagre incomes with beam hewing. During the Depression years hewing licences tended to be issued only to married men, and this led to a shortage of experienced hewers. By 1940 the industry had declined in the Orbost district. Contracts were going elsewhere, chiefly to the Cann Valley–Mallacoota district. Hewers left the area or the industry, some joined the armed forces, and few young men took up the trade.

With contracts for sleepers going further east the Forests Commission opened up new hewing areas in reserved forest adjacent to the State border. This included a large belt of overmature stringybark for sleepers destined for the New Zealand and New South Wales railways. Hewers from New South Wales came down to work in the district, their produce taken out by road transport to the port at Eden. By 1945 sleepers for export to New Zealand were being hewn from all the stringybark species, as well as Silvertop, Mountain Grey Gum and 'Spotted Blue Gum' (Blue Gum).

Gippsland Grey Box in the Cann Valley district was heavily utilised throughout this period. Beam cutters operated in the Noorinbee State forest for many years, and in reserved forest elsewhere in the district. Demand for the beams increased throughout the 1930s, resulting in a scarcity of suitable timber by 1940. The Melbourne Harbour Trust and Victorian Railways were the main consumers of beams, and most of their requirements were met by East Gippsland timbers in these years. Reserved forest in Wangarabell also produced beam timbers.

East Gippsland was a major producer of piles and poles in Victoria, particularly in the early war years. As with other forest products, cutting operations were restricted by inadequate access and the availability of suitable species. By the end of the 1930s pile and pole timbers handy to the Princes Highway and tributary roads in the Nowa Nowa district were becoming scarce, and longer length timber increasingly difficult to obtain. The cutting of grey box piles in the Cann Valley district in the same period also led to a shortage of suitable trees, and the opening of Reserved forest in Wangarabell. The State Electricity Commission let a contract for Yellow Stringybark poles in Orbost in 1939. With manpower shortages due to the war, Orbost Forests Commission staff undertook to cut the power poles, of up to 110 feet in length. White Stringybark poles were also cut for the Electricity Commission in the Nowa Nowa district, beginning in 1941. The contracts were completed before the end of the war.

Mill logs were cut on a selection basis in East Gippsland forests throughout this period. Loggers felled trees with the least defects and left standing those of poor form or quality (McKinty, 1969). At Haydens Bog, Jamieson's sawmill drew logs from an area of about 1500 acres of State forest lying between the Delegate and Bendoc Rivers, in the parish of Kirkenong (Griffin, 1962). Sporadic logging was undertaken elsewhere in the Orbost district, or concentrated in reserved forest in the parishes of Orbost, Loongelaat and Curlip.

In the 1930s sawmills in the Nowa Nowa district processed stringybark, Spotted Gum, Mountain Grey Gum and *E. eugenioides (E. globoidea)* from cutting areas up to 20 miles distant from the rail, including forests in the parishes of Buchan, Colquhoun East and Nowa Nowa. In the early 1940s Silvertop, White Stringybark, Messmate and Blue Gum were taken out of the Stony Creek forest. By 1945 loggers were working in the Boggy Creek, Tildesley, Mundic Creek and Ninnie localities, as well as in the parish of Nowa Nowa.

Annual Reports of the Cann Valley–Mallacoota district throughout these years contain little information on the location of logging operations, but provide estimates of its extent. Approximately 34,000 acres were logged in the years between 1936 and 1945.

To meet increased demand for construction timbers in the late 1930s the Forests Commission allocated new logging areas in the parishes of Jirrah, Kirkenong and Cabanandra. Commission officers marked the trees to be felled. Species were cut on an 'in the round' basis, and included Yellow Stringybark (for the Public Works Department), Silvertop (for local consumption), Messmate and Cut-tail. In 1941–42, though public building was at a standstill, there was record consumption of sawn timber in Victoria for 'war purposes' (Forests Commission Annual Report, 1941–42).

Silver Wattle was logged in the north of the region, beginning in parish of Dellicknora in 1940. The timber was used for defence purposes, principally the manufacture of cases. By 1942 a sustained demand for this timber was coming from Sydney and Canberra. Four mills were working to capacity on Silver Wattle in the Bendoc sub-district, and demand remained high until the last years of the war.

With the onset of the depression the Forests Commission established an Unemployed Relief Work program, setting teams of men to work in native forests and softwood plantations across the State. The gangs were generally limited to 25 men, ideally comprising two thirds from the city, and one third from the forest locality. An experienced forester or leading hand was appointed to supervise. Men from the city were given work for two months, while those from the country gained employment for one month. The men were housed in camps in the forests.

In 1930–31 alone, 5,295 unemployed men were deployed in Victorian forests (Forests Commission Annual Report, 1930–31). They were set to work on liberation and thinning (ringbarking) in native stands, establishing softwood plantations, and clearing fire breaks, fire lines and communication tracks.

In East Gippsland in the 1930s an extraordinary amount of silvicultural work was completed with the aid of the unemployed labour teams, particularly ringbarking in cut-over mixed hardwood forests. In the mid-1930s over 15,000 acres were ringbarked in the Orbost forest district, and 10,000 acres received similar treatment in Nowa Nowa. Ringbarking for silvicultural purposes should not be confused with the 'ringing' of forests on agricultural allotments. Similar methods were used but where the farmer's objective was to clear the forest for pasture or crops, the Commission was more selective, choosing to kill old cull trees in order to open up the forest and assist sapling growth. The teams worked in healthy regrowth stands of Red Ironbark, Gippsland Grey Box, Yellow and White Stringybark, Blue Gum, Mahogany Gum and Silvertop. Ringbarking was also used to reduce fire hazard trees.

Silvicultural work in forests declined in the war years, with labour shortages and a new emphasis on forest road building in the wake of the 1939 bushfires. Very restricted areas of reserved forest were subjected to thinning or liberation treatment in the decade of the 1940s.

Post-1945

Wildfires raged through the ash forests of the eastern highlands of Victoria in the summer of 1939, killing 71 people, including timber workers, and destroying 69 mills. In the aftermath of this devastation, a salvage operation was launched which lasted until the early 1950s. Judge L.E.B. Stretton chaired a Royal Commission into the fires. One outcome of his findings was the Forests Act of 1939, which extended the Commission's powers and responsibilities for fire protection beyond the borders of State forests and timber reserves, to include National Parks and land within one mile of these areas (Moulds, 1991).

After the loss of the ash forests policy makers endeavoured to introduce greater regulation of the timber industry in Victoria. Any illusion of a seemingly endless supply of timber in this State was now shattered. The post-war climate of reconstruction was an ideal time in which to plan more sustainable forest usage. The Commission was able to directly influence the location of timber extraction and sawmilling after this time, through the introduction of its log allocation system. Annual licences were granted to millers to remove specified volumes of timber from defined State forest areas.

In 1939 there were only 60 miles of passable forestry roads in reserved forest in East Gippsland. Historically this had restricted access into forests for timber extraction, and hampered fire fighting and prevention. Throughout the war years old sleeper tracks, mining and coach roads were opened up and improved to the extent of some 200 miles per year (McKinty, 1969). In the post-war period the road building program was bolstered by the greater availability of motor trucks, a burgeoning labour force and advances in earth moving equipment. More than 50 miles of entirely new forest roads in East Gippsland were completed annually until the mid-1950s. Sawmilling firms were also involved in the road building program. Their costs were accounted for in the equated royalty system introduced in 1950. The roading scheme was aligned to the Commission's log allocation policy and planned development of sawmilling centres.

In the same period sawmillers increasingly looked to East Gippsland for log allocations, and new logging areas were set aside in the years after 1945. The expansion of the timber industry in the region was assisted by the roading program, advances in motorised transport, lower costs and more efficient log-hauling (Legg, 1977). Demand for sawn timber in Victoria was stimulated by an accelerated immigration program and post-war building boom. Favourable restrictions on imports also encouraged medium and large sawmilling firms to update and expand.

New mills were established in East Gippsland on the fringes of logging areas and in small towns which had previously served the isolated farming communities. The conversion centres were provided with good roads, community facilities and eventually electric power to the mills. The new agglomeration of mills made good economic sense, though some uncontrolled growth of mills occurred where timber was cut from forests on private land (Legg, 1977). Sawmills were progressively established at Cabbage Tree, Buchan, Orbost, Bruthen, Club Terrace, Cann River, Waygara, Nowa Nowa, Bemm River, Gelantipy, Tostaree and Newmerella.

By the end of the decade in the Orbost district millers were taking logs from newly opened areas in the Murrungowar, Kuark, Curlip, West Bemm, Yerung and Waygara logging units. The situation was similar in Nowa Nowa, where loggers were working in the Stony Creek, Boggy Creek and Mundic Creek blocks, as well as in reserved forest in the parishes of Nowa Nowa, Colquhoun, Ninnie, Maneroo and Windarra. Orbost, Bruthen and Nowa Nowa were developing into major timber producing centres.

Development was slower to reach the Cann Valley–Mallacoota district, frustrated by labour and accommodation shortages, and poor forest access. The local timber industry was described in 1947 as 'practically non-existent', and transport was considered to be 'the major single limiting factor' to progress (Annual Report, 1946–

47). Log extraction was at the extreme end of the economic margin, but despite this millers began to show an interest in the region. By 1950 several mills were operating in private forests, and three more had applied for Crown land allocations.

Hewn timbers, piles and poles continued to be a source of revenue for the Commission in East Gippsland. Gippsland Grey Box areas in the Cann Valley district were closed to hewers in the late 1940s to allow for regeneration. The New Zealand Railways Department acceptance of Silvertop sleepers, together with a general increase in sleeper prices, rejuvenated the industry. Sleeper production in the Nowa Nowa district was healthy throughout the post-war years, when returned soldiers came back to the industry for the good financial returns. More than 130,000 sleepers were produced in the two years from 1947 to 1949 (Annual Reports, 1947–50).

Pole cutting for the State Electricity Commission and Public Works Department also bolstered the Commission's revenue in Nowa Nowa. The industry was little deterred by the Commission's introduction of a more rigid tree marking policy. To protect healthy regrowth stands, diseased, butt-scarred or otherwise unwanted trees were marked for felling. The Commission's intention was to eventually convert pole production forests to those more suited to mill logs.

In 1951 the Commission began to let contracts for felling in cut-over areas. It was recognised that forests would yield a further proportion of logs if previously rejected, or unsound, trees were felled. Contractors were paid on a piecework rate for all logs produced, on the basis of a sliding scale according to the girth of the tree at felling point. Growing and seed trees, marked by the forest overseer, were left untouched. Merchantable logs were sold to sawmillers at the stump, though some sawmillers also felled trees under this system (Shillinglaw, 1951).

In 1950 the Forests Commission introduced an 'equated royalty system' for hardwood logs, to assist with its program of sawmill decentralisation. The system was intended to place all millers in the State on an equal basis, including those operating at long distances from Melbourne. Royalty rates, for timber extracted from State forests, were fixed at levels which recognised the costs involved in placing a base grade of sawn timber on a specified market. The system accounted for factors such as log haulage costs to mills, sawn timber haulage costs to the rail, freight charges, grades of sawn timber output, recovery of sawn timber from log volume and internal roading costs. Log and sawn timber haulage costs were determined on the basis of a road haulage schedule adopted by the Commission.

Annual reports for the three forest districts show a steady increase in mill log output throughout the 1950s, with some variation due to initial labour and equipment shortages and an economic downturn in the early 1950s. The Bete Bolong logging unit was cut out by 1955, and accessible areas in the Bendoc sub-district were also heavily utilised. New allocations were granted in the Falls Creek and Martins Creek logging units. In Nowa Nowa in this period loggers were working in the coastal forests, foothill country north-west of Buchan and in messmate and ash forests west of Gelantipy. Box poles were again taken from the Nooinbee Reserve, and sawmills in Club Terrace were given Crown land allocations.

Sleeper extraction continued to bring revenue to the region, though hewers were increasingly employed as 'fallers' by the new mills. Swing-saws were introduced, and gradually replaced the old cutting methods. Sleeper production for the New South Wales and New Zealand railways was maintained in the Cann Valley–Mallacoota district. In Orbost in the 1960s sleepers were a significant forest output. Timbers were hewn in the Bendoc area for New South Wales.

Despite increasing Crown land allocations, sawmillers at Cann River were still heavily reliant on logs from private property at the beginning of the 1960s. Forest assessment lagged behind other districts in the region, though by 1964–65 units at Lower Bemm, Storey Creek, West Wingan, Thurra, Pyramid Creek, Mt Everard and east of the Genoa River were being logged. At this time in the Orbost district, loggers were working in the Errinundra forest and the Goongerah area, from where they were taking Shining Gum, Cut-tail, Messmate and Mountain Grey Gum timbers. A high demand for sawlogs in this district led to extra allocations for sawmillers, but they were directed into areas of low volume or poor quality logs. In Nowa Nowa there was also increased utilisation of cut-out forest areas, and a trend to logging in the north of the district. Log output was high in the Nunnett locality.

A technology boom accompanied the post-war development. As well as the introduction of motor trucks, bull-dozers replaced inefficient bullock teams, and chainsaws took over from cross-cut saws, allowing loggers to cut greater volumes of timber. In the period from 1950 to 1980 East Gippsland developed into the major supplier of hardwood logs in the State. Clearfelling replaced selective logging, and silvicultural procedures were aimed at regenerating a uniform crop. In 1974–75 the forests of the region produced 40% of the State's log output (Legg, 1977).

The post-war boom ended in the early 1970s, when the building industry entered a long period of instability, and a trend to increased use of concrete and metal for building purposes developed. Prices fluctuated and demand for native hardwoods fell. Pine plantations across the State began reaching maturity, and pine timber products entered the market. The advantages of logging commercial softwood plantations included high productivity and low extraction costs. The use of sawmilling residues in East Gippsland was another development of this period. Woodchip production for export from Eden in New South Wales began in the early 1970s, and continues today.

Since the mid-1950s the dominant trend in the native hardwood sawmilling industry in Australia has been a progressive decline in employment and the number of operating mills (Resource Assessment Commission, 1992). During the 1970s, many mills in East Gippsland amalgamated or were taken over and large log allocations were let against licences of three years duration.

Forest management in recent decades has undergone a major shift, from an emphasis on log production to one which recognises other forest values. The protection of flora and fauna, water catchments, historic places and the expansion of the National Parks system, have developed in response to community expectations.

A log allocation textual database, principally covering the period 1945 to 1970 (with some dates extending beyond this), has been created from non-current Forests Commission files on (selective) logging in East Gippsland. The data has been re-organised into current forest block and compartment format, with fuller descriptions of logging areas provided if available. Data on species logged and volumes of timber extracted have also been entered, where possible, though information across the EGFMA for this period is inconsistent. Some logging has been excluded due to inadequate or insufficient detail on allocated areas.

WOODPULP INDUSTRY

The first shipments of woodpulp arrived in Australia from Scandinavia in 1902–3, and were processed by Australian Paper Manufacturers at their Geelong mill. Within a few years scientists in Western Australia had devised a method to produce woodpulp from native eucalypt species and thereby ended Australia's dependence on expensive imported pulp.

An integrated pulp and paper mill was established in 1939 by Australian Paper

Manufacturers (APM) at Maryvale, on the Latrobe River in Gippsland. The Wood Pulp Agreement Act of 1936, enshrined in legislation an agreement between APM and the Forests Commission, to have access to Mountain Ash and mixed eucalypts in East Gippsland. The agreement provided that utilisation of wood pulp from State forests was in no way to hinder the output of saw logs and other forest products. APM was to receive waste timber only, including cull trees left after logging, heads of sawlog trees, and slash, off-cuts, sawmill waste and thinned trees (Moulds, 1991). The Act granted APM a 50 year lease and access to 223,000 hectares of State Forest (Sinclair, 1991). The Commission considered woodpulp manufacture to be the most important form of waste wood utilisation.

APM began operating in the Orbost forest district in 1937–38 (Annual Report, 1937–38).

Wattlebarking

Wattlebark stripping began in East Gippsland in the 1870s, in the Bairnsdale district and among stands on the Snowy River. J. Jackson opened a tannery in Bairnsdale and processed bark stripped from a range of acacia species, including golden, black and Silver Wattle. Blackwood was also used in the wattlebark industry in Gippsland. Settlers quickly learned of the natural tannins in many native acacias, and leather makers used them extensively. The bark was brewed and the liquor dehydrated to a fine powder, and then rolled into the hides. The preferred trees were usually six to seven years old, with trunks one foot in diameter. Stripping was carried out from September to May, and stripped trees eventually died.

The Lands Department issued licences for wattlebark stripping on unoccupied Crown land. There was little official supervision of the practice and strippers often destroyed immature wattle, including saplings of two to three inches across. Selectors also stripped wattle on their allotments to supplement incomes. Wattlebarking was an important local industry in Mallacoota for many years. A team of fifty strippers reputedly arrived in the district in about 1880, and stripped bark from Mallacoota through to Wangarabell. The bark was shipped out of the district from storage facilities at Gipsy Point.

The State Forest Department licensed strippers in the period up to 1919, with the official season lasting from 1 September to 1 March (Carver, n.d., vol. B). Wattle could also be removed from reserved forest grazing areas for the payment of a fee. The Forests Commission later granted allocations of Silver Wattle for barking purposes. Stripping was popular in the economically depressed 1930s throughout East Gippsland. Unemployed men stripped over 200 tons in the Nowa Nowa district in 1930–31 (Annual Report, 1930–31). So extensive was the practice in Cann Valley–Mallacoota that suitable trees were scarce by the middle of the 1930s, and the industry declined for a decade. Strippers were allowed onto abandoned selections in the Murrungowar district in the 1950s, where Silver Wattle had invaded blocks which had been ringbarked and cleared around the turn of the century.

Primary Sources

1 Former Department of Conservation and Environment: Forest Products Management Branch, Log Allocation records (microfiche), maps and records of Regional Offices, Drafting Services Section, former Forests Commission management and utilisation plans and files (various).

2 Public Records Office: Series 10568, 'Forest Commission Annual Reports' (includes reports of local districts), Series 7036 cancelled forest parish plans and Series 7037 cancelled forest county plans.

Appendix G
ASSIGNMENT OF DISTURBANCE LEVELS BASED ON DISTURBANCE TYPE, EVC, FOREST TYPE, GROWTH STAGE AND CROWN COVER

NOTES

The following table explains the assignment of a disturbance level to each stand of forest (and non-forest vegetation) based on disturbance type, growth-stage and crown cover, ecological vegetation class (EVC) and structural forest type. The rationale for each decision derives from discussion contained in Chapter 7 (Disturbances), Chapter 9 (Definitions) and Chapter 10 (Analysis). Footnotes to the table are listed below. It is important to note that in this analysis only the ecological effect of the disturbance has been taken into account, not the possible intangible effect.

1 Evidence of the effect of disturbances is available from three primary sources; the existing disturbance record, the aerial photo interpretation (both growth stage mapping and additional API notation mapping) and the vegetation class (EVC and forest type). In general the following principles have been adopted for the analysis. The growth stage (GS) and crown cover (CC) is considered to be the most reliable record. When these are unable to confirm or refute a disturbance, the disturbance record is accepted, but may be overridden by the ecological vegetation class. For example, the records may indicate selective-logging in a heathland vegetation class, an EVC which does not carry preferred species for selection logging. As the GS and CC cannot confirm or refute this disturbance, the ecological vegetation class mapping is assumed to be more accurate than the disturbance record, and a negligible disturbance (level 2u) is assigned.

2 Disturbance levels are discussed in Chapter 9 and listed below:

1	Undisturbed
2n	Negligible 'natural' disturbance
2u	Negligible 'un-natural' disturbance
3n	Significant 'natural' disturbance
3u	Significant 'un-natural' disturbance
3	Significant disturbance, type unknown
Unknown	Disturbance recorded, level unknown

3 Disturbance types are discussed in Chapter 7.

4 Crown cover projection classes and API notation classes are discussed in Chapter 4 and listed below; see GIS layer description (CNR, unpubl.) for API notation classes.

Crown cover		API notation classes	
0	none recorded	6	regeneration
1	< 10%	7	agricultural land
2	10 – 29%		
3	30 – 49%		
4	50 – 69%		
5	≥70%		

5 Ecological vegetation class (EVC) descriptions are given in Chapter 6 and Appendix E whilst forest types (FT) are described in Chapter 5 and Appendix C.

6 Table 4.1 in Chapter 4 lists all 32 growth stage combinations.

7 As clearfelling has only occurred since the late 1960s – early 1970s it is unlikely that growth stages will have reached the mature or senescing category following a clear felling event.

8 Analysis of disturbance levels has been undertaken in all ecological vegetation classes, including rainforest and non-forest EVCs, in order to determine the disturbance levels of the old-growth neighbourhood. This information will provide the basis for a 'naturalness' analysis of the old-growth neighbourhood which surrounds old-growth forest stands discussed in Chapter 11. In addition, the analysis of crown cover projection and growth stage mapping classes within non-forest EVCs has been done in the exceptional instances where a forested overstorey (usually of eucalypts) has occurred within a generally non-forest vegetation class.

9 Due to the antiquity of the agricultural clearing records (back to the 1860s) a growth stage label of mature dominance in forested Jacobs EVCs indicates a disturbance when assessed in conjunction with the agricultural clearing record. In such cases agricultural clearance is deemed to have occurred and such areas are assigned a significant un-natural (3u) disturbance level. For more advanced age classes (S_{1-6}, M_{1-2}) a low crown cover density (1, 2, 3) may indicate agricultural clearing where little regeneration has occurred. In such cases a significant disturbance level (3u) was assigned.

10 Although mining records indicate only the point location of mines, associated disturbances would have affected a larger area. The analysis therefore included an arbitrary zone of disturbance of 500 m around reef mines and 100 m either side of streams within 500 m of alluvial mine records.

11 The majority of the study area has been grazed at some time over the last 150 years. The effects of grazing are variable. The magnitude of the effects are dependent upon the stock involved, stocking rates, grazing frequencies, the associated management of the grazed area (particularly the burning practices), the time since grazing ceased and the EVC involved. Information is scant with regard to grazing stock involved, stocking rates and grazing frequencies, but more

specific for the duration of the lease, the time since grazing ceased, the ecological vegetation classes involved and the burning practices of graziers.

Weed invasion and burning practices associated with grazing are assumed to constitute a significant disturbance to forests, however the effects of grazing are assumed to have diminished if grazing ceased prior to 1960 (approximately 30 years ago) for those forested grassy, non-gum-barked EVCs which grow at medium to low site quality localities. Such areas have no API evidence of disturbance and are considered to have a negligible un-natural disturbance level in the old-growth context. Similarly, unpalatable vegetation classes even with current grazing leases, are considered to be negligibly disturbed (level 2u).

12 Frequent burning was used by graziers to promote 'green pick', and will have altered EVCs with an overstorey which includes gum-barked species. Repeated burning increases the structural damage to the base of these trees which are less fire resistant than non gum-barked eucalypts. Veteran individuals that may have had scarring due to natural fires in the past would have been especially vulnerable to this process. The net effect is likely to be the development of a younger age class structure for the overstorey. The absence of a senescing dominated growth stage in conjunction with an ecological vegetation class that is susceptible to burning which is associated with a grazing lease record indicates a significant disturbance has occurred.

13 The effect of grazing has been researched in Rainshadow Woodland. The unique combination of soil structure associated with domestic stock and rabbit grazing, altered fire regimes, climate and vulnerability of plant species involved, has led to severe degradation of this vegetation class. The degradation includes loss of old-growth trees (especially *Callitris* spp.) and severe gully and sheet erosion (Pulsford *et al.* in press). For these reasons the Rainshadow Woodland as a whole has been assigned a significant un-natural disturbance level where a grazing lease is recorded.

14 Due to the antiquity of the grazing records (back to 1875) a growth stage label without senescing at least sub-dominant may indicate a disturbance associated with grazier burning when assessed in conjunction with a grazing lease record. Only senescing dominated areas are considered to be unaffected under this disturbance type.

15 Unpalatable EVCs are considered negligibly disturbed by stock (even when grazing lease is current) because they provide little or no sustenance.

16 Selective logging records data back to the 1940s. Because selective logging at low levels can be difficult to detect using API, selective logging records are assigned a disturbance class of 3u where the crown cover is low (≤3) even where there is no detectable growth stage alteration. In such instances the thinning of the stand due to selective logging is assumed to have occurred without any regrowth developing.

17 Where the EVC has no merchantable species and the vegetation classes have a naturally low crown cover, a selective logging event is unlikely. These records were given a negligible disturbance (level 2u).

18 More detailed analyses of the effects of wildfire should be possible by developing rules which seek to explain the specific effect of wildfires on each EVC and forest type. In particular, the rate (or time) of recovery of structural and floristic attributes following a wildfire of known intensity for given vegetation classes could be used to more accurately assign a distribution level.

19 Fuel reduction burning has significant effects on the structure and floristics of forests because of their frequency, intensity, and the time of year they started. Well documented effects include reduction in habitat diversity (Catling, 1991) and poorer nesting success of native birds (Recher, 1991). However, existing records only indicate the frequency and perimeter of the burn, not the actual intensity or total area burnt. Because the records do not indicate the area burnt within the fuel reduced area, frequency data is not accurate. As a result, generalised assumptions about the effect of fuel reduction burning have been made; although frequent fuel reduction burning can degrade old-growth forest values, inadequacies with the data mean that only a negligible un-natural disturbance level (2u) can be assigned at this stage of our understanding.

Those EVCs which are considered to be less flammable (generally the wetter communities) are considered to be unaffected, while the more flammable ecological vegetation classes (generally the drier and grassier communities) are considered to be negligibly affected.

GIS ANALYSIS STAGES USED TO DERIVE OLD-GROWTH FOREST

Coverage required — composite coverage containing all disturbance types, vegetation communities, crown cover and growth stages, and land use.

Stage 1 Remove all private land, water bodies (except where assigned an EVC) and inlets. Assign code.

Stage 2 Assign disturbance level, using Table in Appendix G.

Stage 3 Remove all non-forest EVCs and rainforest (see Table 6.2 for description of EVCs).

Stage 4 Remove all public land growth stage polygons with a crown cover less than 10%. Indicate as NON-FOREST.

Stage 5 Re-examine private land and assign disturbance level of 3u (significant un-natural) to all freehold land.*

Stage 6 All Jacobs and remaining non-Jacob's EVCs (see Table 6.2) with a growth stage of S_{1-6}, M_{1-2} (see Table 4.5) and a disturbance level of 1, 2n, 2u (undisturbed and negligibly disturbed) are OLD-GROWTH.

* All forest on freehold land is considered to be significantly disturbed due to the inadequacy of existing records and the potential for repeated selective logging, grazing and agricultural clearing.

Stage 7 All remaining non-Jacobs forested EVCs with a growth stage of S_{1-6}, M_{1-2} and M_{3-4}/M_{9-10} (where the forest type (FT) is S_5/S_V, S_4/S_{1V}, Y, P4, 5c, 5d, 1, 6, Ac, B, Ca, O, Po, Rh, W) and a disturbance level of undisturbed or negligibly disturbed (1, 2n, 2u) are OLD-GROWTH FOREST†.

Stage 8 All remaining forested EVCs with a disturbance level of ≤2 are NEGLIGIBLY DISTURBED FOREST.

Stage 9 All remaining forested EVCs with disturbance levels of 3, 3n and 3u. All forest with regrowth dominated growth stages (S_{7-8}, M_{5-11} and R_{1-13}) will be assigned as SIGNIFICANTLY DISTURBED FOREST.

† In non-Jacobs forested ecological vegetation classes, the oldest mapped growth stages that were negigibly disturbed were senescing growth stages, despite being mapped initially as mature. This decision accommodates the inability of the aerial photo interpreter to actually see, or map, the senescing component. Therefore non-Jacobs stands M_3 and M_9 become S_1, and M_4 and M_{10} become S_4.

Appendix G:1

Disturbance Type[3]	Criteria for Selection[1]: Crown Cover Projection Classes[4]	Criteria for Selection[1]: Ecological Vegetation Class (EVC)/Forest Type (FT)[5]	Criteria for Selection[1]: Growth Stage[6] (GS)	Comment	Disturbance Level[2]
All water bodies	Not a relevant selection criterion	Not a relevant selection criterion	Not a relevant selection criterion	Water bodies such as lakes, inlets, rivers and wetlands are considered to be on the whole negligibly disturbed within the study area	1
All private land excluding water bodies	Not a relevant selection criterion	Not a relevant selection criterion	Not a relevant selection criterion	Inadequate disturbance information exists for private land, but there is a high likelihood of significant disturbances.	3a
Clearfelling[7]	All classes 1–5	All forested EVCs: 1–4, 14–18, 20–30, 35–43	S_{1-6}, M_{1-4}, M_{9-10}	Clearfelling indicated by records. Growth stage (GS) mapping from 1990 does not indicate a disturbance has occurred due to the advanced age of growth stages. GS more accurate than Clearfelling records pre 1990. Negligible disturbance indicated.	2a
	All classes 1–7	All forested EVCs: 1–4, 14–18, 20–30, 35–43	S_{7-8}, M_{5-8}, M_{11}, R_{1-13}	Clearfelling is indicated by records. GS indicates a disturbance has occurred due to the presence of regrowth. Area photo interpretation (API) also indicates a disturbance has occurred (see GIS layer description, unpubl. for crown cover classes 6 and 7).	3a
	All Classes 1–5	Rainforest EVCs:[8] 31–34 Non-forest EVCs:[8] 5–13, 19, 44	S_{1-6}, M_{1-4}, M_{9-10}	Clearfelling is indicated by records. GS does not indicate a disturbance has occurred due to ages of growth stages.	2a
	All classes 1–5	Rainforest EVCs: 31–34 Non-forest EVCs: 5–13, 44	S_{7-8}, M_{5-8}, M_{11}, R_{1-13}	Clearfelling indicated by records. GS indicates a disturbance has occurred due to the presence of regrowth. API notation indicates a disturbance.	3a
	All classes 1–7	All forested EVCs: 1–4, 14–18, 20–30, 35–43	All growth stages	All clear felling records from 1990 onwards will be more up-to-date than GS mapping. Significant disturbance indicated.	3a
Agricultural clearing[9]	4, 5	Forested non-Jacobs EVCs: 1–2, 14, 17, 20, 21, 24, 26–28, 40–42 where FT is: S_3/Sv, S_4/Siv, Y, Pa, 5c, 5d, 1, 6, Ac, B, Ca, O, Pn, Rb, W	S_{1-6}, M_{1-4}, M_{9-10}	An agricultural selection is delineated and clearing is recorded. GS evidence indicates no disturbance has occurred.	2a
	4, 5	Forested Non-Jacobs EVCs: 1–2, 14, 17, 20–21, 24, 26–28, 40–42 where FT is: S_3/Sv, S_4/Siv, Y, Pa, 5c, 5d, 1, 6, Ac, B, Ca, O, Pn, Rb, W	S_{7-8}, M_{5-8}, M_{11}, R_{1-3}	An agricultural selection is delineated and clearing is recorded. GS evidence indicates a disturbance has occurred.	3a

Appendix G:2

Disturbance Type[3]	Criteria for Selection[2]			Comment	Disturbance Level[1]
	Crown Cover Projection Classes[4]	Ecological Vegetation Class (EVC)/Forest Type (FT)[5]	Growth Stage[6] (GS)		
Agricultural clearing[9] (continued)	4, 5	Forested Jacobs EVCs: 3–4, 15–16, 18, 22–23, 25, 29–30, 35–39, 43 where FT is: 2a, 2b, 3a, 3b, 4a, 4b, 5a, 5b, A, B, As, F, M_1, M_2, M_3, Ni, P_3, Rb3, S_3, Sng, Wb; and Forested Non-Jacobs EVCs: 1–2, 14, 17, 20–21, 24, 27–28, 40–42 where FT is: 2a, 2b, 3a, 3b, 4a, 4b, 5a, 5b, A, B, As, F, M_1, M_2, M_3, Ni, P_3, Rb_3, S_3, SnG, Wb	S_{1-6}, M_{1-2}	An agricultural selection is delineated and clearing is recorded. GS evidence indicates no disturbance has occurred.	2a
	4, 5	Forested Jacobs EVCs: 3–4, 15–16, 18, 22–23, 25, 29–30, 35–39, 43 where FT is: 2a, 2b, 3a, 3b, 4a, 4b, 5a, 5b, A, B, As, F, M_1, M_2, M_3, Ni, P_3, Rb3, S_3, Sng, Wb; and Forested Non-Jacobs EVCs: 1–2, 14, 17, 20–21, 24, 27–28, 40–42 where FT is: 2a, 2b, 3a, 3b, 4a, 4b, 5a, 5b, A, B, As, F, M_1, M_2, M_3, Ni, P_3, Rb3, S_3, SnG, Wb	S_{7-8}, M_{3-11}, R_{1-13}	An agricultural selection is delineated and clearing is recorded. GS evidence indicates a disturbance has occurred.	3a
	1, 2, 3	All forested EVCs: 1–4, 14–18, 20–30, 35–43	Not a relevant selection criterion	An agricultural selection is delineated and clearing is recorded. API crown cover evidence indicates a disturbance has occurred.	3a
	All classes 1–5	Rainforest EVCs: 31–34 Non-forest EVCs: 5–13, 19, 44	S_{1-6}, M_{1-2}	Agricultural selection is delineated and clearing is recorded. GS does not indicate disturbance has occurred.	2a
	All classes 1–7	Rainforest EVCs: 31–34 Non-forest EVCs: 5–13, 19, 44	S_{7-8}, M_{1-11}, R_{1-13}	Agricultural selection is delineated and clearing is recorded. GS indicates disturbance has occurred as does API notation.	3a
	None recorded	Rainforest EVCs: 31–34 Non forest EVCs: 5–13, 19, 44	None recorded	Agricultural selection is delineated and clearing is recorded. No API mapping is available.	3a
Mining[10]	Not a relevant selection criterion	Not a relevant selection criterion	Not a relevant selection criterion	Mining recorded. Likely severe localised impacts on native vegetation and its structure.	3a
Grazing[11]	Classes 1–5	Jacobs EVCs with gum-barked[12] species: 18, 23, 25, 36–37, 43	S_{1-6}, M_{1-2}	Grazing lease ceased prior to 1960. GS evidence indicates no disturbance has occurred.	2a
	All classes 1–7	Jacobs EVCs with gum-barked[12] species: 18, 23, 25, 36–37, 43	S_{7-8}, M_{3-11}, R_{1-13}	Grazing lease recorded. Irrespective of date of cessation of lease, GS evidence indicates disturbance has occurred. API notation also indicates a disturbance.	3a

Disturbance Type[3]	Criteria for Selection[3]			Comment	Disturbance Level[2]
	Crown Cover Projection Classes[4]	Ecological Vegetation Class (EVC)/Forest Type (FT)[3]	Growth Stage[5] (GS)		
Grazing[11] (continued)	Classes 1–5	Jacobs grassy EVCs generally without gum-barked species: 3, 15, 22, 38	S_{1-4}, M_{1-2}	Grazing leases ceased prior to 1960. GS evidence indicates no disturbance has occurred.	2a
	All classes 1–7	Jacobs grassy EVCs generally without gum-barked species: 3, 15, 22, 38	S_{1-4}, M_{3-11}, R_{1-11}	Grazing leases ceased prior to 1960;however GS evidence shows disturbance has occurred, as does API evidence.	3a
	All classes 1–7	Non-Jacobs gum-barked or grassy EVCs: 40	Not a relevant selection criterion	Grazing leases recorded. EVC strongly favoured for grazing.	3a
	Not a relevant selection criterion	Gum-barked EVCs: 18, 23, 25, 36–37, 43; and grassy non-gum-barked EVCs: 3, 15, 22, 26	Not a relevant selection criterion	Grazing lease recorded post 1960 or is still current, structure and floristics degraded by grazing and associated burning practices.	3a
	Not a relevant selection criterion	EVC: 26	Not a relevant selection criterion	Grazing lease recorded. Degradation is likely from grazing and burning in this EVC.	3a
	Classes 1–5	EVC: 26	S_{1-4}, M_{1-4}, M_{9-10}	No grazing lease recorded, but certainly grazed by rabbits	2a
	Classes 1–5	Rainforest EVCs: 31–34	S_{1-4},M_{1-2}	Grazing lease ceased prior to 1960. GS indicates no evidence of disturbance.	2a
	None recorded	Rainforest EVCs: 31–34	None recorded	Grazing lease recorded. No GS mapping available.	3a
	Not a relevant selection criterion	Non-forest[8] EVCs: 5–13	Not a relevant selection criterion	Grazing lease ceased prior to 1960. Structure and floristics capable of recovery since the cessation of the lease.	2a
	Not a relevant selection criterion	Palatable non-forest[8] EVCs: 7, 9–13, 19	Not a relevant selection criterion	Grazing lease recorded post 1960 or, still current.	3a
	Not a relevant selection criterion	Unpalatable forested[15] EVCs: 1–2, 4, 14, 16–17, 20–21, 24, 27–35, 39, 41, 42; and Un-palatable non-forest[8] EVCs: 5–6, 8	Not a relevant selection criterion	Grazing lease recorded, still current.	2a
	Not a relevant selection criterion	Palatable EVCs: 3, 7, 9–13, 15, 18–19, 22–23, 25, 36–38, 40, 43–44	Not a relevant selection criterion	Grazing lease post-dates 1960 or is still current. Floristic changes are likely as a result at grazing.	3a
	Not a relevant selection criterion	Non-forested EVC: 44	Not a relevant selection criterion	Grazing lease recorded. Structure and floristics severely degraded irrespective of data of cessation of lease.	3a
Dieback	Not a relevant selection criterion	All EVCs: 1–44	Not a relevant selection criterion	Cinnamon Fungus dieback recorded from API completed in 1973.	3a

Appendix G:4

Disturbance Type[3]	Criteria for Selection[1]			Comment	Disturbance Level[2]
	Crown Cover Projection Classes[4]	Ecological Vegetation Class (EVC)/Forest Type (FT)[5]	Growth Stage[6] (GS)		
Selective Logging[16,17]	All classes 1–5	Forested EVCs with no merchantable species16: 1–4, 17, 28, 42	Not a relevant selection criterion	Selective logging is recorded within the forest compartment but these EVCs are not known to have been selectively logged.	2u
	All classes 1–5	Forested Non-Jacobs EVCs that are potentially durable species: 14, 20–21, 24, 26–27, 40–41, where FT is: S_3/S_V, S_4/S_{EV}, Y, P_4, 5c, 5d, 1, 6, Ac, B, Ca, O, Po, Rh, W	Not a relevant selection criterion	Selective logging is recorded within the forest compartment. Because of their low stature and poor form (indicated by the forest types) these EVCs are not known to be selectively logged.	2u
	Classes 4, 5	Forested Jacobs EVCs with merchantable species: 15–16, 18, 22–23, 25, 29–30, 35–39, 43 where FT is: 2a, 2b, 3a, 3b, 4a, 4b, 5a, 5b, A, B, As, F, M_1, M_2, M_3, Ni, P_3, Rb3, S_3, SnG, Wb; and Non-Jacobs forested EVCs with merchantable species: 14, 20–21, 24, 27, 40–41 where FT is: 2a, 2b, 3a, 3b, 4a, 4b, 5a, 5b, A, B, As, F, M_1, M_2, M_3, Ni, P_3, Rb3, S_3, SnG, Wb.	S_{1-6}, M_{1-2}	Selective logging is recorded within the forest compartment. GS and dense crown cover indicates no disturbance has occurred.	2u
	Classes 1–5	Forested Jacobs EVCs with merchantable species: 15–16, 18, 22–23, 25, 29–30, 35–39, 43 where FT is: 2a, 2b, 3a, 3b, 4a, 4b, 5a, 5b, A, B, As, F, M_1, M_2, M_3, Ni, P3, Rb3, S3, SnG, Wb; and Non-Jacobs forested EVCs with merchantable species: 14, 20–21, 24, 27, 40–41 where FT is: 2a, 2b, 3a, 3b, 4a, 4b, 5a, 5b, A, B, As, F, M_1, M_2, M_3, Ni, P3, Rb3, S3, SnG, Wb.	S_{7-8}, M_{3-11}, R_{1-13}	Selective logging is recorded within the forest compartment. GS evidence indicates disturbance has occurred.	3u

Appendix G:5

Disturbance Type[3]	Criteria for Selection[1]			Comment	Disturbance Level[2]
	Crown Cover Projection Classes[4]	Ecological Vegetation Class (EVC)/Forest Type (FT)[5]	Growth Stage[6] (GS)		
Selective[16,17] Logging (continued)	Classes 1, 2, 3	Forested Jacobs EVCs with merchantable species: 15–16, 18, 22–23, 25, 29–30, 35–39, 43 where FT is: 2a, 2b, 3a, 3b, 4a, 4b, 5a, 5b, A, B, As, F, M1, M2, M3, Ni, P3, Rb3, S3, SaG, Wb; and Non-Jacobs forested EVCs with merchantable species: 14, 20–21, 24, 27, 40–41 where FT is: 2a, 2b, 3a, 3b, 4a, 4b, 5a, 5b, A, B, As, F, M1, M2, M3, Ni, P3, Rb3, S3, SaG, Wb.	S_{1-6}, M_{1-2}	Selective logging is recorded within the forest compartment. Low crown cover density indicates disturbance may have occurred.	3u
	Classes 1–5	Rainforest EVCs: 31–34	S_{1-6}, M_{1-2}	Selective logging is indicated for the forest compartment. GS does not indicate disturbance.	2u
	All classes 1–7	Rainforest EVCs: 31–34	S_{7-8}, M_{3-11}, R_{1-13}	Selective logging is indicated for the forest compartment. GS indicates a disturbance has occurred as does API notation.	3u
	All classes 1–7	Rainforest EVCs: 31–34	None recorded	Selective logging is recorded for the forest compartment. No GS is available, but API notation indicates a disturbance.	3u
	All classes 1–7	Non-forest EVCs: 5–13, 19, 44	None recorded	Selective logging is indicated for the forest compartment but is not known for these vegetation classes.	2u
Wildfire[18]	Classes 1–5	Forested EVCs: 1–4, 14–18, 20–30, 35–43	S_{1-6}, M_{1-6}, M_{9-10}	Wildfire is recorded. GS indicates no disturbance at the canopy level. This may mean that no wildfire has occurred at this locality or that wildfire has caused only negligible disturbance to the understorey.	2n
	All classes 1–7	Forested EVCs: 1–4, 14–18, 20–30, 35–43	S_{7-8}, M_{3-8}, M_{11-}, R_{1-13}	Wildfire is recorded. GS indicates a disturbance has occurred.	3n
	Classes 1–5	Rainforest EVCs: 31–34	S_{1-6}, M_{1-6}, M_{9-10}	Wildfire is recorded. GS indicates no disturbance has occurred.	2n
	All classes 1–7	Rainforest EVCs: 31–34	S_{7-8}, M_{3-8}, M_{11-}, R_{1-13}	Wildfire is recorded. GS indicates disturbance has occurred.	3n
	Not a relevant selection criterion	Rainforest EVCs: 31–34	Not recorded	Wildfire is recorded. Because of the sensitivity of rainforest to fire disturbance, significant disturbance is assumed even in the absence of eucalypt regeneration.	3n
	Not a relevant selection criterion	Non forest EVCs: 5–8, 10–13, 19	Not recorded	Wildfire is recorded. There is no GS verification available and these vegetation classes have short recovery periods following wildfire.	2n
	Not a relevant selection criterion	Non forest EVCs: 9, 44	Not recorded	Wildfire is recorded. There is no GS verification available, but these vegetation classes take a long time to recover from fire.	3n

Appendix G:6

Disturbance Type[3]	Criteria for Selection[1]: Crown Cover Projection Classes[4]	Criteria for Selection[1]: Ecological Vegetation Class (EVC)/Forest Type (FT)[5]	Criteria for Selection[1]: Growth Stage[6] (GS)	Comment	Disturbance Level[2]
	Not a relevant selection criterion	All EVCs: 1–44	Not a relevant selection criterion	Wildfire was recorded from API during this project. Wildfire was the only disturbance recorded. All API classes (with significance levels 2 and 6 — see CNR's GIS layer descriptions 1993 [unpubl.]) indicate a measurable wildfire effect in the canopy.	3n
Fuel Reduction Burning[19]	Not a relevant selection criterion	Less flammable EVCs: 9–10, 18, 30–33, 39	Not a relevant selection criterion	One or more fuel reduction burns are recorded for the grid. Because these ecological vegetation classes are wet these sites are unlikely to have been burnt.	1
	Not a relevant selection criterion	More flammable EVCs: 1–8, 11–17, 19–29, 36–38, 40–44	Not a relevant selection criterion	One or more fuel reduction burns are recorded for the grid. These ecological vegetation classes are more flammable but current records are not sufficient to indicate a significant disturbance.	2u
Public land; no record of disturbance	Not a relevant selection criterion	All forested EVCs: 1–4, 14–18, 20–30, 35–43 and rainforest EVCs: 31–34	S_{7-8}, M_{5-11}, R_{1-13}	Significant disturbance implied by GS mapping due to presence of regrowth. No disturbance record available to assign cause for the regrowth and regeneration observed.	3
Public land; record of disturbance	Not a relevant selection criterion	All forested EVCs: 1–4, 14–18, 20–30, 35–43 and rainforest EVCs: 31–34	None recorded	No GS mapping and therefore insufficient evidence to determine the level of disturbance	Unknown
Public land; record of disturbance	Not a relevant selection criterion	All forested EVCs: 1–4, 14–18, 20–30, 35–43 and rainforest EVCs: 31–34	S_{7-8}, M_{5-11}, R_{1-13}	A disturbance record is available and is considered to be significant.	3u
	Class 6	All forested EVCs: 1–4, 14–18, 20–30, 35–43 and rainforest EVCs: 31–34	None recorded	An un-natural disturbance record exists. Crown Cover class 6 indicates regeneration.	3u
Public land; no record of disturbance	Not a relevant selection criterion	All forested EVCs not already assigned a disturbance level: 1–4, 14–18, 20–30, 35–43, and rainforest EVCs: 31–34	S_{1-6}, M_{1-4}, M_{9-10}	Older growth stages imply no disturbance and no disturbance record is available.	1
Public land; no record of disturbance	Not a relevant selection criterion	Rainforest EVCs: 31–34 and non-forest EVCs: 5–13, 19, 44 with no record of disturbance	Not a relevant selection criterion	No disturbance recorded	1

Appendix H

LITERATURE REVIEW OF ATTRIBUTES OF OLD-GROWTH FOREST FOR FAUNA IN EAST GIPPSLAND

SECONDARY ATTRIBUTES OF OLD-GROWTH FORESTS

There are many secondary attributes of old-growth forests which influence faunal distribution and abundance. They are valuable descriptors because old-growth-dependent fauna rely on them to a greater or lesser degree to complete their life cycles. The presence, configuration and development of these secondary attributes is correlated with the ecological vegetation class involved. As a consequence these secondary attributes enable zoologists to assess the habitat suitability of specific old-growth forests for particular species.

All of the attributes listed are more common in older forests than in younger forests of the same vegetation type. As a result, such old-growth-dependent fauna are more common in old-growth forest, although to date no species in East Gippsland are known to be entirely restricted to them. Secondary attributes can be grouped into broad categories and some examples are given in the following discussion.

Structural attributes

Include: uneven height of overstorey canopy trees of old age, large canopy gaps, large sub-canopy gaps, abundance of advanced (large) hollows, large surface areas of decorticating bark, multiple strata, high level of strata development, relatively advanced understorey age and closure, abundant and diverse vascular and non-vascular epiphyte development, large numbers of fallen logs (on forest floor and in streams), large stags (above and below the canopy), and deep leaf litter.

Biotic attributes

Include: high nectar, pollen and exudate flows, high plant species diversity in some communities, high diversity and densities of many fauna species, species or faunal guilds mostly restricted to old-growth forests (indicator species), soil biota active for long periods and very old fire disclimax plant communities such as Damp or Wet Forest8 that develop into climax communities such as Warm or Cool Temperate Rainforests.

Ecological attributes

Include: very well developed nutrient cycling, complex trophic (food web) development and stable or negative rates of biomass accumulation.

Edaphic attributes

Include: relatively uniform stream flows, higher water yields released more gradually, dry season stream flows, stable humidity regimes, reliable soil moisture and high soil fertility as a result of tight nutrient cycling.

CURRENT KNOWLEDGE

From current knowledge it is increasingly evident that there is a high correlation between the abundance of old-growth dependent vertebrates and certain secondary attributes of old-growth forests (Milledge *et al.* 1991, Traill 1991, Dickman 1991, Scotts 1991, Catling 1991). The relative diversity and abundance of invertebrate fauna with respect to old-growth forests even at a general level is poorly understood in Australia. Overseas, where research is more advanced, links between invertebrate diversity and abundance and old-growth forests are well established (Franklin *et al.* 1981, Odum 1971, Cornaby and Waide 1973, Silvester *et al.* 1982, Harris 1984, Sollins *et al.* 1987). There is evidence emerging in Australia which suggests that these factors are also strongly associated with old-growth forest (Scotts and Seebeck 1989, Dickman 1991).

Invariably the secondary attributes upon which many species rely are more commonly associated with older forests than regrowth forests. Those species most at risk from the loss of old-growth forests are those dependent on particular secondary attributes that are most common in old-growth forests. Jenkins and Recher (1990) give a lucid summary of the importance of these secondary attributes to old-growth dependent fauna, including the following species which occur in the study area:

1 Wide ranging species that are either dependent on multiple food sources or on particular food sources which are patchily distributed over a wide area. Examples include Rainbow Lorikeets *Trichoglossus haematodus* which require nectar from large areas of old banksias (Emison *et al.* 1987), Glossy Black Cockatoos *Calyptorhynchus lathami* which eat the seeds of casuarinas, and Yellow-tailed Black Cockatoos *C. funereus* which require the seed of proteaceous shrubs and trees as well as wood boring grubs (Emison *et al.* 1987) which attack mature or senescing trees such as pomaderris and wattles.

2 Rare species, endangered species and species of special concern with small populations and slow rates of population increase. An example is Glossy Black Cockatoos *Calyptorhynchus lathami*.

3 Predators at the top of food webs. Examples include the Powerful Owl *Ninox strenua*, Sooty Owl *Tyto tenebricosa*, Masked Owl *T. novaehollandiae* and Square-tailed Kite *Lophoictinia isura*.

4 Species which are central place foragers. Examples include Yellow-bellied Gliders *Petaurus australis*, breeding pairs of Powerful Owls *Ninox strenua*, Barking Owls *N. connivens* and Grey Goshawks *Accipter novaehollandiae* (Emison *et al.* 1987).

5 Species whose (wider) habitats are altered by disturbances like clearfell or selective logging, such that critical food or habitat resources are significantly reduced or removed. Examples include Musk Lorikeets *Glossopsitta concinna* and old trees of Red Ironbark *Eucalyptus tricarpa* (Emison *et al.* 1987). Other examples of critical food sources or structural components and their dependent species are:
   - a critical food source upon which a rare species is dependent. Examples include loss of hollow dependent prey items (large gliders and possums) which are the staple diet of the Powerful Owl *Ninox strenua*, and the loss of old Drooping Sheoke *Allocasuarina verticillata* from coastal forests, upon which the Glossy Black Cockatoo *Calyptorhynchus lathami* depends (Emison *et al.* (1987).

- a food source which is a critical component of the food web of a number of species. Mistletoes are the prime example for coastal, lowland and foothill old-growth forests within East Gippsland (Cherry pers comm., Turner 1991).
- a structural component of habitat which is crucial as a refuge from predators and the elements. Examples include hollows and fallen logs.
- a structural component of habitat which is crucial for reproduction (courtship, nesting or breeding). Examples include hollows, dead wood, nest camouflage material, and decorticating bark for many mammal and bird species.

Some of the known links between secondary attributes of old-growth forests of the study area fauna are described in the following section. They are compiled from a variety of sources including Atlas of Victorian Wildlife, ABRG (1985), Smith (1985c) cited in Scotts (1991), Loyn (1985b) cited in Scotts (1991), Lunney (1991) and a summary of old-growth dependent fauna occurring in East Gippsland (Duncan and Peel unpubl.) which was sourced from the Ecological Survey Report Series (Department of Conservation and Natural Resources). Species specific information has been included when it is relevant to observations and data from the study area, and where information quoted in the literature is only available to the level of genus.

IMPORTANT OLD-GROWTH CHARACTERISTICS FOR VERTEBRATES IN THE STUDY AREA

Canopy heterogeneity

This feature of old multi-aged forest and old-growth forest provides important open canopy feeding areas for birds that rely on hawking for their prey items. It also gives a heterogeneous canopy which provides abundant foraging opportunities for canopy foraging insectivores (Scotts 1991). Examples include:

- LARGE CANOPY GAPS: Satin Flycatcher *Myiagra cyanoleuca*, Leaden Flycatcher *M. rubecula* and Black-faced Monarch *Monarchia melanopsis*.
- HETEROGENEOUS CANOPY SURFACE: White-bellied Cuckoo-shrike *Coracina papuensis* and Cicadabird *C. tenuirostris*.

Nectar yields, exudate flows, fruits and mistletoe

The rate of flowering and nectar or exudate flows are low in eucalypts which are in the rapid regrowth and early mature growth stages. Once they attain the quiescent senescing growth stages (as defined by this study) where biomass accumulation slows or becomes negative, nectar and exudate flows increase. Animal species dependent on such food resources are therefore most abundant in these forests. Mistletoe densities increase on older trees (Emison *et al.* 1987) and so the abundance of species reliant on the nectar and the fruit of these plants is enhanced. Mistletoes are an important foraging site for many species (Loyn 1985a, Recher 1991). Examples include:

- HIGH NECTAR AND EXUDATE FLOWS: Yellow-bellied Glider *Petaurus australis*, Crescent Honeyeater *Phylidonyris pyrrhoptera*, Lewin's Honeyeater *Meliphaga lewinii* and Regent Honeyeater *Xanthomyza phyrigia*, old-growth banksias and Rainbow Lorikeet *Trichoglossus haematodus*, old-growth Red Ironbark *Eucalyptus tricarpa* and Musk Lorikeets *Glossopsitta concinna*.
- NECTAR AND FRUIT OF MISTLETOES: Crescent Honeyeater *Phylidonyris pyrrhoptera*, Lewin's Honeyeater *Meliphaga lewinii*, Mistletoebird *Dicaeum hirundinaceum*, Silvereye *Zosterops lateralis* and the Regent Honeyeater *Xanthomyza phrygia* and Red Wattlebird *Anthochaera carunculata*.

- MISTLETOE AS A FORAGING SUBSTRATE: Thornbills *Acanthiza* spp.
- FRUITS: Wonga Pigeon *Leucosarcia melanoleuca*, Lewin's Honeyeater *Meliphaga lewinii*, Red Wattlebird *Anthochaera carunculata*, Olive-backed Oriole *Oriolus sagittatus* and Mountain Brushtail Possum *Trichosurus caninus*.

Hollows

The necessity of hollows for the completion of the life cycles of many species has long been recognised (Tyndale-Biscoe and Calaby 1975, Richards (Chapter 5) in Lunney 1991, and Smith and Lindenmayer 1988, Lindenmayer *et al.* 1990a, b, c cited in Scotts 1991). Hollows may take at least 100 years to develop (Jacobs 1955) and can take 300–400 years for some species (Mackowski 1984, Inions, Tanton and Davey 1989 cited in Scotts 1991). Examples include:

- species requiring larger nest hollows include Sooty Owl *Tyto tenebricosa* (Schodde and Mason 1980 in Scotts 1990), Yellow-tailed Black Cockatoo *Calyptorhynchus funereus* (Foreshaw 1969 cited in Scotts 1990), roosting or maternity colonies (or both) of some forest bats (Richards 1991; Lunney *et al.* 1988 cited in Scotts 1991) and Yellow-bellied Glider *Petaurus australis* (Henry and Craig 1984, cited in Scotts 1991). All these species require large deep hollows that only develop in eucalypts greater than 200 years of age (Mackowski 1984, Smith and Lindenmayer 1988, Inions *et al.* 1989, Lindenmayer 1990a).

Denning, nesting, roosting and foraging

Hollows are used for nesting by many species. Roosting sites may offer important thermoregulatory benefits for certain species of birds (Recher 1991) and forest bats. Some bird species show a marked preference for nesting in the forks of horizontal or near horizontal tree branches that are dead or behind loose bark (Recher 1991). These nest sites are primarily associated with large old trees (Recher 1991). Examples include:

- DENNING AND NESTING MAMMALS: Greater Glider *Petauroides volans*, Yellow-bellied Glider *Petaurus australis*, Sugar Glider *P. breviceps*, Feathertail Glider *Acrobates pygmaeus*, Common Brushtail Possum *Trichosurus vulpecula*, Mountain Brushtail Possum *T. caninus* and Tuan *Phascogale tapoatafa*.
- ROOSTING AND NESTING BATS: Great Pipistrelle *Falsistrellus tasmaniensis*, Gould's Wattled Bat *Chalinolobus gouldii*, Chocolate Wattled Bat *C. morio*, Little Mastiff Bat *Mormopterus planiceps*, White-striped Mastiff Bat *Tadarida australis*, Lesser Long-eared Bat *Nyctophilus geoffroyi*, Gould's Long-eared Bat *N. gouldi*, Eastern Broad-nosed Bat *Scotorepens orion*, King River Eptesicus *Eptesicus regulus*, Large Forest Eptesicus *E. darlingtoni* and the Little Forest Eptesicus *E. vulturnus*.
- ROOSTING AND NESTING BIRDS: Powerful Owl *Ninox strenua*, Barking Owl *N. connivens*, Masked Owl *Tyto novaehollandiae*, Sooty Owl *Tyto tenebricosa*, Tawny Frogmouth *Podargus strigoides* Australian King Parrot *Alisterus scapularis*, Rainbow Lorikeet *Trichoglossus haematodus*, Little Lorikeet *Glossopsitta pusilla*, Musk Lorikeet *Glossopsitta concinna*, Yellow-tailed Black-Cockatoo *Calyptorhyncus funereus*, Sulphur-crested Cockatoo *Cacatua galerita*, Galah *C. roseicapilla* Gang-gang Cockatoo *Callocephalon fimbriatum*, Glossy Black-Cockatoo *Calyptorhyncus lathami*, Crimson Rosella *Platycercus elegans*, Eastern Rosella *P. eximus*, Turquoise Parrot *Neophema pulchella*, Laughing Kookaburra *Dacelo novaeguineae*, Tree Martin *Cecropis nigricans*, Sacred Kingfisher *Halcyon sancta*, Red-browed Treecreeper *Climacteris erythrops* White-throated Treecreeper *C. leucophaea*, Brown Treecreeper *C. picumnus*, Striated Pardalote *Pardalotus striatus*, Sacred Kingfisher *Halcyon sancta*, Australian Owlet

Nightjar *Aegotheles cristatus*.

- DENNING AND NESTING REPTILES: Lace Monitor *Varanus varius*, Diamond Python *Morelia spilota*.
- FORAGING SITES: Red-browed Treecreeper *Climacteris erythrops* (Loyn 1985 cited in Scotts 1991).
- OBLIGATE NESTERS ON DEAD WOOD: Varied Sittella *Daphoenositta chrysoptera*
- USUAL NESTERS ON DEAD WOOD: Cicadabird *Coracina tenuirostris*, cuckoo shrikes *Coracina* spp., Satin Flycatcher *Myiagra cyanoleuca*, flycatchers *Myiagra* spp.

Loose bark

Birds which usually nest behind decorticating bark found most often on mature or old trees are likely to have higher nestling survivorship than those that nest in more exposed sites (Ricklefs 1969; Martin and Roper 1988 cited in Recher 1991). Other species utilise ribbon-bark piles at the base of trees for foraging or shelter. Examples include:

- LOOSE-BARK: Scarlet Robin *Petroica multicolor*, Grey Shrike Thrush *Colluricincla harmonica*, Buff-rumped Thornbill *Acanthiza reguloides*.
- RIBBON-BARK PILES: Coventry's Skink *Pseudemoia coventryi*, Spencer's Skink *P spenceri*, Grass Skink *P. cryodroma*, Leaf-green Tree-frog *Littoria phyllochroa*, Dendy's Toadlet *Pseudophryne dendyi* and Peron's Tree-frog *L. peroni*.

Large litter accumulations

Litter accumulates on the forest floor and is broken down by a wide variety of micro-organisms and invertebrates. High levels of litter accumulation are a feature of old-growth forests because of a lack of disturbances such as wildfire and fuel reduction burns which may periodically remove this attribute. Fuel reduction burning may be a very important negative influence on this attribute (Recher 1991; Catling 1991) in the drier and lowland forests of the study area.

Dead standing trees

These prominent structures of old-growth forest provide a variety of resources for fauna dependent on old-growth forests. Hollows for nesting and denning have already been mentioned. The stages of decay of these stags provide different levels of utility for different species of fauna (Smith and Lindenmayer 1988; Lindenmayer *et al.* 1990c cited in Scotts 1991). Many stags in an advanced state of decay provide increased numbers of arthropods for insectivorous birds (Harris 1984 cited in Scotts 1991). When emergent above the canopy these stags are ideal for raptors as perching and feeding trees (Thomas 1979, Maser *et al.* 1988 cited in Recher 1991), as well as providing basking sites for heliothermic reptiles especially in cool temperate wet environments such as Wet Forests (Brown and Nelson 1992).

Emergent stags are not shaded by surrounding vegetation, provide uninterrupted flight path access for large forest birds as well as giving good visibility into the surrounding forest for predatory birds such as raptors and insectivores. Sub-canopy stags have living canopy over-topping them, are frequently in a more advanced state of decay than emergent stags and may have developed as a result of emergent stags losing their crowns and large limbs. It is therefore likely that they have larger populations of invertebrates. Sub-canopy stags also retain some of the hollows that were present when they were emergent stags. They are generally older than emergent stags and have been subjected to more fire events and longer periods of fungal decay which generate these cavities. These are preferred by some species for nesting (Recher 1991 and Pizzey 1983). Examples include:

- EMERGENT STAGS AS PERCHING SITES: Square-tailed Kite *Lophoictinia isura*, White-bellied Sea-Eagle *Haliaetus leucogaster*, Grey Goshawk *Accipiter novaehollandiae*, Spangled Drongo *Dicrurus hottentottus*.
- EMERGENT STAGS AS BASKING AND FEEDING SITES FOR HELIOTHERMS: Spencer's Tree Skink *Pseudemoia spenceri*, Black Rock Skink *Egernia saxatilis intermedia*.
- SUB-CANOPY STAGS WITH OPEN CAVITIES AS NEST SITES: Scarlet Robin *Petroica multicolor*, Hooded Robin *Melanodryas cucculata*, Grey Shrike-thrush *Colluricincla harmonica*.

Fallen logs on the forest floor

Fallen logs are features of older forests that are not frequently burnt and as a consequence are common in more mesic forests. They are an important long-term carbohydrate source (Franklin *et al.* 1981) which provides a concentrated source of energy for arthropod species (Scotts 1991) which in turn are food for many terrestrial vertebrates and birds. They also provide important habitat for reptilian species (Brown and Nelson 1992) because of their high thermal capacity in what are often relatively cold shaded environments (Gilmore pers comm.) The high moisture content of logs also provides important habitats for amphibians (Franklin *et al.* 1981 cited in Scotts, 1991) and may be important refuges during fire (Scotts 1991). Logs also provide travel routes for small mammals in dense undergrowth, as well as nesting, feeding and basking sites for a variety of species and are used as lookout positions (Maser and Trappe 1984 cited in Scotts 1991). The loss of logs in forests that are frequently fuel reduced is therefore likely to have a serious impact on species which need them for feeding, shelter or reproduction (Recher 1991; Catling 1991). The decay of such logs creates an important substrate for the growth of hypogeal fungi, the fruiting bodies of which are eaten by several mammals (Scotts 1991). One species, the Long-footed Potoroo *Potorous longipes*, which is largely restricted to the study area, is totally reliant on this food source (Scotts and Seebeck 1989 cited in Scotts 1991). Some examples of the way animals use fallen logs are:

- FALLEN LOGS AS DENNING, HIBERNATION, NESTING OR INCUBATION SITES: Tiger Quoll *Dasyurus maculata*, Small-eyed Snake *Cryptophis nigrescens*, Diamond Python *Morelia spilota*, Gippsland Water Dragon *Physignathus lesueurii howittii*, Southern Water Skink *Eulamprus tympanum* and *E. heatwolii*, McCoy's Skink *Nannoscincus maccoyi*, Three-toed Skink *Hemiergis decresiensis* and Black Rock Skink *Egernia saxatilis intermedia*, Haswell's Froglet *Paracrinia haswelli*, Dendy's Toadlet *Pseudophryne dendyi*, Martin's Toadlet *Uperoliea martini* and Tyler's Toadlet *U. tyleri*.
- FALLEN LOGS PROVIDE A FOOD RESOURCE FOR MAMMALS: Long-footed Potoroo *Potorous longipes*.

Nesting materials

Spider webs, lichens and mosses are critical nesting materials necessary for high breeding success of some birds (Beruldsen 1980) and are identified by Recher (1991) as being more abundant on mature or dead trees. Spider webs are used as a nest binding material as well as a means of securing the nest itself to a support and are most commonly harvested from hollows and dead branches. Lichens are used by some species as a means of camouflaging nests. The fruticose lichens most commonly harvested for nest camouflage grow commonly on the bark of mature, old or dead non-eucalypt understorey trees and shrubs. Growth of these epiphytes generally occurs on the exposed trunks, twigs and small branches of such trees and shrubs.

Examples include:

- SPECIES REQUIRING NEST-BINDING MATERIALS: Grey Fantail *Rhiphidura fuliginosa*, Rufous Fantail *Rhiphidura rufifrons*, Eastern Yellow Robin *Eopsaltria australis*, Flame Robin *Petroica phoenicea*, Rose Robin *P. rosea*, Pink Robin *P. rodinogaster*, Cicadabird *Coracina tenuirostris*, Lewin's Honeyeater *Meliphaga lewinii*, Brown Warbler *Gerygone mouki*, White-naped Honeyeater *Melithreptus lunatus*, Brown-headed Honeyeater *M. brevirostris*, Brown Thornbill *Acanthiza pusilla*, Buff-rumped Thornbill *A. regaloides* and Striated Thornbill *A. lineata*.
- SOURCE PLANTS: source plants include many rainforest trees such Southern Sassafras *Atherosperma moschatum*, in Cool Temperate Rainforest and Lilly-pilly *Acmena smithii*, Sweet Pittosporum *Pittosporum undulatum* and Large Mock Olive *Notolaea venosa* in Warm Temperate Rainforest. Other species not necessarily associated with rainforest that must however be old to have an abundant fruticose lichen flora include Hazel Pomaderris *Pomaderris aspera*, Silver Wattle *Acacia dealbata*, Blackwood *A. melanoxylon* and Swamp Paperbark *Melaleuca ericifolia*.
- SPECIES USING NEST CAMOUFLAGE: flycatchers *Myiagra* spp., Satin Flycatcher *M. cyanoleuca*, Varied Sittella *Daphoenositta chrysoptera*, robins *Petroica* spp., Eastern Yellow Robin *Eopsaltria australis*, Rose Robin *P. rosea*, Pink Robin *P. rodinogaster* and Brown Gerygone *Gerygone mouki*.
- SPECIES USING PLANT DOWN FROM SAW BANKSIA CONES: Tawny-crowned Honeyeater *Phylidonyris melanops*.

Aquatic ecosystems and old-growth forests

The effects of management in the forested catchments of streams has a profound influence upon the health of the freshwater ecosystems that occur within such forests (Koehn and O'Connor 1990a). A stream is completely dependent on the surrounding land and vegetation in its catchment and is consequently subjected to the effects of actions in the catchment (Koehn and O'Connor 1990b). Although little is understood of the relationship between older forest and aquatic ecosystems within the study area, some evidence indicates that the removal of old forest from stream catchments has detrimental effects on the aquatic ecosystem. Some studies have shown that disturbance of the forest by past agricultural clearance or intensive forestry operations degrades stream values and threatens certain species of fish (Wilson 1991) when compared to undisturbed catchments, despite management prescriptions which significantly ameliorate these effects (Doeg and Koehn 1990).

A major threat to aquatic fauna is increased sediment loadings in streams (Koehn pers. comm.) The increased sedimentation initially leads to an increase in stream turbidity followed by increased sedimentation. Stream turbidity and the rate of stream sedimentation may be elevated by logging (Mackay and Cornish 1982, Cornish and Binns 1987, Doeg and Koehn 1990) but is especially influenced by the development and maintenance of the extensive unsealed forest road network (Koehn and O'Connor 1990a). Unnaturally induced stream turbidity has been found to facilitate macro invertebrate drift (Doeg and Milledge 1991). Logging of catchments has also been shown to increase the storm run-off rates, and may effect the conductivity of cations in the water (Cornish and Binns 1985, McDermott and Pilgrim 1982).

The loss or degradation of native vegetation associated with riparian environments cannot be over-emphasised as a threatening process for aquatic ecosystems (Koehn and O'Connor 1990a). This loss comes about because of the accelerated invasion of the severe environmental weeds such as Blackberry *Rubus fruticosus* spp. agg. which sometimes occurs as a result of its introduction along the forest logging road network (Duncan and Peel in prep.). This species has a demonstrated ability to affect the Riparian Forest within the study area, severely reducing the species diversity and structural heterogeneity associated with streams.

Fallen logs in streams are a common feature of older forests in the study area. Logs that have fallen into streams alter the physical and biological characteristics of streams by providing substrates for plants and animals, changing stream flow, altering stream bed conformation and modifying stream chemistry (Seddel *et al.* 1988). In Victoria these phenomena are known to be important to the ecology of such aquatic ecosystems by providing a diverse habitat (Koehn and O'Connor 1990a cited in Scotts 1991). Hollow logs provide important habitat in streams (Koehn and O'Connor 1990a cited in Scotts 1991, Koehn and O'Connor 1990b), offering refuges from predation, breeding sites, and shelter from the current in swiftly moving streams as well as reducing stream-flow velocities. Some examples are:

- HOLLOWS LOGS IN STREAMS AS FISH BREEDING SITES: Freshwater Blackfish *Gadopsis marmoratus*.
- VULNERABLE AND ENDANGERED FISH SPECIES KNOWN TO BE THREATENED BY DISTURBANCE IN FORESTED CATCHMENTS: Freshwater Herring *Potamalosa richmondia*, Australian Grayling *Prototroctes maraena* (Wilson 1991).

IMPORTANT SECONDARY OLD-GROWTH ATTRIBUTES FOR INVERTEBRATES IN THE STUDY AREA

Ribbon-bark piles

The large accumulated heaps of decorticated bark from gum-barked species are important over-wintering sites for a high diversity and abundance of invertebrates (Dickman 1991). These species in turn are important food sources for vertebrates (Recher 1991; Dickman 1991).

Mistletoes

Many species of butterflies require mistletoes as food plants for their larvae (McCubbin 1985). Because of the increased incidence of mistletoe growth on older eucalypts especially in lowland and foothill forests, it is likely that the larger food source helps sustain greater numbers of these invertebrates in such forests. The larvae of the Olane Azure butterfly *Ogyris olane* feed on the leaves of Box Mistletoe *Amyema miquelii* (a species common in the Rainshadow Woodland country of the upper Snowy and lower Deddick rivers) and the larvae of the Imperial White *Delias harpalyce* feed on the leaves of Drooping Mistletoe *Amyema pendulam* (a species common in the older Wet Forests of the study area and also scattered in the Lowland Forests closer to the coast). The Dark Purple Azure *Ogyris obrata* larvae feed on the leaves of Creeping Mistletoe *Muellerina eucalyptoides*. This mistletoe is common in Limestone Box Forest and Coastal Grassy Forest. The larvae of several butterfly species that occur in the study area have non-species specific mistletoe requirements (McCubbin 1985) including Common Jezabel *Delias nigrina* and Nysa Jezabel and *D. nysa nysa*.

Sedges

Two sedges are commonly used as food plants by butterfly larvae. The Black-fruit Saw Sedge *Gahnia melanocarpa*, which is commonly associated with old-growth Damp Forest on northern aspects or the early seral stages of Warm Temperate Rainforest, is used by Painted Skipper *Hesperilla picta* and *H. chaostola chaostola*. The Tall Saw-sedge *Gahnia clarkei*, which is also common in rainforest and old-growth Riparian Forest although by no means restricted to them, is used by *H. chaostola chaostola* as a food plant.

Southern Sassafras

Southern Sassafras *Atherosperma moschatum* is restricted to Cool Temperate Rainforest and the early seral stages of this community in some older Wet Forest. Macleay's Swallowtail *Graphium macleayanus* feed on the leaves of this species preferring either the young leaves of young plants (that is in the early seral stages of Cool Temperate Rainforest in older Wet Forest), or the young shoots arising from the bases of old trees (McCubbin 1985).

DEFICIENCIES IN CURRENT KNOWLEDGE AND FUTURE SURVEY NEEDS

Although features such as the type of hollow, size, aspect, orientation and abundance of food resources are now known to be important in the distribution and abundance of the larger arboreal mammals of the old-growth Wet Forests of Central Victoria (e.g. Lindenmayer 1992; Lindenmayer *et al.* 1990 a, b, c), as yet no attempt has been made to link such secondary attributes to other old-growth ecological vegetation classes. Milledge *et al.* (1991) have suggested using the large gliders and forest owls as indicator species for old-growth forest that grow in localities of high environmental site productivity. Nutrient levels are known to limit the abundance of forest dependent fauna such as possums and gliders (Braithwaite *et al.* 1984, Kavanagh and Lambert 1990 cited in Dickman 1991). The reduced number of such hollows and the necessary food resources in Shrubby Dry Forests or Montane Dry Woodlands in the same geographic region is probably related to lower environmental site productivity.

These factors combine to limit the abundance of arboreal mammal prey species as well as the large forest owls that feed on them. This reduces the usefulness of the large gliders and forest owls as indicator species of habitat quality for old-growth forests that grow in medium to low site productivity locations. Ecological vegetation classes that occupy low to medium environmental site productivity locations constitute a majority of the study area.

The correlation between fauna dependent on old-growth forest and the ecological vegetation classes described in this study is yet to be researched. Because certain secondary attributes and their configuration and development are restricted to one or several older ecological vegetation classes, it is likely that future research will establish the relationships between these secondary attributes of old-growth vegetation classes and their dependent fauna. Nevertheless, the information contained in this study permits the development of conceptual models to better describe the relationships between old-growth forest and fauna. For example, Figure H1 illustrates the likely optimal habitat domains for some of the fauna dependent on old-growth Wet Forest in the study area. This relationship suggests that the two pre-eminent characteristics of old-growth forest, growth stage and disturbance level, can be used to better determine the likely extent of specific fauna in the old-growth forest domain.

Because of the time and expense necessary for research to link secondary attributes with old-growth dependent fauna, it may be necessary to concentrate survey effort on those indicator species such as the large forest owls and gliders as suggested by Milledge *et al.* (1991), until more precise relationships between secondary attributes and other species can be established. It is however important to note that this approach does not identify old-growth fauna from all vegetation classes (Claridge *et al.* 1991) and is presently only an interim measure for appraising medium to high environmental site productivity old-growth forests. Ecological vegetation classes that grow under low to medium productivity site conditions are not appropriately assessed for habitat quality using large gliders and forest owls.

Relative environmental site productivity for the range of forested vegetation classes that occur within the study area are given in Table H1. These are presented as a preliminary means of stratifying any future fauna surveys focussed on old-growth forests within the study area which are likely to be threatened by disturbance for which little old-growth dependent fauna information is available.

Environmental site productivity is an approximation derived from soil development, parent geologies and climate regimes as well as the structural complexity, physiognomic development and types of life-forms present in the vegetation class involved (Cameron 1979, unpubl.). In summary, species diversity in combination with eucalypt dominated vegetation classes which have many strata with broad leaved shrubs beneath a tall overstorey are considered to have high environmental site productivity; sites with a scattered shrub layer and a dense, grassy field layer beneath a moderate to tall overstorey are considered to have medium environmental site productivity; whilst those with a low shrub layer and a sparse field layer beneath a medium to low overstorey are considered to have the lowest environmental site productivity.

Table H1 Environmental site productivity ratings for forested ecological vegetation classes based on climate, soil fertility, plant physiognomy and life forms represented.

Forested ecological vegetation class		Site productivity rating	Forested ecological vegetation class		Site productivity rating
1	Coastal Dune Complex	L	28	Rocky Outcrop Shrubland	L
2	Coast Banksia Woodland	L	29	Damp Forest	M–H
3	Coastal Grassy Forest	M	30	Wet Forest	H
4	Coastal Vine-rich Forest	M	31	Cool Temperate Rainforest	H
14	Banksia Woodland	L	32	Warm Temperate Rainforest	H
15	Limestone Box Forest	M	33	Cool/Warm Temp. R'forest Overlap	H
16	L'land Forest	L–M	34	Dry Rainforest	L–M
17	Riparian Scrub Complex	L–M	35	Tableland Damp Forest	H
18	Riparian Forest	H	36	Montane Dry Woodland	L–M
20	Heathy Dry Forest	L	37	Montane Grassy Woodland	M
21	Shrubby Dry Forest	L	38	Montane Damp Forest	M
22	Grassy Dry Forest	L	39	Montane Wet Forest	H
23	Herb-rich Forest	M	40	Montane Riparian Woodland	H
24	Foothill Box Ironbark Forest	L–M	41	Montane Riparian Thicket	H
25	Limestone Grassy Woodland	M	42	Sub-alpine Shrubland	L
26	Rainshadow Woodland	M	43	Sub-alpine Woodland	L
27	Rocky Outcrop Scrub	L–M			

Figure H1 Likely optimal habitat domains for some of the old-growth forest dependent fauna of Wet Forest in the study area within the old-growth forest domain.

Predominant Growth Stage	Disturbance Level		
	Undisturbed	Negligible natural	Negligible un-natural
Senescing dominant	Senescing trees dominant over mature trees, no regrowth. Rainforest understorey likely (Growth stages S1, S2, S3). Fauna: Pink Robin, Yellow-bellied Glider, Sooty Owl, Bobuck	Senescing trees dominant over sparse mature and regrowth trees. Wattle understorey likely. (Growth stage S4). Fauna: Yellow-bellied Glider, Sooty Owl, Bobuck	
Codominant	Senescing and mature trees codominant, no regrowth. Rainforest understorey likely. (Growth stage S5) Fauna: Pink Robin, Greater Glider, Bobuck	Senescing and mature trees codominant with sparse regrowth. Wattle understorey likely. (Growth stage S6). Fauna: Bobuck	
Senescing subdominant	Senescing trees subdominant, mature trees dominant, no regrowth. Rainforest understorey likely. (Growth stage M1). Fauna: Pink Robin, Greater Glider, Bobuck	Senescing trees subdominant, mature trees dominant with sparse regrowth. Wattle understorey likely. (Growth stage M2). Fauna: Bobuck	

Note: In the old-growth context, generalist species such as Bobucks have a broader optimal habitat domain (than just old-growth forest) compared with specialist species such as Yellow-bellied Gliders and Sooty Owls. The species used in this illustration are found in lower numbers outside the old-growth domain. This is because the attributes they rely on (which characterise old-growth forest) are found in lower proportions beyond the old-growth forest domain.

Appendix I

DENDROCHRONOLOGICAL STUDY OF REGROWTH, MATURE AND SENESCING *Eucalyptus sieberi* TREES, COBON BLOCK

SUMMARY

Estimates of tree ages were derived for regrowth, mature and senescent trees of *Eucalyptus sieberi* from basal disc ring counts. Age estimates to accommodate hollow centres were made from sound trees. The mature trees were three times the age of the regrowth trees, and the senescent trees about half as old again as the mature trees. Regrowth trees were all of the same cohort regenerating in the period 1940–1 to 1942–3 following a localised wildfire that was interpreted from a growth pulse in the adjacent tree M1. All regrowth were at or about their final top height. Tree ring analysis provided no evidence to support a fire in the study forest in the severe 1952 fire year. The mature trees were interpreted as having a common age regenerating c. 170 years ago. The senescent trees regenerated at different times between 260 and 311 years ago. Senescence develops in mature trees when there is only limited recovery following a series of major stress periods. In the case of the study trees it was estimated that senescence begins when trees reach 250 years and persists for 60 years. A 300 year forest fire history was derived from tree regeneration years and post-fire growth pulses indicating that 12 fires passed through the stand with a fire frequency of 22 years. There was no evidence of an increase in fire frequency since European settlement.

INTRODUCTION

Dendrochronology provides a useful tool for aging trees and dating past forest disturbances, however this is only possible in those species which lay down recognisable seasonal tree rings. Conifers and deciduous hardwoods from cold climates typically possess such rings which are distinct and datable. Evergreen hardwoods can have datable tree rings where growing conditions and growth rhythms are seasonal. In southern Australia there are a number of eucalypt species including *E. sieberi*, which characteristically produce datable tree rings, but in these species the development of absolute chronologies is often difficult because of the frequency of missing and false rings and the difficulty of identifying these anomalies. However, in many ecological studies absolute chronologies are not always essential and approximate tree ages can provide useful tree age data.

Tree ring chronologies have been used for dating sub-alpine and montane eucalypts, (Banks, 1982, 1990, Rhymer, 1991), for lowland coastal eucalypts (Banks 1992) and white cypress pine in south-eastern NSW, (Pulsford, 1991). In Silvertop Ash ring counts have proved to provide accurate tree ages for trees from regrowth stands of known age in the Eden district of NSW (Banks, unpublished). In the present study tree ages for typical regrowth, mature and senescent trees of Silvertop Ash, *Eucalyptus sieberi*, are derived for trees from one forest stand and their tree ring width patterns are used to interpret major events in the stand history.

MATERIALS AND METHODS

The forest stand description and history. The study forest stand was located at 148° 58'E longitude 37° 23'S latitude at 700 m elevation, on a westerly aspect in coupe 03, compartment 513 in the Cobon Block of the Cann River District in the East Gippsland Forest management Area. The soils are a brown gradational soil with a high sand content with the A horizon varying from 25 to 45 cm deep and overlying Ordovician shales and fine sandstones (Marsh 1991). The vegetation of the study area was classified as Damp Forest dominated by Silvertop Ash, *Eucalyptus sieberi* with some Messmate, *E. obliqua*, and Mountain Grey Gum, *E. cypellocarpa*, and with Brown Barrel, *E. fastigata* in adjacent moister gullies. Precipitation of about 1000 mm p.a.. is fairly uniformly distributed throughout the year with a winter-spring maximum. The stand was assessed as comprising a number of different tree age classes, these having regenerated after wildfires. Major wildfires occur sporadically in the region. However the fire history of the study forest was unknown except for anecdotal evidence that a wildfire had occurred in the general area in 1952. The forest had remained unlogged until the present experimental coupes were established and logged in April 1992.

Sample trees

Cross-section biscuit samples were cut in spring 1992 from the stumps of eight trees harvested in April 1992. These provided three samples from each of regrowth and mature trees and two from senescent trees. Details of the eight sampled trees are given in Table I1.

Table I1 *Eucalyptus sieberi* sample trees in the Bungywarr Road Dendrochronology Study, Cann River District, Victoria.

Tree Status	No.	Height (m)	DBHOB (cm)	Crown Diam. (m)	Comment
Regrowth	R1	25.4	37.5	6.5 × 6.5	Late regrowth, close proximity to R2, R3, M1
Regrowth	R2	23.1	28.0	8.0 × 3.8	Regrowth tree, close proximity to R1, R3, M1
Regrowth	R3	25.0	33.5	5.5 × 6.5	Regrowth tree, close proximity to R1, R2, M1
Mature	M1	33.8	108.5	11.5 × 15.3	Late mature, just off ridge top
Mature	M2	31.2	100.5	12.4 × 9.4	Mature, close to S2
Mature	M3	33.8	73.5	10.5 × 10.3	Early mature, in vicinity of M2 and S1
Senescent	S1	32.5	118.0	10.5 × 10.3	Late senescing, in vicinity of M2, M3
Senescent	*S3	31.4	134.5	20.0 × 20.0	Large low branches, westerly aspect

* senescent tree S2 was identified but not sampled

Tree sample preparation
Prior to sub-sampling the discs, the diameters of the missing decayed centres in sample trees, M2, S1, and S3, were estimated. Age estimates for the missing centres when added to the age ring counts provide ages for the samples. From each disc two or three radial sections were selected for tree ring analysis. Short radii were avoided as these are often atypical having zones of narrow rings and a higher frequency of missing rings. The sub-samples were cut to approximately 5.0 × 2.0 cm for ease of handling and to provide an adequate tangential surface for tree ring analyses. The samples were then sanded with progressively finer grades of sand paper finishing off with wet-dry paper to produce a glass-like surface from which the tree rings could be clearly recognised. Wet sanding ensures a clean sharp surface with water flushing the fine wood flour from the wood surface.

Tree ring identification and counts
Tree rings were identified and marked on the prepared samples using a ×10 free-standing hand lens. In all trees the last xylem to be laid down was typical early wood, that is, only half a tree ring. This was in keeping with tree harvesting in April. The development of the early wood was observed to vary between trees indicating independent seasonal growth rates (Banks, 1982). The youngest complete tree ring in all samples represented the 1990–91 growing season.

To minimise errors, tree rings were identified on each sample along radial sections having greatest clarity and typical rings, thus excluding as far as possible zones of indistinct tree rings. This required occasionally shifting or 'side stepping' the study axis on radial sections to accommodate the best available field. Cross-matching of distinctive rings between the same and different trees was then attempted. When successful this provided useful internal marker rings from which the number of tree rings per interval could be compared and checked between samples.

Tree age estimates
Tree age estimates were taken directly from the complete radial cross sections, ie. cambium to the pith, equating tree ring counts to years, since radial growth is seasonal with early wood laid down in spring and summer and the late wood in late autumn and early winter in response to lower temperatures. Where tree centres were hollow, as is often the case in older trees, age estimates were necessarily composites of the ring count from the sound wood plus an estimate for the missing centre. These estimates were derived from the numbers of tree rings laid down in complete cross sections for an equivalent radial interval, and where multiple tree data were available upper and lower estimates were made.

Over and under estimates of tree ages can occur. Over estimates arise when false rings are included in the age estimate. These are mostly produced in response to summer moisture stress and usually appear as diffuse and less distinct rings. Under estimates arise when rings are absent from the study sample cross section. These occur when an incomplete ring or no ring at all is produced in the lower tree bole in response to unfavourable growing conditions. This is more likely to occur in older trees than younger vigorously growing individuals. While absolute tree ages were desirable, in this study they were not essential as there was a major age differential between the different tree categories being aged. Further, in the absence of a master chronology[1] for the species in this forest, it was not possible to identify false and

[1]An absolute chronology for a locality, derived from a large tree sample from which false and missing rings can be identified in individual tree chronologies.

missing rings, although some of these may be indicated by comparing data from two or more trees. Thus for the purpose of this study it was assumed that false and missing rings were relatively insignificant and indeed may tend to cancel each other out, and that the tree ring counts provided a good estimate of the true ages of the sample trees.

Tree ring width patterns
Tree-ring widths were measured to 0.01 mm using a linear traversing microscope at 360 magnification. From these data tree ring plots were produced for each radii sampled using software Kaleioda Graph. Graphed tree data sets were then visually cross-matched by searching for common tree ring patterns and marker rings, and finally these data were combined to produce a composite tree ring plot. The tree ring width data is reverse plotted to allow for the easy comparison of tree growth patterns for trees of different ages.

RESULTS

Tree age estimates
Overall the tree rings were mostly clear and distinct with few zones of narrow and/or indistinct rings. This indicated that estimates of tree ages derived from tree ring counts would be close to real tree ages, particularly for trees with sound centres.

Reliable age estimates were obtained for the three regrowth trees as all had sound centres and relatively clear and easily recognisable tree rings. Missing or false rings were unlikely to be present. Tree ages were derived by adding two years to each tree ring count to accommodate an estimated time interval between the season of tree seedling establishment and sampling height. Thus tree age estimates for the regrowth trees R1, R2, and R3 were 49, 46 and 48 years respectively, Table I2. By assuming all three trees had in fact regenerated at the same time, they regenerated following site disturbance, eg. fire in 1942, Table I3.

Tree age estimates derived from ring counts for mature trees M1 and M2 were 170 and 169 years respectively and estimated to be 158 to 171 years for tree M3. This tree had a ring count of 127 to which was added a minimum of 31 or a maximum of 44 rings to account for the decayed 8cm diameter centre (Figure I1).

The senescent trees S1 and S3 had decayed centres estimated at 15cm for which an age estimate of 59 to 75 years derived from Figure I1, was added to the ring count to provide age estimates of 260–277 years for tree S1 and 296–311 years for tree S3 (Table I2).

Tree ring width patterns
The tree ring width data for the regrowth trees were combined and mean values graphed (Figure I1). This showed the regrowth trees to have gone through one cycle of accelerated growth with ring widths rising to a maximum of 5–6 mm in their 4th decade and then falling to 1–2 mm in the 5th decade.

The tree growth patterns expressed in both the mature and senescent tree ring width plots did not follow the typical decay curve as might be expected for trees 150 or more years old, with the possible exception of tree S3 (Figures I3 and I4). The radial increment growth patterns consist of a series of cyclic growth phases of 30 to 50 years.

Table I2 Tree age estimates for regrowth, mature and senescent trees of *Eucalyptus sieberi* Bungywarr Road Dendrochronology Study, Cann River District, Victoria.

Tree	Missing Radius (cm)		Number of	Tree Age
Category Count	Tree Ring	Hollow Centre	Missing Rings*	Estimate
R1	47	none	0	49
R2	44	none	0	46
R3	46	none	0	48
M1	170	none	0	170
M2	169	none	0	169
M3	137	8	31–44	158–171
S1	201	15	59–75	260–277
S3	237	15	59–75	296–311

* estimates derived from sound trees M1 and M2 (see Figure I1).

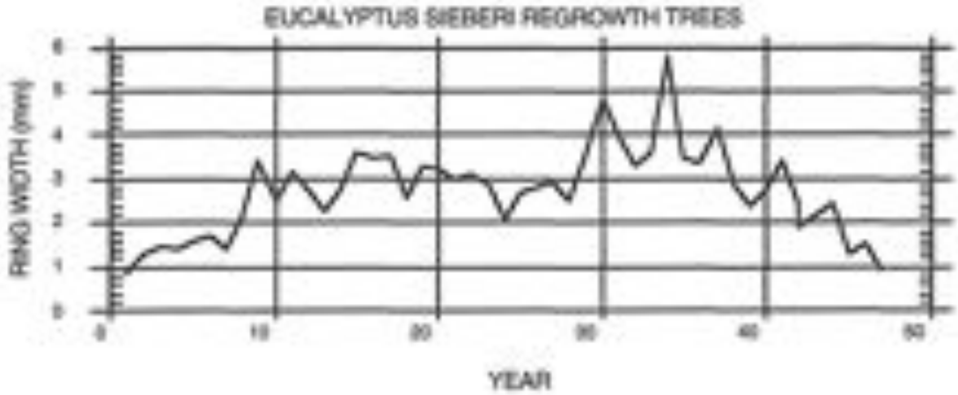


Figure I1 Plot of mean tree ring widths for three regrowth trees of *Eucalyptus sieberi*, Cobon Block, Compartment 513, Coupe 03, Cann River District, East Gippsland, Victoria.

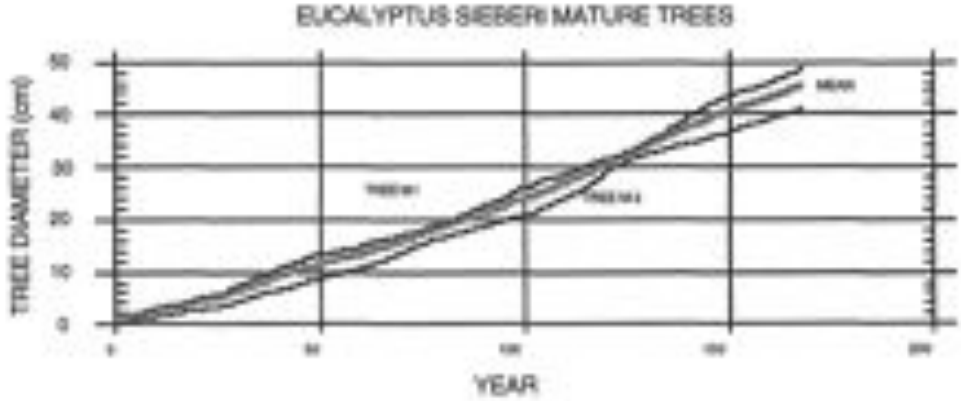


Figure I2 Plot of tree diameter against years for mature trees of *Eucalyptus sieberi*, Cobon Block, Compartment 513, Coupe 03, Cann River District, East Gippsland, Victoria.

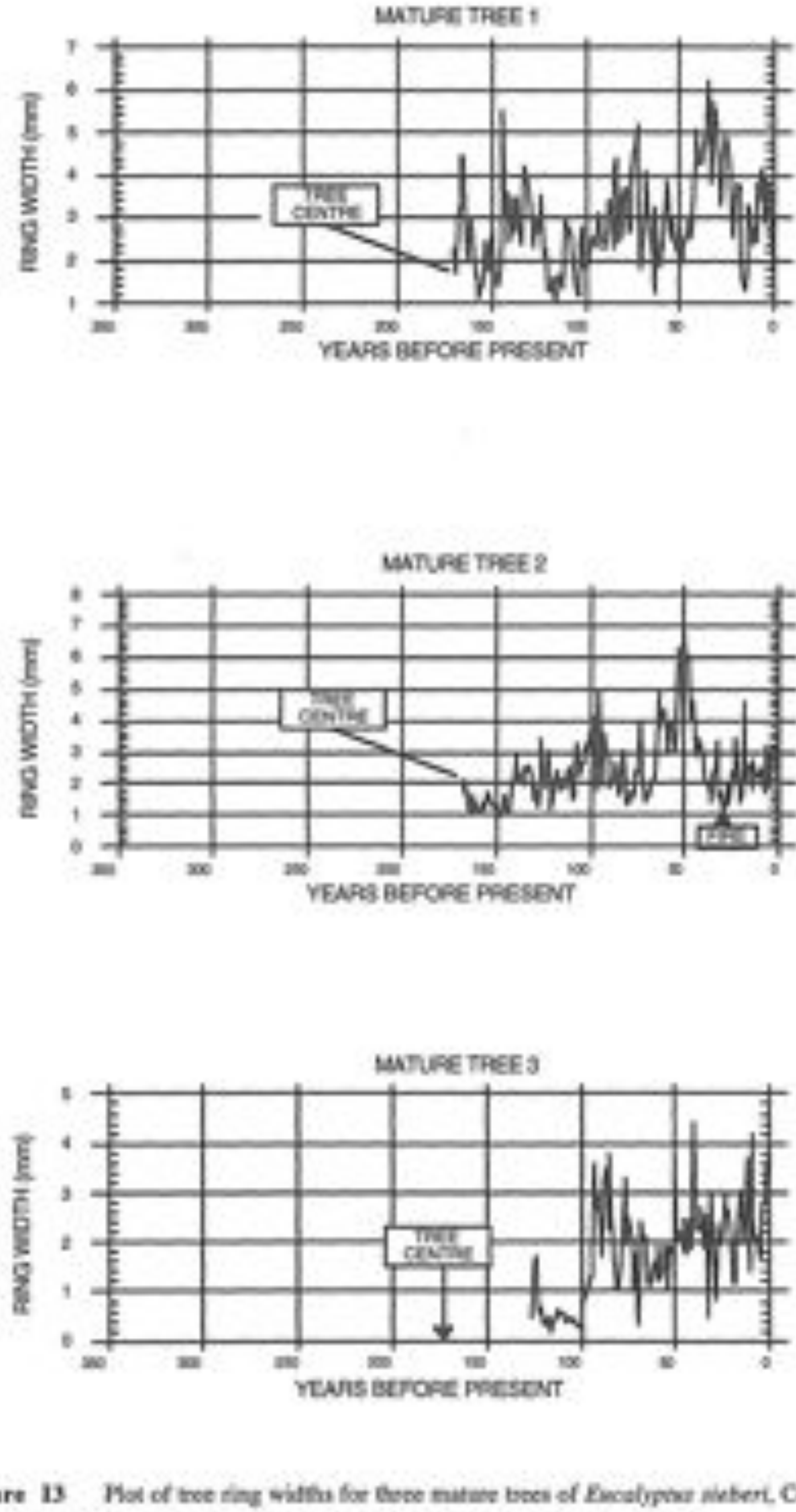


Figure 13 Plot of tree ring widths for three mature trees of *Eucalyptus sieberi*, Cobon Block, Compartment 513, Coupe 03, Cann River District, East Gippsland, Victoria.

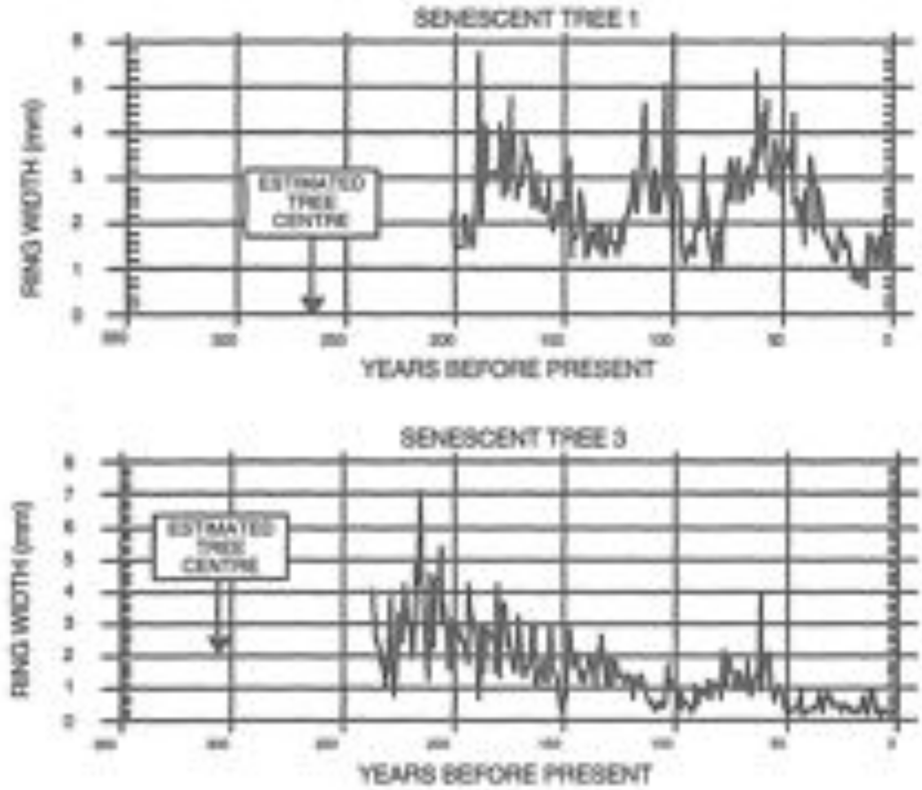


Figure 14 Plot of tree ring widths for two senescent trees of *Eucalyptus sieberi*, Cobon Block, Compartment 513, Coupe 03, Cann River District, East Gippsland, Victoria.

duration, with minimum tree ring widths of less than 1.0 mm persisting for several years to more than a decade in the troughs, and ring widths repeatedly exceeding 4–5 mm and occasionally up to 7.0 mm in periods of maximum growth rates.

The cyclic growth pulses in trees M1, M2, M3, S1 and S3 displayed only limited synchronisation over the entire tree ring record. There was a strong indication of two periods of maximum ring width approximately 50 and 100 years ago with intervening troughs of narrow rings. Tree M1 had three clearly recognisable cycles of varying length (Figure 13). These may be fire related, if so suggested periods for fire would be 50, 125 and 145 years ago (that is, around 1940, 1865 and 1845). In tree M2 a zone of included decayed sapwood resulting from cambium death in the mid 1960s, suggested fire damage. A growth response after this event further indicated fire as the cause. Other fire events were indicated in periods around 1920 and 1845. Similarly for tree M3 fire its radial growth pattern indicates responses to fire about 1920 and 1890 (Figure 13).

The two senescent trees had quite different tree ring width patterns (Figure 14). This indicated that local site histories had differed markedly. Tree S1, displayed three very strong and pronounced cyclic pulses in which ring widths fell to less than 2.0 mm in periods of minimum growth and exceeded 5.0 mm in the three periods of peak growth. Tree S1 showed Silvertop Ash has the ability to respond vigorously to favourable forest disturbances, with four recovery phases following an intervals of narrow rings. These indicate possible fire responses at 80, 90, 125, and 190 rings from the cambium. Ignoring the possibility of missing rings fires may have occurred in 1910, 1900, 1865 and 1800. In contrast the tree ring width pattern for tree S3 approximated to a decay curve over the last 220 tree rings and was only weakly interrupted by two intervening growth pulses. One very weak growth pulse occurred between rings 150 and 140, and a second and stronger growth pulse between rings 90 and 50 in which only one exceptionally wide ring, ring 61, appears. Ring widths then collapsed to less than 1 mm for the last 50 rings. Fire events were indicated about 150 and 230 years ago, 1840 and 1760.

A suggested forest fire history for the *E. sieberi* stand on Coupe 03, Compartment 513, Cann River District, can now be derived from the tree age data and post-fire growth pulses (Table I3). Note the reliability of the data diminishes with decreasing sample size, e.g. pre-1822, and the regeneration dates for the senescent trees are taken from the minimum tree age estimate. These results indicate an average fire free interval of 22.4 years (minimum 10, maximum 40) between 1800 and 1992. Prior to 1800 the fire frequency appears to have decreased, but this trend cannot be identified with confidence from a sample of two trees with missing cores and may well be an artefact of the data.

Table I3 A 300-year forest fire history for the *E. sieberi* stand on Coupe 03, Compartment 513, Cann River District, East Gippsland, Victoria. Fire dates were derived from tree regeneration years and post-fire growth pulses.

Trees							
R1–3	M1	M2	M3	S1	S3	All Trees	Fire-free Interval
						[a]1992	27
			1965			1965	23
[b]1942	1940?					1942	22
		1920	1920			1920	10
				1910		1910	20
			1890			1890	35
	1865			1865		1865	20
	1845	1845			?1840	1845	23
	1822	1822	?1822			1822	22
				1800		1800	40
					1760	1760	30
				[c]1730		1730	38
					[c]1692	1692	

R = regrowth M = mature S = senescent trees
[a] year of sampling [b] estimated fire years [c] earliest estimated fire regeneration year

DISCUSSION

Tree classification in the East Gippsland eucalypt forests has relied on tree physiognomy to characterise trees and hence stands as regrowth, mature or senescent. Mapping these entities provides information on their location, size and spatial array, all essential data for modern forest management planning. However, when considering questions relevant to forest stand dynamics tree age data are essential for the ecological interpretation of existing forest stands, the predictive modelling of stand dynamics and forecasting the impacts of forest management.

The aim of this study was to provide age estimates for a small number of trees representative of regrowth, mature and senescent categories in Silvertop Ash. Whilst this information is restricted to the one species from one site it provides useful tree age data which with care may be extrapolated to similar sites and perhaps to other eucalypt species. In addition the graphic representation of tree ring data is useful for cross matching tree ring series, for identifying zones of missing rings thus allowing for the correction of tree age estimates and for elucidating stand histories by evaluating the timing, magnitude and duration of growth responses to disturbance events. The tree ring data also provides information on the capacity of individual trees to respond to environmental disturbances and whether such events were tree or stand centred.

The three regrowth trees were as tall as the mature and senescent trees and had therefore attained their maximum height for the site. Future increment would be directed towards maintenance of bole structural strength and crown recovery following stress intervals. Tree ring derived ages for these trees were 49, 46 and 48 years, indicating that they were most probably all derived from the same cohort which had regenerated following site disturbance about 50 years ago. This suggested seedling establishment in the period 1940–1 to 1942–3. Silvertop Ash regenerates in response to a disturbance which provides a canopy gap and a suitable seed bed. Fire is the most likely disturbance factor as it readily provides both of these pre-requisites. This is supported by the tree ring width pattern in the closest sample tree M1 which lies within the area of the regrowth trees. It has a major growth pulse just after this period, and such responses are known to be related to fire which provides the two essential requirements for a growth pulse, ie. a flush of ash nutrients and reduction of competition from neighbouring trees and/or understorey. This fire must have been localised in its impact on the study forest stand as none of the other sampled trees show a similar fire response. Anecdotal evidence indicates that 1952 was a bad fire year in East Gippsland, however there is no evidence from the regrowth or other sample trees of a wildfire in the study forest at this time; indeed the 8 to 10 year old regrowth trees in 1952 with their thin bark would have been readily killed by fire at this time. Thus fires in that season almost certainly did not occur on the study site.

The mature trees were all of similar age suggesting that they had also regenerated following a single disturbance event in that part of the study forest. There was no evidence in the growth patterns in the senescent trees to suggest fire at this time but this does not preclude a fire with a patch effect on the forest. The tree ring width patterns in the three mature trees support this interpretation as all possess unique growth patterns indicating responds to past events specific to their micro-sites.

The senescent trees were shown to have different ages. Tree S1 was estimated at 260–277 years and tree S3 at 296–311 years. Tree S3 could be older than 311 years since there may be unidentified missing rings in the outer rings which comprised some 50 very narrow rings. The distinctive growth patterns in these trees support the observations made for the mature trees.

This forest type is believed to experience frequent fire events, which anecdotal evidence suggests occur about every 20 years. The derived fire history for the study site indicates fires have occurred on average every 22.4 years from 1800 to 1992, but only once every 30 to 40 years prior to 1800. This decrease in fire frequency is almost certainly an artefact of the data. The post 1800 fires are most probably from natural ignition sources as the study site has remained remote from European disturbance and there is no evidence of a change in fire frequency coinciding with increasing European activity in Gippsland from around the 1880s as has been found in other studies, (Banks 1982, 1990). Further the fire years for this stand prior to

1865 coincide well with fire years for a similar multi-aged *E. sieberi* and *E. fastigata* stands in Glenbog S.F. in NSW (Banks 1990), which recorded fire years in 1820, 1800, 1760 and 1690. The commonality of fire years suggests that forest fires may have been more widespread across the south-eastern forest zone in these years.

This regime of frequent fire causes butt scars and/or destroys the crowns of some trees in a stand and not others, and also creates a patchwork of seed beds, some of which will support a new cohort of trees. This phenomenon has been documented in a similar multi-aged Silvertop Ash stand in Glenbog State Forest, in the south-eastern forests of New South Wales, where new trees were added to the stand in almost half (11 of 24) of the fires over a 210 year period, Banks, 1990.

Senescence begins in a mature eucalypt when the crown shaping branches begin to fail. Failure results from structural weakening caused by internal decay which begins in a mature tree via a broken branch stub or other damage (Jacobs, 1955). Periodic severe moisture stress may also be a major factor triggering crown dieback (Bird *et al.* 1975). Actual branch losses are triggered by environmental stresses such as a severe wind storm. Replacement branches develop from dormant buds on the trunk, and form a secondary crown which is never as efficient as the primary crown. The secondary crown branches may persist for several decades but finally fail and are in turn replaced as the tree ages. As this process continues tree vigour declines and senescence becomes established. From the tree ring width sequence for senescent tree S1 this tree has been declining for the last 70 years with a period of narrow rings about 20 years ago. Assuming the tree is 268 years old this places its transition into senescence at about age 250 years. The evidence from tree S3 is more convincing. This tree was reckoned to have a mean age of 304 years. Its ring width collapsed around 50 years ago, i.e. at about age 250 years. On this basis the mature trees in the study forest could be expected to remain in a mature condition for another 80 years more so. However this is dependent on favourable forest disturbances, e.g. fire, occurring at say 20 to 50 year intervals and tree crowns remaining in good condition over this period.

CONCLUSIONS

The study has shown that estimates of tree ages in Silvertop Ash can be made from tree ring analyses. The data for the mature and senescent trees are likely to be under estimates of the true tree ages. With a larger tree sample it may have been possible to improve these age estimates by identifying missing rings. Nevertheless, the results have shown that this species can live for more than 300 years and in that period individual trees typically undergo a series of growth pulses that persist for up to 50 years. Fire is probably the most important factor in triggering off these growth pulses through the release of ash nutrients in a generally nutrient poor environment, reducing competition for these resources and providing tree regeneration sites. A 300 year forest fire history based on growth pulses and tree ages indicated an average fire frequency of 22.4 years, and that this was likely to be a natural fire regime persisting in this remote forest up to the present day. Senescence occurs when the tree looses its ability to fully recover its crown following a severe stress, drought, fire, windstorm, etc. On the evidence presented this occurs at around an age of 250 years, but once in a senescent state *E. sieberi* may persist for at least another 50 years before succumbing to some environmental stress.

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- James Turner (Victorian Field Naturalists Association)
- Keith Twyford (previously CNR, Orbost)
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PROJECT TEAM

John Banks, Dendrochronologist and Senior Lecturer, Department of Forestry, ANU
John was responsible for undertaking the dendrochronology (tree-ageing) studies in the Cobon Forest Block. He was co-author of Chapter 8 and lead author for Appendix I.

Anita Brady, Project Historian, CNR
Anita was responsible for the research and compilation of forest disturbance data from historic records, and for gathering anecdotal information about past land uses of the Forest Management Area. In the latter stages of the project, Anita was involved in writing the report. She was the lead author for Chapter 7 and Appendix F.

Jane Coram, Project Scientist (Remote Sensing), CNR
Jane's main responsibility was the aerial photograph interpretation of forest growth stages and crown cover, and the preparation of this information for entry into GIS. In the latter stages of the project, Jane was involved in writing and editing the report and refining the GIS analysis. She was the lead author for Chapters 2, 3, 4 and co-author of Chapter 8 and Appendix G.

Bill Peel, Project Scientist (Ecology), CNR
Bill's main responsibility was to provide the ecological context for delineating and mapping old-growth forests in the study area. This was achieved by mapping the ecological vegetation classes and assessing what impacts the various disturbance influences had upon these classes. Bill was involved in writing and editing the report and was instrumental in the development of GIS analysis procedure. He was the lead author of Chapters 5 and 6, and Appendixes C, D, E and H, and co-author of Chapters 9, 10, 11 and 12 and Appendix G.

Kim Ritman, Project Team Leader, formerly CNR, now with the Department of Conservation and Land Management, NSW
Kim was involved in the project design, leading and coordinating the work of the rest of the team, supervising the field work, overseeing the input of all data collected into GIS, and formulating the data analysis steps. Kim represented the Project Team at all the Technical Advisory Committee meetings and was co-author of Appendixes B and G.

Tony Rule, Project Scientist (Remote Sensing), CNR
Tony contributed during the early stages of the project in a support role to Peter Woodgate. He was later involved in interpreting satellite images for recent forest disturbances, and aerial photographs of forest growth stages and crown cover, and in collating fire records and in the preparation of this information for entry into GIS.

Peter Woodgate, Project Manager, CNR
Peter was involved in the early stages of the project in developing the project design and establishing the project team and overviewing the management of the project. Throughout the project, he had an active role as convener of the Study's Technical Advisory Committee. In the latter stages of the project, Peter was involved in writing and coordinating the editing of the report and refining the GIS analysis. He was the lead author for Chapter 1 and joint author for Chapters 9, 10, 11 and 12 and Appendix G.

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Note: maps are indicated by the letter M followed by the map number

IN 1990 VICTORIA COMMENCED THE first scientific survey of old-growth forests ever undertaken in Australia. The main purpose of the study, which was completed in late 1993, was to describe the nature and extent of forests of different ages in East Gippsland, focusing on the older forests. The results will allow Victoria to ensure it complies with the National Forest Policy Statement, which commits signatory governments to an agreed approach to conserving and managing native forests, including old-growth forest.

This document is the result of that study. Firstly, it develops a working definition of old-growth forest and a standard methodology for surveying, assessing and classifying forest of different age classes and vegetation communities, an approach which can be applied to other forest areas of the state. Secondly, it provides detailed maps of the old-growth forests of East Gippsland which will be used in the next stage of the regional assessment of national estate values in the East Gippsland Forest Management Area being undertaken jointly by the Department of Conservation and Natural Resources and the Australian Heritage Commission.

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