East Gippsland Victoria: Resource and Economics Report

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Acronyms

ABARE Australian Bureau of Agricultural and Resource Economics
AGSO Australian Geological Survey Organisation
AWRC Australian Water Resources Commission
BRS Bureau of Resource Sciences
CAI Current Annual Increment
CRA Comprehensive Regional Assessment
DBH Diameter Breast Height
DCE Department of Conservation and Environment
DCFL Department of Conservation, Forests and Lands
DCNR Department of Conservation and Natural Resources
DPIE Department of Primary Industries and Energy
DWR Department of Water Resources
FMA Forest Management Area
GDP Gross Domestic Product
GIS Geographic Information Systems
GMZ General Management Zone
GSV Geological Survey of Victoria
HARIS Hardwood Area Resource Information System
IFPS Integrated Forest Planning System
LCC Land Conservation Council
LIMS Land Information Management System
LVL Laminated Veneer Lumber
MAI Mean Annual Increment
MDF Medium Density Fibreboard
MPV Minerals and Petroleum Victoria
MRDA Mineral Resources Development Act
NEHTI Network for Excellence in the Hardwood Timber Industry
NFI National Forest Inventory
NRE Department of Natural Resources and Environment
RFA Regional Forest Agreement
RMA River Management Authority
SFRI Statewide Forest Resource Inventory
SMZ Special Management Zone
SPZ Special Protection Zone
SSP Silvicultural Systems Project
SYSS Sustainable Yield Spreadsheet System
TSI Timber Stand Improvement
USGS United States Geological Survey
VAUS Value Added Utilisation System
VSP Value Adding and Silvicultural Systems Project
WHO World Health Organisation

Executive Summary

This report provides the details of the resource and economic components of the Comprehensive Regional Assessment (CRA) for East Gippsland. It details assessments of existing resources of the forest estate in East Gippsland, examines forest management and the range of existing forest uses, provides estimates of future resources and potential usage and develops a framework for the economic valuation of the options to be developed in the next step of the Regional Forest Agreement (RFA) process.

This report, together with the other regional assessment reports, provides a basis for the development of options for resource use and development in East Gippsland. Six broad resource and usage categories are considered:

- native forests - production of sawlogs and residual logs
- plantations - native and exotic species
- other forest produce
- recreation and tourism
- water
- mineral resources.

Information for this report was drawn from a number of sources including existing published and unpublished sources. All data is referenced. Metadata information is given in Appendix F.

Native Forest Management

East Gippsland native forests are managed by the Department of Natural Resources and Environment for a range of uses including conservation of biodiversity, catchment protection, recreation and tourism, and production of wood and wood-based products.

Native forest management in Victoria is guided by a legislative, policy and planning framework for wood and non-wood values. The East Gippsland Forest Management Area Plan (DCNR 1995) provides further detail on land use within State Forests.

The East Gippsland Region is dominated by public land, which totals 1,051,100 ha or 87% of the area. The remaining 13% is privately owned. State forest occupies 637,000 ha or 61% of the region, with the remaining 39% in National Parks. Within State forest, the East Gippsland Forest Management Plan (1995) identifies three forest management zones which set management priorities and specify permitted activities for different parts of the forest. The Special Protection Zone (SPZ) is managed for conservation, timber harvesting is excluded. Timber harvesting is permitted in the General Management Zone (GMZ) and some of the Special Management Zone (SMZ) which comprises an area of some 344,700 ha or 32% of the public lands of the East Gippsland region.

The policy of NRE regarding timber production is that forest management is directed towards the production of sawlogs. Sawlog production is sustainably managed to produce around 250,000 m3 (D+) per year. This will increase through time as more productive regrowth forests mature.

Residual logs are those which are of insufficient size or quality for sawlogs, but which can be used for pulpwood, firewood and craftwoods. Residual logs represent a commercial opportunity that is currently underutilised. NRE has estimated that around 650 000 m3 of residual logs become available as a result of sawlog production every year in the East Gippsland Forest Management Area with an additional 150,000 m3 from the adjacent Tambo Forest Management Area. NRE has recently sought expressions of interest for the utilisation of this wood.

Silviculture

The silvicultural practices used in East Gippsland are designed to optimise sawlog production. Seed tree silviculture offers an economic technique for achieving sufficient disturbance to allow regeneration and optimal growth. Clearfelling is used in some forest types where natural seed supply is insufficient or unreliable for adequate regeneration. Selection methods are not usually practiced in conventional logging as they provide insufficient disturbance for adequate and consistent regeneration and growth.

Thinning, another silvicultural technique for optimising sawlog production, is also practiced in East Gippsland.

Sustainable Yield for Sawlogs

This report examines sustainable yield forecasts for sawlog production in East Gippsland. An independent appraisal of the methodology used by NRE to forecast sawlog yield in East Gippsland was undertaken by the University of Melbourne. The details of the appraisal are discussed in this report. The appraisal is attached in full as Appendix 1.

The forecast of sustainable yield in East Gippsland is contingent upon:

- resource volume estimates for standing timber volume, including the method for collecting, storing and handling resource data;
- growth models used to forecast future product yield by forest type; and
- forecasting method, including the strategy formulation and technology for handling data

The method for forecasting the sustainable yield for East Gippsland was found to be conceptually sound. Limitations were identified in relation to the supporting resource data, The growth rates have been found to be conservative. A number of improvements to the methodology were suggested. NRE has indicated that several of these will be addressed through the implementation of the Statewide Forest Resource Inventory (SFRI) and Integrated Forest Planning System (IFPS).

The apraisal also emphasised the need for sensitivity analysis as a standard procedure for assessing the consequences of potential error in data or methodology. Sensitivity analysis was conducted by NRE for a number of variables, including one scenario for determining the effect of an extreme positive variation in the estimation of standing timber volumes on the sustainable yield. Based on this scenario, the failure to identify such an error would be an additional 1.3% variation to the sustainable yield rate in 2001.

In summary, the forecasting methodology used in East Gippsland, and therefore the forecast, is considered adequate as the basis for developing options in the next step in the RFA process.

Value and significance of the timber based industries

In order to assess the economic circumstances underlying the competitiveness and value of the hardwood sawmilling industry an economic survey of sawmills operating in the East Gippsland Region was conducted. This information was used in conjunction with other market based information to estimate the net economic value of the East Gippsland hardwood sawmilling industry.

The timber industry plays an important role in the regional economy accounting for approximately 27 per cent of manufacturing turnover within the East Gippsland statistical division. In 1995, 19 049 people were employed in the East Gippsland statistical division. Direct employment associated with the timber industry within the East Gippsland region is estimated at 555 people.

In 1994-95, there were twenty-three hardwood sawmills receiving logs from State forests located within East Gippsland. Twenty-two of these mills were operating within the region. Presently, there are 21 hardwood sawmills receiving logs from State forests located within the East Gippsland region, reflecting recent changes in mill processing activities compared to 1994-95. There are also two woodchip companies which receive sawmill residues from the East Gippsland region. These are located in Geelong and Eden.

Total hardwood sawntimber production from sawmills dependent on the East Gippsland resource in 1994-95 is estimated at around 134,000 cubic metres, approximately 14 per cent of total Victorian sawntimber production (including both softwood and hardwood sawntimber).

The total net value of production for 1994-95 for the hardwood sawmilling industry in East Gippsland is estimated at $8.1 million. The total value of turnover (or gross receipts) for the industry is estimated at around $52.5 million in 1994-95. Information collected on the average net returns to the industry in 1994-95 was also used, in conjunction with future anticipated log allocations, to provide a broad estimate of the likely magnitude of the total net returns to the industry in 1995-96 and 1996-97. Assuming real constant costs and prices over these two years, and future anticipated log allocations, the total net economic value of sawmilling production is estimated at $10.7 million in 1995-96 and $11.6 million in 1996-97.

Total capital invested by mills within the East Gippsland FMA is estimated at approximately $49.8 million. This figure includes all plant, machinery and structures in East Gippsland mills and was estimated as the replacement value of existing capital stock in 1994-95.

Market Outlook for Sawntimber

Because Australian trade in most forest products (such as sawntimber) is small in comparison with world trade, domestic prices for forest products are largely determined by the landed or import parity price of imports. The forecast supply reductions in global hardwood timbers, together with projected increases in world population growth and economic activity, are expected to result in rising real prices of logs and solid wood products over the medium term.

The Australian market for sawn timber continues to be influenced by depressed conditions in the new residential construction sector. Total sawntimber consumption is expected to fall by 13% in 1995-96 before recovering moderately by an average 1% per year from 1997-98 onwards.

Strong competition from softwood sawn timber is expected in the house framing market and other structural end use markets in line with future projected increases in softwood sawntimber production. However, the impact of substitution away from hardwoods to lower cost softwoods in housing construction has been offset, in part, by hardwood sawmillers diversifying into kiln-dried timber for furniture, flooring, mouldings and other value-added markets.

Possible wood based industry development opportunities

A number of wood based industry development opportunities have been proposed for the region. These industry development opportunities may be summarised into two broad categories: opportunities for further value adding of hardwood sawlogs; and, opportunities for the increased utilisation of residual logs.

With respect to opportunities for further value adding of hardwood sawlogs, the ability of the hardwood sawmilling industry to maintain profitability and compete against domestic softwood and other imported timbers will depend on the underlying cost competitiveness of the industry, as well as the development of new market opportunities.

While the proportion of kiln-dried and dressed sawntimber to total production is still presently moderate, up to $5.4 million has recently been invested by sawmillers in kiln-drying or sawing facilities designed to increase the proportion of dried and dressed sawntimber over time.

With respect to the increased utilisation of residual logs from East Gippsland, the Department of Natural Resources and Environment has recently called for expressions of interest in the processing of 800,000 cubic metres (m3) annually of residual logs available from East Gippsland (650,000 m3) and Tambo Forest Management Areas (150,000 m3).

The residual log volume of 800,000 m3 per year is of sufficient size to support a range of internationally competitive wood processing activities. With current technology, these logs can be processed into a variety of products, including medium density fibreboard, laminated veneer lumber, plywood, veneer, or other smallwood products (e.g. furniture components). There is an emphasis on the development of domestic processing in relation to this resource.

Other forest products

A review of existing resource and market information was also used to present an economic profile of other direct or potential uses of State forests including apiculture, grazing, non-mineral extractives, recreation, tourism, mining and water production. Cost, price and trade data were obtained either directly from industry, or from published information sources such as the Australian Bureau of Statistics. A range of economic indicators were collated, including estimates of employment, production volumes and gross,value.

The State forests of East Gippsland provide for a range of uses. In addition to the production of sawlogs and residual logs. These include, bee-keeping, stock grazing, recreation, tourism, and water production for domestic and agricultural use. Production of minor products in the region is generally low in terms of value. Total royalties received by DNRE from the sale of minor forest products was $44,956 in 1994-95.

Bee-keeping and grazing in State forests

Apiculture (or bee-keeping) is practiced widely in East Gippsland State forests by a number of commercial and semi-commercial beekeepers. In 1992-93, there were 4 permanent bee farms covering an area of 2454 hectares, and 144 temporary licence holders operating within State forests in the East Gippsland region. However, only 143 bee-keeping sites were operating in 1994-95. In 1993-94, the honey produced from the East Gippsland region had an estimated market value of $172,700.

Grazing licences occupy a total area of 85 000 hectares, or over 90 per cent of the total area held under occupation licences in State forest within East Gippsland. Access to grazing activities in the State forests of East Gippsland is controlled through the issue of grazing licenses and Crown leases.

Recreation and tourism based activities

East Gippsland forests are used as a resource for both recreation and tourism. In 1993-94 total direct employment in the tourism sector was estimated at 279 permanent full-time jobs. East Gippsland forests attract a significant number of visitors as they offer a range of recreational opportunities based on the natural values of the region.

It is estimated that in 1995/96, approximately 600 000 visitor days were made to East Gippsland Parks, representing a total value of approximately $11 million.

It is also estimated that State forests in the region received 140 000 visitor days per year which equated to a total net value of between $0.8 and 2.5 million per annum.

Catchment and Water Values

A supply of water in sufficient quantity and appropriate quality is essential for maintaining natural environments, and for agricultural, recreational, industrial and domestic consumers. For these reasons, water is a very important resource that can be harvested from forests. Streams and catchments in the East Gippsland region include some of the most pristine in Victoria.

The relationship of water, catchments, forests and forest use is complex, and based on many variables including climate and geology, lithology and vegetation. Human impacts can have adverse effects on water values. Water quality and quantity are important forest management issues, and a number of management techniques are used to maintain water values, as detailed in the code of forest practices and regional prescriptions for timber harvesting.

In East Gippsland, areas of the Betka and Rocky River catchments subject to harvesting are included in the Special Management Zone, with several specific management constraints designed to offer additional protection to catchment values.

Plantations

Land availability and suitablility in East Gippsland limits the potential development opportunities for plantations. Current Victorian Government policy prohibits the clearing of native forest on public land for the establishment of plantations. Private land can be cleared for conversion to plantations subject to native vegetation retention controls to protect flora and fauna, and local government planning requirements.

Consequently, plantation development opportunities are available only on public lands that do not presently contain forest, and some areas of private land. Private land represents 156 900 ha (13%) of the land area of East,Gippsland.

Most potential for plantation development or expansion lies to the west of the East Gippsland Region, in Central Gippsland, or to the north-east on the Monaro Tablelands of New South,Wales.

Minerals

An assessment of known mineral resources and potential (undiscovered) mineral resources is provided in this report.

The rock types, the age and geological structures in East Gippsland are similar to those which host major mineral deposits in other parts of Victoria and elsewhere.

East Gippsland is underexplored in terms of exploration expenditure at $736 per km2 as compared with Victoria as a whole at $1298 per km2. There are currently 21 active exploration licences in the region and the minerals being explored include gold, copper, diamonds, iron ore and zinc. In 1994-95 exploration expenditure in East Gippsland totalled $904,818. Exploration expenditure from 1970 to the present is $8.9 million and the minimum expenditure requirement on existing Exploration Licences for 1996-7 is a further $1.3 million.

The Victorian Government has conducted airborne magnetic and radiometric surveys and geological mapping to encourage exploration in East Gippsland at a cost of $2 million over the last 3 years.

There are about 200 mineral occurrences, deposits and old mines in East Gippsland. Known resources of high grade limestone in the Buchan area are large, with lesser quantities of dolomite.

Estimated gold production since 1851 to the present is estimated by the Victorian Geological Survey (VGS) at about of 3,185,000 kg which, at today's prices equates to about $US40M. Current major mining activity is confined to the extraction of high grade limestone and construction materials.

The potential for occurrence of mineral deposits in the area has been assessed using the scientific approach developed by the United States Geological Survey. This approach identifies geological units (tracts) which could contain particular styles of mineralisation. It ranks the potential for occurrence of specific types of mineralisation in specific geological units as high, moderate, low or unknown, based on the professional judgements of the geoscientists involved. To reflect the differing amounts of information available, the mineral potential has also been categorised according to levels of certainty.

It is not possible to have a "final" assessment of potential mineral resources at any given time. The mineral resource potential of areas needs to be monitored and reassessed periodically to take account of new data, advances in geological understanding, in mineral exploration and mining technologies, changes in mineral markets and other factors. Continued access to land for regulated exploration, which is a transient process rather than a long-term land use, is an important issue for the minerals industry and for future mineral development.

The qualitative desk-top assessment, based on a wide range of geoscientific data and information has identified considerable potential for a number of significant types of gold, base metal and other mineral deposits within East Gippsland. These occur in defined tracts throughout the region and are described and mapped in detail in this report.

The relative economic significance of the tracts for different types of mineral deposits would be dictated by the perceptions (of mining companies) of prospectivity, future market conditions, land access and other factors.

1. Introduction:

1.1 Purpose

This report provides the details of the resource and economic components of the Comprehensive Regional Assessment (CRA) for East Gippsland. It details assessments of existing resources of the forest estate in East Gippsland, examines the range of existing forest uses, provides estimates of future resources and potential usage and develops the framework for economic evaluation of the scenarios/options to be developed in as the next step of tin the Regional Forest Agreement (RFA) process.

The report is intended to provide sufficient information on the resource and economic components to allow forest use and management options to be developed for East Gippsland. This process will occur, in conjunction with the environment and heritage and the social assessment reports and with input from stakeholders and the public. In this respect, the report does not propose specific options.

Six broad resource or usage categories are described in the report: They are:

- native forests - production of sawlogs and residual logs (pulpwood)
- plantations - native and exotic species
- othermiscellaneous forest produce
- recreation and tourism
- water
- mineral resources

For each category, the current status of the resource, or level of usage, is examined, an economic assessment made, the outlook (potential) discussed, and the potential for further development is examined.

1.2 The East Gippsland Region

The East Gippsland Regional Forest Agreement Region Management Area (FMA) coincides with the East Gippsland Regional Forest Management Area (FMA) Agreement Region. The East Gippsland Forest Management Plan (DCNR 1995, background document and data), has been used extensively for this report.

Details of the Region, including tenure information and a description of the management zones used in the strategic planning and management of public forests available for production, is provided in the East Gippsland CRA Overview of Assessments Report.

1.3 Scope of assessment

The scope of this report is to:

- provide the details of assessments of existing resources within the forest estate in East Gippsland;:
- examine the range of existing forest uses;
- provide estimates of future potential resources and usage; and
- develop the framework for economic evaluation of the scenarios/options to be developed as the next step in the RFA process.

The information presented in this report is based on existing scientific and economic data, including recent economic survey data on the sawmilling industry conducted for this assessment. The scientific framework and assessment of resources and potential development opportunities in this report draws on a range of disciplines, including forestry, geoscience, and other specialised fields. The collection of relevant cost, price and trade data were obtained, either directly from industry, or from published information sources such as the Australian Bureau of Statistics.

The major objective of efficient and sustainable forest resource management is to maximise the net benefits (which includes timber, non-timber, biodiversity, cultural, heritage and other benefits) to Australians from using a region's resources through time. These include the natural resources, as well as the level of human capital resources (or infrastructure) which may be invested. Due to the long time frames often associated with forest production and conservation based activities, it is important to consider both the short and longer term in the identification of optimal forest use and industry development options for the Region. The potential benefits and costs also need to be viewed from Regional, State and National perspectives.

The economic valuation of forests may be described within a total economic value framework, which includes the following categories of use or value (Figure 1). The economic value arising from a direct use such as wood production, for example, includes the profits earned from hardwood sawmilling activities, as well as royalties and taxes paid to governments from these activities. However, the economic values derived from forests are not limited solely to those that are traded in markets (and may therefore be given a market value). Many conservation attributes in the region, such as forest biodiversity, and natural and cultural sites of significance, represent potential use or non-use values derived from forests. Resources are said to have non-use values when some people obtain a benefit independent of that from any direct resource consumption. Two categories of non-use value include existence values and bequest values. The existence value of a resource is the satisfaction that some people derive from knowing that a particular resource exists, independent of any consumption of the resource. The bequest value of a resource is the benefit some people derive by knowing that a particular resource will remain in existence for the benefit of future generations.

Consideration of all potential use and non-use values of the forest resource in the East Gippsland region will be an important component of the RFA process. The direct use values of forests for wood production are an important focus of this report, as well as the value and future potential for other direct forest uses such as recreation, mining and grazing. Indirect use values such as biodiversity conservation and wilderness attributes are being assessed as part of the environmental and heritage assessments, while non-use values such as existence values will be maintained through the establishment of a permanent forest reserve system and ecologically sustainable forest management of all forest areas.

(Figure 1: Categories Of Economic Values Associated With Environmental Resources Such As Forests
Source: Munasinghe (1993).)

A central aim in the RFA process is to recognise and consider the full range of as many forest values as possible when making forest resource use decisions. This process could include, for example, identifying the least cost options for alternative reserve designs. Incorporating economic criteria in the process will allow opportunity costs, associated with changes in resource availability, to be taken into account. Another important aspect of integrated assessment is to explore the potential for economic benefits flowing from complementary forest uses.

The concept of economic value of a resource carries with it the notion that both the economic return to society from using a resource (benefits) and any adverse impacts arising from its use (costs) must be considered together when making policy or resource use decisions. This implies that an action is desirable if the benefits arising from that action exceed any associated negative impacts.

Economic benefits and costs to society from existing or potential future uses of forests in the East Gippsland Region can also be expected to persist for many years, thus introducing an important time dimension to optimal policy decisions. In the case of wood production, the potential profits earned by industry and taxation revenues (e.g. royalties paid to the Government) are likely to be maintained over long periods of time, assuming sustainable forestry management practices and favourable market conditions. Alternately, long term costs may arise where there is a risk that the pursuit of certain activities will reduce the capacity of the region to provide economic benefits in the future.

This report is a precursor to the integration phase of the Regional Forest Agreement process. In the integration phase all of the assessments, including the environment and heritage, indigenous heritage, social and economic and industry development assessments, will be analysed with stakeholder and public input to produce possible forest use options. This analysis will include identification of areas proposed for commercial forest production, areas that comprise the forest reserve system and management prescriptions and guidelines for ecologically sustainable forest management. It will also include consideration of the community and industry needs to ensure that the effects of implementing different scenarios are an integral part of the options development process.

Several analytical tools have been designed to assist in the evaluation of RFA options that will be developed following the release of the Assessment Reports. They will identify the potential economic and industry implications of each RFA option. These tools include the use of FORPLAN, FORUM and MONASH-CRA.

FORPLAN is a quantitative forest planning tool which will be used to provide future potential wood-scheduling flows for each RFA option. The FORUM model will use the changes in future potential wood scheduling flows from the FORPLAN model to assess potential implications on regional forest industries. These impacts will be measured by identifying changes in net returns and employment in local wood-based industries. The technical details of FORUM and a case study of its use are described in Neck, Stephens and Hansard (1995) and Hansard, Dan, Stephens and Clark (1996). Broader economy-wide effects beyond the local wood-based industries will be evaluated using a modified general equilibrium model of the Australian economy known as MONASH-CRA (Dann, Hemery and Stephens 1996). This model will use the changes in the broader State and national implications for each RFA option, by assessing the spillover effects from the forestry sector of the economy. These spillover effects may be measured by changes in the value of state and national output and employment.

2. Forest Management

2.1 History

Timber harvesting in East Gippsland began in the 1850s and continued at a fairly low level for the next century to support the needs of local gold mines and agricultural development. During the early years of the 20th century, large volumes of wood were harvested from the coastal forests for charcoal production and railway sleepers. Large-scale timber harvesting began in the 1950s in response to the demand for timber during the housing boom following World War II, and the loss of timber resources in the Victorian Central Highlands in the bushfires of 1939 (DCNR 1995).

Forest management and silviculture in East Gippsland during this period was limited by technology and funding. The effect of early harvesting on the forests of East Gippsland was variable and directly related to access and demand for products. Forests close to roads and settlement, or those in the coastal belt, were favoured over those in the more remote locations and were therefore more intensively logged.

This early selection logging had the effect of removing higher quality trees with minimal disturbance, leaving the poorer quality trees which continued to occupy the site and inhibit regeneration. The harvesting regime did not consider the need for regeneration to provide for future sawlog requirements and the net effect was to degrade the forest's and the sawlog producing capacity such that today some forest areas are understocked or unproductive for sawlog harvesting. With higher demand for timber and improvements in technology, timber harvesting operations in the 1950s and early 1960s increased significantly in the region. However, in some cases, high retention of overwood and wastewood on the forest floor reduced the growth and sawlog potential of the regrowth forests.

Proper and adequate silvicultural practices that focused on regenerating the forest following harvesting were not introduced until the late 1960s and early 1970s, with the implementation of when clearfelling and seed tree silviculture. were introduced. The introduction of improved silvicultural practices provided sufficient disturbance, restriction of competition and adequate seed to consistently regenerate the forest eucalypt species. Consequently, most areas of advanced post-logging regrowth which has the potential for sawlog production originate from the late 1960s onwards. The role of silviculture in wood production from East Gippsland is discussed further in Section 2.5.

Wildfire has also had a major impact in fashioning the forests and wood supply of East Gippsland. Depending on intensity, fire can damage trees resulting in a decline in sawlog quantity and, sawlog quality, or even the death of the tree outright. Fire intensity may or may not be sufficient to induce regeneration. East Gippsland, like other parts of Victoria, has a history of natural and human-induced wildfires. Since 1980, approximately 370 000 ha have been burnt by wildfire, the largest single event being the wildfires of 1983 when approximately 230 000 ha was burned between January and March (DCNR 1995).

Annual harvesting rates have varied since the 1950s. The annual sawlog production rose from 90 000 m3 in 1950/51 to 260 000 m3 in the mid 1960s and 345 000 m3 in the 1970s and early 1980s. This level of production was unsustainable and as a result of the Timber Industry Inquiry (Ferguson 1985), the subsequent Timber Industry Strategy (Government of Victoria 1986) and the establishment of new National Parks in the region, sawlog allocations were reduced to 179 000 m3. The 1991 review of sustainable yield resulted in a further reduction to 174 000 m3 C+, arising from further additions to National Parks. Further information on allocation levels is provided in Section 3.1.

2.2 Forest management planning

The principles for forest management in Victoria are set down in the Timber Industry Strategy (1984) which states that forest management must be:

- economically viable;
- environmentally sensitive;
- sustainable for all forest values; and
- assisted by public participation.

Planning for forest management in Victoria is guided by a number of acts, such as the *Forests Act* 1958, the *Crown Land (Reserves) Act* 1978, the *Forests (Timber Harvesting) Act* 1990 and the *Flora and Fauna Guarantee Act* 1988. Management is also guided by Government and Departmental policies and constraints such as the rainforest policy, pest plant and animal instructions and fire protection regulations.

Victoria is divided into fifteen Forest Management Areas, for which management plans are prepared to direct the use and care of forests for planning periods of ten years, with provision for review after five years. The planning process provides opportunities for public consultation and participation in resource use and protection.

Work on the *East Gippsland Forest Management Area Plan* commenced in 1989 and a proposed plan was published in 1995 which invited public comment. The draft plan was modified to take account of issues raised during the consultation process and published at the end of 1995.

In summary the plan:

- shows where logging can take place over the next decade;
- identifies and outlines measures for the protection of special landscapes;
- provides for the protection of botanical, zoological, historical and geological values;
- provides for the protection of streams and water catchments;
- identifies areas and plans facilities for particular activities (e.g. bushwalking, horseriding, community education);
- gives details of reforestation works;
- gives details of roading priorities, including road closures;
- provides a basis for fire management planning;
- gives direction for other appropriate uses; and
- sets priorities for pest plant and animal control programs.

Forest Management Zones

The East Gippsland Region is dominated by public land, which totals 1 051 100 ha or 87% of the area. The remaining 13% is privately owned. State forest occupies approximately 637 000 ha or 61% of the region, with the remaining 39% (409 500 ha) included in National Parks and other conservation reserves (NRE, 1996). Within State forest, the East Gippsland Forest Management Plan (1995) identifies three forest management zones which set management priorities and specify permitted activities for different parts of the forest. The Special Protection Zone (SPZ) is managed for conservation, and; timber harvesting is excluded. The Special Management Zone (SMZ) is managed to conserve specific features, while catering for timber production under certain conditions. The General Management Zone (GMZ) is managed for a range of uses with timber production a priority.

The gross available area for harvesting is the area contained within the GMZ and the SMZ, and extending over 472 400 ha. However, not all of the gross available area can be harvested. The GMZ totals 434 500 ha and is divided into two subzones; the Timber Production subzone which has an estimated net productive area of 332 600 ha (or 32% of public land), and the Other Uses subzone which comprises 101 900 ha (or approximately 25% of the GMZ) and is unavailable or excluded from harvesting due to unsuitable slope or soils or, is unproductive forest (generally less than 28 metres in height). Approximately 12 000 ha of the SMZ (which totals 37 900 ha) is estimated to be available for harvesting. Most timber harvesting will occur in the (GMZ). The net productive area available for timber harvesting is approximately 344 700 ha.

2.3 Land units

For management purposes, State forest in the Region is divided into forest blocks generally of about 10 000 hectares in area. Blocks are sub-divided into compartments with an area of some 300 to 700 hectares. Compartment boundaries are the smallest permanent forest planning unit. Timber resource data is collated on a compartment basis for strategic planning purposes. Within the State forest area, land is further divided in land units for management purposes. Compartments are further divided into The smallest management unit is the coupes, the smallest management unit, for the purpose of planning for timber harvesting. Coupes have a maximum area of 40 hectares, the boundaries of which are determined by natural features, for example ridges and drainage lines.

All coupes, compartments and Blocks are individually numbered and identified, for example Block ZZ, Compartment YY, Coupe XX.

2.4 Code of Forest Practices

The Code of Forest Practices (CFL 1989) lays down Statewide goals and minimum standards that apply to timber harvesting, timber extraction, roading, regeneration and reforestation in native forests. Provisions of the Code are designed to achieve the following objectives:

- land managed for forestry is adequately regenerated and managed following timber harvesting;
- reforestation is achieved efficiently and with environmental care;
- environmental values (including landscape, flora, fauna, archaeological, historical and cultural values) are conserved, and water catchments are protected; and
- opportunities are provided for recreation, scientific study and education.

The Code is augmented by regional prescriptions that consider the local variables around the State with respect to climate, forest type, topography, elevation, soil type, land ownership and various management objectives. Prescriptions for the Control of Timber Harvesting of Native Forests (Operator Prescriptions) East Gippsland Forest Management Area were produced in January 1996. In addition to the Code and Prescriptions, Wood Utilisation Plans, Forest Coupe Plans and Timber Harvesting Plans provide a framework for various levels of operational planning to regulate the harvesting of timber from native forests.

2.5 Silviculture

Silviculture is concerned with the treatment of forest stands to achieve identified management aims. Treatment can include harvesting, regeneration and tending operations such as thinning and fertilising. Combined, the treatments form a system that can manage the structure, composition and growth of a forest stand. Flexible silviculture provides scope to vary the types and patterns of trees retained in coupes, and the volume of timber removed.

The choice of a silvicultural system depends on a range of ecological, environmental, economic and social factors.

Environmental factors including soil type, rainfall, elevation and aspect influence the nature of the site. Ecological characteristics of the tree species such as seed production, dispersal, germination characteristics and the ability of tree species to respond to treatment (growth response) determine the range of appropriate silvicultural treatments.

Economic considerations are also an important factor where the system must be cost effective to implement and produce an appropriate financial return. In East Gippsland, rotation lengths vary from 80 to 120 years. It is difficult to justify a large outlay when returns may not be realised for up to 80 years from the initial outlay. To be economically feasible at an operational scale, silviculture is often integrated with timber-harvesting operations.

Other economic considerations may relate to non-wood values, for example where water production is important, harvesting can be regulated to optimise water production values for downstream consumption.

Social factors such as aesthetics may be important in forest areas used for recreation, and silvicultural practices can be modified to minimise visual impact.

In response to these factors, NRE has developed a management planning system (see Overview Report) which allow for a flexible approach to the choice of silvicultural system and scheduling of harvesting. This includes a Forest Management Zoning System in which sets priorities and specifies permitted activities for different parts of the forest. The General Management Zone (GMZ) is managed for a range of uses, but timber production has a high priority. The Special Management Zone (SMZ) is managed to conserve specific features, while catering for timber production under certain conditions.

NRE have a range of policies related to silvicultural practices:

- to maintain a natural range of age classes and the complement of species and genetic strains native to the locality;
- to establish trials to study alternative silvicultural systems to clearfelling and, depending on the results, restricting clearfelling to areas where other systems are inappropriate; and
- to investigate the potential for thinning regrowth stands to improve sawlog production, and utilising the thinnings for various products.

The Code of Forest Practices for Timber Production (CFL 19898) provides further policy guidance with respect to silviculture and utilisation:

- the regeneration of coupes is by silvicultural methods that are economically and environmentally appropriate to the particular type of forest; and
- native forests are, as far as possible, regenerated with local provenances (varieties within species).

Regeneration is fundamental to the success of a silvicultural system. Before any silvicultural operation can be applied to improve growth, the system applied must reliably result in regeneration. The success or failure of regeneration is dependent on a large number of variables, including the ecological characteristics of the different forest types.

The key variables affecting regeneration success are seed availability, seedbed receptivity and the subsequent conditions for the germination, survival and growth of seedlings (Faunt *et al*, in prep. 1996). In general terms, growth of eucalypts is directly related to the availability of sunlight and nutrients. Eucalypts are generally intolerant of competition, and will not successfully regenerate unless competition is reduced or eliminated. In nature, the conditions necessary for regeneration are created by disturbance to the forest, which releases nutrients and allows sunlight to reach the forest floor.

Disturbance occurs naturally through the effect of wind, drought, disease and wildfire. Of these disturbance regimes, wildfire has the most extensive and intensive effect on forest ecology.

Fire is not a constant variable, but behaves stochastically within certain parameters. Lower intensity fires occur more frequently than higher intensity fires. Fire intensity is a function of many variables including fuel load and dryness (flammability) and ambient temperature. The general pattern of fire intensity and fire frequency is called the fire regime. The effect of fire on forests is dependent on the fire regime, and the adaptive responses of the forest type and it's constituent species (Gill *et al* 1981). Two broad generalisations can be given for the adaptive responses of eucalypt forests to fire.

Wet or damp forest types (known as wet schlerophyll) are generally regarded as fire sensitive. Low intensity fires are relatively rare, and, and fuel accumulation occurs until weather conditions will support a high intensity fire resulting in extreme mortality. Regeneration occurs by seed fall following the fire, and is favoured by the release of nutrients and sterilisation effect of the ashbed. Stands tend to be even-aged and long-lived, with relatively little regeneration occurring between high intensity wildfires.

Drier forest types (known as dry schlerophyll forests) are characterised by frequent low intensity fire. Fire impact is generally smaller and regeneration in small canopy -gaps is possible through the formation of lignotubers and higher shade tolerance. Forests therefore tend to develop a multiple-aged overstorey, which contrasts markedly with the tendency of wetter forest types to be even-aged.

It is important to note that in presenting this generalisation, there is a large middle ground between high and low intensity fire, and wet and dry forest types. In nature, the variation in forest type and fire regime contributes to the diversity of species and age structures found in forests.

A schematic representation of the general characteristics of disturbance requirements for regeneration, fire regime and stand structure for some forest types found in East Gippsland is given in Figure 2.

Regeneration systems

In native forest management, regeneration systems can be used to simulate the effect of wildfire with the purpose of inducing forest regeneration. Regeneration systems can be broadly classified on the basis of the stand structure they create.

Silvicultural methods used to achieve even-aged stands include:

- Clearfelling
- Seed tree methods
- Shelterwood or uniform methods

Silvicultural methods used to achieve uneven-aged stands include:

- Selection method
- Single tree selection
- Group selection

(Figure 2: Environmental range of the major commercial forest types in the East Gippsland region, adapted from Florence (1996))

In determining the appropriate regeneration system for a forest type, there are a number of operational issues that must be considered.

Drier forest types will respond to a greater range of regeneration systems than wetter forest types. For example, dry forest types will respond to even-aged and uneven-aged regeneration systems, whereas wet forest types will not generally respond adequately to selection methods. This relates to the disturbance requirements for forest types described in Figure 2:

Seed availability is critical to regeneration success. In native forest, seed is naturally available in the soil, or held in woody capsules in the tree. Different forest types have different seeding patterns, with a general decline in seed availability from the drier forest types to the wetter forest types. In managing for regeneration, the need to provide for sufficient disturbance to optimise conditions for germination and growth must be traded off against the need to make seed available. Seed supply in drier forest types is often adequate for regeneration as it is persistent in the soil and available from seed trees, which are retained to provide an ongoing source of seed after disturbance. Seeding in wetter forest types is less dependable, and measures such as hand sowing may be required to ensure adequate regeneration.

Regeneration systems must consider the risk of mortality, and a number of measures can be taken to improve regeneration success rate. Seed is prone to predation by invertebrates, seedlings can be lost to frost heave and drought, and juvenile foliage may be browsed by wallabies. For example, the shelterwood system, although providing sub-optimal growing conditions by shading juveniles, may offer protection from frost, and the dessiccating effect of wind. Other approaches may include providing sufficient seed to allow for mortality rates, or direct control of predators and browsers.

Wildfire is a risk for regenerating coupes as juvenile eucalypts are particularly fire sensitive. If wildfire occurs below seed-bearing age, there may be insufficient seed supply to replace the killed trees. This is a concern in clearfelled coupes that do not contain seed trees. To manage this risk, fire can be used to reduce fuel loads immediately after logging. Burning also has the effect of providing a more receptive seedbed by releasing nutrients and eliminating competition to the emerging eucalypts.

Each of the variables discussed here presents a challenge for forest management in providing for sufficient regeneration to maintain or increase the sawlog bearing capacity of the forest, without impairing the long-term ecological sustainability of the forest. These variables also occur in nature where they contribute to the floristic and structural diversity of the forest. Diversity in forests is regarded as a cornerstone in maintaining fauna populations. In nature, change to a wildfire regime or a single significant wildfire event may not necessarily favour all species of flora and fauna and lead to local absence or permanent species extinction. Forest managers cannot risk species loss, and the challenge is to be mindful that in managing to meet the community's needs for wood production and consumption, the silvicultural systems applied to forests do not lead to change or decline in regional species abundance.

In East Gippsland, clear-felling and seed -tree systems are the most commonly used systems as they provide sufficient disturbance for consistent and adequate regeneration of harvested areas. Selection methods such as single tree and group selection were used in the past in East Gippsland but have not been continued because of poor regeneration success. Other alternatives to clearfelling and seed tree silviculture are currently being investigated as part of the SSP (Silvicultural Systems Project) trials, and are discussed below.

The operational practices for silviculture and harvesting are detailed in the *Prescriptions of the Control of Timber Harvesting of Native Forests (Operator Prescriptions) East Gippsland Forest Management Area* (NRE January 1996).forest prescriptions.

Clearfelling

This system is typically employed in the wet sclerophyll forests dominated by Alpine Ash, Mountain Ash and Shining Gum and Mountain Mixed Species.

Clearfelling is used in these forests for the following reasons:

- the mature/over mature stands tend towards an even-aged structure and it is therefore appropriate to use an even-aged regeneration system;
- extensive disturbance to the site to reduce competition for light and moisture is necessary before seedling establishment of the dominant tree species will occur;
- the great height and bulk of the trees makes selection logging difficult and dangerous, and causes extensive damage to retained trees; and
- adequate seed crops are infrequent and so artificial seeding is necessary to ensure adequate regeneration.

The components in the local application of the system are:

- all trees except those required for environmental purposes (such as habitat trees) are felled;
- logging slash and other debris is burnt with a high intensity burn in late summer/early autumn to prepare a receptive seedbed and reduce the fire hazard; and
- the coupe is hand or aerially sown with eucalypt seed in accordance with regeneration prescriptions in late autumn/ early winter. Coupes dominated by Shining Gum are often planted with seedlings due to the difficulties of obtaining adequate seed.

The Code of Forest Practice for Timber Harvesting (CFL 1989) requires the maintenance of species patterns and genetic pools following harvesting and complex seed collection arrangements are in place to satisfy this requirement.

Clearfelling results in an even-aged forest and is used to regenerate approximately 20-30% of coupes logged in the region in any one year.

Seed tree

More reliable seed crops in moist, dry and lowland sclerophyll forests means that the seed tree system can be employed. In practice, the components of the system are:

- All trees are felled except those required as a source of seed or for environmental purposes (a number of trees often serve both purposes). Seed trees are selected to reflect the natural mix of species present on the site prior to logging. Usually 4 to 5 per hectare are retained.
- Logging slash and other debris is burnt, generally in autumn, with a moderate intensity fire to produce a receptive seedbed, reduce the fire hazard, and induce seedfall from retained trees.

The seed tree system results in an even-aged forest stand with scattered mature trees, and is the dominant silvicultural system employed in the Region with approximately 70% to 80% of coupes being regenerated under this system (DCNR, 1995).

Regrowth management

Following successful regeneration, the growth habits of eucalypts, such as intolerance to competition for site resources, rapid early growth, self- thinning and tendency to self- prune, are such that silvicultural treatments including overwood removal, fertilising and thinning can be applied to promote or influence growth for sawlog production or total volume.

From early next century, an increasing proportion of sawlog supplies in East Gippsland will come from regrowth forest. Silvicultural treatment of some regrowth stands offers the potential to enhance sawlog production in selected areas and contribute to an even sawlog supply during the transition period from mature/over mature forests. In particular, thinning of the older regrowth stands originating from wildfire or logging in the late 1960s and 1970s can produce sawlogs before 2030 as a result of increased growth rates.

As with regeneration silviculture, the cost of some regrowth management practices can be off-set by achieving silvicultural advantage through commercial harvesting. Indeed, given the temporal and spatial extent of operations in East Gippsland, commercial treatments provide the best opportunity for increasing wood production.

Accordingly, regrowth management is conventionally classified as pre-commercial or commercial, relating to the age and commercial size of the trees in the stand. Management that does not conveniently fall into either classification is often referred to as Timber Stand Improvement, which can also offer some commercial opportunities.

Pre-commercial treatments

Pre-commercial treatments include the control of stocking through seed supply, early thinning (spacing) and fertilising.

Given the propensity for eucalypts to germinate under high disturbance, the situation can develop where the young stand is overstocked. Although eucalypts forests have the capacity for self-thinning, i.e. the faster growing trees will out-compete the slower growing trees, artificial thinning has the effect of reducing competition earlier, and encourages a growth response in the superior stems.

The response of eucalypts to thinning has been well documented. Florence (1996) demonstrates the growth responses capable in Mountain Ash forest from thinning, as an increase in the average size of trees (measured as diameter breast height - dbh) and merchantable volume:

Residual stocking after thinning at 3 years (stems/h)	Mean dbh of largest 74 trees/ha at 11 years	Standing merchantable volume (underbark to 10 cm small end) at 11 years
Unthinned	22.4	132
1235	26.9	282
618	31.5	265

Borough et al 1978 cited in Florence 1996.

This type of growth response could in some cases be further enhanced through fertilising, however the use of pre-commercial treatments may be economically unjustified when assessed on a discounted cash flow basis over the duration of a rotation. Relatively long rotations (80 years) carries a high interest burden on investment and therefore returns to investment must be high.

Another approach to controlling stocking, although not routinely operationalised, is to control the seed supply. This could be done through reducing the number of seed trees, or reduce the coverage in sowing and planting. The benefits of such an approach however, would have to be weighed against the ever present risk of seedling mortality through frost, drought, predation of seed by ants, and browsing of juvenile foliage by wallabies.

Commercial thinning of regrowth

Thinning can be carried out to achieve a number of objectives:

- to remove dead, dying and suppressed trees where pathogens attracted to them may affect the health of the stand as a whole;
- to commercially utilise commercially, stems which would otherwise die through the natural process of self- thinning;
- to provide remaining trees with greater access to growing space and soil resources, thus accelerating their diameter growth and reducing the time taken to reach optimum commercial size;
- to remove trees with poorer quality boles (e.g. crooked stems, stems with sweep or heavy branching), and in so doing focus the growth potential of the site on better quality boles; and
- to provide an early financial return. (Florence 1996)

The optimal thinning regime is determined by a number of factors including ability of the stand to respond, operational and technological considerations, and the commercial return.

The following guidelines have been adopted by NRE for thinning in East Gippsland:

- To be viable for commercial thinning, stands should have a basal area of at least 30 sq.m of regrowth per ha and less than 8 sq.m of overwood per ha. This means most viable stands in Foothill Mixed Species forests are 20-30 years old.
- Existing harvesting technology places operational constraints on thinning of regrowth stands on slopes greater than 18o or with substantial amounts of large-diameter log debris on the ground.

Taking these factors into account, approximately 4 500 ha of Foothill mixed species forest type have been identified as suitable for thinning over the next ten years (CNR, 1995).

Refer to Map 5 which illustrates the estimated productivity of regrowth by forest type.

Timber Stand Improvement (TSI)

TSI operations involve selective removal of mature and overmature trees from established stands of regrowth, with the aim of releasing the regrowth from competition. This increases the sawlog-producing capacity of selected forest stands by removing some of the overwood. It can also produce a small quantity of sawlogs, but tends to produce more residual logs. More widespread use of TSI is currently constrained by the small residual -log market.

The East Gippsland Forest Management Plan states that TSI operations will continue to be applied to selected stands where they confer the maximum silvicultural advantages and that techniques for combining regrowth thinning and TSI will be further explored where appropriate.

Large areas of Lowland Forest and Limestone Box Forest in the region have a long history of selective harvesting for sawlogs and minor produce. The effect of this is that better quality merchantable trees have been removed from these forests, particularly species producing durable timbers such as Ironbark (*Eucalyptus tricarpa*), Gippsland Grey Box (*E. bosistoana*), Red Box (*E. polyanthemos*) and Blue Box (*E. baueriana*). Poor regeneration of these species and the prolific seeding and early rapid growth rates of Silvertop Ash (*E. sieberi*) and White Stringybark (*E. globoidea*) have altered the forests' species composition (Featherston 1985). In addition, the effects of wildfire and dieback from Cinnamon Fungus (*Phytophthora cinnamomi*), have further degraded many thousands of hectares of lowland forests in the Region.

In their current condition, these forests carry low sawlog volumes and have little capacity to achieve their potential for future sawlog production unless rehabilitation works are undertaken. This could be achieved most economically using a silvicultural system such as seed tree which removes the small volume of sawlogs still remaining together with the residual logs. Given the condition of these forests, it is likely that regeneration would have to include supplementary sowing or planting to restore the original species mix. Currently, treatment such as this is constrained by restricted access to markets for residual logs.

Integrated harvesting

Harvesting the sawlog component within a forest stand generates significant volumes of wood below sawlog standards which is suitable for other purposes. Approximately 650 000 m3 of residual logs become available each year as part of normal sawlog harvesting operations in East Gippsland. Some of this is sold through residual log licenses, however most is not utilised. Logs that do not meet sawlog grades account for over 70% of the current resource. The foothill and coastal forests produce a higher proportion of residual logs, due in part to past disturbances. Furthermore, the quantity of available residual logs will increase as more areas of low volume forest are harvested to meet sawlog licence commitments. However, as the transition is made to regrowth forest, the biomass per unit area will increase and a greater proportion of the biomass will be of sawlog quality. Therefore the volume of sawlogs will increase, contributing to higher sustainable yields in the future, and while the ratio of residual logs to sawlogs will decline, the total volume of residual logs will remain broadly the same.

Integrated harvesting, involving the utilisation of both sawlogs and residual logs, would provide greater economic returns, improve harvesting efficiencies and broaden the options for silvicultural treatment of low volume forests. At present, due to the lack of available markets for residual logs, a large proportion of potentially unmerchantable trees remain in many coupes and may cause silvicultural problems in the future.

The Department of Natural Resources and Environment, in conjunction with industry, is investigating the feasibility of establishing processing facilities within the East Gippsland FMA and the adjacent Tambo FMA, in order to fully utilise the residual log resource and to produce value-added products from this material.

Research in progress

The East Gippsland Forest Management Plan (1995) specifies the following:

- Silvicultural prescriptions for use in the General Management Zone (GMZ) will continue to be reviewed and revised in the light of research findings and operational experience. Alternative silvicultural systems will be used where a higher regeneration success rate can be assured or where values other than timber production have priority.
- Techniques for timber harvesting in the SMZ will be considered on a case-by-case basis. Where current harvesting systems are deemed inappropriate, smaller coupe sizes, retained overwood systems and uneven-aged systems will be considered.
- Research studies in the high elevation mixed species forest type, aimed at improving regeneration success, will be maintained.

Several research projects are underway in East Gippsland under the title Value Adding and Silvicultural Systems Project (VSP) incorporating:

- the Silvicultural Systems Project (SSP) is comparing several alternatives to the clear-felling and seed tree systems currently used in East Gippsland.
- the Value Added Utilisation System (VAUS) which is examining the environmental effects of harvesting residual logs in East Gippsland.

Numerous documents have been published, and in addition, as many of the trials are still on-going, several reports are currently in press or in preparation:

Reports which have been prepared include:

VSP Reports:

- No. 13 Rab, MAB. 1992. Impacts of timber harvesting on soil disturbance and compaction with reference to residual log harvesting in East Gippsland, Victoria. A Review.
- No. 20 Sharp, R. 1993. Regeneration costs under alternative silvicultural systems in Lowland Sclerophyll forests
- No. 22 Stucken, ER. and Hajeck, CF. 1993. Seedbed assessment following harvesting under alternative silvicultural systems in a Lowland Sclerophyll eucalypt forest in East Gippsland.
- No. 23 Bloch, A and Muphy, S. 1994. Safety of forest harvesting under alternative silvicultural systems in a Lowland Sclerophyll eucalypt forest in East Gippsland.
- No.26 Bassett, O. 1995. Development of seed crops in *Eucalyptus sieberi* and *E. globoidea* in a Lowland Sclerophyll eucalypt forest in East Gippsland.

CSIRO Reports:

- CSIRO Division of Forestry. 1991. Collaborative silvicultural systems research in East Gippsland between CSIRO and Victorian Department of Conservation and Environment. Interim Report.
- CSIRO Division of Forestry. 1993. Collaborative research in regrowth forests of East Gippsland between CSIRO and Victorian Department of Conservation and Natural Resources. Second progress report.

VAUS/SSP Departmental Reports:

- DCE, Orbost Region. 1992. Report on the SSP project July 1986-June 1989.
- DCE, Orbost Region. 1992. Development of forest management systems for the Value Added Utilisation Trial, East Gippsland. 1990-1991 pilot trial.
- DCE, Native Forest Research. 1992. First interim report for the Value Added Utilisation System trial.

Other Reports Relating to East Gippsland Regrowth Management include:

- Department of Conservation, Forests and Lands, CSIRO Division of Chemical and Wood Technology, CSIRO Division of Forest Research and Victorian Sawmillers Association. 1986. Management of eucalypt regrowth in East Gippsland-the feasibility of thinning regrowth forests for value-added products and the creation of permanent jobs.
- Kerruish, CM. Raison, RJ. Rawlins,W. and Turnbull,P. 1993. The Potential of regrowth forest to contribute to industrial production. Proc. 15th Biennial Conf. IFA, pp. 154-162. Alexandra Headland, Sept. 1993.
- Raison, J. Geary,P. KeRuish, CM. Connell, M. Jacobsen, K. Roberts, E and Hescock, R. 1995. Opportunities for more productive management of regrowth eucalypt forests: a case study in the E.sieberi forests of East Gippsland.
- No. 19 Bassett, O. and White, MD. 1993. Development and Testing of seed crop assessment models for three Lowland Sclerophyll forest eucalypts from East Gippsland.

VSP reports in preparation:

- Faunt, KA. Geary, PW. Cunningham,RB. and Gibbons,P. (1996 in prep) Silvicultural Systems Project: Germination and Early Survival of Eucalypt Regeneration Following a Range of Harvesting and Site Preparation Treatments in a Lowland Sclerophyll Forest. Draft.
- Faunt, KA. Geary, PW. Gibbons,P. and Cunningham,RB. (1996 in prep) Silvicultural Systems Project: Height Growth of Eucalypt Regeneration Following a Range of Harvesting and Site Preparation Treatments in a Lowland Sclerophyll Forest. Draft.
- Sticken, ER. Brennan, NP. and Geary, PW. (1996 In prep) Regneration of the VAUS Experimental Coupes in East Gippsland.Draft.

Other reports include trials investigating Species dynamics and Overwood Survival.

3. Timber Production

3.1 Forest type, extent and merchantability

The classification and description of forest types for commercial purposes is based on the predominant commercial species, and the quality and quantity that will provide sawlog material. Victorian Government policy states that, subject to a number of constraints including tenure and zoning, forests in East Gippsland become commercially available only when the potential stand height exceeds 28 metres.

Thirteen forest types, determined on the basis of predominant overstorey species, are found in the East Gippsland region. These forest types are described in this report using standard terminology, but are different from the Ecological Vegetation Classes discussed in the Environment and Heritage report. Of the thirteen, six forest types are considered to be commercial.

Table 1 below gives the area of forest types that are commercially important and are available for sawlog production. The Alpine Ash, Mountain Ash and Shining Gum, and Mountain Mixed Species forest types occur in the high elevation and plateau areas in the north of the region. They generally have a mature stand height greater than 40 m and are the most productive forests in East Gippsland. . Foothill Mixed Species and Coastal Mixed Species forest types occupy a broad east-west band through the foothills and coastal plains and are regarded as less productive than the higher elevation forest types. Alpine vegetation is generally unproductive and is not harvested. Only a limited amount of the Alpine Mixed Species stands are harvested, due to low productivity and defect. Box-Ironbark forest has low productivity and has been harvested in the past for minor produce. Callitris Pine and Closed Forest are not harvested. Other forest types are unproductive.

Forests are also classified by age or maturity:

- Regrowth (REG) = 0-60 years of age
- Advanced Regrowth (ADV) = 61-80 years of age
- Mature (MAT) = greater than 80 years of age
- Overmature (OM) = greater than 80 years of age with evidence of senescing crowns.

The purpose of these classifications is to describe age structure for commercial forest types and are different from the growth stage classifications used to describe old growth in the Environment and Heritage report.

Table 1 Net Productive Area of forest in the East Gippsland FMA by forest type and year of origin

Net Productive Area (ha)

Year	Alpine Ash	Mountain Ash and Shining Gum	Mountain Mixed Species	Foothill Mixed Species	Coastal and Alpine	Thinned Foothill Mixed Species	Total Mixed Species
Mature/ Overmature	767		797	47 338	101 924	74 722	225 548
1915			38				38
1925	52	30	556	1210			1848
1935	395	7	2082	1388	41		3913

1945	42		459	29	38		568
1955			1450	2623	746		4819
1965	122	128	4129	7517	11026	1850	24772
1975	1663	750	6900	7205	7378	2700	26596
1985	1283	558	13612	18943	12841		47237
1995	263	68	4437	3410	1179		9357
Total Area	4587	2338	81001	144249	107971	4550	344696

Source : Review of Sustainable Sawlog Yield East Gippsland Forest Management Area (NRE, 1996, in press). Please note the data used to comprise Map 3 includes regrowth information only to 1991/92 Map 4 has been constructed using data from the Hardwood Area Resource Information System (HARIS) to demonstrate the proportion of compartments that are available for logging within the General and Special Management Zones. As can be seen there is a complex spatial arrangement of areas available for timber harvesting **Sawlog classification**

Sawlogs and Residual roundwood are graded according to sawlog grading instructions and interpretations. The details are given in Appendix B. All sawlogs are classified on the basis of quality and sometimes species into Grades A to D. Logs that fall below the specifications of the classification described in Appendix B may be suitable for a range of purposes as pulpwood and are termed residual logs. Further discussion on residual logs is contained in Section 3.4.

- It is important to understand and focus on the units reported against any discussion of sawlogs in this report, as for historical reasons, reporting and forecasting has changed from between grade C and better (known as C+) to grade D and better (known as D+). The discussion on units for sawlogs referred in this report refers to either can vary between C+ or D+ as appropriate.

Recent history of sawlog allocations

In 1988, 15-year licences were issued to sawmillers for an average total allocation of 179 000 m3yr of C+ sawlogs in line with the estimated sustainable yield. As the allowable cut was being reduced from 345 000 m3 to the sustainable yield level, licensees were given several options to achieve the reduction in order to minimise the effect on industry profitability and workforce disruption. The options included:

- phasing down to sustainable yield over the first (15-year) licence period without exceeding the total sustainable cut over the 15 year period;
- an immediate reduction to sustainable yield; and
- the ability to obtain remaining portions of pre-1988 licenced allocations that had not been cut.

In 1990, a number of State forest areas within the East Gippsland Region were incorporated withdrawn from State forest and included into existing National Parks. As a result, the sustainable yield for the FMA Region was reduced from 179 000 cubic metres per year of C+ sawlogs to 174 000 cubic metres per year of C+ sawlogs. As 15- year licences had already been issued under the previous sustainable yield of 179 000 C+ cubic metres per year of C+, it was decided that any adjustments would be made when licences were next reviewed (DCNR 1995).

Subsequently, the East Gippsland Forest Management Plan (NRE, 1995) identified the area available for timber production as 332 600 ha, following the designation of the Special Protection Zones to enhance biodiversity conservation. This zone excludes timber harvesting. A further 12 000 ha is available in the Special Management Zones under certain conditions. The current review of sustainable yield (NRE 1996, in press) incorporates adjustments for land availability and forecasts sustainable yield in terms of D+ (rather than C+) sawlogs. The forecast sustainable yield of D+ sawlogs is at 249250 0600 m3, which incorporates 174 000 m3 of C+ sawlogs. The sustainable yield forecast is contingent upon the thinning of 4,500 ha of advanced regrowth which will result in the production of sawlogs from these forests sooner than would be expected without thinning.

As a result of past reductions in sustainable yield described above, the Region is going through a phase- down in harvesting. The majority of the phase- down occurred in 1988/89 and 1989/90, but other significant reductions have occurred in 1995/96 and will continue until 1998/99. In order to compensate for the elevated level of cut in the early years of the 15 year licence period, the cutting level will decrease below the sustainable yield level in the latter years of the 15- year period (DCNR 1993).

This method of regulating the yield, and of implementing reductions in yield, is based on an ability, subject to certain constraints, to vary the cut (either above or below the calculated even/annual flow rate) in early years and balance out in subsequent years of a forest rotation.

Sawlog licences are managed to allow certain flexibility over time, thus allowing licensees to respond to market demands. Provision is therefore made for licensees to overcut or undercut their annual allocation by up to 30% (i.e. between 70% and 130%) so they can respond to changes in market demand for timber. Overcuts and undercuts are averaged over the licence period and the total volume harvested must not exceed 110% of annual allocation over any five- year period (DCNR 1995). The Forests Act (1958) further states that at the end of a licenceing period, the total volume harvested must not exceed more than two percent of the total licenced volume for that period.

Current sawlog standing volume

Table 1 above shows the available area of mature/overmature and regrowth forest by commercially important forest type. Table 2 below shows the volume of currently available standing timber volumes for mature/overmature forest and future sawlog production from regrowth by forest type. This information is also represented in Map 2. Commercially available standing timber volume is a function of net harvestable area, forest condition, and type. In relation to Map 2, higher yielding compartments are those that have larger available areas, in which the forest is inherently high yielding (e.g. Alpine Ash or Mountain Ash type) or is in good condition. Lower yielding compartments are those which have smaller harvestable area, or have been recently logged, or in which the forest condition has been reduced by wildfire or past selective logging practices.

Table 2 illustrates that the Ash-type forests comprise only 2% of the net productive area and that the Foothill Mixed Species forest type is the most extensive, comprising nearly 43% of the net available area in the region. These figures also show that approximately 225 500 ha (65%) of the net productive area is mature/overmature forest, with the remaining 119 200 ha (35%) being regrowth forest. With the exception of the regrowth which originated from the 1926 and 1939 wildfires, the majority of the regrowth resource has resulted from harvesting since the late 1960s (DCNR 1995).

Forest resource information

Timber resource information for East Gippsland is collected and stored in the Hardwood Area Resource Information System (HARIS). HARIS is a summary database system used to store timber resource information for a particular region of the State and is designed as a strategic level database, suitable for regional sustainable yield forecasting. Sustainable yield has been calculated for East Gippsland using a spreadsheet package SYSS (Sustainable Yield Spreadsheet System) based on standing timber volumes from HARIS and growth models (yield curves) for the range of commercially important various forest types occurring in the region.

The sustainable yield forecast is determined from the management strategy and the available area for harvesting (East Gippsland Forest Management Plan, CNR 1995).

Collection of data and modelling for timber production, like other types of modelling is subject to practical, economic and logistical constraints. Decision-making on the basis of modelling requires an understanding of the strengths and weaknesses of data and the model. Where the level of certainty is known, the confidence can be expressed statistically. However, where a statistical expression cannot be given, sensitivity analysis can be used to determine the effect of bias or error in the data and model.

3.2 Sustainable yield

The sustainable yield of wood production from a forest is defined in Victoria as the estimated annual rate of hardwood sawlog production that can be achieved without impairing the long-term productivity of the land, taking into account the structure and condition of the forest (NRE, 1996, in press)

Sustainable yield management in Victoria has three main objectives:

- to provide a non declining supply of sawlogs of above a defined standard;
- to provide the highest yield available at any point in time; and
- to approach the maximum potential productivity of the forest. (NRE, 1996 in press)

Sustainable yield calculations in Victoria are undertaken on the basis of sawlogs, as this is the major high value component of wood production. Sawlogs attract a higher unit price but comprise a relatively small proportion of the cut. The sawlog component is also the component that is usually the subject of supply commitments or sales agreements, and operations are directed at meeting those commitments. In this respect, timber harvesting in Victoria is 'sawlog-driven' with residual logs produced as a by-product of sawlog operations. Residual logs, while currently comprising a larger proportion by volume, are of lower quality and generally attract a lower unit price. Nevertheless, as part of the management strategy to supply sawlogs, commitments can be made to supply sustainable levels of residual logs so that silvicultural regimes can be implemented and waste is minimised.

Legislative and policy framework for sustainable yield

The Forests Act (1958) defines the legislative requirements for sustainable yield from State forests. The Act specifies that the total hardwood supply levels in a Forest Management Area (FMA) must equal, or be within the sustainable yield rate calculated for each fifteen year timber supply period (within a permitted margin of 2%). The Act, amended in 1990, also specifies that in every five year period beginning in 1991, sustainable yield rates are to be reviewed to determine whether they are still appropriate or need to be changed. The Minister, at any time, may seek a review of sustainable yield. In accordance with the legislation a review of sawlog sustainable yield in East Gippsland will shortly be concluded.

Strategic framework for sustainable yield

Sustainable yield is calculated on the basis of a management strategy for the forests in a defined area. The strategy is determined by developed on the basis of the characteristics of the forests (species, age class structure, health, site factors) as well as the market, or potential markets, and other such factors. The history of the forests is particularly relevant in gaining an appreciation of the factors influencing the condition of the stands and in developing a management strategy. Major events, such as wildfire, withdrawal of forest from production, changes to markets or alterations in silviculture may necessitate a review of the sustainable yield forecast.

Forecasting sawlog sustainable yield

The method used to forecast sawlog sustainable yield in East Gippsland is documented in Lau *et al* (1992), in press). Lau *et al* describe the method used in 1992 to calculate C+ sawlogs, and NRE (in press) forecasts sustainable yield for D+ sawlogs and reports on the available volume of residual logs arising from the sawlog forecast. The same principles and methods have been used in both forecasts.

There are three main components to sustainable yield forecasting for East Gippsland:

- Resource volume estimates for standing timber volume, including the method for collecting, storing and handling resource data;
- Growth Models are used to forecast future product (sawlog and residual roundwood) yield by forest type ; and
- Forecasting method, including the strategy formulation and technology for handling data.

As defined in 3.1 the objectives of NRE for sustainable yield is to provide a non-declining supply of sawlogs and to reach the maximum potential productivity of the forest. In context of maintaining non-wood values as defined in the Forest Management Plan (NRE 1995), the strategy for sustainable yield of wood production involves the production harvesting of sawlogs and residual logs from mature/overmature forest until sufficient regrowth forest is at a harvestable age to produce sawlogs at a rate equal to or above the current rate of sawlog production.

This management strategy is designed to eventually establish a balanced representation of age classes in the major forest types. This strategy will allow an optimal flow of sawlogs, within the constraints of managing for non-wood values.

The time frame for planning of sustainable yield is generally in multiples of forest rotations, that is, in the order of 100 to 200 years. The current sustainable yield forecast for D+ sawlogs is made for the period 1991 to 2148. A major fire event, withdrawal of forest from production, changes in to markets demands, and alterations in silviculture, harvesting or processing technology, may necessitate review of the basis for sustained yield forecast.

It is important to understand the assumptions made in the forecast of sustainable yield. Variations to these assumptions may affect sustainable yield and therefore may have an impact on the future availability of sawlogs to industry.

The following assumptions are taken from the Review of Sustainable Sawlog Yield for East Gippsland Forest Management Area (NRE, 1996, in press):

1. Current and future land use as recommended by the Land Conservation Council and approved by Government and zones delineated by the Forest Management Plan will continue to apply.

2. Timber harvesting will be conducted in accordance with the Code of Forest Practices for Timber Production (CFL ,1989) and the East Gippsland Forest Management Plan (DCNR ,1995a).

3. Current harvesting prescriptions will continue to apply (i.e. exclusions relating to steep slopes, streamside reserves and rainforest buffers will apply within the General Management Zone (GMZ)).

4. No allowance is made for loss of resource through fire damage, insect or fungal attack, or storms.

5. The growth rates of grade D+ sawlogs for mature/overmature forests are zero. Growth rates for regrowth forests will be:

Alpine Ash	2.75 m3/ha/yr;
Mountain Ash and Shining Gum	3.30 m3/ha/yr;
Mountain Mixed Species	2.40 m3/ha/yr;
Foothill Mixed Species	1.80 m3/ha/yr;
Alpine Mixed Species	0.60 m3/ha/yr;
Coastal Mixed Species	0.60 m3/ha/yr.

6. Current silvicultural systems and utilisation standards, as detailed in the East Gippsland Forest Management Plan, will not change.

7. All forest areas which are harvested will be regenerated to satisfactory stocking levels.

8. The minimum harvest age is 65 years for all forest types except Coastal and Alpine Mixed Species where it is 85 years and thinned Foothill Mixed Species forest where it is 55 years of age.

9. Nominal rotation age is 80 years for all forest types except Coastal and Alpine Mixed Species where it is 120 years.

10. All volumes are net of allowable defect, as specified by the Secretary, DNRE.

Forecast of sustainable yield

The current sustainable yield for sawlogs in East Gippsland has been set at 174 000 cubic metres of C grade and better sawlogs, or 250 000 cubic metres of D grade and better sawlogs per year. This resource is obtained from approximately 7500 ha per year, (DCNR 1995) or 0.7% of the Public land in East Gippsland.

The long term sustainable yield is expected to progressively increase from 2048. This increase in sustainable yield are is expected as the transition is made to harvesting the more productive regrowth. Map 5 illustrates the estimated productivity of regrowth by forest type.

A balanced distribution of age classes should be reached by the end of the forecast period (2148), achieving the long term sustained yield of approximately 550 000 m3/year net of grade D and better sawlog. Management aimed at producing a more balanced age structure within each forest type will maximise sustainable yield levels in the longer term.

The future sawlog availability is determined by the growth capacity of the forest, which is expressed in cubic metres per hectare per year. Rotation length (age) for regrowth is determined by the estimated growth of the forest and the area of forest available for harvesting. Rotation length is assumed to be 80 to 120 years, depending on forest type.

The future sawlog volume of regrowth forest is expected to greatly exceed that of the current standing mature/overmature forest. The future sawlog availability is forecast to increase from itÆs current rate, according to the following timetable:

- present to 2048 : 250 000 m3/yr D+ (incorporating 174 000 m3 C+)
- 2048 to 2068 : 455 500 m3/yr D+
- 2068 to 2138 : 516 000 m3/yr D+
- 2138 to 2148 : 522 300 m3/yr
- 2148 onwards: 549 ,000 m3/yr D+

Table 2 demonstrates the expected yields for regrowth and the current yields for mature/overmature forest. Map 5 shows future sawlog availability by compartment, and Map 2 shows the current available sawlog resource (excluding regrowth). A comparison of Map 5 and Map 2 demonstrates the potential increase in sawlog capacity for compartments that will be converted from mature/overmature forest to regrowth. A compartment currently classified as high yielding and is currently estimated to have a standing volume of approximately 15 000 m3 C+ (and yields 50 m3/ha), could have a standing volume, under regrowth at rotation age, of greater than 70 000 m3 C+ (yielding greater than 200 m3/ha).

The area of regrowth is the result of harvesting or wildfire and has been generated from HARIS. Map 3 illustrates the extent of regrowth in the region as a proportion of each compartment. It can be seen that the spatial distribution of regrowth is presently such that a majority of compartments contain regrowth forest.

According to the schedule in Table 2, the annual area subject to harvesting will decline from the current approximate area of 7500 ha (DCE 1995) to approximately 4300 ha in 2048, due to the effect of increases in sawlog productivity per hectare in regrowth forest.

Table 2: Standing Volumes (1989) and Future Sawlog Availability (circa 2148) m3 D+

Year	Alpine Ash	Mountain Ash and Shining Gum	Mountain Mixed Species	Foothill Mixed Species	Coastal and Alpine Mixed Species	Thinned Foothill Mixed Species	Total
*Mature/Over Mature	95000	142700	2696000	3437000	1333000		79760000
Standing Volumes yield per ha	124	1798	6351	34	18		
Regrowth MAI	2.75	3.30	2.40	1.80	0.6	2.18	
Nominal rotation age	80	80	80	80	120	80	
Regrowth future sawlog yield at rotation age	1009000	617000	15552000	20772000	7774000	749000	
future anual sawlog availability (after 2148)	12600	7700	194400	259600	64800	9800	548900
yield per ha at rotation age	220	264	192	144	72	174	

Source: Derived from NRE, 1996

3.3 Review of the sawlog sustainable yield method

Fundamental to the precision of sustainable yield forecasting is the quality of data used (HARIS data and yield curves), the quality of the model itself, and the assumptions used to derive the forecast.

As part of the Comprehensive Regional Assessment process, the Victorian Steering Committee sought an independent appraisal of the method and information used to forecast sawlog growth and yield for East Gippsland. The report in full is provided in Appendix A.

The appraisal, by the University of Melbourne, evaluated three main aspects of sustainable yield method for East Gippsland:

- resource data used to describe the available forest in terms of its current or potential timber resource, including the manner in which the resource data is updated, maintained and stored
- models used to predict forest growth and future yield
- the processes used to integrate the resource data with future predictions and the resulting estimation of sustainable yield.

The appraisal examined the method used to forecasting the sustainable yield of C+ sawlogs, undertaken in 1991. Reference was also made to revision of yield estimates associated with the East Gippsland Forest Management Plan (1995) and sensitivity analyses undertaken in the 1996 NRE review of sustainable yield.

The appraisal found the overall methodology approach to be conceptually sound and noted the following:

- the source data in HARIS is derived from numerous assessments over the past 30 years, which have been modified and updated to meet current needs. As a result, the accuracy of this data cannot be statistically determined , and consequently, the confidence of the sustainable yield forecast for sawlogs in the East Gippsland Region cannot be determined;
- growth models for sawlogs are conservatively estimated for mature/overmature and regrowth forest are conservatively estimated; and
- the modelling system used for forecasting sustainable yield (SYSS) is adequate for the purpose, given the quality of data and growth models available.

The appraisal also suggested several improvements to the method. The suggestions are detailed in Appendix A and are discussed below.

In relation to the data supporting the forecasts the appraisal noted that statistical precision cannot be determined for the supporting data and therefore the model output. As described earlier, HARIS is a summary database system used for strategic purposes, including regional sustainable yield forecasting. It contains data for standing timber volume which is of variable quality and derived from a variety of sources collected over a number of years. As a result, some of the data cannot be statistically validated. due to its age and fitness for its current use. This situation is not unique to East Gippsland, nor is it unique to forest modelling, as models in general, whilst attempting a quantitative assessment, are often derived from qualitative information and assumptions. Where statistical validation is not possible, sensitivity analysis may be used, as discussed below.

The HARIS design and maintenance procedures were developed and implemented before the availability of advanced spatial databases and modelling tools, and consequently does not offer the advantages of data handling, storage, retrieval and interrogation that are now available. However, this is a systems design issue and not related to data and therefore the accuracy of the forecasts derived from using HARIS.

Growth models forest type have been derived from numerous sources, including regional forest inventories, past utilisation of mature and maturing stands, and permanent growth plots. For mature/overmature forest, growth of sawlogs is conservatively estimated at zero. This assumption is established and generally accepted by the forestry profession. The growth estimates used for regrowth forest in East Gippsland, detailed above, are also considered to be conservative and are averages for each of the forest types, taking into account local, regional and Statewide information.

Given that growth rates form a central component of long term sustainable yield forecasting, forecasting it may be useful to consider and validate the growth rates for forest types in East Gippsland, as variation in the growth of either mature/overmature or regrowth forest can represent either a risk (due to overcutting) or an opportunity (through increased production) to industry. An initial indication of the priority to be accorded for such work can be gained through sensitivity analysis, as discussed below.

The sustainable yield forecast for East Gippsland has been derived using the Sustainable Yield Spreadsheet model (SYSS). The University of Melbourne considers that SYSS is "simple, yet adequate given the extent and quantity of available data and growth rates. Adoption of a more complex approach at this stage would be of little value, except for the inclusion of detailed sensitivity analysis".

In recognition of the issues discussed above, and as part of improving its management data, NRE has initiated a Statewide Forest Resource Inventory (SFRI), designed to give high quality spatial and textural data in the order of +/- 15% for regional forecasts of timber yields. This will be linked with an Integrated Forest Planning System (IFPS) to replace the HARIS database and SYSS modelling system. SFRI and IFPS are designed to provide state-of-the-art data and modelling outcomes. Both are being introduced progressively throughout Victoria, and will eventually be used to review sustainable yield for East Gippsland. The IFPS methodology was reviewed by Turner (1995 unpublished) for its application to the MidlandÆs Management Area of Victoria and found to be consistent with international best practices. The SFRI methodology has not been reviewed in this process.

Sensitivity analysis

Estimates developed from models are usually derived from a range of information sources and based on a range of a series of assumptions such that the results must be qualified by caveats and conditions. Decision-makers need to be aware of the uncertainties exposure to risk and concomitant consequences involved in determining any course of action. The appraisal emphasises the need for sensitivity analysis as a standard procedure for assessing the consequences of any potential error and/or bias in the data and method used in East Gippsland.

Sensitivity analysis entails varying the *key components* of the forecast methodology, singly or in combination, to determine the impact on the sustainable yield forecast. The use of sensitivity analysis can assist in identifying the components which have the greatest impact on sustainable yield. Once these are identified, any available resources can be targeted to improving the data supporting the critical variables components. The costs and benefits of increasing the accuracy and precision of sustainable yield forecasts by further data collection or model improvement, should be weighed against the current performance of the forecast and magnitudes of risk, as determined through monitoring of actual against predicted yields and sensitivity analysis.

Some of the components underlying the sustainable yield forecast in East Gippsland include resource volume estimates and growth rates, harvesting strategies, silviculture (including regeneration success), prescriptions, harvestable area and disturbances (for example wildfire). The sensitivity of the forecast to changes in the components can be analysed over a range of forecast periods.

Not all of these variables components will display equal sensitivity to the sustainable yield forecast, and similarly, not all will have equal probability of occurring. Expert opinion can be used to estimate the exposure to variability and to select the key variables components to be tested.

The application of sensitivity analysis to sustainable yield is somewhat iterative. The principle objective is the transparent identification and analysis of key components, to understand the consequences of any potential error and to formulate appropriate strategy options. The 1996 review of sustainable yield uses sensitivity analysis to determine the consequences of variation in three of the key components used in the forecast:

- variation of estimates in standing timber volume in mature/overmature forest by forest type to current sustainable yield;
- variation to growth rates for regrowth forest on current term and long term sustainable yield; and
- a decrease in net harvestable area on current sustainable yield.

As stated earlier, the appraisal found that the supporting timber volumes could not be statistically validated, and that sensitivity analysis could be used to determine the consequences of error or bias in the data. While a range of values could be tested, (for example +/- 5%, +/-10% or +/-15%) NRE has tested an extreme variation of 20% to standing timber volume A sensitivity analysis was undertaken to determine the effect on current sustainable yield. The analysis indicates that a 20% variation in the mature/overmature standing volume across all forest types could change the current sustainable yield rate by 30 000 m3/year (or 13.2%) (NRE 1996, in press).

It is worthwhile to examine the degree of risk associated with the forecast, given that the next review of sustainable yield is due in 2001. The analysis by NRE found that the compounding effect of such a 13.2% variation in sustainable yield would be 150 000 m3 or 14.5% over the next five years. Based on this scenario, the failure to identify such an error would be an additional 1.3% variation to the sustainable yield rate in 2001 (NRE 1996, in press).

An analysis was also carried out to determine the consequence to the forecast of sustainable yield is to a variation in the MAI figures used for regrowth. Increasing the MAI figures by 10% resulted in an increase in current sustainable yield of 4.4%, with the long term sustained yield increasing from 550 000 to 604 000 m3/year (10%). A reduction of 10% in MAI resulted in a decrease in the current sustainable yield of 4.6%, with the long term sustained yield decreasing from 550 000 to 494 400 m3/year (10%) (NRE 1996, in press). Given the appraisal the Universtiy of Melbourne found the growth rates to be conservative, the probability of variation of 10% in MAI is very low.

Table 3 Effect of Area Reduction to Current Sustainable Yield Based on Sawlog Availability (NRE)

	Minimum Yields greater than					
	Base Model	**5m3/ha**	**10m3/ha**	**15m3/ha**	**20m3/ha**	**25m3/ha**
Mature/ Overmature Resource (m3 D+)	7976000	7958000	7849000	7570000	7014000	6225000
% Reduction in Standing Volume		-0.02%	-1.6%	-5.1%	-12.1%	-22.0%

Sustainable Yield Rate (m3/yr D+)	250000	250000	248000	242000	232000	
Reduction in Sustainable Yield Rate		0.0%	-0.8%	-3.2%	-7.4%	-14.2%

(NRE 1996 In press).

A further study was made to determine the effect of excluding low sawlog yielding stands from the forecast of sustainable yield. Standing volume figures for the mature/overmature resource were recalculated after excluding those volume stands which did not meet a range of minimum yields. The results are summarised in Table 3.

Another suggestion made by the consultants was that future yield estimates should report on forest structure of age classes by area and location to demonstrate the progressive spatial and temporal changes in structure. The review for D+ and residual roundwood has initiated reporting by area over the course of the first rotation, nominally 80 years. At the start of the forecast, 479 000 ha or 76% of the total forest area is mature/overmature, of which 225 500 ha or 36% of the total area is available for sawlog production.

At the end of the first rotation, the area of mature/overmature forest will have reduced to 280 000 ha, and the balance, approximately 344 000 ha, will be distributed within various age classes.

In summary, the methodology for forecasting the sustainable yield for East Gippsland was found to be conceptually sound. Limitations have been identified for the supporting resource data, however the growth rates were found to be conservative. A number of improvements to the methodology have been suggested and NRE has indicated that several of these will be addressed through the implementation of the Statewide Forest Resource Inventory (SFRI) and Integrated Forest Planning System (IFPS).

Sensitivity analysis was conducted for a number of components including one scenario for determining the effect of an extreme variation in the estimation of standing timber volumes on the sustainable yield forecast. The analysis indicated that the compounding effect of error until the next review is an additional 1.3%.

Taking these factors into account, the forecasting methodology used in East Gippsland, and therefore the forecast, is considered adequate as the basis for developing options in the next step in the RFA process.

3.4 Residual logs

Residual logs are those that are either too small or too defective to meet current sawlog specifications (see Appendix B). The Timber Industry Strategy (Victoria 1986) sets the context for Departmental policy regarding the production of residual logs from East Gippsland. Native forest timber production in Victoria is geared towards sawlog production and value-adding. Residual logs are produced as a by-product of harvesting for sawlogs, or from silvicultural activities such as thinning or overwood removal which are designed to enhance future sawlog production.

Currently, approximately 650 000 m3 of residual logs become available in East Gippsland each year as a by-product of normal sawlog harvesting operations, with an additional 150 000 m3 from the Tambo Management Area. A total of 800 000 m3 of residual log is available annually from Eastern Victoria. Some of this is sold through residual log licences, but most is not utilised. Approximately 10% of the residual log resource is committed under long term (15 year) licences.

The available yield sustainable yield of residual logs has been forecast for 50 years, based on three main components:

- standing residual log volumes from HARIS as given in Table 4,
- positive growth rates for residual logs predicted for some mature/overmature forest types,
- scheduled thinning of 4500 ha regrowth forest.

(NRE 1996 In press).

Table 4 below gives standing volumes for currently available residual logs from HARIS. The available yield is based on the average harvestable area of 7 500 ha (DCNR 1995), and the average yield of 95 m3/ha given in Table 4.

In addition to the current standing volume of residual logs in mature/overmature forest (Table 4), the available yield of residual roundwood also incorporates growth for mature/overmature and regrowth forests.

The current annual increment (CAI) for mature/overmature residual log is assumed to be zero for the ash species and equivalent to 20% of the regrowth MAI for sawlog for the mixed species forest types. Growth in regrowth forest types is derived using sawlog to residual logwood ratios given in figure 3. These were determined by the Forest Planning and Assessment Section using STANDSIM (Incoll, 1983) analyses and data from assessment trials of Silvertop Ash in East Gippsland.

Table 4: Standing Volumes for Residual Logs

	Alpine Ash	Mountain Ash and Shining Gum	Mountain Mixed Species	Foothill Mixed Species	Coastal and Alpine Mixed Species	Total
Residual Logs	88300	98100	5601200	9791500	5474600	21053700
yield per ha	115	123	118	96	73	93

Source: DCNR 1993

(Figure 3. Residual log to Sawlog ratios used for the calculation of residual logs in East Gippsland.)

As indicated earlier, 4,550 ha of Foothill Mixed Species forest type will be commercially thinned over a ten year period to bring forward the availability of additional sawlogs. This in turn will produce an additional 43500 m3 per year of residual logs over a forty year period (DCNR 1995).

The potential utilisation of residual logs produced from East Gippsland is currently being examined. The Department of Natural Resources and Environment has called for Expressions of Interest to purchase and process this material, the emphasis being on domestic processing. The details of this proposal are considered further later in this report.

4. Plantations

Plantations have the potential to provide an alternative supply of particular products to the timber industry, particularly pulpwood and small diameter sawlogs. Plantations in South-Eastern Australia are typically of native species (*eucalyptus sp.*), referred to as hardwood, or exotic Monterey Pine (*Pinus radiata*) referred to as softwood. To date, hardwood plantations in Australia have largely been managed to produce short rotation pulpwood for paper manufacturing, however it is anticipated that technology will eventually enable economic sawlog production from hardwoods, as is currently possible from softwoods.

Land availability and suitability in the East Gippsland limits the potential development opportunities for plantations. Current Victorian Government policy prohibits the clearing of native forest on public land for the establishment of plantations. Native forest can be cleared on private lands for conversion to plantations subject to native vegetation retention controls to protect flora and fauna, and local government planning requirements.

Consequently, plantation development opportunities are available only on public lands that do not presently contain forest, and some areas of private land. Private land represents 156,900 ha (13%) of the land area of East Gippsland.

Most potential for plantation development or expansion in the region lies outside the Region, lies to the west in Central Gippsland or the north-east on the Monaro Tablelands of New South Wales.

4.1 Land Capability

Due to the high investment costs required to establish plantations, commercial management requires land of high site quality to support required growth rates and provide adequate economic returns. Hardwood plantations would require land of high and reliable rainfall (>1000mm/year), deep well drained soils, and reasonably flat topography (DCE 1990). *Pinus radiata* can be grown in areas with rainfall greater than 600mm/year.

In East Gippsland the area of land suitable for plantation has been approximated, using Geographic Information System (GIS) to determine the area of privately owned, cleared (non-forest) land, on slopes less than 25 degrees, and with sufficient rainfall to support economic plantations:.

Rainfall	600-800 mm	800-1000 mm	>1000 mm
Area cleared land	28 000 ha	55 000 ha	4000 ha

Source: Bureau Resource Sciences, NFI

The results of GIS analysis shows the area receiving greater than 1000mm, were it to become available, would be insufficient to support a viable and economic eucalypt plantation-dependent industry (nominally 40,000ha), due to the small size and scattered nature of the land-base. The areas receiving greater than 600mm and 800mm rainfall would be sufficient to sustain a softwood plantation resource. However, most of this area is currently used for agricultural purposes, largely grazing (sheep and beef), dairying and vegetable cropping on the more productive lands.

Plantation establishment therefore, would be in competition with existing agricultural activities. However, some potential does exist for plantation development, particularly where commercial (wood production) values are considered in conjunction with land rehabilitation (amelioration of soil degradation) benefits. Agroforestry also offers some potential for plantation development on higher site quality lands in conjunction with conventional agricultural enterprises. It is estimated that up to 10% of land can be planted to trees without decreasing agricultural productivity (Reid and Wilson 1986).

Currently, there is a lack of information regarding growth potential or species performance for eucalypt plantations in East Gippsland. A series of small plantation trials have been established by NRE to trial the best species and provenances, optimum site preparation and fertiliser application. Progress and results are not yet available.

4.2 Plantation Timbers

The most likely products from plantations developed in East Gippsland would include pulpwood from thinning and at full rotation age, and small diameter sawlogs. The plantation resource would be sufficiently different from native forest timbers produced in East Gippsland that the current industry would have limited ability to process plantation products without retooling. Plantation economics relies on high-input and consistency of size to justify high capital expenditure required to develop and maintain infrastructure for drying, reconditioning and machining. As the technology and markets for processing plantation-grown eucalypt sawlogs are still being developed, it is unlikely that a plantation resource would be able to significantly contribute to eucalypt sawlog production in the foreseeable future.

However, some opportunity does exist for plantation-grown eucalypt pulpwood, particularly with the development of native forest regrowth, and the current interest in developing an industry to process residual logs derived from East Gippsland and the adjacent Tambo FMA.

4.3 Current plantation resource

Within the Region there are approximately 3,000 ha of softwood (*Pinus radiata*) plantations on private land in the Bendoc area, and 277 ha of trial hardwood plantations on State Forest and 63 ha owned by the East Gippsland Water Board for effluent disposal.

In South-Eastern NSW, a considerable plantation resource of some 31,200 ha *Pinus radiata* has been developed in the vicinity of Bombala. It is the intention of State Forests of NSW to expand this by up to a further 10,000 ha over ten years, in order to provide sufficient resource to attract and support a vertically integrated industry in that Region (SF NSW pers comm).

Industry that develops in the Bombala area may offer market opportunity and incentive for further commercial plantation establishment of exotic Pine in East Gippsland, particularly in the northern part of the Region.

4.4 Land Rehabilitation

The Regional Plantation Committee for Gippsland have secured federal government funding (through DPIE) of $1.2 million over 4 years, to develop plantations on degraded farmland throughout Gippsland. They intend to plant 1,000 ha per year, giving priority to sites of greatest productivity potential. The areas most suitable is the Strzelecki region of Southern Gippsland. Various industry groups, including regional power companies, will contribute to the funding of this project, with management intending to produce short-rotation pulpwood (Gippsland Regional Development 1996).

5. Timber Industry Current Position and Competitiveness

5.1 Economic significance of the timber based industry

The timber industry plays an important role in the East Gippsland regional economy, accounting for approximately 27 per cent of manufacturing turnover within the East Gippsland Statistical Division (Australian Bureau of Statistics 1996). In addition, the timber industry has been estimated to generate approximately $55 million each year in total revenue within the Division (Network for Excellence in the Hardwood Timber Industry 1996).

In 1995, 19 049 people were employed in the East Gippsland Statistical Division. The forestry, logging and wood and paper products manufacturing industries account for around 5 per cent of total employment (table 5). The East Gippsland Statistical Division also accounts for approximately 15 per cent of employment in the Victorian forestry and logging sectors and 4 per cent of employment in the Victorian wood and paper products manufacturing sector (Australian Bureau of Statistics 1996).

In response to previous structural changes, there has been some decline in direct employment in the timber industry within the East Gippsland region over the past few years. The National Institute of Economic and Industry Research prepared a report for the Land Conservation Council (LCC) in 1986. The LCC report estimated that there were 580 direct jobs associated with the wood based industries, or 52 per cent of total full time jobs in the LCC's East Gippsland Study Area (which largely encompassed the former Orbost Shire boundaries).

Presently, direct employment associated with the timber industry within the East Gippsland Region is estimated at 555 people. This represents a reduction of around 5 per cent in direct employment associated with the timber industry in 1994-95 compared to 1986. However, it should be noted that the East Gippsland Region is larger than the LCC's East Gippsland Study Area, and hence the estimated reduction in direct employment associated with the timber industry within the East Gippsland region over this period is likely to be an underestimate.

Table 5: Total persons employed in the East Gippsland Statistical Division, 1995

Industry	Employment (number of persons)	Percentage of total employment (per cent)
Agriculture, fishing and hunting	1143	6.00
Forestry and logging	318	1.67
Wood and paper products manufacturing	655	3.44
Mining	297	1.56
Other manufacturing	980	5.14
Electricity, gas and water supply	129	0.68
Construction	885	4.65
Wholesale and retail trade	4575	24.02
Transport, storage and communication	843	4.43
Financial and business	1583	8.31

services		
Government administration	819	4.30
Education, health and community services		23.38
Cultural, recreational and accommodation	1717	9.01
Personal and other services	651	3.42
Total	**19049**	100.00

Source: Australian Bureau of Statistics (1996). Notes - Figures are given for the East Gippsland Statistical Division which is larger than the East Gippsland FMA. Figures given include working proprietors and partners and both permanent and casual employees but excludes unpaid workers and persons sub contracted to a business.

In terms of direct employment associated with the timber industry in East Gippsland, the results from the sawmill survey conducted for this assessment indicate that total sawmill employment in 1994-95 was 361. This figure includes, full time, part time and casual workers. In addition, it has been estimated that there are approximately 106 people directly employed as contract harvesters and log carters within the FMA (K. Wareing, Victorian Association of Forest Industries, personal communication, April 1996). A further 88 people are employed in the public sector in forest management and planning (G. Featherston, Department of Natural Resources and Environment, personal communication, May 1996).

5.2 Log pricing and allocation arrangements

East Gippsland hardwood sawlogs are classified using a system of log grades in diminishing order of sawlog quality from A through to D. Presently, C and D grade sawlogs account for the bulk of sawlog production from the region. Residual logs are also produced.

Sawlog licence allocations are measured in gross volume terms, which includes the percentage of defect material in the log which is unsuitable for sawmilling. Sustainable yield forecasts are calculated in net volume terms.

Sawlogs derived from State forests within East Gippsland are currently sold at the stump. That is, royalties are charged on the sawlog before any processing occurs. Licences include the right to harvest and buy timber. Sawmillers also pay private contractors to harvest and transport sawlogs from the forest to the mill.

Provision is made in the licence arrangements for licensees to receive logs above or below their annual allocation by up to 30 per cent, thus allowing for fluctuations in market conditions. Allocations must be averaged over the licence period with no more than 110 per cent of the annual allocation being used in any 5 year period. Total sawlog licence allocations and intended volumes for 1996/97 are provided in table 6.

The proportion of sawlog grades which are allocated to licensees are reviewed periodically on the basis of the degree of further processing being undertaken. In general, If a licensee is engaging in further processing then that licencee will be allocated a higher proportion of the calculated yield of higher grade logs; that is the licencee will receive a higher quality log mix while lower value-adding licencees will receive a lower quality mix. However, the total allocation of C+ logs does not vary through this process.

Table 6: East Gippsland log allocations and intended sawmill intake volumes for 1996/97 by log type

saw log type	log allocations (cubic metres)	intended volumes (cubic metres)
B+	9 999	11 235
C	188 727	205 869
D	120 168	141 362
D+	319 347	358 859
E	30 000	27 000
residual	135 000	162 990
thinnings	26 000	26 000

Source: G. Featherston, Department of Natural Resources and Environment, personal communication, May 1996. Notes - Log allocations and intended sawmill intake volumes are measured in gross volumes, while sustainable yields are measured in net volumes. Sawlog allocations include those for specialty timbers.

5.3 Sawmilling industry survey

In order to provide an accurate assessment of the economic circumstances underlying the competitiveness and value of the hardwood sawmilling industry, an economic survey of sawmills operating in the East Gippsland region was conducted as part of the Comprehensive Regional Assessment process. The four aims of the survey were to:

- obtain information on the size and range of hardwood sawntimber production activities in the region (including the degree of further processing);
- obtain estimates of sawntimber and woodchip production capacity, recovery rates, mill door prices and the final product markets targeted by the hardwood sawmill industry;
- derive an economic profile of the hardwood sawmilling industry, highlighting the competitiveness and relative magnitude of mill operating costs in the region; and
- identify any future investment plans or strategic directions for the hardwood sawmilling industry, particularly over the medium to longer term.

The survey contained a series of questions designed to assess the economic conditions underlying the long term competitiveness and value of the industry. First, the size and range of sawntimber production activities was assessed by asking sawmillers the maximum annual sawntimber production capacity of their mill and total sawntimber production for the previous three financial years (1992-93 to 1994-95). Data were also collected on the number of employees and the number of mill operating days.

Second, volume estimates for each grade of sawntimber output were obtained (for 1994-95) and, where possible, sawmillers were asked to specify any major species targeted for particular end use products. Market destinations and average mill door prices were also obtained for each grade of sawntimber output.

Third, data were collected relating to the sawmiller's net receipts and operating costs for 1994-95. Total gross receipts, total operating costs and items representing significant components of operating costs were collected. Details of mill age, capital expenditure and replacement value were also collected.

Finally, sawmillers were asked to indicate any planned changes in their production mix over the next five years, such as a shift toward further processed products in the mill's overall production plan.

The survey was conducted over one week in May 1996, with face to face interviews with sawmill owners/managers. All sawmill owners/managers were contacted as part of the economic survey. Completed mill cost and production data were collected Questionnaires were completed for from 14 of the 23 hardwood sawmills receiving State forest logs from the East Gippsland (or 61 per cent of sawmills dependent upon logs supplied from the region). In log intake terms, the survey responses accounted for approximately 55 per cent of total State forest logs received by the East Gippsland sawmilling industry in 1994-95. Partial survey data were also collected for a further two mills.

This information may be used in conjunction with other market based information to estimate the total net economic value of the East Gippsland hardwood sawmilling industry. A review of existing resource and market information was also used to develop an economic profile of other direct uses of State forests, including apiculture, grazing, non-mineral extractives, recreation, tourism and water production. A range of economic indicators was collated, including estimates of employment, production volumes and gross value.

5.4 Structure and value of the timber based industry

In 1994-95, there were twenty three hardwood sawmills receiving logs from State forests located within the East Gippsland region. Twenty two of these sawmills are operating within East Gippsland. Presently, there are 21 hardwood sawmills receiving logs from State forests within the East Gippsland region, reflecting recent changes in mill processing activities compared to 1994-95. The following financial and physical information presented on the hardwood sawmilling industry relate to the 1994-95 financial year, as this was the latest year for which complete records were available. Complete mill cost and production data were collected from fourteen of the twenty three hardwood sawmills contacted as part of the sawmill survey, representing a response rate of around 60 per cent. Partial survey data were also collected for a further two sawmills. These data have been used to assess the current economic value and significance of the sawmilling industry.

There are also two companies which receive residual logs or sawmill residues from the Region. These companies produce and export woodchips from Geelong, in Victoria, and Eden, in southern New South Wales. These operations have not been included in the estimated value of the sawmilling industry in East Gippsland. However, as sawmill residues are an important by product for many hardwood sawmills operating within the region, the returns to sawmillers from the sale of residues to these companies have been included in the estimated value of the sawmilling industry.

For the fourteen sawmill survey respondents, around 97 per cent of their total sawlog intake came from State forests located within East Gippsland. The remaining 3 per cent of sawlogs received were sourced from private forests or forests located outside the region. Total hardwood sawntimber production for the fourteen sawmill survey respondents in 1994-95 was approximately 86 500 cubic metres.

In 1994-95, total sawntimber production in Victoria was 961 307 cubic metres. Total hardwood sawntimber production from sawmills dependent on the East Gippsland resource for the same period is estimated at 134 000 cubic metres, or approximately 14 per cent of the Victorian total (including both softwood and hardwood sawntimber). Due to data limitations, it was not possible to estimate the total volume of sawmill residues which was produced and converted into woodchips from the twenty three hardwood sawmills in the region. However, for the fourteen sawmill survey respondents, approximately 122 500 tonnes of woodchips were produced in 1994-95, which were derived from sawmill residues. It is estimated that 90 per cent of woodchips produced from the region are exported, primarily through Eden and on to Japan (Network for Excellence in the Hardwood Timber Industry 1996).

Some of the key financial features of the hardwood sawmilling industry in the East Gippsland region are presented in table 7, based on data collected during the sawmill survey. Estimates for the industry as a whole were derived using average production costs and returns for sawmills which responded to the survey, which were stratified into three groups based on the size of their total log intake for 1994-95. Stratified survey averages of key variables (expressed per unit of log intake) were then multiplied by the actual log intake in 1994-95 of non-respondent mills to estimate total industry production costs, receipts and replacement value of existing capital stock.

Table 7: Key financial features of the East Gippsland hardwood sawmilling industry, 1994-95

Item	**Total for survey respondents ($ million) a**	**Estimate for industry total ($ million) b**
Gross value of production (gross receipts)	32.2	52.5
Gross receipts from sale of sawntimber and solid wood products	27.7	na
Gross receipts from sawmill residues (woodchips)	4.5	na
Total operating costs	27.6	44.4
Net value of production (gross receipts minus total operating costs)	4.6	8.1
Expenditure on fixed assets	0.6	na
Labour costs	7.0	11.0
Replacement value of fixed capital	32.1	49.8
Debt outstanding	2.5	na
Non-sawmilling income	0.6	na

a *Based on the completed questionnaires for the 14 sawmill survey respondents.*
b *Preliminary estimates for industry based on sawmill survey.*
na *- Not available with existing data.*

Using the sawmill survey results and State forest log allocations for non-respondent mills, the total net value of production (or net profits earned) for 1994-95 for the hardwood sawmilling industry in East Gippsland is estimated at $8.1 million. In addition, the total value of turnover (or gross receipts) for the hardwood sawmilling industry is estimated at around $52.5 million in 1994-95, with total capital investment in sawmilling plant and equipment of $49.8 million.

Information collected on the average net returns to the hardwood sawmilling industry in 1994-95 was also used in conjunction with future anticipated log allocations to provide a broad estimate of the likely magnitude of the total net returns to the industry in 1995-96 and 1996-97. Assuming real constant costs and prices over these two years, and future anticipated log allocations, the total net economic value of sawmilling production is estimated at $10.79.4 million in 1995-96 and $11.60.5 million in 1996-97. These projected increases in the net value of production reflect the higher intended volumes of log allocations for these two years compared to 1994-95.

Sawmills are also geographically dispersed within East Gippsland. Nowa Nowa is the most westerly mill location, with Genoa being the most easterly. Cann River has the highest number of mills within the region, with single mills located at Genoa, Noorinbee North and Waygara.

(**Figure 4: Distribution of East Gippsland sawmills by location**
Source: Mill survey, May 1996. Note: Mills included above are those situated within the boundaries of the East Gippsland FMA.)

Mills situated in East Gippsland also vary markedly in capacity. Processing capacities ranged from less than 1 000 cubic metres per year to greater than 30 000 cubic metres per year.

(**Figure 5: Distribution of East Gippsland sawmills by processing capacity**
Source: Sawmill survey, May 1996. Note - Mill capacities given are for sawntimber production only. Capacities included are for mills situated within the East Gippsland FMA.)

Based on the survey results and information provided by the Department of Natural Resources and Environment, it is estimated that mills in East Gippsland employ a total of 361 people. Approximately 95 per cent of these employees are full-time workers. Sawmill employment varies from less than 5 employees per mill to greater than 30 employees per mill. Approximately 41 per cent of sawmills employ between 15 and 24 people (figure 6D). Average labour productivity for sawmills in the region has been calculated as approximately 421 cubic metres of sawntimber per full-time employee per annum.

(**Figure 6: Distribution of East Gippsland sawmills by number of employees**
Source: Sawmill survey, May 1996. Note: Figures include full-time, part time and casual workers.)

5.5 Log harvesting and transport arrangements

At present, sawmillers hire contractors to harvest and transport logs from the forest to the mill. Base cartage rates for sawlogs are calculated as a set price per kilometre of bitumen and non bitumen road travelled. In addition to the base cartage rate, an upfront fee is paid per cubic metre of sawlog. This fee is reduced proportionally for each kilometre travelled. There is an additional charge for using certain major roads such as the Bonang Highway.

There are approximately 25 log harvesting and carting contractors operating within the East Gippsland. FMA. These contractors operate in a number of different areas across the region.

(**Figure 7: Distribution of East Gippsland timber carting contractors by area of operation**
Source: A. Fry, East Gippsland Loggers and Carters Association, personal communication, May 1996. Note: Some contractors operate in more than one area.)

Log harvesting and transport contractors employ around 106 persons within the Region. A recent survey of a sample of log carting contractors conducted by the East Gippsland Loggers and Carters Association found that the number of employees per contracting firm ranged between single owner/operators to firms with up to 6 employees (figure 8).

The current value of plant and equipment (eg trucks) in the log harvesting and transport sectors has been estimated at around $14 million. Due to the high level of capital invested, it has been argued that the profitability of many log harvesting and transport operations is particularly sensitive to any future changes in the availability of wood resources from East Gippsland. This is because the maximum potential capacity of most log carting operations is well above current volumes of wood presently being harvested and transported within the region. It has been estimated, for example, that an annual volume of around 18 000 cubic metres of log (eg 180 carting days of around 100 cubic metres per day) would be necessary to maintain an economically viable log carting operation with existing trucks and equipment (A. Fry, East Gippsland Loggers and Carters Association, personal communication, May 1996). Many operators are presently carting less than 65 per cent of their maximum capacity.

Within this context, it is important to note that NRE has recently called for expressions of interest in the processing of 800 000 cubic metres annually of residual logs available from the

East Gippsland and Tambo forest management regions. The processing of these residual logs has the potential to generate significant economic benefits from the wood based industries in the region.

(**Figure 8: Distribution of East Gippsland timber carting contractors by number of employees**
Source: A. Fry, East Gippsland Loggers and Carters Association, personal communication, May 1996. Note: Employee numbers are for those workers paid by wage or by piece.)

5.6 Major end use products and markets

Approximately 79 per cent of sawntimber produced by the fourteen sawmill survey respondents in East Gippsland in 1994-95 was sold as unseasoned sawntimber (or green scantling), while palings and pallets accounted for approximately 10 per cent (table 8). Other dried structural grade sawntimber accounted for around 8 per cent of total sawntimber output. Other products sold included large beam construction timbers, sleepers, woodchips, firewood and landscape products.

Table 8: Major sawntimber products and markets of the East Gippsland sawmilling industry

Product	**% sawntimber production 1994-95**	**Major markets 1994-95**	**anticipated % sawntimber production 2004**
unseasoned sawntimber a	78.5	Melbourne/Sydney	64.0
palings and pallets	9.9	Melbourne/Sydney	6.8
other dried structural grade sawntimber	7.6	Melbourne/other Victoria	15.0
furniture grade sawntimber	1.8	Melbourne/Canberra	6.3
other	2.2	Melbourne/Canberra	7.9

Source: Sawmill survey, May 1996. Note: Figures presented are based on results from the 14 mills which responded to the survey.
a Otherwise known as green scantling.

Historically, most East Gippsland sawlogs have been used for green scantling, fencing materials, pallet materials, house framing timbers and heavy construction timbers. Until recently, there has been little further processing of products undertaken. However, there is a growing recognition by the East Gippsland timber industry that further value adding will be necessary to maintain profitability or gain access to new markets over the medium to longer term. Results from the fourteen mills surveyed indicate, for example, that:

- Sawmill processors also indicated future plans to increase the proportion of dried and furniture grade sawntimber over the next five years (from 9.4 per cent to 21.3 per cent), indicating further timber processing and greater diversification of outputs.
- twelve sawmills in East Gippsland produced further processed products beyond the green scantling stage in 1994-95; and
- of these twelve sawmills, nine were found to process products beyond basic dried and undressed structural timbers.

There is also one specialty timber allocation within the region. Specialty timbers from East Gippsland include red ironbark, red box, blackwood, silver wattle, black olive berry and southern sassafras. These species produce timber suitable for furniture and woodturning. At present specialty timbers are considered a by product of harvesting operations for the major commercial species, which may result in the infrequent supply of these species.

Melbourne is the major market for a diverse range of East Gippsland timber products, including green scantling, furniture grade timber, appearance grade timber, large beam construction products and palings and pallets. Sydney and Canberra are also significant markets for sawntimber products such as dried sawntimber and furniture grade timber. Woodchips derived from East Gippsland are currently transported to Eden or Geelong, where they are exported to Japan for use in paper making. Other markets for East Gippsland timber products include local markets for firewood, craftwood and furniture timber, and country Victoria for construction grade timbers.

6. Timber Industry Outlook & Possible Industry Development Opportunities

Potential development opportunities within the region can be broadly classed into resource development and market development. Resource development concentrates on increasing the volume available for production or improving the size, quality or species range of the product. Market development concentrates on utilising material that currently is unsaleable or improving the end use of material that currently is being sold. In practice market development opportunities are often critical to implementing silvicultural regimes and realising resource improvement strategies.

6.1 Market outlook for sawntimber

The domestic market outlook for sawntimber is strongly influenced by international market conditions for forest products, due to the fact that Australia is a large net importer of most forest products (with the exception of woodchips). Because Australian trade in most forest products (such as sawntimber) is small in comparison with world trade, domestic prices for forest products are largely determined by the landed or import parity price of imports. Consequently, the extent to which the domestic hardwood sawntimber industry can maintain or increase profitability depends strongly on the cost competitiveness of local products compared with imported substitute products. The majority of Australia's softwood sawntimber imports are supplied from the United States and New Zealand, which are predominantly used in the house framing and other structural end use markets. Hardwood sawntimber imports are largely supplied from Malaysia (for example, meranti), and generally attract a higher price premium than imported softwoods, due to their decorative end use applications in higher value markets such as furniture, decking and mouldings markets.

(**Figure 9: Real prices of sawntimber imports in Victoria, 1988-89 to 1995-96**)

In recent years, real prices of imported sawn softwood (Douglas Fir) from the United States have decreased from previously high levels, reflecting weaker demand for sawntimber in both the United States and Japanese housing markets (figure 9). In 1994-95, for example, the landed price of sawn Douglas Fir from the United States fell by around 27 per cent compared to the previous year, and has remained low in 1995-96. In addition, real prices of imported radiata pine are expected to remain depressed in the short term, due to the expected higher supply of plantation softwoods from New Zealand and Chile.

However, over the medium to longer term, forecast reductions in the allowable harvest of public softwood timber from North America and Europe have been projected to result in tightening world supplies of softwood logs. Similarly, the future global supply of hardwood logs to 2010 has been projected by some analysts to remain at around 1992 levels, with large forecast reductions in the allowable timber harvest from countries such as Malaysia and Indonesia (for a review of recent studies on the global outlook for industrial wood, for example, see Nielsen and Associates 1995). These supply reductions together with projected increases in world population growth and economic activity are expected to result in rising real prices of logs and solid wood products over the medium term. In the southern United States, for example, it has been estimated that prices for softwood logs may more than double between 1991 and 2010 (United Nations Economic Commission for Europe and Food and Agriculture Organisation of the United Nations 1996). However, projected global price rises for sawntimber products will be tempered to some extent by the increased availability of logs from plantation forests, which are expected to mature over the next few decades. It has been estimated, for example, that future additional plantation log supplies may be of the same magnitude as projected marginal increases in world demand over the next few decades, but well below projected reductions in supplies from existing native forests (see Nielsen and Associates 1995).

Between 1991-92 and 1994-95, real prices of hardwood sawntimber imports into Australia increased as a result of decreases in supply of tropical logs from South East Asia and increasing demand in growing markets such as South Korea, China and Japan. Despite a short term fall in 1995-96, real prices of hardwood sawntimber (eg meranti) are expected to remain buoyant over the medium term, due to continuing global restrictions on the availability of tropical logs for hardwood sawntimber production.

Australian consumption of sawntimber is also largely influenced by the general level of domestic housing and construction activity. The Australian market for sawntimber continues to be influenced by depressed conditions in the new residential construction sector. After a fall of 7 per cent in 1994-95, new dwelling commencements at a national level are estimated to have fallen by up to 25 per cent in 1995-96. The other key determinants of sawntimber consumption, alterations and additions and non residential construction, are forecast to increase by just 3 per cent and 5 per cent respectively in 1996-97, marginally tempering the full effects of the downturn experienced in new residential construction. As a result of this easing of activity in new residential construction activity, total sawntimber consumption is expected to fall by 13 per cent in 1995-96, before recovering moderately by an average 1 per cent a year from 1997-98 onwards (Neck, Curtotti and Sar 1996).

Another important factor affecting the outlook for the hardwood sawntimber industry is the degree of substitution occurring between hardwood and softwood sawntimber. Three key factors influencing substitution between hardwood and softwood sawntimber include resource availability, the degree of technical product substitution, and price competitiveness with imports. Historically, competition to seasoned hardwood from radiata pine was limited as pine's advantages were offset by the cheaper price of hardwood framing. However, production costs have fallen to such an extent in large automated softwood mills, that softwood producers have increased their market share at the expense of hardwood producers (Ford 1992).

The substitution away from unseasoned hardwood to softwood in the house framing and other structural end use markets is demonstrated by the declining market share of hardwood production to total domestic consumption. Over the past decade, the contribution of hardwood sawntimber to total apparent consumption (that is production plus imports minus exports) of sawntimber in Australia has declined (figure 10). In 1985 apparent consumption of hardwood sawntimber was approximately 2 040 000 cubic metres (or 47 per cent of total apparent consumption). However, in 1995 apparent consumption of hardwood sawntimber was only 1 580 000 cubic metres (or 35.5 per cent of total apparent consumption).

In 1995-96, domestic annual production of both softwood and hardwood sawntimber is estimated to be 461 000 cubic metres and 408 900 cubic metres respectively.

(**Figure 10: Apparent consumption of hardwood sawntimber in Victoria, 1977-78 to 1995-96**)

Over the last ten years, production of softwood sawntimber in Victoria has increased by 70 per cent while production of hardwood sawntimber from native forest has declined by 25 per cent. Furthermore, since 1979, wall framing construction using hardwood has declined by around 51 per cent in Victoria (Ford 1992).

Strong competition from softwood sawntimber is expected in the structural house framing market, in line with future projected increases in softwood sawntimber production. Increasing domestic softwood production is expected due to the projected rise in resource availability of softwood sawlogs over the medium to longer term (Resource Assessment Commission 1992), along with an expansion in softwood sawmill capacity through upgrading and greater utilisation of existing plant and equipment. The average cost of softwood sawntimber produced by a new softwood mill has been found to be 10 per cent lower than for a new hardwood mill producing predominantly unseasoned sawntimber (Jaakko Poyry 1993).

However, the impact of substitution away from hardwoods to lower cost softwoods in housing construction has been offset, in part, by hardwood sawmillers diversifying into kiln-dried timber for furniture, flooring, mouldings and other value added markets (Neck, Curtotti and Sar 1996). The domestic hardwood sector has increasingly advocated the development of new applications and markets, such as increased production of kiln dried sawntimber which may compete in higher value markets. Many of the new applications involve further processing and replacing imported products. Import replacement opportunities include the increased use of hardwood sawntimber as structural beams (substituting for Douglas fir, for example) and kiln dried hardwood substituting for meranti in window frames. The general trend toward further processing in the hardwood sector is reflected by the installation of over 40 new kilns in Victoria since 1987 (Gooding 1993), including recent investment in further timber processing activities in East Gippsland (see section 7.2).

6.2 Value adding opportunities for hardwood sawmilling industries

Under the current licencing arrangements that are in place until 2002/03 (inclusive), the sustainable yield volume of 250,000 m3 (net) of D grade and better is fully committed to existing licensees. Current forecasts of sustainable yield do not predict a change in sustainable yield until 2038. Therefore, there is no opportunity to increase the sawlog volume that can be harvested. However there is opportunity to alter the types of sawn timber products being produced. In general, the majority of sawn timber products presently being produced in the region consist of unseasoned framing, special construction timbers, fencing and pallet materials.

With increasing competition from the supply of plantation softwood sawntimber in major end use markets such as structural house framing, the Victorian timber industry has increasingly advocated the development of the hardwood sector through marketing opportunities in value adding or niche markets (Victorian Wood Products Working Party 1993). The ability of the hardwood sawmilling industry to maintain profitability and compete against domestic softwood and other imported timbers will depend on the underlying cost competitiveness of the industry, as well as the development of new market opportunities. Over the medium term, the general outlook for the hardwood based industries may be enhanced by a number of positive market factors. These factors include:

- the unique marketing characteristics of selected Australian native eucalypts (such as strength, durability and appearance grades);
- the decreasing global availability and rising prices of tropical hardwood logs (Sar, Bhati and Lockey 1994);
- the growing demand for forest products in the newly industrialising regions of Asia; and
- the prospects offered through glue lamination technologies for value added products in general construction or furniture markets (Gunnersen 1994).

Kiln dried sawntimber has substantial advantages over unseasoned timber in terms of structural stability and can therefore attract a higher price premium. Kiln dried sawntimber can be used to manufacture a range of products for specific end use or market segments, including structural beams, furniture, flooring and cabinetry. There are also likely to be significant transport cost benefits with kiln dried products compared to green sawntimber, since the weight for a given volume of product transported is up to 50 per cent lower (Network for Excellence in the Hardwood Timber Industry 1996).

To further encourage the development of value adding opportunities, a joint industry and community based project in the East Gippsland region called NEHTI - the Network for Excellence in the Hardwood Timber Industry - has recently been established. This project links timber processors, educational institutions, unions, local government, forest managers and the business community to a range of activities designed to promote new value adding enterprises. Some of the key priorities of the group are to:

- expand kiln drying facilities in eastern Gippsland;

- develop products and markets for local appearance grade timbers;
- strengthen the linkages both within and outside the region to provide access to high quality commercial advice, research support, market identification and promotion;
- expand relevant forest-related courses such as those offered by TAFE; and
- develop skills in further value adding enterprises such as furniture design and manufacture.

To do this, the NEHTI project is seeking to attract funding to offer low interest loans to sawmillers in the region to cover installation of kilns and air drying facilities, as well as the development of an integrated research, training and marketing complex.

While the proportion of kiln dried and dressed sawntimber is presently small, hardwood sawmill operators in the region have recently committed a total of around $2.15 million in kiln drying and other further processing processes, with further investment planned of around $3.25 million (K. Wareing, Victorian Association of Forest Industries, personal communication, December 1995). Other recent processing investments have included the installation of machining and planing equipment which may increase the proportion of dressed sawntimber for particular end uses such as furniture components. A general shift towards the production of further processed products such as kiln dried sawntimber represents a positive marketing strategy in light of the declining long term competitiveness of green or unseasoned hardwood sawntimber, which competes mainly with domestic softwood and imported oregon in the structural house framing market (Ford 1992).

In addition, drying times and stock inventories have an important influence on the ability of processors to develop further processing opportunities. Kiln dried timber is firstly air dried before it is reduced to the required moisture content in the kiln. For this process, future timber stocks of between 9 and 12 months are usually required, depending on the particular species. Consequently, the further development of marketing opportunities for kiln dried products will need to recognise the additional costs of holding stocks of timber for longer periods of time.

Another important characteristic of further processing investments such as the production of kiln dried sawntimber is that these activities are generally more labour intensive, compared to the production of commodity grade products such as green sawntimber. It has been estimated, for example, that up to 1.5 times more labour is required in the production of kiln dried timber compared to the production of unseasoned timber (Network for Excellence in the Hardwood Timber Industry 1996). The development of further processing opportunities therefore has the potential to increase regional employment, while at the same time increasing the net returns from the hardwood sector.

However, the extent to which the hardwood sawntimber industry can maintain or increase profitability and generate additional economic benefits will depend strongly on the cost competitiveness of local products, compared with substitute products on domestic or export markets, such as imported hardwood timbers (for example, meranti). The international competitiveness of investment in a stylised case study of a new and existing Australian hardwood sawntimber mill was recently evaluated by Jaakko Poyry (1993) as part of a broader evaluation by the Industry Commission into the potential for adding further to Australia's forest products. This particular assessment provides a good example of the types of further mill processing activities that may be developed in the East Gippsland region. The study assumed a medium sized sawmill located in north east New South Wales which was supplying a high proportion of dried and dressed hardwood sawntimber to the Sydney market.

In this study it was assumed that an existing Australian sawmill with an annual capacity of 10 000 cubic metres of dressed and dried sawn hardwood was competing with a Malaysian sawmill with an annual capacity of 13 500 cubic metres of dried and dressed meranti. Under this scenario, it was found that the processing costs of the Australian sawmill were generally equivalent to the Malaysian mill, but the Australian mill had a distinct transport cost advantage. This resulted in an overall cost advantage of around 10 per cent to the Australian mill, compared to the Malaysian mill supplying the Sydney market.

The second scenario assumed an Australian sawmill with a total annual capacity of 30 000 cubic metres with 20 000 cubic metres, of this annual capacity being dried and dressed hardwood. The competing Malaysian sawmill was assumed to have an annual processing capacity of 30 000 cubic metres of dried and dressed meranti. Under this scenario, the Australian mill was found to have a distinct processing cost advantage of around 10 per cent, in addition to lower transport costs. Overall, the Australian mill was estimated to deliver dried and dressed sawn hardwood to the Sydney market for approximately 20 per cent less than the Malaysian mill.

The development of further processing and marketing opportunities is also closely related to the current marketing and allocation of timber from State forests to sawmills. As discussed previously, hardwood sawlogs are classified using a system of log grades in diminishing order of sawlog quality from A through to D. In order to capture the potential higher returns from the marketing of specific timber species which have distinctive natural attributes, the allocation of public logs to sawmillers in the region is increasingly being oriented toward the provision of selected species, in addition to the conventional log quality grades. Many sawmillers contacted during the sawmill survey indicated a preference toward receiving log allocations by quality and species grades, whereby individual species could be sold on the basis of their natural features rather than as a mixed species or commodity grade product. Many of these specific features, for example, could be exploited in product markets for furniture, linings, flooring, architraves and skirtings and seasoned beams.

While there may exist significant marketing benefits from the allocation of logs by quality and species, it is important to acknowledge that this might impose higher forest management costs, due to the additional wood scheduling requirements to ensure continuity in supply of selected species. This is largely due to the fact that the forests within the East Gippsland region are essentially mixed species forests, including forest types such as mountain mixed species, foothill mixed species, coastal mixed species and alpine mixed species. The potential returns from marketing individual species however may offset the additional forest management and wood scheduling costs.

In addition to the allocation of logs based on the major occurring species, there is also one specialty timber allocation of minor forest species within East Gippsland. Species which are considered specialty timbers include, blackwood, silver wattle, Red box, red Ironbark, and southern mahogany. and yellow stringybark. These species have special colour and grain characteristics which have the potential to replace imported cabinet timbers such as meranti or other hardwood rainforest species. Marketing opportunities may exist for those products which are well differentiated and service niche markets, both domestically and internationally.

6.3 Market outlook for residual logs

The utilisation of the residual log resource available in the East Gippsland region will be influenced by future market conditions for the types of products which could potentially be produced from these logs. There is a diversity of products that can be derived from residual logs, including: composite wood panel products (such as medium density fibreboard, laminated veneer lumber and plywood); solid wood products (such as green framing and fencing timbers, laminated beams and small furniture grade products); and wood fibre products such as woodchips which are used for making pulp and paper.

The growth in world production and consumption of composite wood panels and other engineered wood products over the past decade reflects the growing market acceptance and competitiveness of these products in a diverse range of end use markets. Wood based panels comprise three main product categories - particleboard, medium density fibreboard and plywood - and are used in a wide range of building, construction and furniture uses. In Australia, total annual consumption of wood based panels has remained at levels above 1.2 million cubic metres over the past few years. As in the case of sawntimber, the outlook for wood based panel products is strongly influenced by the general level of domestic housing and construction activity.

In 1995-96, the effects of low activity in the building and construction resulted in a decline in domestic consumption of wood based panels. However, the resumption of housing and non-residential construction activity over the medium term is projected to raise domestic consumption of wood based panels by 5 per cent in 1996-97, followed by projected average annual growth of around 3.5 per cent a year up to 2000/01. This projected growth in consumption reflects higher forecast building activity, as well as increasing use of wood based panels such as medium density fibreboard in new dwelling construction, particularly in flooring, bracing, mouldings and kitchen applications (Neck, Curtotti and Sar 1996). Current manufacturing capacity is expected to meet this projected growth.

Over the medium term, strong economic growth in South East Asian markets may also provide export market opportunities for Australian producers of wood based panel products. These opportunities will be assisted by the forecast reduction in supply of tropical timbers to the Japanese and Korean markets (of which a large proportion is used for the production of plywood), and potential substitution trends in structural end use markets between wood based panels and other building materials such as sawntimber.

The market outlook for Australian woodchips is largely influenced by international pulp and paper market conditions, as woodchips are mainly used in the production of paper and paper products and there is little growth in domestic demand for native forest sourced hardwood chips. Presently, woodchips are the main source of export earnings for the forestry sector in Australia, which are mainly exported to Japan. In 1994-95, hardwood chip exports from Australia were valued at around $438 million (ABARE 1996).

While the export volume of Australian hardwood chips has remained fairly stable over the last few years, Australia's market share in the Japanese woodchip market has declined since the early 1990s as Japan has diversified it's range of supply sources. Following the slow growth of the Japanese economy in the early 1990s, woodchip prices remained depressed as the production of paper and paperboard in Japan declined by around 2-3 per cent in 1992 and 1993. However, over the medium term, export woodchip prices are forecast to rise, due largely to an expected increase in demand in Japan and other East Asian markets such as South Korea and China, and an expected reduction in woodchip supply from North America (Sar and Sledge 1994). The expected increase in woodchip demand in the Asian region reflects stronger forecast growth in the Japanese economy, as well as the planned development of large scale pulp and paper industries in the Asian region over this period.

6.4 Development opportunities for residual log based products

As noted above, NRE has recently called for expressions of interest in the processing of 800 000 cubic metres annually of residual logs available from the East Gippsland and Tambo forest management areas, of which 650,000m3 is proposed to be sourced from East Gippsland. The processing of this material has the potential to generate significant economic benefits through the use of a previously unutilised native forest resource.

The volume of 800 000 cubic metres per year is of sufficient size to support a range of internationally competitive wood processing activities. With current technology, these logs can be processed into a variety of products, including medium density fibreboard, laminated veneer lumber, plywood, or smallwood products (eg furniture components). This material may also be used for pulp and paper making activities, either domestically or overseas. A brief outline of potential domestic processing options based on the development of internationally competitive sized mills is presented in table 9.

Table 9: Possible mill processing opportunities for residual log resource

Product type	Production output (cubic metres per annum)	Potential markets
Medium density fibreboard (MDF)	130 000	Domestic, Asia

Laminated veneer lumber (LVL)	40 000	Domestic, United States and Asia
Plywood	40 000	Asia
Solid wood products (eg furniture components)	5 000 - 20 000	Domestic
Residual log	na	Asia, mainly Japan

Source: Department of Conservation and Natural Resources (1996)
na - Not applicable.

These processing opportunities reflect an emphasis on glue lamination and composite wood panel products, which are increasingly supplying a range of building and construction uses in both domestic and international markets. The global trend toward reconstituted wood panel and beam products reflects ongoing restrictions on the global availability of mature sawlogs and associated solid wood products such as sawntimber.

The economic impact of investment in an MDF or LVL wood processing plant in the East Gippsland region was recently evaluated by McLennan and Gerardi (1995). In that study, input-output analysis was used to examine the effect of mill investment on gross domestic product (GDP) and employment using local and state based multipliers.

For an MDF plant with an annual output capacity of 130 000 cubic metres, it was estimated that an initial capital investment of $47 million would contribute up to $114 million annually to GDP and 210 jobs in the East Gippsland economy, and up to $150 million annually to GDP and 250 jobs in the Victorian economy.

For an LVL plant with an annual capacity of 40 000 cubic metres, it was estimated that an initial capital investment of $22 million would contribute up to $50 million annually to GDP and 318 jobs in the East Gippsland economy, and up to $66 million annually to GDP and 380 jobs in the Victorian economy.

It should be noted that the use of input-output analysis provides an estimate of the gross economic impact of these projects rather than an estimate of the net economic benefits. In order to determine the net economic benefits flowing from these types of investments, it would be necessary to measure the extent to which resources used in these projects have alternative uses elsewhere in the economy. These results are therefore likely to overestimate the net economic benefits arising from these investments, since the analysis does not take account of the movement of capital and labour inputs between industries in the East Gippsland or Victorian economy. In the case of employment, for example, the level of net economic benefits would depend upon whether people employed by the project would have been unemployed or would have been earning a lower wage. However, due to the relatively high level of unemployment in the East Gippsland region, these measures are likely to provide a broad indication of the magnitude of potential economic benefits arising from these projects. In 1995, approximately 3600 persons or 13 per cent of the adult population were classified as unemployed in the East Gippsland Statistical Division (Australian Bureau of Statistics 1996).

The 800 000 cubic metres of residual log available from the East Gippsland and Tambo forest management areas may also be marketed as a suitable resource for the production of pulp and paper, either on domestic or export markets. However, large scale investment in a new 'greenfields' processing facility such as a bleached kraft pulp mill is generally in the order of around $1 billion dollars, and would require an annual log input of around 1.65 million cubic metres. As the total residual log resource available from the East Gippsland and Tambo forest management areas is 800 000 cubic metres per annum, this resource may only provide a partial source of fibre to support large scale pulp or paper making facilities. State Forests of New South Wales has recently estimated the total potential resource of pulplogs presently available from the Batemans Bay, Eden, Narooma and Queanbeyan forest management areas at around 420 000 cubic metres per annum (C. Nicholson, State Forests, personal communication, June 1996).

At present, residues from sawmilling operations and some residual logs are utilised in pulp and paper making. Australian Paper uses East Gippsland pulpwood in its pulp and paper making complex at Maryvale in Central Gippsland. Harris-Daishowa, a major exporter of woodchips from Eden on the New South Wales south coast, obtains a portion of its requirements from East Gippsland.

The residual logs and residues generated from logging and sawmilling will often be insufficient or unsuitable for the development of new or expanded local processing facilities. Therefore, woodchips may continue to be a viable domestic and export industry with value-adding potential. As the forest products industry develops in East Gippsland, the availability of processing residues may increase. At the same time, uncommitted residual wood in the forest will also become available. Therefore, there is potential to establish more systematic chip export operations for significant volumes of woodchip until such time as major new processing facilities are developed that can utilise such wood. These operations would complement any new projects and could be progressively reduced as capacity to process the resource in East Gippsland increases.

For example, the economic implications of proposed investment in large scale pulp processing facilities in the South-East Forest Region (taken to include the Forest Management Areas of Eden, New South Wales, and East Gippsland and Tambo, Victoria) was previously evaluated by Gibbs (1991) as part of an integrated economic study for the region. Assuming an adequate supply of wood resources from the three forest management areas (up to 1.67 million cubic metres per year), the total annual value of output (or sales) from a pulpmill in the region was estimated at around $396 million, with the generation of approximately 216 additional jobs. Using regional and state based input-output tables, it was estimated that investment in a pulp mill may contribute an additional $650 million to total regional output and $641 million to Victorian output.

The feasibility of large scale investments in wood processing facilities is influenced by a number of market related factors. First, there are the usual commercial risks associated with large scale capital projects such as future costs, prices and interest rates, as well as the perceived risk or uncertainty associated with access to resources. A Regional Forest Agreement is intended to provide certainty regarding access to forest resources for wood production, and promote greater investor confidence in significant capital projects. Second, it is important to note that macroeconomic conditions can fluctuate both in the domestic and world economy. Hence, to maintain long term competitiveness, wood processing investments need to be sustainably competitive over a range of exchange rate, interest rate and product price ranges. The issue of long term competitiveness of the wood based industries is particularly relevant when the investment horizon for these activities is typically in excess of 10 to 20 years.

7. Other Forest Produce

The State forests of East Gippsland are managed to supply a range of other products and benefits in addition to sawlogs and pulplogs. These can be divided into minor forest produce (posts and poles, other hewn timber, firewood and specialty timbers), extractives (such as gravel and stone) grazing, apiculture and tree-ferns. Up until 1992, minor forest produce included the harvesting of durable and non-durable timber (ironbarks) and non-durablewas undertaken in the region to supply railway sleepers for the Public Transport Corporation. However, this activity has now ceased. The current economic values arising from these activities are described in this section, to the extent that relevant information is available.

Other forest uses include recreation, tourism, mineral exploration and mining and water production, and are discussed separately in this report.

Management

Like larger scale sawlog and residual log production, management of other forest produce is aimed at sustainability of supply and minimisation or avoidance of any impact on the environment. The nature and level of the activity will determine the degree of management planning and control required. For example, production of firewood and specialty timbers occurs on a small scale in the region, and consequently the overall environmental impact is small, relative to pressures that may be exerted in forests closer to large regional populations.

Licencing and supervision arrangements reflect the level of activity. Firewood and specialty timber collection is usually a non-commercial activity, and is restricted to salvage operations within the State forest General Management Zone. Trees may not be felled unless authorised by a Forest Officer. Under most circumstances, the licensee will operate without the requirement for supervision from NRE, as a system of self regulation is used with periodic monitoring by field officers.

Management planning and supervision increases in relation to the nature and potential impact of the production activity. For example, commercial firewood collection in State forest is more closely regulated than is required for domestic firewood collectors in East Gippsland.

In contrast to larger scale timber operations, the opportunity for harvesting of firewood and miscellaneous produce to be combined with silvicultural programmes is limited. Some silvicultural benefit can be gained through the removal of non-sawlog trees, however the net effect of this is small indeed.

Where relevant, operations are regulated to accord with the sustainable yield capacity of the forest. Other products may be derived as by-products or in salvage, for example tree-ferns and specialty timbers. Rock, gravel, and other extractives are not regarded as renewable, and are subject to control to minimise impacts on the local environment. Accordingly, extraction operations are required to meet specific planning controls for site location and ongoing management, with closer monitoring by NRE field staff. Erosion mitigation and pollution abatement procedures are placed on all NRE and commercial extractions, and utilised areas are progressively rehabilitated, according to regional Departmental prescriptions.

Grazing and honey production activities must also be carefully managed within the long term ecological carrying capacity of the land.

7.1 Profile of existing supply, usage and demand

Minor forest produce

The level of minor forest produce harvesting in East Gippsland is low, due to the small size of the local market and long transport distances to other major markets. While a number of 12 month licences are issued to commercial cutters for the production of fencing material (posts, poles, rails) and firewood, a large proportion of the harvest is undertaken under short-term, small quantity licences, issued to individuals for private use.

Wherever possible, harvesting of these products is integrated with other forest operations, such as sawlog harvesting and road construction (CNR, 1995).

Total royalties received by NRE from the sale of minor forest products was $44 956 in 1994-95 (tables 10 and 11).

Firewood

Durable timbers are often preferred by firewood collectors. However, firewood must be collected from material already on the ground, and this material is more readily available in logging coupes which mostly occur in the Foothill Mixed Species Forests.

Licences for between 2 000 and 3 000 m3 of firewood are sold annually in East Gippsland. This is certainly within the productive capacity of the forest. For example, assuming a growth rate for firewood of of 0.05 m3 per ha for the General Management Zone net available area of 332,600 ha, the annual sustainable yield would be in the order of 167,000 m3. This growth rate is inherently conservative and would be equal to a piece of wood 25cm in radius by 30cm in length per hectare per year. Whilst this example simplifies the spatial characteristics of the supply and demand for firewood, for example around towns and villages of the FMA, it serves to demonstrate the capacity for production within the region.

Posts and other hewn timbers

While a small number of commercial cutters supply posts and other hewn timbers to the local market, many land-owners have traditionally met their own requirements under licences issued over forest close to their properties (CNR, 1995). This small market is reflected in the figures in table 10. The existing level of demand for posts and other hewn timbers is mostly supplied from coupes scheduled as part of normal harvesting operations.

Specialty timbers

Species such as Red Ironbark (*Eucalyptus tricarpa*), Red Box (E. polyanthemos), Blackwood (*Acacia melanoxylon*), Silver Wattle (*A. dealbata*), Black Olive Berry (*Elaeocarpus holopetalus*) and Southern Sassafras (*Atherosperma moschatum*) produce timber with attractive colour and figure, making them sought after for use in furniture and for woodturning (CNR, 1995). Burls from trees cut in logging coupes are also produced from normal sawlog operations and are highly sought after by woodturners.

Resource information for the region is neither species-specific nor precise enough to determine sustainable yields for specialty timbers. These timbers become available in small quantities during sawlog harvesting and road construction and it is therefore prudent to consider them as a by-product of sawlog harvesting, and to issue licences accordingly (CNR, 1995). Interest in specialty timbers has been increasing in recent years, and 450 m3 are currently supplied annually under licence. One long-term licence has been issued in the region for specialty timbers. There is however likely to be considerable potential for the expansion of specialty timber sales.

Craftwood licences are also issued for smaller quantities.

Table 10: East Gippsland minor forest produce revenue for 94/95 and 95/96

		1994/95		1995/96
Minor produce	**Volume (m3)**	**Revenue**	**Volume (m3)**	**Revenue to April**
Posts and Poles	-	$5 493	-	$3 816
Other Hewn Timber	approx. 4 500	$12 584	approx. 3	$10
Firewood	2 774	$13 273	2 139	$10 200
Specialty Timbers	approx. 360	$8 509	approx.174	$4 091

Source: NRE District records

Extractives

Stone, rock, gravel, sand, clay and soil, are extracted mainly for construction and maintenance of roads in the region. Users include NRE, Vic Roads, the local shire councils and a number of local businesses. Both the East Gippsland Shire and Vic Roads obtain roading material from pits and quarries in State forest, as supplies of these products are not always available from private property (Lugg et al, 1993). The cost of hauling gravel for road works becomes prohibitive at 20 km, making it necessary to maintain a network of regularly spaced gravel-pits across the region. The Department currently is rationalising the number of gravel-pits and quarries on public land. This will result in a reduction in the number of pits open at any one time (CNR, 1995). Revenue from extractives is given in Table 11.

Table 11: East Gippsland extractives revenue for 94/95 and 95/96 (to June 1996)

		1994/95		**1995/96**
Districts	Volume (m3)	Revenue	Volume (m3)	Revenue
Orbost Bendoc and Cann River	6 736	$11 518	12 467	$16 130
Nowa Nowa (EG FMA)	3 555	$4 089	8 558	$10 985
Total	**10 291**	**$15 607**	**21 025**	**$27 115**

Source: NRE District records

Grazing

Grazing licences occupy a total area of 85 000 hectares, or 13% of State forest within East Gippsland. Such licences comprise over 90 per cent of the total area held under occupation licences in the region (CNR 1993). Access to grazing activities in the state forests of East Gippsland is regulated through the issue of grazing licenses and crown leases.

Four types of grazing licence have been issued within the East Gippsland region. These include:

- bush grazing (seasonal) permits covering large tracts of land adjacent to private properties. This land is available to farmers on a seasonal basis when stock feed becomes scarce (such as during drought);
- alpine grazing permits covering areas of land either wholly or partly above 1220 metres with seasonal restrictions in force;
- agistment permits allowing grazing for a fixed but usually short term period; and
- grazing permits allowing all year grazing on certain areas of land. These permits allow intensive grazing (Lugg, Marsh and Bartlett 1993).

Grazing has decreased in importance as a forest activity in the region over recent years. In the last half of last century, it was the major use of State forest. Graziers burnt large areas of forest to encourage forage. However, following the 1939 wildfires, burning by private individuals was made illegal, and widespread grazing of forest was no longer prevalent. Nevertheless, grazing still takes place in State forest, most notably on the subalpine plains at Nunnett (CNR 1993). Sub-alpine leases are generally more highly valued than those in foothill areas, as they offer better grazing potential, with a reasonable degree of security against drought. However, most of the region is unsuitable for grazing due to dense forest cover.

While grazing licences in State forest often cover large areas, stock movements and grazing pressure are usually localised. In most cases the grazing pressure is very low. A review of grazing licences during preparation of the East Gippsland Forest Management Plan identified Grey Box Woodland at Noorinbee as the only locality where current stock grazing may conflict with the values of the area (CNR, 1995). Licence Fees are given in Table 12.

Table 12: East Gippsland grazing revenue figures

Year	Licences in State forest	Revenue
1995/96	38	$6 735

Source: Departmental LIMS records

Apiculture

The various species of flora of importance to honey production, flower at different times of the year and tend to produce differing quantities and qualities of nectar and pollen. The honey produced from individual species also varies widely in colour, flavour, density and tendency to candy. In some cases, different species may flower consecutively and hives may be kept at the one site for many months. More usually though, as flowering declines, hives may be moved to where a different species is flowering (Lugg *et al*, 1993). Coastal and foothill forests containing box, ironbark and stringybark species are traditional areas for honey production.

Apiary sites are either temporary or permanent. The location of permanent sites remains fixed and they are usually held by one apiarist for many years. This does not mean, however, that they are permanently occupied. On the contrary, they are typically occupied for only two to three months each year. Temporary sites are typically used less regularly. Their location is not fixed, although a particular site may be used on a recurring basis. They permit access to localised flowering which could not be utilised from permanent sites. A large proportion of State forest in the region is unused by beekeepers. This is due to poor access, inappropriate site conditions, unsuitable honey flora, or lack of demand (CNR 1993).

Table 13: East Gippsland apiculture revenue for 94/95 and 95/96.

		1994/95		**1995/96**
District	**Number of sites**	**Revenue**	**Number of sites**	**Revenue to April**
Orbost	59	$1 060	-	$780
Cann River	104	$1 560	-	$160
Nowa Nowa (EG FMA)	95	$2 060	96	$1 980
TOTAL	**-**	**$4 680**	**-**	**$2 920**

Source: NRE District records

When interpreting Table 13 it is important to note that royalties received from bee-keepers represent only part of the total economic value derived from bee keeping activities. In 1993-94, the honey produced from the East Gippsland statistical division had an estimated market value of $172 700 (Australian Bureau of Statistics 1996).

Access to bee-keeping activities in the State forests of East Gippsland is controlled through the issue of bee-keeping permits by DNRE. At present bee-keeping is mainly restricted to state forest areas (although some bee keeping is allowed in National parks including Croajingolong National Park). Additional restrictions apply to bee-keeping in some areas of State forest which are adjacent to National parks (Lugg, Marsh and Bartlett 1993).

Tree-ferns

Harvesting of tree-ferns from public land has not generally been permitted in Victoria, although exceptions have been made where the plants faced permanent destruction, for example, by road clearing. The main species suitable for harvesting is the Soft Tree-fern (*Dicksonia antarctica*) which is common in timber production areas in the region (CNR, 1995).

Tree ferns are sold by the lineal metre, calculated on the height of the plant.

Table 14: East Gippsland tree-fern revenue for 94/95 and 95/96.

Year	Quantity	Revenue
1994/95	75.2m	$141
1995/96	139.3m	$293

Source: NRE District records

Other forest produce

Presently there is low demand for forest products such as the seed of eucalypts and understorey species, cut flowers and live plant specimens. The Department also employs contractors to collect seed for regeneration of logging coupes. A wide range of plant species can only be taken from public land when covered by a suitable Flora and Fauna Guarantee permit. A permit for harvesting of minor forest produce and payment of a royalty are also usually required (CNR, 1995).

7.2 Outlook and development opportunities for other forest produce

Minor forest produce

As current demand for the range of products is generally low, it is unlikely that future demand will increase significantly. Future expansion in the supply of some products is possible.

Extractives

Potential development of an increased market for extractives from State forest appears to be limited due to the lack of quality materials required for road construction. There are no major roads likely to be built by East Gippsland Shire or Vic Roads and so there would not be any apparent market for extractive materials due to the high cost of transport to other regions.

Grazing

Grazing for domestic stock under forest shelter is an important service to farmers. However grazing is likely to continue on a small scale in East Gippsland.

Apiculture

Roads developed for timber production potentially increases access to large areas of State forest for beekeeping, and the NRE fire protection program provides a level of security for the hives and other equipment used in the industry. Due to the preference for coastal forest types (particular forest trees) and access to suitable apiary locations, it is expected that current levels of demand are likely to continue.

Tree-ferns

A considerable number of tree-ferns that are currently destroyed in logging coupes or during road construction are not utilized. They are a potentially valuable revenue source. However, distances to markets, departmental supervision time and coupe access present some potential limitations to an expansion in the local tree-fern industry.

Other forest produce

A large amount of other forest produce is currently unutilized in logging coupes. There is considerable potential to expand market demand for products such as cuttings, seed and live plants.

8. Catchment and Water Value

Introduction

A supply of water in sufficient quantity and appropriate quality is essential for maintaining natural environments, and for agricultural, recreational, industrial and domestic consumers. For these reasons, water is a very important resource that can be harvested from forests. Streams and catchments in the East Gippsland region include some of the most pristine in Victoria (DWR 1990, LCC 1991a). Catchments in State forest are used for a range of uses including conservation, timber production, and water supply.

The relationship of water, catchments, forests and forest use is complex, and based on many variables including climate and geology, lithology and vegetation. In brief terms, water enters a forested catchment by rainfall, snow, fog or sleet, and is usually intercepted by vegetation, before landing on the soil. At the soil surface, water will usually infiltrate until saturation occurs, and then run off as surface flow. Overland flow contributes to short term river flow following a rainfall event, and infiltration contributes to underground water (aquifer) reserves which may be discharged into rivers and streams at a later date.

Infiltration is a function of soil porosity and storing capacity. Sands and loamy soils will absorb more water more quickly than clays or rock. Where the soil becomes saturated, or rain falls quicker than it can infiltrate, overland flow can lead to erosion. Vegetation serves to disperse the energy of water as it hits the ground and runs off, and has the capacity to hold soil and stabilise slopes.

Vegetation also uses water for maintenance of physiological functions. Water use by forests will vary with forest type and age, for example a very young forest uses less than a mature forest, but the greatest demands for water use are usually associated with vigourously growing, evenaged juvenile forests.

Water quality and quantity is therefore affected by forest and catchment values, and changes over time. Bushfires, storms and floods, droughts and forest growth will affect the quality and quantity of water. The impact of these factors on water quality and quantity is dependent on soil type (physical and chemical properties), slope and forest cover.

Human impacts can have adverse effects on water values. Permanent removal of forest cover will lead to a decrease in water use by vegetation, causing water tables to raise, and in some soil types, cause salinity of lower-lying areas. Compaction of soils can decrease infiltration, and increase overland flow, which can lead to erosion without the mitigating effect of vegetation to reduce energy in the water.

Forest management does not involve the permanent removal of vegetation but does have some potential to impact on water values. Water quality can be impacted by harvesting as it involves the temporary removal of forest cover, and can disturb soils thus allowing the potential for erosion. Water quantity can be affected where old forest is regenerated, and the consequent water demand is high. Fire management, road construction, road maintenance and road use can also impact on forest water.

Water quality and quantity are therefore important forest management issues, and a number of management techniques can be used to maintain water values. Water quality is managed by limiting the opportunity for soil or high energy waterflow from directly entering drainage lines. For example, forest harvesting in East Gippsland is regulated according to the Code of Forest Practices, and Regional Prescriptions which provide for the use of filter strips, (also known as protection or buffer strips) on drainage lines. This has the effect of protecting the drainage lines from direct disturbance, and streambanks from erosion. Filter strips also prevent soil that is dislodged through the effects of harvesting from directly entering the drainage line.

The design and construction of roadlines and landings considers soil and water management principles in location, construction techniques and standards. Drainage structures are designed to collect, and disperse water from the road surface into vegetated areas as quickly as possible. An additional management concern is the timing of road use and harvesting operations. Traffic on saturated unpaved roads, and log extraction (called æsniggingÆ) on wet soils will increase soil movement and damage soils and drainage structures, thus impacting on water quality. Harvesting and road use is timed seasonally and in response to weather, with the application of road closures and harvesting limitations.

The effect of harvesting and regeneration on water quantity and quality can also be managed by limiting the amount of harvesting in a catchment area spatially (size of an area) and temporally (over time). It should be noted that whereas harvesting can lead to water yield reductions for a given area, it can also be manipulated maintain or increase water yield for example, through thinning, which reduces tree stocking.

8.1 Stream and catchment values in East Gippsland

Groundwater

The East Gippsland Forest Management Area has an extensive shallow aquifer system (less than 150m below the surface) but no significant deep aquifer systems (DWR 1988). Quality is good, declining to marginal and even brackish in the south-west of the FMA. Use of groundwater is currently minimal, being restricted to a few bores along the lower reaches of the Bemm, Cann and Snowy River valleys.

Surface waters

The Australian Water Resources Commission (AWRC) has divided Australia into twelve Drainage Divisions which are sub-divided into basins. East Gippsland is wholly within the South East Coast Drainage Division and extends across three basins: East Gippsland, Snowy and Tambo (DWR, 1989).

The East Gippsland Basin (No 21 AWRC) covers a total area of 604 000 ha of which 150 000 ha (25%) is in NSW. The average annual streamflow of the basin totals 770 0000 ML (3.5% of Victoria's total discharge). Approximately 1200 ML is diverted each year (DWR 1989). The main rivers in the basin are the Bemm, Cann, Thurra, Wingan and Genoa, all of which flow south or south-east into coastal inlets or lagoons, before entering the sea.

The Snowy River Basin (No 22 AWRC) has a total area of 1 580 000 ha of which 6470 000 ha (41%) lie in Victoria, with the remainder in NSW. The area that occurs in NSW generates the greatest proportion of the basin's total annual streamflow, which is 3 490 000 ML. Of this, 1 130 000 ML (32%) is diverted into the Snowy Mountains Hydroelectric Scheme. The Snowy River is the main river in the basin, but there are a number of major tributaries including the Suggan Buggan, Little and Buchan Rivers to the west, and the Deddick, Rodger and Brodribb Rivers to the east. Average annual water use within the Victorian part of the basin is only 2230 ML, three-quarters of which is used for irrigation (DWR 1989).

The Tambo River Basin (No 23) has a total area of 425 000 ha and an average annual discharge of 325 000 ML (DWR 1989). The majority of this basin lies outside the region. However, the Timbarra River, a major tributary of the Tambo, forms part of the western boundary of the East Gippsland region.

Available data for salinity, dissolved oxygen and nutrients indicate a general high suitability of the water for maintenance of aquatic life. The high quality of the water reflects the fact that a large percentage of each basin remains covered by natural forest.

8.2 Water quality

The quality of surface water can vary considerably from one catchment to another. These variations are related to the inherent characteristics of the catchment such as soil type, slope, vegetative cover and climate, as well as land use within the catchment. In general, all water users prefer high quality water although some users (e.g. irrigators) can accept lower quality water than other users (e.g. domestic consumers). While it is possible to treat domestic water supplies to compensate for poor water quality, treatment is rarely feasible where the water is destined for environmental use, and it is therefore important to strive for good water quality in all catchments, rivers and streams.

Some water quality problems that do exist in East Gippsland are largely the result of diffuse inputs such as runoff from agricultural land, and soil erosion from land disturbance activities (DWR 1989)and many domestic water supplies in the region regularly fail to comply with standards set down by the World Health Organization (WHO) for bacteriological contamination, colour and turbidity. The reasons for these failures are not currently well understood but are likely to be the result of a combination of factors including inherent features of the catchments, and the effects of land management activities. Water Boards have expressed concern that further deterioration in these water quality indicators will necessitate installation of water treatment facilities which would not only be costly but are also strongly opposed by local residents. If water treatment facilities are installed, it remains important not to allow deterioration of water quality since treatment then becomes less effective and more expensive.

Over the past decade, sand deposition in the lower reaches of the Genoa and Wallagaraugh Rivers, as well as in Mallacoota Inlet, has caused concern to local landowners, environmentalists, tourists, and fishermen. A recent investigation of sediment sources in the Genoa River catchment (Erskine 1992) concluded that channel erosion as a result of the 1971 flood is the most important sediment source. Harvesting in native forests and agriculture were found not to be important contemporary sediment sources.

8.3 Quantity

Not all areas of the region are equally important for water production. The amount of water produced per unit area of catchment is determined by the combined effects of various components of the water cycle; rainfall, evaporation, transpiration and infiltration. The mountainous, high elevation areas particularly the Errinundra Plateau and Cobberas Range, are the main water producing areas with an average annual rainfall of around 1400 mm and a median annual runoff generally in excess of 125 mm. In contrast, most of the lowland coastal area has an average annual rainfall between 800 and 1200 mm and a median annual runoff of less than 50mm (LCC 1989).

The runoff producing capacity of the high elevation mountainous areas is directly related to the higher rainfall in these areas in conjunction with site aspects such as soils, slope and extent of forest cover. This is reflected in the permanence of the streams in the region. Those streams originating in the high elevation sections such as the Buchan, Brodribb and Errinundra Rivers tend to flow permanently throughout the year, whereas streams originating in the foothills and coastal plains such as Boggy Creek, Cabbage Tree Creek and the Betka River tend to regularly run dry.

Streamflow is never constant, varying in response to climatic factors, especially rainfall, and other features of the catchment such as soil types. Consumptive uses of water (i.e. domestic, agricultural and industrial use) require a regular assured supply and storages are often constructed to maintain flow through dry periods. In East Gippsland, the small population and historically low level of use throughout the region means that there has not been a need to establish major storage reservoirs to date. Additionally, in the absence of large scale industry, there are no large individual consumers although irrigation collectively represents a relatively large demand.

In recent times, East Gippsland Water has reported difficulties in obtaining adequate supplies of good quality water for some townships, especially during summer when river flows are low and demand, partly associated with the influx of tourists, is high. Cann river has experienced water restrictions in the recent past, and both Orbost and Mallacoota find it necessary to augment the main supply from other sources (groundwater in the case of Mallacoota, and water from the Brodribb River in the case of Orbost). The Board must either construct enlarged water storages or seek alternative sources. Both of these options increase the cost of supply.

Supply problems are also evident in the Snowy River, which has part of its flow diverted by the Snowy Mountains Hydroelectric Authority. Irrigators on the lower Snowy River floodplain are concerned that reduced stream flow is allowing saline estuarine waters to enter the lower stretches of the river, rendering the water unsuitable for irrigation.

8.4 Effect of forest management on rivers and streams

The potential for forest management activities to impact water quality and quantity, and aquatic values is well recognised, and a large amount of information has been compiled on this subject both in Australia and overseas.

The impact of timber harvesting in forests of the Eastern Australian seaboard on the quantity and quality of water available is discussed by Dargavel *et al* (1995) and O'Shaughnessy (1985). Both authors stressed the importance of compliance of timber harvesting codes of practice for maintaining water quality, particularly in applying such codes to road construction and maintenance. Dargavel concludes that avoidance of direct stream disturbance by these activities and prevention of turbid inflows will provide a high level of protection, based on local and overseas studies.

Effect of management on water yield In East Gippsland.

Most water supply catchments in the region are large, capable of supplying the small towns and farms that draw on them. The Rocky and Betka River catchments, supplying Orbost and Mallacoota respectively, are exceptions, being small for the population centres they service. The former Orbost and Mallacoota Water Boards (now encompassed by East Gippsland Water) have reported difficulties in maintaining supplies, especially during summer, when river flows are low and demand is high. It has sometimes been necessary to augment the main supply from other sources. Maintenance of water supply is therefore important in these catchments.

While water supplies drawn from the Rocky River can be readily augmented from the nearby Brodribb River, such alternatives do not exist to supplement the Betka River. Some members of the Mallacoota community have expressed concern that vigorous regenerating forest resulting from fires and timber harvesting in the Betka River catchment may use more water than older forest, and consequently decrease summer flows in the Betka River. Such an effect is well documented for Mountain Ash forests near Melbourne (Kuczera 1985) but less well documented for the drier forest types associated with the Betka. There is little empirical data available on water yields in the Betka Catchment and the possible effects of regrowth forests on water yield are therefore speculative. However a recent study did find that apparent decreases in flows in the Betka River between 1982 and 1988 could not be attributed to timber harvesting because such an effect has not had time to manifest (Jayasuriyah and O'Shaughnessy 1994). These authors also noted that, based on catchment hydrology research elsewhere, at least 30% of a catchment needs to be subject to a change in land use to produce a significant impact on water yield. The area available for timber production in the Betka catchment is 3370 ha (approximately 29% of the catchment). It is therefore unlikely that timber harvesting alone would have a major impact on water yield.

However, the possible combined effect of regrowth forest originating from both wildfires and timber harvesting, remains uncertain. Studies of fire affected Mountain Ash forest on water yield clearly demonstrate the relationship between regenerating forest and water yield. O' Shaughnessy (pers. comm 1996), notes at least two factors would be likely to temper any comparable effect in the Betka River catchment. First, the Lowland Forest that predominates in the area is adapted to an extremely fire prone environment, and mature trees survive all but the most severe fire. For example, significant areas of forest in the catchment were burnt in the severe fires of 1983 and the canopy has recovered in most areas. This contrasts with Mountain Ash forest where fires can readily kill overstorey trees and lead to a dense regrowth forest. An overstorey of older trees significantly depresses the growth of young trees and therefore any effect they might have on water yield. Secondly, shallow soils (such as found in the Betka) have a lower capacity for storing soil moisture than deep mountain soils associated with Mountain Ash. There is therefore less time for trees to utilise water passing through the system and less opportunity for different rates of water use (between young and old trees) to manifest.

Problems with maintaining water supplies to Mallacoota are therefore most likely a consequence of the small size of the catchment, and the area's highly variable climate that affects summer flows in the Betka River. A major factor is the dramatic increase in the population of Mallacoota in the Summer period, resulting in a significant increase in the demand for water.

Effect of water quality in East Gippsland

There are no apparent water supply problems clearly associated with forest management activities in the region. However, the importance of the Rocky and Betka River catchments for domestic water supply is acknowledged by NRE, as well as the level of public concern over land use activities in these areas, and the need for ongoing consultation and monitoring.

Water in the Betka River is naturally high in tannin and organic matter. Water drawn from the river for domestic use is currently chlorinated to ensure it is safe to drink. Unfortunately this produces an odour problem that contributes to general concern over Mallacoota's water supply. East Gippsland Water is currently examining the feasibility of a water treatment plant to eliminate the problem and provide a domestic water supply that meets World Health Organisation standards. This issue is unrelated to timber harvesting or other forest management activities.

Issues relating to biodiversity protection in East Gippsland streams are discussed in the Environment and Heritage report.

8.5 Management

Relevant Government policies and legislation

Government Policy, as reflected in recent legislation, emphasises that land and water management are inseparable and the Government has directed public authorities to aim for stable, well managed systems which will protect and not damage rivers and their environments.

The Gippsland Water Strategy, which covers all the rivers in the region, aims to protect high value areas, promote sustainable catchment and waterway management, and provide a balanced allocation of water to off-stream users and the environment. Recommendations made in the draft strategy include monitoring water quality before during and after forest operations, determining effectiveness of the Code of Forest Practices, and ensuring that the importance of water values be emphasised in forest management plans.

The Timber Industry Strategy (Govt. of Victoria 1986) cites æensuring the sustained capability of forests to maintain and enhance water quality and yield' as one of six objectives for environmental management. It also indicates that priority will be given to water production in those catchments with limited stream flows that service regions with high current or potential water demand. The strategy for achieving this water quality and yield objective includes undertaking land capability assessments to delineate hazardous areas; preparing appropriately detailed codes of practice/prescriptions to set required standards; and monitoring adherence to standards, together with periodic re-evaluation of the standards themselves. To maintain or enhance yield, the forest age class distribution, forest structure and rotation lengths may be manipulated.

Government policy to protect water quality and quantity, is implemented through five main processes:

I. Identification of special areas under the provisions of the *'Catchment and Land Protection Act'* 1994.
II. The Land Conservation Council, which protects water quality for in-stream environmental benefits, landscape and recreation through land use planning.
III. Specific controls such as the Code of Forest Practices enacted under the provisions of the Forests Act 1958 designed, inter alia, to protect water quality and quantity in all areas where forest operations take place and through a range of provisions specified in Forest Management Plans.
IV. The appointment of River Management Authorities under the *Water Act* 1989.
V. General provisions related to environment protection for potable water supply catchments apply to the Bemm, Cann and Betka Rivers, under the provisions of the Environment Protection Act 1970 and State Environment Protection Policy No W-21.

Each of these processes is dealt with below.

I. Designation of special areas

The listing of special areas under the Catchment and Land Protection Act 1994 highlights their significance as a source of water and indicates that water catchment values - such as water yield, quality and flow regime - are of prime concern. The region includes eight Special Water Supply Catchment Areas listed in the *Catchment and Land Protection Act* 1994 (formerly these were called Proclaimed Water Supply Catchments under the now repealed *Soil Conservation and Land Utilisation Act* 1958) . Ninety-five percent of their area is State forest. The *Code of Forest Practices for Timber Production* (Code) requires that water quality and yield are protected in water supply catchments. Table 15 below identifies the catchments listed under the Act:

Table 15: Special catchments in East Gippsland under the Catchment and Land Protection Act 1994

Name of Catchment	Area (Km2)	For the protection of:
Betka River	117	Town water
Cann River	642	Town water
Brodribb River	935	Town water, Stock and Domestic use
Rocky River	24	Town water
Buchan River	801	Town water
Bemm River	904	Town water, Stock and Domestic use
Tambo River	206	Town water and Industrial use
Boggy Creek	271	Town water

Note: Only 206 km2 of the total Tambo catchment is within the FMA. Areas are derived from Geographic Information System analysis and may show some variation from previously published figure

II. Land Conservation Council

The Land Conservation Council (LCC) has completed five major studies of land use in the Region: the initial study of East Gippsland (19774), the East Gippsland Review (19865), the Gippsland Lakes Hinterland Study (1983a), the Alpine Study (197977) and the Alpine Area Special Investigation (1983b). Each of these has made specific recommendations for land use relating to the conservation of stream environments and streamside reserves. The recommendations include æNatural Feature Zones' along many of the Region's major rivers. Natural Feature Zones have been recommended for the following:

Ada River	Bemm River	Betka River	Boggy Creek
Brodribb River	Buchan River	Butchers Creek	Cann River
Combienbar River	Genoa River	Goolengook River	Mellick Munjie Creek
Mueller River	Murrindal River	Snowy River	Wallagaraugh River
Wingan River	Timbarra River	Thurra River	

The primary aims of management for Natural Features Zones are the protection of natural and scenic values and the provision of recreation activities and interpretative aids. Timber harvesting and gravel extraction are not permitted. Natural Features Zones have not been exactly delineated by the LCC although guidelines for their delineation have been given. Zones are delineated more precisely by the Forest Management Plan.

The LCC has also undertaken a Statewide investigation into Rivers and Streams (LCC 1991). The purpose of the LCC investigation was to evaluate the scenic, recreational, cultural and ecological values of rivers and streams and to make recommendations on the use of these rivers and how best to protect their identified values. As a result, five æVictorian Heritage Rivers', eleven æEssentially Natural Catchments' and two æRepresentative Rivers' have been identified and protected within the Region under the provisions of the *Heritage Rivers Act (1992)*. Most of these areas are within National Parks; however, part of the Snowy River and the Bemm, Goolengook, Arte and Errinundra Rivers Heritage River corridors, as well as the Thurra River and part of the Buchan River Representative River corridors occur within State forest and have been considered in the development of the Forest Management Plan.

Timber harvesting is not permitted within the Bemm, Goolengook, Arte and Errinundra Rivers corridor, but low intensity selection felling is permitted in that part of the Snowy River corridor that is in State Forest but outside the Natural Features Zone. With the exception of a small stand of regrowth forest on the lower Snowy River Catchment (within which timber harvesting is permitted (LCC 1991) all Natural Features Zones and Heritage River corridors in State forest have been included in the special protection zone. In addition, a network of linear reserves (200m average width), linking larger portions of the special protection zone and existing conservation reserves, has been established as part of the fauna conservation strategy outlined in the East Gippsland Forest Management Plan.

III. Controls enacted under the Forests Act 1958

Code of Forest Practices for Timber Production and Regional Prescriptions

The Code of Forest Practices for Timber Production (Code) includes measures to minimise soil erosion and preserve water quality in forest areas. These include:

- standards for the design, construction, maintenance and rehabilitation of roads, tracks, bridges, log landings and log dumps.
- retention of riparian and other vegetation for at least 20m from permanent streams, swampy ground and bodies of standing water.
- retention of a filter strip of a least 5m wide on either side of temporary streams and drainage lines.
- suspension of timber harvesting and log carting during periods of wet weather.
- the application of a general maximum slope limit of 30 degrees for harvesting operations.

The Code provides the basis for detailed harvesting prescriptions which take account of local conditions such as soil type, rainfall, and the type of harvesting operations. As a rule, the Code provides minimum standards which may be increased (in favour of increased environmental protection) through local prescription or through judgement of NRE Forest Officers while developing Coupe Plans. Forest operations in the region are conducted in accordance with a set of local prescriptions (DCNR1996) that are no less stringent than the Code. Regional prescriptions were reviewed in 1995. Implementation of these prescriptions is the principal mechanism for conserving stream and catchment values in State Forest. Routine auditing of compliance with prescriptions and ongoing review of their efficacy is also important to ensure that requirements of the Code are met.

In recognition of the potential effect of regrowth forest on water yield the Code requires that *æappropriate rotation lengths, silvicultural techniques and limitations on the areas harvested annually'* are applied in water supply catchments.

Some "Potentially Threatening Processes" listed under the *Flora and Fauna Guarantee Act* 1988 are addressed by the Code and associated prescriptions; in particular increased sedimentation of streams and the alteration of natural stream temperatures.

The forest road network is designed to minimise the need for new major stream crossings. Where stream crossings are necessary, they will be constructed in accordance with the Code. Where the crossing of linear reserves is unavoidable, special attention is paid to minimise road width and to retain canopy closure over the road wherever possible.

Water quality and quantity

Protection of the quality of water flowing down rivers and streams remains an important objective for land outside special catchments and LCC reserves. Some activities such as logging, road construction and maintenance, grazing, recreation and fuel reduction burning, along with some natural events such as wildfire, have the potential to degrade quality and quantity of water resources.

The activity of most concern is timber harvesting and associated roading, primarily because of the amount of soil disturbance and exposure that takes place during these operations.

The Code of Forest Practices recognises the potentially damaging effects of forestry activities and sets standards and guidelines to be applied to timber harvesting, timber extraction roading, regeneration and reforestation operations. These standards may be tightened where appropriate to provide a higher level of protection. The Code also states that priority must be given to the protection of catchments with limited streamflow servicing regions with high current or potential demand.

Soil protection

Of the three main types of potential land degradation relevant to forested land (soil erosion, soil compaction and nutrient decline), soil erosion is the most significant. It can have undesirable on-site effects, such as the removal of nutrients and soil organisms important for plant growth, and off-site effects on water quality and stream values. Road construction and timber harvesting, if not managed properly, can cause unacceptably high erosion.

Increasing slope is directly related to increasing erosion hazard. Current prescriptions place a general slope limit of 30 degrees on timber harvesting. This can be varied with soil type and stability, intensity and magnitude of harvesting and the type of logging machinery used. Granite-based soils are more susceptible to erosion, mainly due to their low clay content, which provides limited cohesion. In areas with these soils, 30 degree slopes are generally too steep for harvesting with current technology.

It is now a requirement that all logging coupes, new roads and upgrading of major roads be included in Wood Utilisation Plans. In areas with high erosion hazard, harvesting will only be permitted in accordance with specialist advice. Timber harvesting will be excluded from areas with extreme erosion hazard.

Field officers will be trained to recognise the characteristics of different soil types and their associated erosion hazards.

Harvesting prescriptions place a general limitation on harvesting operations in areas with granite-based soils and slopes steeper than 25 degrees.

IV. Appointment of River Management Authorities

Recently the State Government has encouraged the expansion of river management across whole catchments and, to facilitate this, has appointed whole of catchment River Management Authorities (RMAs). RMAs include River Improvement Trusts and River Management Boards. They are statutory authorities operating under the Water Act 1989 and are managed by boards of volunteer community members. The general objectives of RMAs are:

- to protect and enhance environmental, economic, recreational and aesthetic values of river; and
- to protect public and private assets from damage by rivers and streams.

There are two RMAs in the East Gippsland region: the Snowy River Improvement Trust and the East Gippsland River Management Board. These authorities are primarily concerned with instream or æbed-and-bank' management of streams and watercourses within their area.

V. State Environment Protection Policy

The *Environment Protection Act* 1970 provides for the declaration of environment protection policy for defined areas in order to maintain environmental quality sufficient to protect existing and anticipated uses. One such policy applies to the waters of far East Gippsland and includes the catchments of the Bemm, Cann and Betka Rivers, as well as Mallacoota Inlet and several waters in Croajingolong National Park. With respect to catchments, the main benefits to be protected include domestic, agricultural and industrial water supplies, recreation, and maintenance of aquatic ecosystems and streambank vegetation. The policy specifies the control of waste discharges into surface water and appropriate land uses to maintain the level of water quality required to protect the identified values. It also specifies that forestry operations in the vicinity of surface waters should be controlled to minimise land disturbance and the input of sediment to streams and damage to aquatic habitats.

At a more specific level, the State Environment Protection Policy, the Waters of Far East Gippsland (No. W-21), gazetted in 1985, applies to the region east of and including the Bemm and Cann Rivers. It sets out the beneficial uses to be protected, objectives for various water quality indicators and a program for attaining these objectives. This policy is binding on all government departments. In respect of forestry operations, the policy directs that harvesting and regeneration prescriptions will be adhered to, reviewed where necessary and that action be taken to prevent wildfire.

Considerations under the East Gippsland Forest Management Plan

NRE is committed to ensuring that water quality in Special Water Supply Catchment Areas will continue to be protected by strict adherence to the Code and associated prescriptions.

The catchments of the Rocky and Betka Rivers are included in the Special Management Zone and the following constraints on forest management activities apply:

- No new road crossings will be built on major streams.
- All roads and tracks will be maintained in accordance with the Code and associated prescriptions. Some old roads and tracks may need to be closed and rehabilitated or upgraded to meet these standards.
- The maximum area to be harvested annually and the minimum size of stream buffers will be in accordance with Table 16.

Table 16: Characteristics and management of the Rocky River and Betka River Special Water Supply Catchment Areas

	Betka	Rocky
Total catchment area (ha)		
Area available for timber production (ha, % of catchment area)1	3370 (29%)	1087 (45%)
Maximum area to be harvested annually (ha, % of catchment area)	120(1%)	40 (1.7%)
Buffer strip on main river (metres)2,3	150	100
Minimum buffer strip on major tributaries (metres)2	20	40
Minimum buffer strip on all other permanent streams (metres)2	20	30
Minimum buffer strip on water supply off-take weir	in National Park	100

Notes:
1. The areas estimated to be available for timber production are based on HARIS (1993) and local knowledge about factors such as accessibility and terrain.
2. Buffer strips specify the minimum width of vegetation retained between a logging coupe and an adjacent stream. They apply to both sides of a stream. The 20 m buffers specified here for the Betka are a minimum set down in regional prescriptions. This standard may change as a result of the current review of the Code of Forest Practices for Timber Production (CNR 1995b). The buffers on the main rivers are designated for wildlife conservation (see Section 3.5) and are much wider than strictly necessary for protection of water quality.
3. The Rocky River æSpecial Area Plan' specifies buffers of 100m buffer on the off-take weir, 40 m on the river upstream of the weir, 40m on major tributaries, and 30 m on other water courses.

Development of Consistent Nationwide Baseline Environmental Standards for Native Forests

Under the *National Forest Policy Statement* (1992), a subcommittee known as the JANIS formed to "develop consistent nationwide baseline environmental standards..to put to Governments for endorsement through codes of practice" (JANIS 1995).

A draft report was produced in July 1995, which considered, amongst other things, water values, is relevant to the CRA process. The report found that "... at this stage, identifying scientifically valid 'national standards' is generally not possible". The report restricted itself to the development of goals and guidelines and protocols. The report also recommended the development of a national set of monitoring protocols, directed towards the development of national standards (JANIS 1995).

9. Recreation and Tourism

9.1 Profile of existing opportunities, use and demand

The coast, mountains and extensive forests of East Gippsland, together with its mild climate, provide an important setting with potential for nature-based recreation, education and tourism. Recreation and tourism in the region centre on the coast and the region's national parks. NRE manages State forest to complement national parks within the region, providing a diverse range of recreation and tourism opportunities, including camping, walking, fishing and other forest-related experiences.

The population of East Gippsland is small and the majority of people involved in recreation activities come from population centres outside the region such as Melbourne, Sydney, Canberra and the LaTrobe Valley. These centres are too far away for weekend recreation to be important. The dominant trend, therefore, is for recreation and tourism to involve visitors from outside the region staying for one week or longer during holiday periods (CNR 1993).

The Bureau of Tourism Research (1994) recently surveyed visitors to the East Gippsland region and found that:

- the majority of visitors were Melbourne residents (54 per cent) and residents from country Victoria (34 per cent);
- private vehicles (93 per cent) were the most popular mode of transport used by visitors;
- almost 60 per cent of trips to the region were for pleasure and holidays; and
- 72 per cent of visitors stayed less than 8 days.

Tourism activities are recognised as an important part of the East Gippsland regional economy. It is estimated that expenditure in East Gippsland Statistical Division in 1992-93 by Australian and international tourists was at least $171 million. This figure is based on 2.2 million visitor nights in 1992-93 (Bureau of Tourism Research 1994) and an average expenditure by Australian tourists in Victoria of $79 per day (Bureau of Tourism Research 1993). In 1993-94 total direct employment in the tourism sector was estimated at 279 permanent full time jobs (Australian Bureau of Statistics 1996). At present there are 47 licensed commercial tour operators within the region. This figure includes commercial tour operators in both State forests and National parks.

The network of townships and other areas which cater for tourists can be divided into two main components according to the types of visitor which are serviced - highway townships and holiday destinations. The main types of accommodation used by visitors to the region include caravan parks, holiday flats and houses and licensed motels (table 17).

Table 17: Visitor nights and expenditure on accommodation in East Gippsland Statistical Division, 1993-94

Caravan parks	1993-94
Visitor nights (no.)	747496
Expenditure ($ 000)	6243
Holiday flats and houses	57137
Visitor nights (no.)	3158
Expenditure ($ 000)	
Licensed motels	

Visitor nights (no.)	352686
Expenditure ($ 000)	10197

Source: AustralianBureau of Statistics (1996).

NationalParks

National Parks and other conservation reserves are regarded as significant tourist attractions in the region and include:

- The Alpine National Park (part of Cobberas/Tingaringy Unit)
- Croajingololong National Park
- Snowy River National Park, Errinundra National Park, Coopracambra National Park, Alfred and Lind National Park, Lake Tyers State Park, Cape Conran/Sydenham Inlet Coastal Park, Buchan Caves Reserves

National parks are valued sources of biodiversity and often contain natural or cultural features of significance . In addition, people visit national parks as they view them as a source of wilderness, aesthetic and spiritual values (Streeting and Hamilton 1991). Currently, National parks attract more visitors and support more commercial tours than State forests in East Gippsland.

It is estimated that in 1995/96, approximately 600,000 visitor days were made to East Gippsland Parks and Reserves and other coastal areas. Using a figure of $18 per visitor day, the total value of Park and Reserve visitation in East Gippsland is estimated to be approximately $11 million (Reed and Sturgess 1995 Unpublished).

State forests

Many of the visitors to State forests comprise a particular segment of the market whose needs cannot be met in National parks which complements the recreation opportunities occurring in national parks. Some activities are constrained in National Parks, for example taking domestic pets or hunting.

Recreational Opportunities in State Forests include:

- forest tracks for four-wheel driving, motor-cycling and horse riding;
- rivers and streams which are accessible for picnics, camping and fishing;
- hunting introduced animals such as fox, rabbits, deer and goats;
- cliffs for rock climbing and hang gliding;
- aboriginal sites with cultural and historical significance;
- historical timber mill and gold mine sites; and
- current forest activities for example timber extraction,

There are a number of different groups who use State forests for recreation. These groups include:

- day visitors using picnic spots within State forests;
- visitors interested in sites within the forests which are unique due to their natural, cultural or historical significance;
- tourists passing through the forests on their way to another destination who stop and use the facilities provided;
- visitors who are interested in specific facilities within the forests such as four wheel driving tracks and streams for trout fishing;

- tourists who want a forest setting for their activities but cannot or do not want to carry them out in National parks due to certain restrictions (eg restrictions on taking domestic animals).

Read Sturgess and Associates (1995) found that recreation in Victorian State forests tended to be of a more dispersed nature such as four wheel driving, hunting, trail bike riding and horse riding. However, within East Gippsland, visitors to State forests tended to be more site specific compared to other State forests within Victoria.

For the State forests situated in East Gippsland estimated recreational usage for 1994-1995 is summarised in Table 18.

Table 18: Estimated State forest recreational usage for East Gippsland in 1994/95

Day visitors	84 000
Campers	15 000
Disperse usage	41 000
Total	**140 000**
Major activities:	
Picnics	
Nature observation	
Forest Drives	
Walks	
Fishing	

- In a ranking of total visitors to State forests, East Gippsland is 11th out of the 15 Forest Management Areas with approximately 4% of the State's estimated total visits.
- *Source: Read Sturgess, 1995 (Unpublished)*
- This represents around four per cent of total recreation visitor days to Victorian State forests in 1994-95. Due to the remoteness of the region and distance from major population centres such as Melbourne, high usage of the forests for recreation generally only occurs during periods of peak seasonal demand, such as on long weekends, Easter and the summer holiday period (Read Sturgess and Associates 1995).

The Resource Assessment Commission (1992) estimated the community's willingness to pay for recreational use values in National Estate forests using contingent valuation techniques and the travel cost method. A number of other studies using these techniques have also been completed in natural forest settings (see for example, Sinden 1990).

Drawing on such studies, Read Sturgess and Associates (1995) suggest that the net economic value of recreation in Victorian state forests may be of the order of between $6 and $18 per visitor day. As East Gippsland receives approximately 140 000 visitor days per year, this equates to a total net economic value of between $840 000 and $2.52 million per annum. This suggests that recreation activities may be a significant component of the direct economic values derived from the State forests of the East Gippsland region.

9.2 Outlook and development opportunities for recreation and tourism

The growth in visitor numbers to National parks in Victoria averaged 3.4 percent per annum in the 5 years to 1993-94 and growth is expected to continue (Read Sturgesss and Associates 1995). It has been estimated that growth in visitor numbers to State forests has been similar and that a 3 percent to 5 percent annual growth rate can be expected to the end of the decade (Read Sturgess and Associates 1995).

Tourism has been widely advocated as a potential area for economic growth due to the diversity of natural resources in the East Gippsland region. It is important to note that both National parks and State forests contribute to the overall attractiveness of the area as a potential tourist destination.

Ecotourism is nature-based tourism that involves education and interpretation of the natural environment. It is a form of tourism which has a capability to create a positive impact on all facets of the tourism industry in an area as richly endowed with natural assets as East Gippsland. With the improvement of transport, accommodation, infrastructure and other tourist services, the diversity of the area should attract higher visitor numbers from Melbourne and Canberra. If the area becomes better recognised for it's tourism products the international market could also be expected to increase over time.

Vehicle-based touring is considered to be an activity with a great deal of potential in East Gippsland. When well managed, these provide good interpretive opportunities, giving people a greater understanding of the region, its industries and the environment. Tours can range from the short, well signposted tourist drive, through the use of longer map designated touring routes, to the more arduous multi-day 4WD trek.

Management of State forest for recreation complements National park management by catering for activities such as deer-hunting, four-wheel-drive touring and horse-riding that either are not permitted or where opportunities are limited in national parks. Dispersed camping opportunities, not available for vehicle-based camping in National parks, provide people with an alternative choice, particularly in peak use times when formal camp grounds are full.

The extensive track network in East Gippsland offers the potential for considerable increases in activities for example mountain bike recreation. Provision of information to riders on the remote riding experiences available within region may increase demand for these activities.

9.3 Future recreation and tourism opportunities

As tourism in East Gippsland is strongly focused on natural attributes, there are potential opportunities for further ecotourism in State forests, and an ecotourism strategy for far East Gippsland is currently being prepared (CNR 1995).

In managing public land, NRE aims to provide a wide range of recreational opportunities while conserving and protecting the resources and assets of the land. At present, recreation sites are distributed unevenly throughout the region, with the majority of vehicle based facilities being located on the coast. This means that access to inland areas are more limited - especially during winter, due to weather conditions (CNR 1993). The management of State forests has the potential to provide complementary infrastructure (such as roads and bridges) for both timber production and some types of recreation activities.

It has been suggested that the management of tourism and recreation in State forests in Victoria should be improved to realise the has further potential value of State forests for these activities (Read Sturgess and Associates 1995).

Any management strategies for tourism and recreation in multiple-use State forests state forests within East Gippsland should be considered as part of total recreation opportunities within the broader East Gippsland region.

10. Minerals

10.1 Introduction

Known mineral resources and potential (undiscovered) mineral resources have been assessed as part of the Comprehensive Regional Assessment (CRA) of the forest areas in the East Gippsland region. This region is referred to in this report as 'East Gippsland', 'East Gippsland region', or 'the region'.

This assessment of the mineral resources was conducted on a regional scale for the whole of East Gippsland and is based on data and recent geological reports provided by the Geological Survey of Victoria (GSV). Professional staff of the Bureau of Resource Sciences (BRS), Australian Bureau of Agriculture and Resource Economics (ABARE) and GSV collaborated in the preparation of this assessment.

GSV reports were the prime source of information on identified mineral resources in East Gippsland, and material from these reports is included in this assessment. These reports describe the geology, mineralisation and exploration of East Gippsland. The principal reports used for this assessment, cover the 1:250 000 map sheet for Mallacoota (VandenBerg et al. 1995), in the eastern part of the Bairnsdale map sheet (VandenBerg and O'Shea 1981), a small portion of the southeast corner of the Tallangatta sheet (Oppy et al. 1995), and in a special report for the 1994 Orbost Airborne Survey area (Buckley et al. 1994; Sands 1980). More detailed summaries are presented in reports for the 1:100 000 map sheets for Bendoc (VandenBerg et al. 1992), Murrindal (Orth et al. 1995) and the Nowa Nowa-Tyers and Orbost-Hartland 1:50 000 map sheet area (Vandenberg et al. 1996). Industrial minerals in East Gippsland are included in a report by McHaffie and Buckley (1995). The reports also contain summaries of past mineral exploration in the region. Conclusions published on the Lachlan Fold Belt in a recent issue of the journal *Economic Geology* were also considered in this assessment.

Appendix F contains data documentation information for mineral occurrence locations, geological and airborne geophysical data, and for mining tenements.

This report covers mineral exploration in East Gippsland; data aquisition initiatives by the Victorian Government; exploration and mining rules and regulation; geological setting of the region; known mineral resources; potential (undiscovered) mineral resources; and the economic aspects, including economic potential, of mineral exploration and mining.

10.2 Recent Victorian mineral exploration initiatives

East Gippsland has been subjected to successive cycles of mineral exploration, mainly for various types of base metal deposits, particularly after the discovery of the Wilga and Currawong deposits near Benambra, just outside the north western corner of East Gippsland (Map 6).

However, due to difficult access and lack of detailed modern geological maps and data, East Gippsland is relatively underexplored in terms of modern exploration technology. It is also underexplored in terms of exploration expenditure at $736†per†km2, as compared with Victoria as a whole at $1298 per km2 (1996†dollars). Exploration expenditure from 1970 to the present has totalled $8.9†million and minimum expenditure requirements for existing exploration licences for 1996-7 is a further $1.3 million.

In order to redress the deficiencies in the geological database for East Gippsland, the Victorian Government has mounted a series of intensive data gathering initiatives by conducting airborne magnetic and radiometric surveys. There have been temporary freezes on new exploration tenements while surveys were being†completed.

Detailed geological mapping in East Gippsland (1:50 000 and 1:100 000 scale) has also commenced in recent years to replace the dated 1:250 000 scale reconnaissance maps. However, geological mapping in East Gippsland east of 149ºE longitude is still restricted to a reconnaissance scale of 1:250 000. Total Victorian Government spending on improving the geological database for East Gippsland is $2 million. The GSV is in the process of releasing data and reports from these initiatives which is being assessed and used by the minerals industry to target exploration programs in East Gippsland.

The recent airborne geophysical surveys over the region show that the large granitic batholiths in the eastern part of the area are much more fractured and faulted than previously realised. Such deformation could create open spaces within these rocks favourable for deposition of mineral deposits. It is clear that with ongoing evaluation of the airborne geophysical results by exploration and detailed geological mapping, the current understanding of the structure, geological setting, and the mineral potential of East Gippsland, will need to be continually updated. This applies particularly to the areas of reconnaissance mapping in the eastern part of the region, but also to areas of detailed geology where mapping was carried out before the benefits of data from the airborne surveys were available.

This desk top broadscale assessment of potential mineral resources is based on the currently available data.

10.3 Legislation and regulations relevant to mineral exploration and mining

In Australia (regardless of who owns surface rights) and extending 3 nautical miles out to sea, ownership of mineral resources and control of mineral exploration and development lies in the hands of the State and Territory governments (although a small amount of privately exercised mineral rights remain from British common law carried through from the late 1800s). The Commonwealth Government has control over mining and exploration activities outside three nautical miles offshore and uranium and other radioactive substances in the Northern Territory under the *Atomic Energy Act 1953*. It also exercises its international trade, taxation, defence, and external affairs powers to exert control over the way States and territories access and use their mineral resources (Industry Commission 1991).

The legislation covering mining and exploration licences in Victoria includes the *Mineral Resources Development Act* 1990 (MRDA) which came into effect in 1991 and the *Mineral Resources Development (Amendment) Act* 1993 (Department of Energy and Minerals 1994a, 1994b and 1994c). In addition, amendments were made to the principal act in 1994. The Act is administered by the Victorian Department of Natural Resources and Environment and seout the rules for the granting of licences and gaining approval to commence operations. Other relevant legislation includes the Mineral Resources (Titles) Regulations 1991.

Currently, under the MRDA there are four main land types: private land and three categories of Crown land - exempt land, restricted Crown land, and unrestricted Crown land. No exploration or mining activities can be carried out on exempt Crown land and the approval of the Minister is required before exploration or mining can be carried out on restricted Crown land. On unrestricted Crown land, the Ministerís consent is not required, however, the Minister must be consulted. Work can commence on private land provided that the consent of the owner and occupier is obtained or compensation arrangements in place.

As shown in Table 19 mining and exploration is currently excluded from approximately oneñthird of the land in the East Gippsland region. The consent of the Minister is required for exploration and mining to be carried out on a further 3 per cent of the region. Over half of the region is classified as unrestricted.

Table 19.0: Land use categories as a percentage of total land area,

East Gippsland

Land Use Category	Area (ha)	percentage of East
Gippsland		
Private Land	158 925	13
Exempt Crown land	377 415	31
Restricted Crown Land	35 685	3
Unrestricted Crown Land	643 040	53
Total	1 215 065	

10.4 Geological setting

East Gippsland forms the Eastern Belt of the Lachlan Fold Belt in the south eastern Australia. The regional geological setting is shown on Map 6 and Figure†13, and the main geological and mineralising events are summarised in Figure†11. The main geological events, rock suites and mineralising events known to accompany them in East Gippsland, are outlined as follows:Ordovician to Early Silurian (490-430 million years ago (Ma)).

Widespread deposition of marine sediments, mainly sandstones, siltstones, black shales and mudstones.

Early to Middle Silurian (434-425Ma).

Compression of the marine sediments into a thick sequence during the Benambran/Quidongan orogeny; intensifying deformation led to faulting and thrusting in the Yalmy fold and thrust belt in the west; elsewhere the sediments were altered (metamorphosed) under increasing temperatures and pressures; widespread intrusion of granitic rocks, particularly in the eastern part of East Gippsland, commenced in the later part of this period; the intrusion of granites continued well beyond the end of this period into Devonian; a large proportion of East Gippsland is now occupied by the Ordovician-Silurian metasediments and granitic intrusives.

The styles of mineralisation accompanying these geological events, as indicated by known mineral deposits were:

gold bearing quartz veins which were emplaced after the peak phase of metamorphism of the sediments, and their emplacement is believed to have continued into the Devonian, porphyry copper-gold (± molybdenum) and related styles of mineralisation generated in association with granitoid intrusions,

tungsten, molybdenum and bismuth mineralisation, associated with granitic rocks, and

massive pyrite mineralisation in the rocks of the Yalmy Group may have taken place during this time.

The granitic rocks also provide a source for construction materials and are a possible source for dimension stone.

Middle to Late Silurian (425-410 Ma).

- The far north western part of East Gippsland was subjected to faulting and rifting with parts of the area subsiding to be filled with volcanic rocks, shallow water limestones and deeper water marine siltstones in the Limestone Creek Graben which is one of the two remnants of the†Cowombat Rift; the area was then uplifted by folding and faulting during the Bindian Deformation; only a small part of this graben is in East Gippsland.

- Volcanic hosted massive sulphide deposits (copper-zinc-lead-silver-gold) were formed during part of the volcanic activity of this period near Benambra.

Figure 11. Summary of main geological and mineralising events Early to Middle Devonian (410-385Ma).

- Renewed rifting led to the formation of a north-south trending rift basin called the Buchan Rift in the western part of East Gippsland; recurring subaerial volcanism filled this basin with a thick pile of volcanic rocks (Snowy River Volcanics) with interbedded lake and river sediments and marine sediments in the south; towards the end of this period, dolomitic carbonates, limestones and calcareous muds were deposited in deepening marine conditions; similar conditions of volcanic activity and limestone deposition occurred in a much smaller Boulder Flat Graben near Errinundra where volcanic activity accompanied limestone deposition.
- Styles of mineralisation associated with the Snowy River Volcanics and their associated igneous rocks of this period include:
- epithermal gold, silver, base metal and barite mineralisation,
- copper, gold, mineralisation generated by hydrothermal activity associated with igneous rocks of the Snowy River Volcanics,
- volcanic hosted massive sulphide mineralisation.
- Irish-style stratabound base metal mineralisation was emplaced in the carbonate rocks of the Buchan Group.

The carbonate rocks are a source for limestone and dolomite for industrial use and construction materials and are a possible source for dimension stone.

Middle to Late Devonian (385-360Ma).

- This period commenced with the whole of southeastern Australia subjected to the Tabberrabberan Deformation; in East Gippsland there was large scale northeast and northwest trending faulting; limestones deposited earlier were folded; towards the end of this period, erosion of mountains formed during the deformation resulted in widespread deposition of terrestrial 'red bed' sediments (outcropping in the Combienbar area) which may be favourable host for sediment hosted copper and sandstone type uranium mineralisation.
- Carbonate hosted base metals in limestones may have been remobilised into fractures formed during the deformation.

Early Carboniferous to Middle Cretaceous (354-100Ma).

- At the start of this period East Gippsland was subjected to the Kanimblan Deformation causing block faulting and formation of small grabens; the deformation was followed by a long period of tectonic quiescence and erosion over most of southeastern Australia.

Mid-Cretaceous to Recent (95Ma to present).

- Separation of Australia from Antarctica at about 95Ma with the subsidence of the Gippsland Basin south of East Gippsland and the uplift of the region in the north including most of East Gippsland; these events were followed with the erosion of the uplands and later, at about 35Ma, by eruption of basalts (outcropping in the Gelantipy area); the youngest deposits in East Gippsland formed during the last few million years comprise limestone deposits on the coastal plain, gravel and sands deposited by streams and widespread coastal dune and swamp deposits.
- Mineral deposits formed during this period include alluvial gold and heavy mineral sand deposits.

- The coastal limestone, sand and gravel deposits provide an important source for construction materials.

10.5 History of mining and known mineral resources

In East Gippsland there are no active mines, apart from quarrying for limestone and construction materials. The region, however, has a history of over a hundred years of mining for gold and base metals. About 200 mineral occurrences, deposits, and old mines have been recorded in East Gippsland (Map 7, Figures 14 to 16, and Table 2 in Appendix D). The known mineral resources are described in more detail in Appendix D. Gold was first discovered in East Gippsland at Bendoc in 1851 but serious alluvial mining did not start until 1856-7. More discoveries followed with rushes to Bonang in 1876 and other areas such as Blackwater Creek, Boulder Creek, Brodribb River, BA Creek, Cabbage Tree Creek, Combienbar and McKenzie River.

Reef mining occurred at Mt Tara, Kanni Creek, Bonang, Clarkeville, Boulder Creek, Club Terrace and at Holly Reef on the eastern shoreline of Mallacoota inlet. The last of the significant gold mines, the Victoria Star Reef at Bendoc, was worked from 1911-1938 to produce 141 kg of gold. This area is currently being extensively explored by Zephyr Minerals N.L. In April 1996, the company reported a small inferred gold resource of 250 000 t of ore with a grade of 2 g/t of gold. Additional drilling results were still being assessed (Zephyr Minerals N.L. 1996). Anomalous values of zinc were also reported by the company (Zephyr Minerals N.L. 1995).

Estimated total reef production of gold from East Gippsland is in the order of 1000†kg. Alluvial gold was extensively worked but there is no record of production. If a ratio of alluvial/reef gold production, similar to that in other areas of the State, is used for the East Gippsland region, then alluvial production of at least 2000 kg is†likely.

Small scale mining of base metals has also been active in East Gippsland at various times in the past after the initial discoveries in 1869. Mining continued intermittently until 1928 and a total of about 800 t of lead ore was produced from the Hume Park, the Pyramids and Back Creek mines. Silver was also recovered as a by-product from the smelting of lead concentrates at a small smelter at Hume Park but production has not been recorded. In 1883 about 100 t of copper was produced from the Spring Creek mine. During 1959 to 1970, 3 666 t of copper ore with a grade of 2-5% Cu was also produced from the Accommodation Creek copper deposit south of Deddick River. Mine workings in the Deddick silver-lead field to the west suggest that many hundreds of tonnes of ore must have been produced before the turn of the century, but only 20 t of production has been†recorded.

Orth et al. (1995) noted that in the Buchan area there are large resources of high grade limestone and lesser quantities of dolomite in the carbonate sediments of the Buchan Group.

Teichert and Talent (1958) documented about fifteen outcrop areas of massive, high grade limestone that may be suitable for quarrying. Such deposits have not been tested in detail, and the siting of new quarries would have to take into account environmental considerations and the possible presence of caves.

The limestone near the base of the Buchan Group is of considerable economic importance because of the relatively high purity and extent of outcrop. It has the greatest potential for industrial use, as it is relatively free of insolubles, muddy intercalations, quartz sand and carbonaceous matter (McHaffie and Buckley, 1995).

Hard crystalline limestone has been quarried in the past from Cameron's and Heath's quarries at Buchan South and at Rocky Camp, 5 km north of Buchan, and used as dimension stone in building, construction and monumental industries.

The Rocky Camp Limestone is currently quarried for production of quicklime, flux, stock feed, paper manufacture and agricultural purposes. Geochemical testing also indicates this unit is suitable for use in polymers, but the high iron content may preclude its use in paper and paint. Parts of the Buchan Caves Limestone may reach sufficiently high grade for use as lower grade general fillers where brightness is not important (Buckley et al. 1994). Buckley et al. (1994) noted that in 1994 the total limestone production in Buchan area was of the order of 30 000 t.

A limestone of Tertiary age occurs on the coastal plain west of Orbost. It forms a continuous subsurface sheet, and to the north, the limestone grades into sand and gravel. These deposits have been mined intermittently for agricultural purposes (VandenBerg et al. 1996).

Small iron ore deposits occur in the Nowa Nowa area. Published resources for the Two Mile deposit, for the Five Mile deposit; and for the Seven Mile deposit total about 6 million tonnes. Iron deposits in this area were reportedly worked briefly in 1900 and small scale intermittent mining, for industrial use, continued at least until 1970 (VandenBerg et al. 1996).

Several hundred tonnes of barite were extracted between 1982-1986 for use in drilling muds in the Bass Strait oil fields. 840 kg of wolframite were mined at Mt Bendoc during 1910 to 1918 and 11 tonnes of molybdenum was mined at Wangarabell between 1910 to 1921.

Construction materials used for road maintenance are quarried near Nowa Nowa and Orbost. Sand and gravel is also extracted locally for construction purposes.

The gross value of mineral production from East Gippsland from 1851 to the present is estimated by the VGS to be about $50 million (1996 dollars). The figure is considered to be conservative and is based on the estimated gold production of 3 000 kg which accounts for $48 million at a nominal gold price of $A500/oz. The remaining $2 million is attributed largely to production of limestone, and to minor production of copper, lead, iron ore, barite, wolframite and molybdenum.

10.6 Assessment of mineral potential and land access

Mineral exploration is a long term and ongoing process. Exploration is extremely costly, it is a commercially high risk activity, and areas often have to be explored many times over before the initial clue that leads to a discovery is found. Only recently, a major new gold find was announced at Rio Narcea in Spain in an area that was mined very extensively by the Romans almost 2000 years ago. For many years people thought that there was no oil in Arabia, that there was no iron ore, nickel, oil, bauxite, or diamonds in Australia. All have been proved wrong. No one believed that one of the world's largest copper-gold-uranium deposits would be discovered below 300 metres of barren cover at Roxby Downs, or that huge heavy mineral deposits would be found under shallow clay overburden at Horsham in Western Victoria. Other examples of new mineral fields being located include gold in Drummond Basin (Queensland in 1980s), base metals in Canning Basin (WA in 1980s), nickel in eastern Yilgarn (WA in 1960s) and Olympic Dam (SA in 1975).

The advent of Carbon-In-Pulp and Carbon-In-Leach gold extraction technologies in the 1970s provide examples of the way in which technological (and economic) change can affect exploration. These technologies dramatically changed the costs of gold recovery and also reduced the risks associated with exploration for gold-oxide ores by allowing gold to be mined profitably at much lower grades. This triggered intensive, Australia-wide exploration for bulk gold oxide deposits at considerably lower cut off grades than were previously considered economic (Blain 1992). CarbonñInñPulp and CarbonñInñLeach processing are also used for treatment of low grade primary gold ores.

New geological models can also affect exploration. The discovery of the world class Olympic Dam copper-uranium-gold deposit is an example. This deposit, which was discovered in 1975, is concealed 300 metres below the surface and was the first of its kind to be identified in Australia. The exploration program was based upon new ore deposit models developed by

Western Mining Corporation geologists that postulated the existence of copper deposits in the region (Reeve†et†al. 1990). Closer to the East Gippsland region, the exploration for the nearby Benambra copper zinc deposit (which is a potential deposit type in the study area) began largely as a result of the discovery of the Woodlawn deposit in New South Wales in 1969 (Allen and Barr 1990). The discovery of this deposit changed geologistsí understanding of the prospectivity of particular sequences of Silurian (438ñ408 Ma) volcanic rocks in the area. Many discoveries occur in this fashion. That is, the discovery of a deposit usually leads to the discovery of deposits nearby or in other areas that share similar geological characteristics.

Land access

No area can ever be classed as unprospective and no assessment of potential (ie., undiscovered) mineral resources can ever be classed as 'final'. New information, new concepts and better understanding of geological processes continually change the perceived prospectivity of areas and regions. New models are continually being developed and refined. Continued access to land is therefore a significant issue for the mining industry and for future mineral development.

In order to examine the implications of alternative land access arrangements for exploration and mining in the region it is important to understand both the nature of exploration and its likely costs and benefits

Generally, exploration can be defined as the process of searching for and assessing mineral deposits. Although discovery and delineation are the primary reasons for exploration, lack of discovery from an exploration program does not imply that the effort yielded no benefit. Information gained from exploration will usually increase the understanding of a regionís geology.

From the perspective of a private firm, the potential benefits from an exploration program derive from the economic returns that will accrue from the discovery of an economic deposit. Because exploration is a high risk activity (that is, there is a small probability of any one venture being successful), companies will approach exploration in a sequential and systematic fashion. This enables the decision to abandon or keep exploring in the area to be made in a efficient manner. The typical sequence of events that underlie a modern exploration program are shown in below in Box 1.

The cost and duration of exploration programs will vary from company to company and across commodities. Clark (1996) suggests that the development of a typical major deposit (worldwide) involves a 5-20 year lead time. This estimate results from a typical 3-10 years exploration program prior to the mine development†phase.

It is important to note that the exploration process starts with assessments of very large regions and is then systematically narrowed down as the exploration target becomes better defined. The direct costs facing explorers increase as the target area becomes smaller and exploration methods more intense. The environmental impact associated with exploration also increases as the area being explored becomes smaller and the exploration methods used become more invasive (for example, drilling).

Box 1: Modern mineral exploration: the typical sequence of events

1. Global considerations

- Assessment of political stability
- Assessment of security of title
- Assessment of access and restrictions
- Assessment of financial climate, restrictions or inducements
- Determination of geoscientific framework and availability of information

2. Preliminary investigations

- Review regional geoscientific data (geology, geophysics, satellite imagery)
- Formulation of geological concepts and selection of prospective areas
- Examination of known mineralisation

3. Reconnaissance exploration

- Acquisition of exploration tenements
- Collection and assessment of geoscientific data over the tenement
- Examination of available regional geoscientific data
- Conducting of geoscientific surveys required to augment available data
- Selection of target areas, for more detailed exploration

4. Detailed exploration

- Detailed geoscientific surveys to detect and delineate anomalies
- Drilling of anomalies in search of significant mineralisation
- Delineation of mineral deposits by further drilling and other methods to determine configuration, approximate tonnage, grade, metallurgical characteristics of the deposits
- Pre-feasibility studies
- Acquisition of mining tenements, if justified, at appropriate stage of program.

Source: ABARE, AGSO and BRS (1993).

Modern exploration, which is increasingly using remote sensing from satellites or aircraft, is able to proceed to surface phases with no disturbance. The early stages of a surface exploration program involve activities such as mapping, geophysical measurements and geochemical sampling of stream sediments which are likely to have little effect upon the environment. Followñup investigations that would require other techniques and that may have some localised and temporary effects may include (see ABARE, AGSO and BRS (1993):

- rock chip sampling;
- collecting soil samples; and
- electrical, gravity, magnetic or seismic ground surveys.

If the results of this work were positive, additional followñup work may include some drilling and use of heavier equipment. Drilling usually involves construction of a drill pad (of variable size), which would need to be cleared. However, it should be noted that not all exploration results in drilling. In a submission to the Industry Commission ëMining and Metals Processingí inquiry, the Australian Minerals Industry Council reported that less than 10 per cent of exploration projects in Australia reach the surface exploration phase, and only around one per cent reach the subsurface exploration phase (Industry Commission. 1991b).

In contrast to exploration, mining itself generally involves greater disturbance to the land surface in the immediate area of the mine, the generation of substantial amounts of waste and leaves potentially significantly changed landforms when mining is finished. Mining is generally therefore seen as posing greater difficulties in terms of compatibility with other uses. Many potential environmental effects of mining activities can be eliminated or mitigated, though at a cost to the mining company. Given the relatively limited areas of land disturbed by the operation of a mine, water pollution probably represents the major potential threat to the environment from mining. However, this can be controlled by using techniques like impoundment and evaporation of tailings, sedimentation, filtration and pH neutralisation. Rehabilitation of minesites at the completion of operations can restore many of the features of the landscape that existed before mining began, substantially assist the reñestablishment of vegetation and reduce the potential for pollution from the abandoned mine site.

10.7 Mineral potential assessment methodology

The potential mineral resources (or 'mineral potential') of East Gippsland have been assessed by determining the types of mineral deposits likely to be found under the geological conditions known or believed to exist in East Gippsland. The method used is a broadscale qualitative assessment of mineral potential. It is essentially the first stage of the three part method for assessment of mineral potential developed by the United States Geological Survey (USGS). The method has been used successfully for mineral resource assessments of forest areas in North America and elsewhere and was thoroughly evaluated, and subsequently supported, by a panel of experts in 1993 (Harris and Rieber, 1993). A summary of the qualitative assessment methodology is described in publications by Marsh, Kropschot and Dickinson (1984), Taylor and Steven (1983), and by Dewitt, Redden, Wilson and Buscher (1986).

An assessment of potential mineral resources of a region combines knowledge of its geology, geophysics, geochemistry, mineral deposits and occurrences with current theories of mineral deposit genesis and results of mineral exploration. The assessment process requires a study of available geoscientific data to determine the history of geologic processes and environments. Geologic environments judged to have characteristics known to be associated with specific types of mineral deposits are then identified. In particular, the assessment draws on regional and local characteristics of mineral deposit models to establish whether or not specific types of mineral deposits are likely to occur.

The mineral potential of an area, that is the likelihood of it having a particular type of mineral deposit, is ranked as high, moderate, low or unknown, based on professional judgments of geoscientists involved in the assessment. If there are insufficient data to classify the areas as having high, moderate or low potential then the mineral resource potential is categorised as unknown. To reflect the differing amounts of information available, the assessments of mineral potential are also categorised according to levels of certainty, denoted by letters A-D in order of increasing certainty (Figure 1, Appendix C). That is, A denotes the lowest level of certainty and D the highest. The method is described in more detail in Appendix C.

Geological areas (or 'tracts') in East Gippsland, judged to contain geological environments permissive of the formation of specific types of mineral deposits are delineated and the mineral potential is ranked (see Figures 17 to 27).

10.8 Potential mineral resources

Appendix C describes the descriptive models for the various styles of mineralisation in East Gippsland. The qualitative broadscale assessment of East Gippsland has identified mineral potential for a number of different types of mineral deposits. The favourable geological tracts for these types of mineralisation are indicated on Figures 17 to 27. The potential mineral resources are summarised in Table 20 and are described below as follows:

Gold

- Tract Au1: Epithermal precious metal (gold, silver) deposits (Figure 17).

This area is occupied by the subaerial Snowy River Volcanics and several prospects with features similar to typical epithermal gold and silver deposits are present (Glen Shiel Silver Mine, W-Tree, Pyramid Mountain and Halls Peninsula prospects). The presence of caldera structures, ring fractures and characteristic alteration (silicification, propylitic, argillic and phyllic alteration) also support the possible presence of epithermal gold and silver deposits. This area is considered to have a high potential for epithermal precious metal (gold, silver) deposits with a certainty level of C.

- Tract Au2: Low-sulphide Au-quartz vein (slate-belt gold) deposits (Figure 18).

This tract extends throughout East Gippsland over areas underlain by Ordovician metasediments. Gold deposits occur at widely scattered locations in these rocks. Although locally the structural control for these deposits is not clear, on a regional scale they appear to be more concentrated near some of the major structures. The potential for slate-belt gold deposits is considered to be moderate to high for the whole of the tract with a certainty level of B.

There may also be large low grade auriferous stockwork vein extensions in some of the old goldfields which may suitable for large tonnage/low grade operations.

Tract Au2 could also have potential for fine grained disseminated gold in Ordovician metasediments, which would not have been detected by early prospectors or by the earlier less sophisticated exploration surveys (VandenBerg et al. 1995). However more detailed information is required on the structure and tectonics of the area, such as the presence of detachment faults in order to assess the potential for this style of mineralisation. The potential for these types of deposits is unknown.

Table 20. Summary of potential mineral resources as assessed by BRS and GSV for the various tracts in May 1996.

Type of mineral deposit assessed in tract	Commodity	Level of potential / level of certainty	Total mineral area of existing National Parks / reserves km2	Proportion of total tract in (%)
Epithermal gold-silver	gold,silver	high/C (Figure 17)	1502	45
Slate belt gold (this tract also has and unknown potential for large tonnage low grade fine grained gold)	gold	moderate to high/C (Figure 18)	4852	22
Gold in massive sulphides in Yalmy Beds	gold	moderate to high/B (Figure 19)	281	86
Volcanic hosted massive sulphides	base metals, gold, silver	moderate to high/B&C (Figure 20)	959	24
Irish-style base metals, (also high potential for limestone)	base metals, limestone	high/C (Figure 21)	105	5
Porphyry copper gold, (also unknown potential for base metal skarn, epithermal veins, polymetallic replacement and volcanic hosted massive replacement deposits)	copper, gold, molybdenum, bismuth	moderate to high/C (Figure 22)	7890	20

Fissure style vein style copper-gold in granites	copper, gold	low to moderate/B (Figure 23)	1341	35
Tungsten-molybdenum veins	tungsten, molybdenum, bismuth	moderate/C (Figure 24)	3101	31
Sediment hosted copper and uranium	copper, uranium	low to moderate/B (Figure 25)	168	46
Heavy mineral sand in Quaternary sediments	ilmenite,rutile, zircon, monazite	low to moderate/B (Figure 26)	557	56
Heavy mineral sand in Tertiary sediments (parts of this tract has also Tertiary limestone used for agricultural purposes)	ilmenite, rutile, zircon, monazite, limestone	unknown (Figure 26)	1596	24
Alluvial Gold in Tertiary and Quaternary sediments, (also moderate potential for primary gold in the underlying basement)	gold	moderate to high/B (Figure 27)	2768	26
Diamonds (in mafic intrusives?)	diamonds	unknown	unknown	

Other deposits/commodities not listed include dimension stone, construction materials such as sand gravel and aggregate derived from sandstone, granite and volcanics.

- <u>Tract Au3 (Figure 19)</u>: The Yalmy Beds are age equivalents to the strongly mineralised rocks in the Limestone Graben. Strong pyritic mineralisation is known in several areas and the potential for gold associated with massive sulphide mineralisation is considered to be moderate to high with a certainty level of B.

Base metals (Copper, lead, zinc)

- <u>Tract BM1a</u>: Volcanic hosted massive sulphide deposits (Figure 20).

This area is underlain by the Snowy River Volcanics where they were deposited in part in shallow marine environment. Volcaniclastic units above and below the Snowy River Volcanics/Buchan Group contact frequently contain occurrences of base metal mineralisation which are characteristic of volcanic hosted massive sulphide deposits. Such mineralisation is present at Blue Bullocks Creek, Shaw's Gully, and the New Guinea prospects. On available information the area is considered to have a moderate to high potential with a certainty level of B for the presence of massive sulphide deposits.

- Tract BM1b: Volcanic hosted massive sulphide deposits (Benambra type) (Figure 20).

This Tract straddles the northwest boundary of East Gippsland and encloses the Limestone Graben. Volcanic hosted massive sulphide deposits (Wilga and Currawong) are present in volcanic and sedimentary rocks deposited in a marine environment along the northwest margin of the graben. It is considered that on the available information, there is a moderate to high potential with a certainty level of C, for additional massive sulphide deposits.

- Tract BM2: Irish style carbonate hosted base metal deposits(Figure 21).

The tract is occupied by the carbonate rocks in the Buchan Rift (Buchan Group limestones) in the western part of East Gippsland, and in the Boulder Flat Graben in the east.

In the Devonian limestones of the Buchan Group there are over 40 base metal occurrences which have features similar to carbonate-hosted base metal deposits. Lead ore was produced from some of the old mines at Back Creek, the Hume Lead Mine and the Pyramid Mines.

In the Boulder Flat Graben, volcanics and carbonate/black shale sediments were deposited in a shallow marine environment. The tract contains the Boulder Flat 1 and 2 lead-zinc, the Zinc Hill lead-silver and the Gibson Creek copper prospects. Five separate barite lenses are also present, some of which have been mined. The base metal prospects display features that are similar to the Irish style carbonate base metal deposits. Recent airborne geophysical data indicate that the Errinundra Group extends in a south westerly direction enhancing the potential of this area for carbonate hosted base metal deposits. On available information there is a high potential for carbonate hosted deposits in both areas with a certainty level of C.

- Tract Cu-Au1: Porphyry copper-gold deposits(Figure 22).

This tract delineates the distribution of mineral prospects reported to have features similar to porphyry copper deposits and includes Silurian to Early Devonian granitoids associated with these prospects. The tract includes aeromagnetic lows which indicate the presence of granitoids concealed at shallow depths near known occurrences of porphyry style mineralisation. Porphyry copper systems identified in the tract include Sunday Creek, Double Bull Creek, Dogwood and Mount Buck prospects. The highest grades of mineralisation are often associated at the base of a partly leached capping at some of these prospects. Recent exploration results indicate that geochemical signatures over mineralising systems can be strongly suppressed by surface leaching and may have been overlooked in previous exploration programs.

The tract also includes mineralisation which is similar to the copper porphyry systems but is related to some of the younger granitoids and dykes associated with the Early Devonian Snowy River Volcanics. Such mineralisation has been identified at the Accommodation Creek copper mine, Deddick silver-lead field, Tiger Creek and Scorpion Creek prospects.

Minor molybdenum and gold mineralisation has been identified in many of the porphyry systems but the gold potential has not always been fully tested.

Based on the above information, the tract is considered to have a moderate to high potential for porphyry copper-gold deposits with a certainty level of C.

- Porphyry systems generate hydrothermal activity which is capable of forming several other styles of mineralisation. Most common of these are base metal skarn, copper skarn, epithermal veins, polymetallic replacement and volcanic hosted massive replacement deposits. On the available information the potential for such deposits in Tract Cu-Au1 is unknown.

- Tract Cu-Au 2 (Figure 23): The recent airborne geophysical surveys over East Gippsland suggest the granites in the eastern part of the areas are complexly faulted and fractured. It is considered that there is a low to moderate potential with a certainty level of B for fissure vein style copper-gold mineralisation in these granites.

Tungsten, molybdenum, bismuth veins

- Tract W1: Tungsten and/or molybdenum veins with minor bismuth (Figure 24).

Granitoids of Silurian to Devonian age define this tract in East Gippsland. The country rocks in the immediate vicinity of these granitoids are also considered to be part of this tract as they may also host tungsten and molybdenum veins. Prospects known to be associated with these granitoids are Mount Bendoc (tungsten-bismuth), Wangarabel (molybdenum); and Genoa Peak and Mangan Creek (both tungsten and molybdenum). Tungsten and molybdenum veins are also associated with similar granitoids across the state border in NSW (Creenah, Hammond, Standens, Whipstick, Blackrange, and Cathcart prospects). There may also be tungsten-molybdenum pipes within these granitoids. On available data, including the lack of evidence for fractionated granites, the potential for tungsten and molybdenum vein deposits in East Gippsland is considered to be only moderate with a certainty level of B.

Apart from tungsten and molybdenum vein deposits, there is also potential in the tract for tungsten-skarn deposits where the granitoids intrude limestone. The eastern part of East Gippsland has not been mapped in detail and the potential for tungsten-skarn deposits in the tract is unknown.

Sediment hosted copper and sandstone-type uranium

- Tract Cu and U (Figure 25): Red-bed sediments of the Combyingbar Formation occur in small grabens in the eastern part of the region. Such sediments are known to contain sediment hosted copper and sandstone type uranium deposits in Australia and elsewhere in the world. Occurrences of copper and anomalous uranium are known to occur in similar rocks in the Mansfield Basin, 150 km west of East Gippsland. One occurrence of copper (Genoa River Beds) is located in one of the red bed tracts in East Gippsland but the host rock for this occurrence is not known. No uranium occurrences are known in these red beds. On the available information there is a low to moderate potential, with a certainty level of B, in red beds of the Combyingbar Formation for deposits of sediment hosted copper and for sandstone type uranium.

Heavy mineral sands in Tertiary and Quaternary sediments

- Tract MS1a: Heavy mineral sands in Quaternary sediments (Figure 26).

This tract includes present day beach sands and ancient dune and swamp sediments of possible early Quaternary age (Quaternary, up to about 1.8 Ma) which may extend up to 7 km inland and form part of the coastal plain. The distribution of these sediments has not been mapped in detail. Small and thin heavy mineral concentrations of ilmenite, with minor amounts of rutile and zircon, are known to occur at Point Pearl, Cape Conran, Betka River and Point Hicks. It is possible that heavy minerals have been also concentrated inland in sediments along the old shorelines. Occurrences of primary gold are also present in the basement under the coastal sediments and north of the coastal plain at Cabbage Tree Creek, McKenzie River, Bemm River, Genoa Creek, and Mallacoota. Primary gold may have been eroded, transported and concentrated in the sediments along old shorelines together with other heavy minerals. On the available information the potential for substantial concentrations of heavy minerals in this tract is low to moderate with a certainty level of B.

- Tract MS1b: Heavy mineral sands in Late Tertiary sediments (Figure 26).

This tract lies over the Late Tertiary (about 5 Ma) sediments on the coastal plain. Image analyses of airborne radiometric surveys show east-west lineaments which may represent monazite in old shore lines developed in the Late Tertiary. Another possibility is that the lineaments represent younger Quaternary sediments which have not been mapped. According to published reports, the dominant lithology in some areas in these sediments appear to be limestones which do not represent a favourable environment for deposition of heavy mineral sands. The distribution of the lithologies in this sequence has not been mapped in detail and the potential for the presence shoreline placers of heavy minerals in this tract, including gold, is unknown.

- Tract Au3: Alluvial gold in Tertiary and Quaternary sediments (Figure 27).

Alluvial gold has been recovered from the Tertiary and Quaternary sediments in some parts of East Gippsland, and more deposits of alluvial gold are probably present in such sediments. Primary gold occurs in the basement under these sediments at Cabbage Tree Creek, McKenzie River, Bemm River, Genoa Creek and Mallacoota and other occurrences of primary gold could well be concealed below the sediments. Past alluvial gold workings are reported to have been widely distributed over the floodplain areas and rarely concentrated in drainage channels. These sediments however have not been mapped in detail and the assessment of the potential for deeply buried alluvial deposits would require detailed information for areas where Tertiary and Quaternary sediments have only been mapped at 1:250 000 scale. On the available information, the potential for alluvial gold deposits is moderate to high with a certainty level of B. This tract also has a moderate potential, with a certainty level of B, for primary gold deposits (eg. slate-belt gold) in the basement rocks underlying the Tertiary and Quaternary sediments.

Another type of alluvial/placer deposit occurs at Pinch Swamp Creek in the northern part of East Gippsland. Here a thin layer of monazite sand is believed to have been derived from a nearby granitic source. On the available information the potential for such heavy mineral alluvial deposits is unknown.

As mentioned previously, parts of the coastal plain in East Gippsland are extensively overlain by a sequence of Tertiary sediments containing limestones. These limestones have been worked locally on a small scale for agricultural purposes and constitute a resource for future use. Tracts to show the distribution of these limestones have not been delineated because the Tertiary sediments have not been mapped in detail.

Diamonds

The total magnetic intensity images from the airborne geophysical surveys over East Gippsland show numerous small pin point anomalies, particularly west of the Berridale Batholith (located near Cann River). It is possible that some of these anomalies represent small concealed mafic intrusives, like those which are known to host diamonds in other parts of the world, and GSV have advised that some of the exploration companies in East Gippsland are searching for diamonds. These magnetic intensity images require comprehensive assessment together with exploratory drilling, if warranted, to determine the geological source for these anomalies. On the available information the potential for diamonds in East Gippsland is unknown.

Other commodities

Large resources of limestone and smaller quantities of dolomite are known to occur in the limestones of the Buchan Group in the western Tract BM2 on Figure 21 where marble is also known to occur. This part of Tract BM2 has a high potential for more limestone, dolomite and moderate to high potential for marble with a certainty level of B. The eastern part of Tract BM2 in Boulder Flat Graben has a high potential for limestone with a certainty level of C. Marble is reported to occur at Martin Creek but its potential for commercial use is not known.

Possible sources for dimension stone from igneous rocks has been reported at Colquhoun, Orbost, Cann River, Genoa, Maramingo, and Betka. The possible use of these rocks for dimension stone depend upon a wide range of characteristics and hence their potential for dimension stone is unknown.

Summary of mineral potential in East Gippsland

Table 20 summarises mineral potential by type of deposit, commodity, level of mineral potential/certainty, area of permissive tracts, and proportion of existing tracts in national parks/reserves.

There is no standard method for summarising the mineral potential for various types of mineral deposits in a single map. Maps 8 and 9 show two different approaches for bringing together information from the primary mineral potential maps (Figures 17 to 27).

Map 8 is a composite of the highest mineral potential tracts across East Gippsland. It shows the highest level of mineral potential assessed (in May 1996) for any particular area in the region (see Figures 17 to 27). The map shows that the highest levels of mineral potential (epithermal gold, carbonate hosted (Irish style) base metal deposits and limestone) are in the western half of East Gippsland and a small tract of high potential for base metals is in the central part of the region. Areas of moderate to high potential cover most of the remaining part of the region and depict potential for slate belt gold, alluvial gold, porphyry style copper-gold, gold in massive sulphides, base metals in volcanic hosted massive sulphide deposits. Areas of moderate potential in east and west of the region are for tungsten-molybdenum vein style deposits and a small area of low to moderate potential for sediment hosted uranium and copper deposits is situated in the eastern part of the region. Other tracts of low to moderate potential for other types of mineral deposits are obscured by overlapping tracts of higher potential.

It should be noted that Map 8 is a composite of mineral potential tracts for different types of deposits that do not have equal economic values. For example, a tract with moderate to high potential for slate belt gold deposits may be considered to have a higher economic value than a tract with high potential for limestone

On Map 9, all of the mineral potential tracts (Figures 17-27) are superimposed to highlight areas of overlapping tracts of greater than moderate potential. This was done by allocating scores according to a subjective ranking of levels of mineral potential as follows - high potential (9), moderate/high (6), moderate (3), low/moderate (1), unknown potential (no score). Scores of overlapping tracts were then added to derive 'cumulative mineral potential'. Areas with high cumulative scores indicate potential for more than one type of deposit eg. moderate/high for alluvial gold (6) + moderate/high for copper-gold porphyry (6) + moderate for primary gold (3) = 15.

Map 9 takes account of the fact that many geological units have potential for more than one style of mineralisation. Areas with overlapping tracts emphasise diversity of mineral potential but are not necessarily more prospective than a single tract of high potential, for example for epithermal gold. The relative economic significance of the tracts for different types of mineral deposits, as perceived by mining companies, would be dictated by their perceptions of prospectivity, future market conditions, land access and other factors. Maps 8 and 9 can't be used on their own as an indication of the relative economic potential of minerals in East Gippsland.

Areas with the highest cumulative scores are those where high potential for epithermal gold and carbonate hosted base metals overlap in the west and a much smaller area in the east where an area of high potential for carbonate hosted base metals overlap with areas of high to moderate potential for porphyry copper-gold and slate belt gold deposits. The central southern part of the area is dominated by moderate to high potential for porphyry style copper-gold deposits and alluvial gold deposits, moderate potential for primary gold and low to moderate potential for heavy mineral sand deposits. This area extends to northeast across East Gippsland as a lower cumulative score made up of overlapping tracts of moderate to high potential for porphyry style copper-gold and slate belt gold. The areas with lower scores of cumulative potential are in the far east of the region.

10.9 Economic potential

As discussed above, East Gippsland contains a number of known mineral deposits and may contain a number of undiscovered deposits but there is currently limited mineral production in the region. At some time in the future these deposits may be mined and yield economic benefits. This potential economic value is affected by a number of factors, including: the mineral prospectivity of the region; future metal prices and mining costs; and the rules and regulations which govern exploration and mining. Ideally, an economic assessment of a regionís known and potential mineral resources would involve an estimation of the value of the right to explore and mine in that region. Unfortunately, due to data limitations, this has not been possible. However, the major factors affecting potential economic value are outlined below and some indicators of that value are examined.

It is important to note that while the mineral resource assessment provides an indication of which land is likely to be prospective for minerals, no assessment of the potential value of mineral resources is possible without an estimate of the probability distribution for the number of deposits occurring in a particular region. As such, it is not possible to directly compare the value of land that has been assessed as prospective for minerals with other land (whether prospective or not).

Although various minerals have been mined in the region for over a hundred years, the region has remained relatively underñexplored, due in part to the ruggedness of the area but also because of the sparse geoscientific information available for the region. The recent geophysical and geological surveys undertaken by the Geological Survey of Victoria, and subsequent increased exploration, is likely to lead to a better understanding of the regionís geology and mineral potential.

The value of East Gippslandís mineral potential derives from the possibility that, economic mineral deposits may be discovered and subsequently produce economic benefits. The qualitative assessment of the regionís mineral potential described earlier, does not provide estimates of the number of potential deposits (by deposit type). Current exploration expenditures and a hypothetical base metal deposit discovery are examined below to provide an insight into the economic potential of utilising a mineral deposit in the region.

Exploration expenditures in the region

Current and historical exploration expenditures provide some indication of the potential value of East Gippslandís undiscovered mineral resources. This is because a decision to invest in exploration is based partly on a companyís perception of the mineral potential of an area. That is, exploration expenditure will tend to be higher in areas of higher perceived mineral potential. However, because of the uncertainty and dynamics of exploration, expenditures will not always indicate true prospectivity. Sometimes deposits are found in previously unprospective areas through the application of new ideas or technology where little previous exploration has occurred. On average, however, historical data show that there is a positive correlation between the level of exploration expenditure and the number of discoveries within an area (Williams and Huleatt 1996).

Exploration expenditures in East Gippsland for the period 1990-91 to 1994-95 are shown in Table 21. Although exploration expenditure in the region has increased by over 20 per cent since 1990-91, the regionís share of base metals (nonñproduction lease) exploration in Victoria has declined from 8 to 4 per cent. This is largely due to the fact that in 1994 all of East Gippsland was temporarily exempted from new exploration licenses while the Geological Survey of Victoria undertook regional mapping of the area. However, as can be seen from Table 21, the level of exploration in East Gippsland has increased in 1994-95 as the survey results have been made available and exemptions in the area were progressively lifted.

Table 21: Exploration expenditures, 1990-91 to 1994-95

Year	East Gippsland exploration expenditurea **percentage of**	**Victorian base metals and gold non-production**	**Exploration expenditure in East Gippsland**
lease explorationb Victorian non-production lease Base metal and gold exploration			
1990-91	805 839	8 774 519	9
1991-92	796 994	6 789 417	12
1992-93	408 481	7 704 011	5
1993-94	297 340	15 450 783	2
1994-95	904 818	19 110 000	5
Total (average)	3 077 583	55 926 000	(6)

Notes

a *Includes some exploration other than base metals and gold exploration, however, in 1994-95 base metals and gold were the principal exploration targets on 18 of the 21 active exploration leases.*

b *Non-production lease exploration was estimated on the basis that, over the period exploration on non-production leases averaged 78% per cent of total exploration expenditures (this was the Australian average over the same period). Sources: Australian Bureau of Statistics (1995); Minerals and Petroleum Victoria (1996).*

East Gippsland has areas currently under exploration licence or temporary moratorium. As part of the area is still under moratorium exemption, it is likely that 1995-96 and 1996-97 will see increased expenditures in the region as survey data become available for these areas and exemptions are lifted. In the longer term, it is likely that exploration in the region will, like exploration throughout Australia, be affected by larger macroeconomic factors, such as prevailing and expected commodity prices. As pointed out by the Industry Commission, historically, mineral exploration expenditures have tended to fluctuate with changes in mineral prices, with a one to three year lag between changes in market prices and changes in exploration expenditure (Industry Commission 1991a).

It is worthwhile noting that 93 per cent of the $3.1 million dollars spent in the region between 1991ñ1995 was on exploration in the western half of East Gippsland (Minerals and Petroleum Victoria 1996).

An examination of historical exploration expenditures and discoveries in Australia provides a useful perspective on the current exploration activities in East Gippsland. Mackenzie and Dogget (1992) found that between 1955 and 1986, it required, on average, $51 million (real 1990 dollars) to find an ëeconomicí deposit in Australia.

Mackenzie and Dogget also estimated that, on average it takes 9 years to find an economic deposit in Australia. However, examination of major base metal deposit discoveries in Australia show that exploration time is rather variable. For example, using information from Hughes (1990), it can be ascertained that the Warrego base metal deposit in the Northern Territory took 4 years to discover while the Hilton North base metals deposit in Queensland took 30 years. The length of time taken for gold deposits to be discovered ranged from less than one year in the case of the Coronation Hill deposit in the Northern Territory to 18 years for the Big Hill deposit in Western Australia.

In summary, exploration expenditures in East Gippsland show that the region is prospective for a number of deposit types, although it is difficult to quantitatively link these expenditures to the potential value of exploration in the region. Region specific events, such as the recent withdrawal of East Gippsland from exploration whilst aerial surveys were undertaken will tend to cloud any comparison of the areaís exploration expenditure with national or State-wide trends. However, given that private expenditures of over $3 million dollars have been made over the last five years in the region, it appears that the value of the option to continue exploring is likely to be considerable.

Case Study: Economics of a hypothetical base metals deposit

It must be noted that the information provided by this exercise is limited in that it is purely hypothetical, and is provided only to give an indication of what a copperñzinc mine in the region could be worth if a deposit similar to that at Benambra were discovered. This information cannot be used to infer anything about the expected value of undiscovered resources in the region.

Although it is has not been possible to assess the expected value of undiscovered mineral resources in the region, an indication of the order of magnitude of potential benefits from an economic deposit being discovered can be provided. The Benambra copperñzinc mine, located just outside the study area provides a basis for examining the potential benefits, as parts of the region are considered prospective for the same type of deposit, that is, volcanic associated massive sulphide (VMS) deposits.

The Benambra deposits were discovered in 1978 by a Western Mining CorporationñBP Joint Venture (Allen and Barr 1990). Production from the mine commenced in September 1992, and finished in July of this year, due to declining copper grades, lower prices and poor concentrate.

The value of a deposit similar to the Benambra deposits occurring in East Gippsland area has been estimated. The most appropriate measure of the value of a resource is the economic rent accruing to that resource. Economic rent is defined as the difference between the international price for the mineral and all the costs of extraction and exploration, including a normal return on capital but excluding taxes, royalties and other costs that are not part of the process of physical extraction (Born 1992). The resource valuation approach used here is based explicitly on the net revenue stream from utilising a resource. Using this approach the estimated flow of future revenues, less all payments for inputs, are discounted to current dollar values. Revenues have been calculated using ABARE copper and zinc concentrate price forecasts and operating and setñup costs have been estimated from commercialñinñconfidence data. Exploration costs have not been deducted so the values shown here represent the value of the deposit when found, rather than the value of the option to explore or the true economic rent associated with the deposit. Some of the assumptions underlying the financial analysis are shown in Table 22.

Table 22: Assumptions for financial analysis of a Benambra type deposit

		1996	1997	1998
Ore mined	kilotonnes	135	285	255

Ore grade				
Copper	%	10	8	6
Zinc	%	ñ	6	5
Zinc concentrate price	($US/t)	ñ	283	271
Copper concentrate price	($US/t)	401	372	341

On the basis of these assumptions, a Benambra type deposit, if developed in the study area today would employ around 70 people and have a net present value (before tax profits) of approximately $10 million, assuming a real risk free interest rate of 6% per annum. It was assumed that the mining infrastructure fully depreciates over the life of the project, and thus realises a zero scrap value. In practice, it is likely that for such a short lived project that mining infrastructure would be sold or used elsewhere at the end of the project.

In order to test the sensitivity of this project to different deposit types, a scenario was modelled in which production at 1998 levels continue for another three years. In this case, the net present value of the project is over $30 million dollars.

Both scenarios modelled here involve relatively small deposits (due to the availablility of relevant cost data). If a larger deposit were to be found, its net present value could be expected to be higher. An examination of worldwide data (Table 23) suggests that VMS deposits range in size from 15 thousand tonnes to 242 million tonnes, with an average size of 10 million tonnes. There are currently eight VMS deposits producing minerals in Australia and 27 known deposits in total ranging in size from 48 thousand tonnes to 80 million tonnes. The known deposits have an average size of 9 million tonnes.

Table 23: Descriptive statistics for worldwide VMS deposits

		Minimum	Maximum	Mean	Median
Size (Mt)		0.015	242	9.52	1.75
Grade (%)	Copper	0.1	9.01	1.68	1.38
	Zinc	0	25.1	3.37	2.0
	Lead	0	9.3	0.59	0

Source: Cox and Singer (1986).

The annual gross revenues shown in Table 24 provide some indication of the likely range of annual revenues that could be derived from a discovery of a VMS deposit in the region. The average gross annual revenue of existing VMS deposits for 1993-94 is estimated at $56 million.

Table 24: Australian VMS deposit characteristics 1993-94

Deposit	Size (Mt) **a**	Ore Production (kt) **b**	Concentrate (kt) **c**			Annual Gross Revenue ($m) **d**
			Copper	Zinc	Lead	
Rosebery-Rea **d**	19.4	539	4	84	22	31
Mt. Lyell	18.0	1700	113	0	0	68
Hellyer	16.9	1 306	11	288	62	102
Woodlawn	11.0	666	40	119	41	67
Golden Grove	10.5	901	27	171	0	64

Thalanga	7.0	616	28	88	21	46
Wilga	4.0	285	84	3	0	52
Girilambone	3.4	1530	33e	0	0	20

***a** Hughes (1990); Cox and Singer (1986). **b** Wilkinson (1995). **c** ABARE data.*

***d** Estimate obtained by multiplying concentrate volumes by average annual export price for each concentrate type (as actual export prices for concentrates vary across mines these values can only be considered as approximate estimates of gross revenue). Export price data obtained from Australian Bureau of Statistics (1996). **e** Estimate obtained by converting from metal produced.*

However, these values are gross, so that the economic value of a project would depend upon costs of extraction, development and expected mine life. Of the VMS deposits shown in Table 24, it is estimated that mine lives range from 2 to 36 years, with an average of 14 years.

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Appendix A - Appraisal of Sustainable Yield Methodology

Consultant's Report

by School of Forestry and Resource Conservation, University of Melbourne.

Contents

Executive Summary

This report examines the methodology used to determine the sustainable yield rate for the East Gippsland Forest Management Area (FMA). This examination is being done as part of the appraisal and accreditation process required for Regional Forest Agreements (RFAs). The examination also considered and appraised the methodology for data collection and growth modelling, which are seen as vital components of sustainable yield estimation. Three major components of the sustainable yield methodology were considered:

- Resource data used to describe the available forest in terms of its current or potential timber resource, including the manner in which the resource data is updated, maintained, and stored.
- Models used to predict forest growth and future yield.
- The processes used to integrate the resource data with future predictions, and the resulting estimation of sustainable yield for the Forest Management Area.

The review concentrated on the methodology and data used to estimate the current legislated sustainable yield rate of 174,000 cubic metres of grade C+ net sawlogs per year, which was published in the Forest Management Plan for East Gippsland (CNR 1995). The consultancy brief was to review the methodology used to calculate the sustainable yield, not the actual sustainable yield estimates.

The processes undertaken by the Victorian Department of Natural Resources and Environment (NRE) in the estimation of sustainable yield, including data collection and preparation, are documented in Lau *et al.* (1992).

Resource Data

Resource data are stored in the Hardwood Resource Inventory System (HARIS) database. The data are derived from a series of assessments, and then updated prior to use for sustainable yield estimation.

The regrowth resource, which comprises over 100,000 hectares of forest, was extensively assessed during 1988 (Radic 1990), although the data from this assessment were not used to update HARIS. As part of the assessment, stands were assessed for their suitability for thinning although the assessment did not include any quantitative measure or stratification of productivity within each forest type. The inclusion of this measure in future assessments would assist in providing more precise estimation of sustainable yield. However, due to the young age of the regrowth forests, the effect of possible variations in productivity on current sustainable yield estimates would be marginal.

The resource data for mature and overmature forests are based on a series of assessments carried out over the past 30 years. The assessments were designed to estimate net volumes of sawlogs to prescribed standards of utilisation current at the time of the assessment. Some of these standards no longer apply due to the application of the new sawlog grading system. The impact of this on availability estimates is unclear, but it is unlikely to be a major factor in sustainable yield estimation. It is noted that the Statewide Forest Resource Inventory (SFRI) is addressing this issue in its inventory design.

There are four recognised levels of reliability of assessment data, ranging from intensive assessment through to desk studies. The majority of the data is recorded as having one of the two intermediate levels of reliability. No specifications of the limits for sampling error or bias have been provided for any reliability level, although in the past two HARIS statements it is inferred that the overall stratified sampling error is typically of the order of $\pm$ 5%. However, it is doubtful that the actual sampling error of the resource data used for sustainable yield estimation can be estimated.

Even if 50% by area of the HARIS data were regarded as being of class 1 reliability, the lack of inventory plots in the remainder precludes overall statements about precision or bias. Notwithstanding this, HARIS represents the only source of strategic timber data available at present. Further, it is recognised that HARIS does contain some high quality data.

Given this situation, more extensive sensitivity analysis of the estimates of sustainable yield would have been desirable. It is noted that during the current sustainable yield review some sensitivity analysis has been performed.

Techniques used to update the HARIS data are generally sound and well documented, although improvements could be made. Specifically, greater precision and repeatability of results would have been achieved had GIS technology been utilised during this process.

Current estimates suggest that the SFRI program in East Gippsland may not be initiated until after the year 2000, making improvements in the situation unlikely prior to the next review of the sustainable yields under the Regional Forest Agreement in 2001.

If completion of the SFRI for East Gippsland is likely to be delayed beyond the year 2000, it would be highly desirable to commence entering HARIS specific maps onto the GIS now to enable their use in the review in the year 2001. Further, it would be prudent to maintain HARIS and its data for East Gippsland until the SFRI is completed for East Gippsland.

Growth Models

Accurate growth models are important in the estimation of sustainable yield.

Growth rates for the broad forest types of regrowth forests in East Gippsland are derived from a range of sources such as forest inventories, past utilisation, and permanent growth plots. Details of how these sources were used to derive the growth rates for regrowth forests are unclear. It was reported that comparisons with similar forests in other locations of the State were used to confirm the order of magnitude of these growth rates which represent a sound and pragmatic approach. Statements have indicated that the growth rates appear conservative, based on the limited knowledge available, and this concurs with our professional judgement.

The growth rate of the mature and overmature resource is assumed to be zero, on the basis that any growth is balanced by decay. Whilst this assumption appears to be widely accepted throughout Australia, there are no formal data to support it. As the mature and overmature resource comprises the majority of the expected timber harvest over the next 30 years or so, it would be advisable to subject this assumption to rigorous review. The assumption of zero net growth is, however, probably conservative.

Sustainable Yield Estimation

The Department of Natural Resources and Environment employed a simple, heuristic approach, utilising a computerised spreadsheet (SYSS), to estimate sustainable yield for the East Gippsland Forest Management Area.

Net area and volume estimates for sustainable yield estimation were derived from HARIS and forest zone information. Individual stand areas were then summarised by forest type and age class, providing a table of areas and potentially harvestable yields per hectare. Predetermined yields and available areas for each resultant forest stratum (forest type by age class) were then entered into the Sustainable Yield Spreadsheet (SYSS) which cross-checked the entered data.

Areas to be harvested from each stratum were manually allocated to a harvesting period and the resultant timber volume (area by yield) was calculated. The analyst then performed manual balancing of volumes between periods and by forest types to achieve a more balanced timber flow, bearing in mind other management goals.

This process is simple, yet adequate, given the extent and quality of available data and growth rates.

The 1995 East Gippsland Forest Management Plan (CNR 1995) proposes the thinning of approximately 4,500 hectares of foothill mixed species forest. This area has been derived by taking into account viability for commercial thinning, productivity, and existing harvesting technology. Other thinning regimes, of greater extent or different type, are not explicitly considered in the plan, and as a consequence their potential effect on sustainable yield is not known.

A more formal simulation or mathematical programming model would enable the evaluation of a range of management options. Not only would this provide greater assistance to decision makers, it could also potentially enable monitoring of the process in terms of the options examined.

In addition, it would be advisable that future developments have the facility to report on predicted forest structure of age classes by area and location through time to enable decision makers to gauge the condition of the forest during the period under consideration.

The Department of Natural Resources and Environment has indicated that future sustainable yield reviews will use the Integrated Forest Planning System (IFPS), and enhancements to IFPS are planned.

Based on the findings of this report, the following suggestions are offered for areas of improvement to the sustainable yield methodology for East Gippsland. As noted in this report, some of these issues may be addressed though the Statewide Forest Resource Inventory and the Integrated Forest Planning System.

1. That a project be initiated to assess the productivity of the regrowth forests of East Gippsland to enable more precise estimation of sustainable yield.

2. That more extensive sensitivity analyses be carried out on the sustainable yield estimates for the East Gippsland Forest Management Area. The sensitivity of all components of the resource estimates (mature and overmature forests and regrowth by forest type, productivity, year of origin, etc.), including growth rates of all forests, be analysed and reported as part of the methodology to determine sustainable yield.

3. If the completion of the SFRI is likely to be delayed beyond the year 2000, the HARIS specific maps should be entered into GIS as a basis for forest type analysis and management planning to enable their use in the review of sustainable yield in 2001.

4. That the HARIS database, data, and attendant processes be maintained, utilising regular updating procedures, until there is a viable replacement.

5 .That projects be initiated to develop appropriate biometric models for modelling the growth of regrowth forests, including the impact of alternative silvicultural practices.

6. That projects be initiated to determine growth, mortality, and decay rates for mature and overmature forests in order to develop appropriate biometric models for those forests.

7. That a larger range of silvicultural thinning and other options be considered when estimating sustainable yield for the East Gippsland Forest Management Area.

8. That the methodology used to estimate sustainable yield be enhanced to enable monitoring of successive iterations undertaken by analysts.

9. That a simulation or mathematical programming approach to estimating sustainable yield be used where possible, to enable a wider array of options and sensitivity analyses to be canvassed.

10. That future sustainable yield estimations report on forest structure of age classes by area and location through the period under consideration so that the progressive spatial and temporal changes in structure can be seen.

Introduction

Background

The National Forest Policy Statement (Commonwealth of Australia 1992), which was signed by all States, Territories, and the Commonwealth, is being implemented through a series of Comprehensive Regional Assessments (CRAs) leading to Regional Forest Agreements (RFAs) between the Commonwealth and the State concerned. The East Gippsland Comprehensive Regional Assessment involves an appraisal and accreditation of sustainable yield methodology.

The East Gippsland Forest Management Plan, which covers the Regional Forest Agreement Region for East Gippsland, was published in 1995 (CNR 1995). Within the plan, estimates of current resources, resource availability and an estimate of the sustainable yield of sawlogs were reported.

This report examines the methodology used to determine the sustainable yield for the East Gippsland Forest Management Area (FMA).

Terms of Reference

The terms of reference for the project were as follows:

- 1. Work with the Bureau of Resource Sciences (BRS) and the Victorian Department of Natural Resources and Environment (NRE) to undertake project scoping, in order to develop a works program for an appraisal of yield modelling.
- 2. Consider and appraise the methodology for data collection and modelling, as applied for sustainable yield forecast for East Gippsland.
- 3. Provide an indication of the strengths and weaknesses of the methodology used for data collection and modelling sustainable yield forecast.
- 4. Consider assumptions and constraints underlying data and methodology as provided by NRE.
- 5. Provide a written report to an agreed standard, no later than 31 May 1996.

The appraisal was based on information from two main sources: discussions with Department of Natural Resources and Environment staff, and review of published and other documents. The consultancy team met with staff from the Department of Natural Resources and Environment at Orbost, with Head Office staff of the Forest Service in Spring Street, and in meetings with both Bureau of Resource Sciences and Department of Natural Resources and Environment staff held at the University.

Appraisal Procedure

The review of the methodology used to calculate the East Gippsland sustainable yield was approached from three major perspectives:

- Resource data,
- Growth models, and
- Estimation processes for sustainable yield.

The review first examined the source and derived data used, followed by the models used to transform it into future volume estimates. It then focussed on the numerical processes in which the data and models were brought together to determine the sustainable yield.

The consultancy brief was to review the methodology used to calculate the sustainable yield, not the actual sustainable yield estimates. No calculations were performed.

Thus, this report deals solely with the methodology used to calculate the legislated sustainable yield rate for East Gippsland of 174,000 cubic metres (net volume) of grade C+ sawlogs per year.

Sustainable Yield

Introduction

'Sustained yield' has a long history in forestry and needs to be distinguished from 'sustainable yield', which is the yield capable of being sustained but not necessarily one that is sustained in the sense of being held constant over time.

Where wood production was the dominant use of a forest, the traditional approach was to set the allowable cut at the maximum level that could be sustained over time, for a given silvicultural system and level of investment in silviculture. The underlying model assumed that the sole objective of management was to maximise the average annual volume of wood harvested in perpetuity, subject to maintaining a constant level of cut in terms of volume. In the nineteenth century, when the sustained yield formulae were developed, this objective and the underlying model may have been eminently sensible, especially given the complexities of the problem and the limited resources to apply more complex solutions. However, it is no longer appropriate for the management of public forests which have many uses, not just timber production.

The Board of Inquiry into the Timber Industry in Victoria (Ferguson, 1985) pointed out that the many uses of public forests necessitated determining the appropriate combination of uses. That combination may involve all, some, or only one use but also entailed determining the appropriate level/s of use. To some degree, the subdivision of forest into conservation zones in which wood production is not permitted, and zones available for wood production, resolves some of these issues but the balance between the level of wood production and other uses in the zones available for wood production remains an issue.

The underlying objective for such an analysis is to maximise the net social benefits, given that the forests are publicly owned and that society benefits both as producers of the goods and services and as the consumers thereof. However, pursuit of an analysis on this basis is simply not practicable because many of the data required are not available and may never be available, given the difficulties of measuring the benefits from goods such as conservation (Ferguson, 1996). The Inquiry recommended that public forest management should be guided by a set of operational principles that were broadly consistent with this objective and substantially capable of reconciliation with one another. Those principles were adopted by the then Victorian Government in the Timber Industry Strategy (Government of Victoria, 1986) which stated that public forest management should be:

- economically viable with respect to the provision of wood and other market goods,
- environmentally sensitive with respect to the provision of non-wood goods and services,
- sustainable with respect to the interests of future generations, and
- assisted by public participation in the planning process.

There is, not surprisingly, a marked similarity between these principles and those subsequently adopted by the Commonwealth Government in the National Forest Policy Statement for ecologically sustainable forest management.

However, sustainability and the balance between uses remain key issues to be resolved. The Timber Industry Strategy noted that:

The Government accepts that wood production and utilisation is an integral part of the future management of State forests and that management needs to be sufficiently flexible to provide for sustainable levels of all forest values, timber and non-timber, at adequate levels. In relation to timber this does not mean that all the timber available on a sustainable basis will be utilised. *Rather it represents the maximum volume that can be produced without compromising the sustainable levels of other forest values.* (Author's Italics)

This simple change represents the essence of sustainable yield (as distinct from sustained yield) and is critical in discarding historic notions of the implicit primacy of timber production on public forests. Just as the sustainable level of timber is a variable, so too are the sustainable levels of supply of other goods and services. In the case of timber, one can set the sustainable level very high in the interests of the economic returns, but in doing so, change the structure of the forest so that it cannot sustain viable populations of certain plant or animal species. Alternatively, one can set it at a lower level, enabling a progressive change in structure (ie. the distribution of age classes by areas) that may enhance (or in some cases reduce) its capacity to sustain certain plant or animal populations or of other goods and services.

Regional sustainable yield attempts to address these issues of balance. They cannot be resolved at the site of the harvesting operations because they involve matters of scale relative to the region as a whole.

Estimating the Sustainable Yield of Wood

There are many techniques available for estimating the sustainable yield of timber from a forest. Some involve sophisticated computer models using linear programming or similar techniques and these enable an array of strategies for different stands to be analysed simultaneously. Yet others are based on simulation models that enable the analyst to answer "what if" questions. Less sophisticated models work on scheduling the area to be cut, or the volume to be harvested, in the region constantly through time, or moving towards this goal.

The better of these techniques do not just focus on the estimation of the sustainable yield: they also schedule the harvest according to a system of priorities that recognises that young forest grows more rapidly than old and therefore, for wood production, priority ought to be given to harvesting older and less vigorous forest. They also recognise that agglomeration of coupes harvested annually may be highly undesirable for reasons of habitat management, landscape, water quality, roading and/or fire protection. These priorities are often not explicitly stated in descriptions of the systems used and this does a great disservice to the role of the sustainable yield estimation because it performs a very important spatial and temporal scheduling of harvesting and associated activities to reduce the impacts of those activities on the sustainable levels of other uses.

The notion of moving towards a uniform or balanced distribution of age classes in the case of even-aged forest management is implicit in any system that applies a sustainable yield approach. The concept of a balanced distribution can be illustrated simply by considering a large area of bare land of uniform site productivity. Let us say the rotation to be used is 80 years. Then if one eightieth of the area is planted each year, it would lead to a situation 80 years hence when equal annual areas and hence volumes could be clear-felled and harvested in perpetuity. However this uniform or balanced distribution of age classes is an ideal and one that is probably never reached because of natural disturbances, changes in economic conditions and technology, and changes in demand. The reality is therefore that forest management entails the intelligent management of imbalanced structures (Clutter *et al* 1983:p238).

One corollary is that, given the length of time involved in forest production, it may be more realistic to estimate a sustainable yield and a schedule for harvesting the stands in a forest over say the next 40 or 50 years at most, rather than longer periods, because attempts to predict future markets become unrealistic and unrepresentative beyond this period. However, it is then important to examine what the extent, location, and distribution of age classes are at the end of the 40 to 50 year period, to see whether the structure of the forest then appears to be beneficial to other uses.

Sustainable yield estimation methodologies require (i) data on the areas of stands of different forest types and their ages or structures, (ii) estimates of the volume per hectare standing and that might be harvested now in each of those stands, and (iii) estimates or other means of predicting what net growth and harvest volumes might be in those stands in the future. The extent and quality of these data control the choice of the method of estimating sustainable yield. The particular problem that tends to bedevil data from mature and older native forests is that some trees carry internal defects that limit their use or reduce their merchantable volume. Such defects are often difficult to detect in the standing tree, greatly increasing the variance attached to estimates of merchantable wood volume per hectare.

Recent History for East Gippsland

Following Land Conservation Council recommendations in 1986, substantial forest resources were withdrawn from timber production for conservation purposes. As a result, the Timber Industry Strategy adopted a much reduced sustainable yield of 179,000 m3 per year, compared with the previous allowable cut of sawlogs for this area. Victorian legislation (Forests Act 1958, amended by the Forests (Timber Harvesting) Act 1990) required that the sustainable yields of wood for all Forest Management Areas be approved by Parliament and reviewed periodically. The first such determination and approval took place in 1991 and resulted in a further reduction from 179,000 to 174,000 m3 per year of grade C+ sawlogs following further additions to National Parks in the Region. It is the methodology used to determine this latter figure which is the focus of this report.

In summary, the relevant sequence of events was:-

- 1989 HARIS update upon which the current legislated sustainable yield rate was published.
- 1991 Sustainable yield was set at 174,000 cubic metres net volume per year for grade C+ sawlogs, based on the 1989 HARIS update.
- 1992 Methodology used to calculate the legislated (1990) sustainable yield rate documented and published in the Department of Conservation & Environment, Lands and Forests Technical Report No. 8.
- 1992 Revision of timber resources for the East Gippsland Forest Management Area and update of the HARIS resources database and statement carried out, published in CNR (1993).
- 1993 Statement of Resources Uses and Values for the East Gippsland Forest Management Area, based on the CNR (1993).
- 1994 Proposed East Gippsland Forest Management Plan published using the 1992 resources estimates.
- 1995 Final East Gippsland Forest Management Plan published.
- 1996 Review of the sustainable yield rate for the East Gippsland Forest Management Area (in progress) based on CNR (1993) and modified by overlaying the Forest Management Zones published in the 1995 East Gippsland Forest Management Plan.

Sustainable Yield Methodology

The general methodology for the estimation of sustainable yield in East Gippsland is well documented in the Lands and Forests Technical Report No. 8 (Lau *et al.* 1992). In summary, the general procedure is:

1. Update knowledge on resources data by reviewing assessments, volumes harvested, growth, and losses due to natural causes, eg. fire. 2. Undertake base calculations to account for possible differences in product definitions, defined management zones, conversions from gross to net available area, plus viable harvesting levels. 3. Stratify the forest into mature and overmature and regrowth by forest type and year of origin. 4. Carry out an iterative process (utilising *computer* based spreadsheet technology) to schedule the harvesting of the mature and overmature forest and grow and schedule the regrowth forests to determine, according to management assumptions and constraints, sustainable yield.

Resource Data

Resource data for East Gippsland come from a series of assessments and are stored in the Hardwood Resource Inventory System (HARIS) database. Prior to the estimation of sustainable yield, the data are updated to reflect recent harvesting activities and natural disturbances.

This chapter reviews the assessments and the updating process and then the HARIS database itself.

Regrowth Forests

The regrowth resource comprises an estimated 104, 155 hectares of varying age, most being less than 30 years old. The regrowth forests of East Gippsland were extensively assessed during 1988 (Radic 1990) for forest type and age. They were also assessed for their suitability for thinning on the criteria of commercial viability, response or growth potential, and in light of existing harvesting technology. The assessment did not include any quantitative measure or stratification for productivity within each forest type. It should be noted that the data from this assessment were not used to update HARIS.

Given appropriate biometric models, stratification of the regrowth resource by forest type, age and productivity would enable the more precise estimation of sustainable yield. However, as the majority of the regrowth forests are not scheduled for harvesting during the next 30 years or so, the recognition of different productivities of regrowth forests may not have a large effect on estimates of sustainable yield.

Nevertheless, it would be highly desirable that a project be initiated to assess the productivity of the regrowth forests of East Gippsland to enable more precise estimation of sustainable yield.

Mature and Overmature Forests

Timber resource data for the mature and overmature forests within the East Gippsland Forest Management Area were derived from a series of assessments of individual Management Blocks within the Forest Management Area. The currency of the assessments range from recent (within the last few years) to greater than 30 years old, with most being dated prior to the mid 1980s, ie. greater than 10 years old.

Statistical reliability

The Department of Natural Resources and Environment recognises four reliability levels for their assessment data:

- 1. Intensive assessment with detailed mapping and field inventory plots.
- 2. Reconnaissance with detailed mapping supported by field checking and fewer or no plots.
- 3. Reconnaissance with broad stand mapping and little or no inventory plots.
- 4. Desk study with estimates based on experience.

The majority of the HARIS data is recorded as having either level 2 or 3 reliability. No specifications of the limits for sampling error (ie. the confidence limits around the mean at the 95% probability level) or bias (ie. the difference between actual and sample mean volume) have been provided for any reliability level. Within both the 1989 and 1992 HARIS statements it is stated that "...the overall stratified sampling error is typically of the order of ± 5%." Although this statement might be justified when applied to any single assessment with sufficient stratification and sampling, its relevance to the HARIS data for the entire Forest Management Area is quite unclear, given the wide variety of sources of data and the lack of field sampling in those areas classified in reliability classes 3 and 4.

Only 21% of the gross available area is classed in reliability class 1, 19% in class 2, 36% in class 3, and 24% in class 4. However, these figures are misleading because a substantial number of Management Blocks were assessed to class 1 standards prior to the 1980s but were then relegated in the late 1980s to class 2 on the basis of the relative age of these assessments. Since many of these Management Blocks contain mature or overmature forests, the change in their status over the intervening period therefore deserve better recognition. Nevertheless, even if 50% of the area were regarded as being of class 1 reliability, the lack of inventory plots in the remainder precludes overall statements about precision or bias. It is understood that the Statewide Forest Resource Inventory will involve field sampling across all relevant strata, within the limits of reasonable access.

Because of the inability to make considered judgements about either the precision or the basis of the resource inventory, due to the absence of appropriate statistics, the review team believes that sensitivity analyses should therefore be carried out to assess the effects of possible inaccuracies in HARIS estimates of standing volumes on the sustainable yield estimates for the East Gippsland Forest Management Area. The sensitivity of all components of the resource estimates (mature and overmature forests and regrowth by forest type, productivity, year of origin, etc.) ought to be analysed and reported as part of the methodology to determine sustainable yield.

It was noted that the current sustainable yield review by the Department of Natural Resources and Environment of the legislated sustainable yield has undertaken some sensitivity analyses. These indicate that a 20% change in total merchantable (D+ grade) volume of mature and overmature forests gives rise to a 13.2% change in the sustainable yield of the same sign. Whether resulting from bias or sampling error, the principal operational concern is that of an overestimate of volume, leading to a possible inability to sustain production. The Department has pointed out that, even if a hypothetical overestimate was of the order of 20%, the implied reduction in sustainable yield would be of the order of 30,000 m3/year, or an accumulated volume of 150,000 m3 over 5 years. The Department argues that such an overestimate does not have irretrievable consequences. For example, if this hypothetical overcut was maintained for the next 5 years, a reduction of the sustainable yield by 14.5% would be required from 2001 onwards, only 1.3% more than the hypothetical correction now. This is of some comfort, although not directly verifiable for the methodology under review in this report.

HARIS estimates of current resources were derived from the previous assessments after updating to take into account losses of available area, volumes harvested, and changes to log grading.

Utilisation standards

The assessments were designed to estimate net volumes of sawlogs to prescribed standards of utilisation current at the time of the assessment. However, the standards and definitions used within each assessment are not necessarily consistent with today's standards and definitions.

The application of grading systems always involves a series of judgements at the margins of grades and these judgements are sometimes influenced by experience in relation to the utilisation of logs, especially those of lower grades. The estimation of sustainable yield is based on the volumes of grade C+ sawlogs, not lower grades, so this represents the critical boundary. It was reported that the stricter application of logging standards has tended to result in what were previously D grade sawlogs now being classified as C+ grade.

The extent of this, and its impact on the volumes of C+ sawlogs, is far from clear but represents potential bias. However, it is unlikely to be a major bias relative to the total volume of all grades of C and better sawlogs.

To overcome possible problems relating to utilisation standards, future inventories ought to be designed to record tree, stand, and forest parameters that enable a consistent standard to be adopted for the purposes of estimating sustainable yield but also allow ready and precise conversion to product yields current at any one point in time. It is understood that the Statewide Forest Resource Inventory (SFRI) is using this approach. However, it is imperative that standardised data management procedures (standards, guidelines, control procedures, and documentation of the data definitions) be adopted to assist in this process.

Updating Processes

A major update of the resource data used in the estimation of sustainable yield is generally undertaken before each sustainable yield review. The 1992 sustainable yield review used the results of the 1989 HARIS update. Further adjustments are also made to the updated HARIS data to cater for events such as fire and logging which have occurred after the major update, and to correct any errors.

Documentation
Staff of the East Gippsland Forest Management Area, primarily located in the Orbost Region, produced a HARIS Update Manual in June 1992 (revised in September 1993). This manual clearly sets out the objectives, procedures, and standards used for updating the HARIS data. The consultants were impressed by the quality and detail of this manual, and commend the staff involved in its production. Reasonably complete standards for the documentation of the data sources, assumptions, and processes are described, and if those instructions are closely followed quality information relating to the sources of records within HARIS will result.

Staff collated land tenure and assessment information from a number of sources. Some concern must be expressed regarding the use of 1974 LCC Vegetation and Height Class maps where Volume Class maps and/or Forest Type maps were not available. Whilst the extent to which these old maps were employed is limited, their usage indicates a lack of basic resource data. It is accepted that staff used the best available data, however.

The manual refers to a 10-step process for updating the HARIS data, and this process was used to update HARIS in 1991/92.

Maps of forest types
The HARIS update manual states that 'prior to this update, HARIS specific maps were not produced, and the map source of existing statements was often unclear'. Thus, while the HARIS update represents a considerable advance, some area statements still lack reference to specific maps, and this will not be redressed until GIS based maps from the recently initiated SFRI become available. Current estimates suggest that the SFRI program in East Gippsland may not be initiated until after the year 2000, making improvement of the situation unlikely prior to the next review of the sustainable yields under the Regional Forest Agreement in 2001.

If completion of the SFRI for East Gippsland is likely to be delayed beyond the year 2000, it would be highly desirable to commence entering HARIS specific maps onto the GIS now to enable their use in the review in the year 2001.

The detailed drafting instructions issued within the manual ought to stand the test of time, even within the SFRI.

Area
Sound techniques, albeit manual, appear to have been employed to create the gross area statements.

In the absence of GIS, a standard 5% reduction was applied for streamside reserves. This is a pragmatic approach obviating an otherwise tedious and time-consuming process using manual methods of measurement. However, this is an unsatisfactory long-term approach which could lead to substantial errors. Possible sources of error include variations in the pattern and density of streams and the non-linear relationship between buffer size and net productive area. This problem is exacerbated by the fact that gullies usually represent better sites, hence higher timber volumes (Bren 1996).

Thus, apart from any miscalculations of area, proportionate reductions of volume based on area ratios could lead to biased results. A GIS-based system, presently being introduced by the Department, ought to provide much improved estimates of net available area. However, it needs to be complemented by procedures designed to partition volume estimates to account for higher productivity sites if it is to satisfy the most stringent requirements. Stratified sampling is needed to partition areas of differing productivity in order to fully meet these requirements and they may be achieved in the SFRI.

HARIS, as noted elsewhere, is a summary database. Management decisions are made and applied to the source data which are then updated into the HARIS database. Whilst these decisions are not always apparent when viewing the HARIS data, they are adequately documented. Further, HARIS cannot easily represent Special Management Zones which are restricted in a non spatial manner.

The Department recognised these problems, and for the sustainable yield estimations for the East Gippsland Forest Management Plan and the current review used the source data and applied the new zonal information to create a new area statement. This involved a complex, manual process, proportioning HARIS stand data and GIS data (at 1:100000 scale). This process is likely to result in errors, and it is unlikely that the same result could be obtained (the area statement), even if the same procedure were again used to derive it.

The resultant area information from this process was not recorded in HARIS. This means that the area statement as reported by HARIS is not consistent with that used in the East Gippsland Forest Management Plan. A formal reconciliation between the two using GIS to update HARIS for the introduction of new Zones and other minor changes would be highly desirable.

With the advent of proper GIS data and applications, and correct database structure, most of the problems inherent in this approach will disappear. We strongly encourage the use of GIS technology in the future determination of area statements. The logical place to apply gross to net area reductions is inside the GIS, providing the resultant area statement.

Volume Estimates

Where possible, volume estimates from assessment reports were compared with recent harvesting to verify their accuracy. Volumes in HARIS were also adjusted from the 1989 figures during the 1993 update to remove harvested volumes. Where coupes were located wholly within a single forest type, age class, and Management Block, adjustments were made to both area and volume to account for harvesting. However, in most cases this was not possible, and rather than subtracting both the harvested areas and volumes from the HARIS availability figures, only the harvested area was subtracted: the volume remaining being recalculated on a volume per hectare basis. In some areas, harvesting favours forests with higher than average volumes per hectare for the Management Block. To the extent that this is so, the HARIS estimates will tend to be optimistic because of the adjustment process used.

HARIS database

HARIS is a database and reporting system for timber resources which stores resource estimates by stand, compartment or block, by forest type, year of origin and LCC availability class. It provides either standard or *ad-hoc* reports as requested by users.

HARIS does not process inventory data and as a consequence all data in HARIS has been pre-calculated, summarised, or otherwise processed. Thus the integrity of all data in HARIS is dependent on the updating processes covered elsewhere. Therefore, it is essential that the data contained in HARIS be as up to date as possible (especially for the mature and overmature estimates) prior to its use for the estimation of sustainable yields.

HARIS provides a useful repository for the currently available resources data. Whilst some of the data within it leaves a lot to be desired with respect to its quality, there are also some good resource estimates within it.

The Department of Natural Resources and Environment is no longer updating HARIS data for East Gippsland, given that the SFRI will eventually replace it. However, it is not expected that resources will be released for the SFRI program in East Gippsland until after the year 2000. Consequently, the SFRI data may not be available for the next sustainable yield review in 2001.

As such, it would be prudent to retain HARIS as the authoritative basis for resource estimates in East Gippsland until the completion of the SFRI program. It is recognised that full HARIS updates are costly, with the last taking 12 person years. A program of frequent, regular updates would, however, reduce the call on resources that a major update makes.

GROWTH MODELS

Information on growth rates is important in the estimation of sustainable yield. The data and methods for modelling the growth of firstly the regrowth component of the resource, and secondly the mature and overmature component, are as follows:

Regrowth Forests

Estimated annual increments, for the appropriate rotation ages, expressed as net m3/ha/yr of grade C or better sawlogs (Lau et al. 1992), are shown in Table 1.

Table 1: Estimated annual increments used in sustainable yield estimations for East Gippsland.

Forest Type	**C+ Sawlog MAI**
Alpine Ash	2.5
Mountain Ash & Shining Gum	3.0
Mountain mixed species	2.0
Foothill mixed species	1.5
Alpine mixed species	0.5
Coastal mixed species	0.5

For alpine ash, mountain ash and shining gum, mountain mixed species, foothill mixed species and alpine mixed species the nominal rotation age is 80 years. For the coastal mixed species forest type it is 120 years (Lau *et al.,* 1992).

These growth rates have been derived from a number of sources including forest inventories over the past 30 years, past utilisation of mature and maturing stands, and permanent growth plots. Details of how these sources were used to derive the growth rates are unclear.

CNR 1993 reported that the majority of these assessments have considered the mature and overmature resource, but a single extensive assessment of regrowth resources was carried out in 1988 (Radic 1990). As stated elsewhere in the report, the regrowth assessment did not directly consider productivity, other than its suitability for thinning.

There are 122 continuous forest inventory plots in the East Gippsland Forest Management Area - all located in regrowth stands of *E sieberi* (silvertop stringy bark) or *E sieberi* mixed with other species. Of these, 33 plots were established over five locations specifically to monitor growth of unthinned stands. The rest (73%) address a variety of management objectives relating to non-commercial and commercial thinnings, tree spacing, fertilisation, and alternative silviculture. The oldest stands represented in these growth plots originated in 1941 (current age 55 years); the youngest in 1988 (current age 8 years). Plots from only two of these locations (Spring Creek and Jirrah) have been assessed for log production, respectively at ages 25 and 27 years, in the context of non-commercial thinning.

It is concluded that these 122 plots, although giving some indication of regrowth productivity, only apply to part of the regrowth resource.

Comparisons with similar forest types elsewhere in the State have been used to confirm the order of magnitude of these growth rates, which represents a sound and pragmatic approach.

It was reported that 'Individual stands within each forest type can be expected to vary in productivity around the estimate of MAI for the forest type.' As noted earlier, not enough is known about regrowth productivity to gauge the importance of this potential range of variation on the estimation of sustainable yield.

Although harvesting in regrowth forests will not be a significant component of projected harvest volumes until after the mid-2020s, their growth rates impact on the determination of sustainable yield, hence on the current rate of harvesting the mature and overmature forests. These growth rates will not only affect the total volumes produced, but also tree sizes. The latter are more critical to the maintenance of the calculated sustainable yield of sawlogs in the first instance.

Sensitivity analysis recently carried out by the Department of Natural Resources and Environment on the growth rates of regrowth have indicated that a 10% change in all growth rates would have an effect approaching 4.5% on the sustainable yield. This appears to be a linear relationship given the assumptions inherent in the modelling of growth.

It was noted that the linear growth models being applied to regrowth forests make no allowance for the eventual change of regrowth forests into mature forests.

As statements have been made that the increment figures presented in Table 1 appear conservative based on the limited knowledge available, projects ought to be initiated to develop appropriate biometric models for modelling the growth of regrowth forests, including the impact of alternative silvicultural practices.

Mature and Overmature Forests

There are no continuous forest inventory plots in the mature and overmature stands in the East Gippsland Forest Management Area, therefore there is no explicit quantitative growth data for the mature and overmature forests in the Forest Management Area. In the absence of information from these sources, growth of these forests is estimated to be zero, on the assumption that any growth is balanced by decay.

Whilst this is not an unreasonable assumption, and indeed this is a common assumption throughout Australian forestry, no actual data is known to be available to support it. Consequently, this assumption ought to be subjected to rigorous review and amended, if necessary, when better information becomes available. This assumption of zero growth is probably conservative. The impact of this assumption does not appear to have been evaluated. In order to clarify the risks associated with this assumption, sensitivity analyses ought to be carried out to determine the effects of both positive and negative net growth.

Sustainable Yield Estimation

Lau *et al* (1992), in describing the estimation of sustainable yield for the East Gippsland Forest Management Area, defined sustainable yield as 'the estimated annual rate of harvesting of hardwood sawlogs in any Forest Management Area that is capable of being produced without impairment of the long term productivity of the land, taking into account the structure and condition of the forest.'

The structure and condition of the East Gippsland Forest Management Area are such that there is a small proportion of older and overmature forest available for harvesting in the immediate future and a much larger area of regrowth forest of predominantly young areas available for harvesting beyond that time. The sustainable yield of timber of 174,000 m3 per year was therefore best applied by restricting harvesting activities to the mature and overmature resource in the initial period (to approximately 2025), supplemented by some harvesting of regrowth stands that are older than a specified minimum age (65 years) towards the end of this period. Thereafter, the sustainable yield will come from the regrowth forests and is expected to increase progressively until 2062, when the long-term potential yield of approximately 500,000 cubic metres per year of grade C+ sawlogs may be reached.

The adoption of 174,000 m3 per year reflects consideration of the trade-offs necessary to establish a more comprehensive and adequate conservation reserve system and consequent withdrawal of resource from harvesting in order to do so. These trade-offs lie in the province of the planning team, rather than the analyst, and were aided by public input and therefore do not feature as an explicit part of the sustainable yield methodology, but are critical to it.

Description of Process

The Department of Natural Resources and Environment used a simple heuristic approach utilising computerised spreadsheets to estimate sustainable yield for the East Gippsland Forest Management Area.

Net area and volume estimates for sustainable yield estimation were derived from HARIS and forest zone information. Individual stand areas were then summarised by forest type and age class, providing a table of areas and potentially harvestable yields per hectare. Predetermined yields and available areas for each forest stratum (forest type by age class) were then entered into the Sustainable Yield Spreadsheet (SYSS) which cross-checks the entered data.

An age class of nominally 1850 origin was allocated to mature and overmature stands, whereas regrowth stands are grouped by 10 year age classes, based on recorded age.

Areas to be harvested from each stratum were manually allocated to a harvesting period and the resultant timber volume (area by yield) is calculated. The analyst then performed manual balancing of volumes between periods and by forest types to achieve a more balanced timber flow, bearing in mind other management goals.

Appraisal of Methodology

The East Gippsland Management Plan points out that consideration of conservation has led to 'concerns about the compatibility of commitments to timber supply and conservation in State forests'. It is important to note that the exercise of estimating sustainable yield was not just a computational one. Much liaison with the planning team, not to mention community participation, was involved initially to ensure that the timber foregone on those additional areas likely to be required for conservation was balanced against the conservation values involved, and the opportunity costs of the trade-off reduced accordingly.

The overall approach used thus attempts to meet the objective of maintaining the legislated sustainable yield, whilst ensuring adequate provision for biodiversity conservation.

In our opinion, the methodology for estimating sustainable yield is simple yet adequate, given the extent and quality of available data.

Some limitations

SYSS only allowed for a maximum of 6 forest types and approximately 10 age classes to be modelled at the time of the reviewed sustainable yield estimations. This limitation was addressed by aggregating minor forest types. The spreadsheet methodology works well with the limited data currently available. It does, however, require operation by expert analysts to ensure consistent and optimal results. Even so, SYSS may prove to be unwieldy when more detailed and accurate resource data become available.

SYSS, by nature of its flexibility, allows the analyst free range over the timing and breadth of harvesting operations. However, this flexibility provides a potential for sub-optimal or inconsistent scheduling. For example, SYSS does not force the analyst to harvest regrowth from oldest to youngest, even where this would be the most appropriate course of action, and thus in more complex situations the possibility of sub-optimal scheduling arises.

Furthermore, with more detailed resource information, the number of forest types and age classes will rise substantially, requiring even more aggregation, with consequent loss of information. The Department of Natural Resources and Environment has very recently modified SYSS to allow it to model an almost unlimited number of forest types. Due to the highly interactive nature of SYSS, an increase in the number of forest types dramatically increases the time taken to perform a sustainable yield estimation. Thus, it will become increasingly difficult for an analyst to picture the forest being modelled as the size of the data set grows.

The 1995 East Gippsland Forest Management Plan has within it approximately 4,500 ha of foothill mixed species forest thinning. The 4,500 ha has been derived by taking into account viability for commercial thinning, areas of low productivity, and existing harvesting technology. Alternative thinning regimes of greater extent or different type would presumably result in different sustainable yield estimates, and different trade-offs, but these and other options are not considered explicitly in the Plan.

A more formal simulation or mathematical programming model which would enable a range of options to be considered and that incorporated some of the key priorities as decision rules would be beneficial. The Department of Natural Resources and Environment has successfully employed this type of technology in the past both in softwood plantations, and for regrowth mountain ash stands. This is not to suggest that the present methodology for East Gippsland is inappropriate. However, greater assistance could be provided to the analyst, the planning team, and the community, if a more sophisticated model was used when suitable resource data and models became available.

The methodology used to estimate sustainable yield of 174,000 m3/yr of grade C+ net sawlogs made no allowance for fire loss or sampling variance. SYSS has been recently modified to include the ability to adjust for these factors for the current review.

The fire loss factor is intended to take account of expected losses from fire and is certainly a factor that ought to be considered when calculating sustainable yield. It ought to be based on historic data, rather than subjective estimates. That said, it is necessary to stress that the estimation of losses is not a simple matter, except in the case of young, fire-sensitive regrowth that might be killed by fire with the consequent loss of all standing volume. In all other cases, the problem is to gauge the extent of the losses or damage, some of which is exceedingly difficult to assess, being largely hidden until the tree is felled.

The second adjustment factor, termed sampling variance, takes account of the lower confidence limit of the net volume estimates, based on the 95 percentile bound, where this is known.

Generating alternative management strategies

Using SYSS, an analyst can evaluate alternative strategies quite quickly to show the net result of proposed or actual changes. However, due to the manual and iterative nature of SYSS inputs, it is difficult to determine the nature of the strategies being employed by the analyst. The only way to determine this, is through laborious manual checking as there is no built-in audit trail, although the analyst is required to document assumptions. The methodology ought to be enhanced to enable the iterations to be monitored during sustainable yield estimations via an audit trail.

Outputs are quite simple and there is little room for misinterpretation. The only possible area for incorrect interpretation is that volumes are listed by period, usually 10 or 15 years (Lau *et al.*, 1992). These are significant durations and in regrowth forests it is possible that the volume predicted will not be available evenly over the period. The solution is to refine SYSS, using shorter time periods and less aggregated data. Presently, the data currently available are inadequate for this.

A simulation or mathematical programming model would allow an analyst to present and evaluate a number of rule-based options and their effects. As noted earlier, we believe the Department of Natural Resources and Environment ought to investigate enhancements or alternatives to SYSS based on simulation or mathematical programming, to enable consideration of more detailed forest descriptions and growth models, and a wider range of options and sensitivity analyses.

In addition, no description of the structure (eg. age class by area) of the forest at any point in time has been produced to show the progressive changes in structure of age classes by area and location. The Department of Natural Resources and Environment has indicated that it would be a simple matter to produce these descriptions. A description of the forest at the end of the planning horizon enables the change in condition over that horizon to be gauged, and is of prime importance in considering the future availability of wood and non-wood values.

The Department of Natural Resources and Environment has indicated that future sustainable yield reviews will use the Integrated Forest Planning System (IFPS). Improvements to IFPS are expected to include cascade modelling, enhanced visualisation, SPECTRUM, and remotely sensed monitoring. However, it should be noted that unless source data and biometric models are also improved, the resultant sustainable yield estimate will be no more accurate than at present.

Conclusion

The overall approach by which the Department of Natural Resources and Environment estimate sustainable yield for East Gippsland is conceptually sound. However, in each of the three major components of the approach, resource data, growth models, and estimation of sustainable yield, possible improvements have been identified.

The regrowth forests of East Gippsland were extensively assessed during 1988 (Radic 1990) for forest type and age. They were also assessed for their suitability for thinning on the criteria of commercial viability, response or growth potential, and in light of existing harvesting technology. The assessment did not include any stratification of productivity within each forest type.

The resource data for mature and overmature forests are based on a series of Block assessments over the past 30 years to varying standards and reliability.

These resource data for regrowth and mature and overmature forests are summarised and recorded in the HARIS database. The sampling error of the HARIS data, whilst inferred to be ± 5%, is actually unknown. Notwithstanding this, HARIS represents the only source of strategic forest data available at present, and it is recognised that there is some high quality data within it.

The Department of Natural Resources and Environment does not intend to maintain HARIS and its data for East Gippsland, on the premise that the SFRI will eventually replace it. If completion of the SFRI for East Gippsland is likely to be delayed beyond the year 2000, it would be prudent to maintain HARIS and its data for East Gippsland until the SFRI is completed for East Gippsland.

Accurate growth models are important in the estimation of sustainable yield. Growth rates for the regrowth forests of East Gippsland have been estimated for the broad forest types. It is reported that these growth rates have been determined by considering a range of sources such as forest inventories, past utilisation, and permanent growth plots. The Department has indicated that comparisons with similar forests elsewhere indicated that these figures were conservative.

Growth for mature and overmature forests is assumed to be balanced by decay, resulting in a zero net growth rate. Whilst this is not an unreasonable assumption, and indeed it is commonly used throughout Australia, no actual data is available to support it. This assumption should be tested and the estimates of sustainable yield amended, if necessary, when better information becomes available. The assumption is, however, considered to be conservative.

The Department of Natural Resources and Environment employ a simple, heuristic approach, utilising a computerised spreadsheet (SYSS), to estimate sustainable yield for the East Gippsland Forest Management Area. It is our opinion that this approach, although simple, is adequate, given the types and quality of available data and growth rates. Adoption of a more complex approach at this stage would be of little value, except for the inclusion of detailed sensitivity analyses. It is noted that, in the current sustainable yield review, some sensitivity analysis is being undertaken. The analysis shows that even if a hypothetical overestimate of the standing volume in mature and overmature forests was of the order of 20%, the implied reduction in sustainable yield would be of the order of 30,000 m3/year (13.25). If this hypothetical overcut was maintained over the next 5 years, a reduction of the sustainable yield by 14.5% would be required from 2001 onwards, only 1.3% more than the hypothetical correction now.

It would be worthwhile for the Department of Natural Resources and Environment to develop, in parallel with the SFRI, a more formal simulation or mathematical programming based model that would enable the evaluation of a range of management options. This will complement the outcome of the SFRI which will provide new, more detailed resource data for the East Gippsland forests, and provide age and growth data for mixed species forests.

The Department of Natural Resources and Environment has indicated that future sustainable yield reviews will use the Integrated Forest Planning System (IFPS), and enhancements to IFPS are planned.

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Appendix B - Definition of Sawlog Grades

In Victoria all hardwood sawlogs other than River Red Gum and box-ironbark species must be graded in accordance with hardwood sawlog grading instructions and interpretations. The *Hardwood Sawlog Grading Card* (Jeremiah and Roob 1992) defines sawlogs by grades (A to D) as described below, and allows for some variation between grades by relative changes between diameter, number of defective quarters and size of pipe defect.

Definition of sawlog:

A sawlog is defined as any length of a log of merchantable species which:

- is at least 2.7 m in length
- has a small end diameter (measured under bark) of 25 cm or greater
- does not have sweep or crook which exceeds one-fifth of the diameter along a 2.4 m straight edge
- is of grade D standard or better

Definition of sawlog grade

A Grade

Any sawlog with a minimum small end diameter under bark of 50 cm which has no defective quarters and maximum defects on exposed ends of:

- one-quarter diameter lengths of all gum vein or gum pockets
- light stain

In addition:

- maximum angle of sloping grain of 1:10 along the length of the sawlog

B Grade

Any sawlog with a minimum small end diameter under bark of 35 cm which has maximum allowable defects on exposed ends of:

- one quarter diameter length of loose gum veins/pockets and shakes
- one diameter length of tight gum vein more than 3 mm in width
- two diameters length of tight gum vein less than 3 mm in width
- light stain

In addition:

- 1:10 angle of sloping grain along the sawlog axis
- a maximum of one defective quarter along the length of the sawlog
- a maximum of 105 cm squared of pipe in an exposed end.

C Grade

Any sawlog with a minimum small end diameter under bark of 30 cm which has maximum allowable defects on exposed ends of:

- one diameter length of loose gum veins/pockets and shakes
- seven diameters length of tight gum vein more than 3 mm width
- unlimited lengths of tight gum veins less than 3 mm width
- dark stain

In addition:

- maximum sloping grain angle of 1:8 along the length of the sawlog
- maximum of two defective quarters
- maximum of 112 cm square of pipe in an exposed end

D Grade
Any sawlog with a minimum small end diameter under bark of 25 cm which has maximum allowable defects on exposed ends of:

- two diameters length of loose gum veins/pockets or shakes
- 10 diameters length of tight gum vein more than 3 mm width
- unlimited lenght of tight gum vein less than 3 mm width
- dark stain

In addition:

- maximum sloping grain angle of 1:8 along the length of the sawlog
- maximum of three defective quarters
- maximum of 120 cm square of pipe on exposed ends

(NRE 1996)

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Appendix C - Summary of Methodologies

Summary of Methodologies for Assessment of Unidentified Resources

The mineral potential of the study areas has been assessed by determining the types of mineral deposits likely to be found under the geological conditions known or believed to exist there. The general methodology used, described below, was developed by the United States Geological Survey (USGS), and has been used successfully for mineral resource assessments of forest areas in North America and elsewhere. The qualitative methodology for the assessment of potential mineral resources is described by Marsh, Kropschot and Dickinson (1984), Taylor and Steven (1983) and by Dewitt, Redden, Wilson and Buscher (1986).

The qualitative method is essentially the first step of the three-part USGS methodology for quantitative mineral potential assessment, which was thoroughly evaluated and subsequently supported by a panel of experts in 1993. There has been no quantitative assessment in East Gippsland.

An assessment of potential mineral resources of a region combines knowledge of its geology, geophysics, geochemistry, mineral deposits and occurrences with current theories of mineral deposit genesis and results of mineral exploration. The assessment process requires a study of available geoscientific data - for a region to small area, as required - to determine the history of geologic processes and environments. Geologic environments judged to have characteristics known to be associated with specific types of mineral deposits are then identified. In particular the assessment draws on regional and local characteristics of mineral deposit models to establish whether or not specific types of mineral deposits are likely to occur.

The mineral deposit models used in this assessment are generally those published by Cox and Singer (1986). These mineral deposit models are the systematic arrangements of information describing the essential attributes (properties) of groups or classes of mineral deposits. The models used are empirical (descriptive) - the various attributes are recognised as essential even though their relationships are unknown. Each model encapsulates the common features of a group of deposits as these are known from deposits around the world, and is constructed (as far as possible) to be independent of site-specific attributes not common to the group. The value of these models lies in the ability to apply what is known about a group of significant mineral deposits to the known geological environment of the area being assessed.

The assessment takes into account all of the features of the deposit models and whether these features can be recognised in the geoscientific data available for the area being assessed. Local and regional-scale features provide evidence as to whether the geological environment is conducive to, or permissive of, the formation of a given deposit type.

There are probably at least 70 styles of mineral deposits of economic or potential economic significance in Australia, which have distinct features and formed in different ways. It will not be feasible to apply models for all of these deposit classes systematically in each study area. Only the deposit types judged to be most likely to constitute economically significant resources in each area have been assessed in any detail. Where necessary, variations on USGS deposit models (Cox and Singer 1986) can be made to better fit regional circumstances, but this was not found necessary in East Gippsland.

1.1 Qualitatively assessed potential resources

A qualitative assessment of the potential resources of an area is an estimate of the likelihood of occurrence of mineral deposits which may be of sufficient size and grade to constitute a mineral resource.

The mineral potential of an area is assessed for specific types of mineral deposits. For each type of deposit considered in a given area, the mineral potential is ranked in qualitative terms as 'high', 'moderate', 'low', 'no' or 'unknown', based upon professional judgements of geoscientists involved in the assessment. A qualitative mineral potential assessment is not a measure of the resources themselves. It cannot be classified according to the two dimensional ['McKelvey'] diagram used for identified resources. For this reason the qualitatively assessed potential resources are shown in a separate box (Figure 1). The rankings are defined as follows:

H. An area is considered to have a **high mineral resource potential** if the geological, geophysical or geochemical evidence indicate a high likelihood that mineral concentration has taken place and that there is a strong possibility of specific type(s) of mineral deposit(s) being present. The area has characteristics which give strong evidence for the presence of specific types of mineral deposits. The assignment of high resource potential does not require that the specific mineral deposits types have already been identified in the area being assessed.

M. An area is considered to have a **moderate mineral resource potential** if the available evidence indicates that there is a reasonable possibility of specific type(s) of mineral deposit(s) being present. There may or may not be evidence of mineral occurrences or deposits. The characteristics for the presence of specific types of mineral deposits are less clear.

L. An area is considered to have a **low mineral resource potential** if there is a low possibility of specific types of mineral deposit(s) being present. Geological, geophysical and geochemical characteristics in such areas indicate that mineral concentrations are unlikely, and evidence for specific mineral deposit models is lacking. The assignment of low potential requires positive knowledge and cannot be used as a valid description for areas where adequate data are lacking.

N. The term **'no'** mineral resource potential can be used for specified types of mineral deposits in areas where there is a detailed understanding of the geological environment and geoscientific evidence indicates that such deposits are not present.

U. If there are insufficient data to classify the areas as having high, moderate, low or no potential then the mineral resource potential is **unknown.**

To reflect the differing amount of information available, the assessment of mineral potential are also categorised according to levels of certainty, denoted by letters **A-D** (Figure 1).

A. The available data are not adequate to determine the level of mineral resource potential. This level is used with an assignment of unknown mineral resource potential.

B. The available data are adequate to suggest the geologic environment and the level of mineral resource potential, but either the evidence is insufficient to establish precisely the likelihood of resource occurrence or the occurrence and/or genetic models are not well enough known for predictive resource assessment.

C. The available data give a good indication of the geologic environment and the level of mineral resource potential.

D. The available data clearly define the geologic environment and the level of mineral resource potential.

Figure 1: Relationship between levels of resource potential and levels of certainty

H/D	H/C	H/B	U/A
HIGH POTENTIAL	HIGH POTENTIAL	HIGH POTENTIAL	
M/D	M/C	M/B	
MODERATE	MODERATE	MODERATE	

POTENTIAL	POTENTIAL	POTENTIAL	
			UNKNOWN
L/D	L/C	L/B	POTENTIAL
POTENTIAL LOW			
	LOW	LOW	
N/D	POTENTIAL	POTENTIAL	
NO POTENTIAL			
D	C	B	A

Decreasing level of certainty

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Appendix D - Identified Resources

Identified Resources And Known Styles of Mineralisation

1 History of mining

1.1 Gold

In East Gippsland, gold mining first started within the Bendoc region, where alluvial gold discoveries were first made during 1851 to 1852 by the Reverend W. C. Clarke. The first claim was made at the site of Bendoc town (then known as Waggra) in 1855 and gold was discovered on the Bendoc River in 1856-1857. More discoveries soon followed in Bonang area with major rushes in 1876. Other alluvial gold localities include Blackwatch Creek, Boulder Creek, Brodribb River, BA Creek and Cabbage Tree Creek (VandenBerg et al. 1992). Good returns of gold were reported from alluvial mines at Combienbar and the Mackenzie River (VandenBerg et al. 1995).

The first reef at Bonang, the Rising Sun, was discovered in 1866 followed shortly by the Morning Star and Come Love reefs (VandenBerg et al. 1992). Other discoveries of reef gold were made at Clarkeville (1889), Boulder Creek (1897) and at Club Terrace (1895). Gold was also mined in diorite and quartz lodes at the Holly reef and Spotted Dog in 1894, on the eastern shoreline of Mallacoota inlet.

Gold mining has continued in East Gippsland sheet area for over 100 years, spanning 1851 to the present day, with the majority of the activity occurring before 1900. The last of the significant mines, the Victoria Star reef at Bendoc, was worked from 1911-1938 to produce 141 kg of gold, with an average grade of 51 g/t. This effectively marked the end of company reef mining in the Bendoc district, although several small current operations are still worked intermittently.

The Bendoc area is currently being explored by Zephyr Minerals N.L. who have reported intersections of gold and anomalous base metal values.

The discovery in 1893 of silver in the Tara Range south of Buchan, led to the opening up of gold reefs at Mount Tara and Kanni Creek from 1896 (VandenBerg et al. 1996). The Tara Goldfield operated throughout the early 1900s but had largely been abandoned by the 1920s with only sporadic activity continuing up to present.

Recorded gold production for East Gippsland is summarised in Table 1. These figures are incomplete as alluvial gold production was not recorded during the period 1855 to 1887 when the majority of alluvial gold was won. It is presumed that some thousands of kilograms were mined during this period. Production records for reef mining are also incomplete and it is estimated that total reef production was in the order of 1 000 kg of gold (VandenBerg et al. 1992).

1.2 Other metallic minerals

In the Buchan area, a lease was taken up in 1869 to mine galena in 1871. Additional leases were taken up in the area for silver and lead but the poor quality of the ore required concentration or on site smelting. By 1876 most of the silver-lead mines had been abandoned. Another burst of mining activity took place in the mid 1880s when a smelter was established at the Hume Park mine, and many of the silver-lead mines, especially those at Back Creek, treated their ore there. The silver-lead mines in the Buchan area were worked intermittently until the 1940s by prospectors.

In 1887, mining leases were taken up for iron near Nowa Nowa and 2 tons of ore were forwarded for testing. These mines were worked briefly for iron during 1900. Much later, small tonnages of hematite were mined from the Seven Mile iron ore deposit and sold for industrial use in Melbourne.

Other metallic minerals mined in East Gippsland include small deposits of wolframite, barite and molybdenum.

Manganese was briefly mined from 1910 to 1911 in the vicinity of Iron Mask.

Table1: Recorded Reef Gold Production in East Gippsland CRA

Mine Name	Main	Alluvia of l/ Reef	Recorded (kg)*	Production (g/t)	Average Grade
Mountain Maid reef	B.A. Creek	1897	Reef		7
Mt Lyell reef	B.A. Creek		Reef		30 -120
Reward reef	B.A. Creek		Reef		15 - 45
White Star	B. A. Creek		Reef		30
Bonanza reef	Bonang	1892 -1905	Reef	54.9	27
Croesus reef	Bonang (east of)	1888 - 1889	Reef	1.8	51
Duke of Westminister reef	Bonang	1889	Reef	12.7	57
Rising Sun reef	Bonang	1866 - 1897	Reef	183.1	33
South Bonanza reef	Bonang	1899 - 1904	Reef	38	209
Come Love reef	Bendoc	1866 - 1872	Reef	30.3	25
Dunlop	Bendoc (east of)	1912	Reef	1.7	15
Eclipse reef	Bendoc	1887 - 1889	Reef	7.7	78
Jamieson's IXL reef	Bendoc (east of)	1948 - 1954	Reef	0.56	47
Lower Bendoc - Hydraulic Sluicing	Bendoc	1948 - 1952	Alluvial	13.4	
Morning Star reef	Bendoc	1866 - 1870	Reef	9.4	15
Splitters Creek	Bendoc		Reef		
Victoria Star reef	Bendoc	1911 - 1938	Reef	141.0	51
Welcome Stranger reef	Bendoc	1888 - 1915	Reef	25.3	68
New Discovery reef	Clarkeville	1890 - 1903	Reef	26.1	28
South Discovery reef	Clarkeville	1890	Reef		90
Sunbeam reef	Clarkeville	1891 - 1898	Reef	9.3	47
B.A. Creek			Reef/Alluvial		
Bemm River			Alluvial		
Boulder reef		1897 - 1907	Reef	123.2	55
Buldah			Alluvial		
Cabbage Tree Creek			Alluvial		
Club Terrace - Birthday reef			Reef	52.7	
Cobon Creek		1898	Alluvial		
Combienbar reef			Reef	3.7	
Delegate River		1898	Alluvial		
Genoa Creek		1898	Reef		
McKenzie River			Alluvia		

			l		
Poddy Creek			Alluvial		
Quadra Creek		1898	Alluvial		
Thurra River		1898	Alluvial		
Wingan River		1898	Alluvial		
Tara goldfield	Buchan	1904-1905	Reef//?	7.1	All
Tara Crown (Armistice)	Buchan	1917-1920	Reef//?	26.7	All

Limonite was intermittently extracted from McRae's ironstone quarry from 1955 until 1970 with the product sent to West Melbourne for use as a scrubber for town gas (Cochrane 1982).

Five separate lenses of barite were discovered at the Boulder Flat prospect 1. A few hundred tonnes of the material was extracted from 1982-1986 from shallow open cuts and used in drilling muds for the Bass Strait oil fields (Buckley et al. 1994).

Tungsten was first mined at Mount Bendoc in 1910-1918 and the only recorded production was 840 kg of wolframite from 52 tonnes of hand-picked ore in 1915 and 1916 (VandenBerg et al. 1992).

At least 11 tonnes of molybdenum was mined at Wangarabell between 1910 and 1921.

1.3 Other commodities

The most significant mining for other commodities in the past has been for limestone in the Buchan area for industrial and agricultural use. Most rock types such as granite, volcanics, gravel, sand and limestone have been used for road maintenance and construction materials. Limestone and granite have also been used for dimension stone in the past.

2 Styles of mineralisation of known mineral

occurrences and deposits.

There are about 200 mineral occurrences, deposits and old mines in the East Gippsland CRA (Table 2). The main commodities are gold, base metals, and a few molybdenum and tungsten occurrences in the far east of the region.

Known gold mineralisation is largely concentrated in the northern central part of the region in several goldfields at Bonang, Bendoc, Clarkeville, BA Creek, and at Tara in southwest.

Base metal occurrences and deposits are known to occur in three main areas in East Gippsland. In the western part of East Gippsland copper, lead and zinc are widespread in the Lower Devonian Snowy River Volcanics. At some of the occurrences base metals are associated with silver, gold and barite.

The most significant base metal province in Victoria lies in the Limestone Creek Graben just outside the far north-west corner of East Gippsland. The province contains two copper-zinc-silver deposits at Wilga and Currawong. Part of the Limestone Creek Graben extends into the East Gippsland CRA.

The economic geology of East Gippsland has been described and summarised in reports by VandenBerg & O'Shea (1981), VandenBerg et al. (1992), VandenBerg et al. (1995), VandenBerg et al. (1996), Buckley et al. (1994), Oppy et al. (1995) and Orth et al. (1995).

On a regional scale, base metal and gold occurrences and deposits appear to be concentrated in the western half of the East Gippsland CRA where there is a greater density of north-east and north-south trending structures. Tungsten and molybdenum occurrences are more conspicuous in the eastern half of the region where the regional geology is dominated by Late Silurian to Early Devonian granites which form the Berridale and Bega Batholiths.

Styles of mineralisation described in the area are as follows:

2.1 Alluvial gold

In East Gippsland gold mining was largely concentrated within the principal goldfields of Bonang, Bendoc, Clarkeville, Boulder, B.A. Creek. VandenBerg et al. (1992) describe alluvial workings in the Bendoc 1:100 000 map sheet area as widely distributed over floodplain areas and rarely concentrated in drainage channels. Worked deposits reveal 'immature quartz washes, including sub-angular slate and sandstone clasts'. Alluvial gold production in East Gippsland was generally not recorded but could have been of the order of several thousand kilograms. If a ratio of alluvial/reef gold production, similar to that in other areas of the State, is used for the East Gippsland Region then alluvial production of at least 2000 kg is likely.

The small Tara Goldfield occurs in the south-western part of East Gippsland CRA.

Sediments of Late Tertiary and Quaternary age (about 5Ma to present) are widespread along the foothills and the coastal plain of East Gippsland CRA. Although the region has been prospected for alluvial gold deposits in the past, it still has a moderate to high potential for further concealed alluvial gold deposits.

2.2 Reef gold

Reef gold occurs as primary deposits hosted by quartz veins within deformed Ordovician bedrock. VandenBerg et al. (1992) consider the earliest emplacement of primary gold-quartz mineralisation to have occurred during the Early to Middle Silurian Benambran Deformation, after the most severe folding had taken place. Hydrothermal fluids formed during low-grade metamorphism are thought to be responsible for gold deposition, which occurred within favourable strain sites such as shear zones, tension fractures and fold hinges. The authors describe mineralisation as extending through to the Middle Devonian, to account for nearby gold deposits associated with later fault activity.

This style of mineralisation is represented by the 'low-sulphide Au-quartz vein' model commonly referred to as the 'slate belt' quartz vein gold deposits or 'reef gold', similar to those of Bendigo and Ballarat in eastern Victoria.

Details of the major goldfields is presented in VandenBerg et al. (1992) and production is summarised in Table 1. The larger workings from each of the major goldfields is summarised below.

2.2.1 Bendoc Goldfield

The Bendoc Goldfield includes major reef workings such as the Victoria Star/Victoria Reef, Morning Star, Welcome Stranger, Come Love, Eclipse and Bendoc Star. The goldfield consists of 13 worked reefs occurring within a 5 km by 1 km elongated, north-south trending belt. The reefs strike between north and north-east, with steep easterly or westerly dips. This group of reefs appears to be constrained by regional north-east trending folds. Total recorded reef production as listed by VandenBerg et al (1995) is about 216 kg with another 13 kg recorded from alluvial gold production.

The area is currently being explored by Zephyr Minerals N.L.. In April 1996, the company reported a small inferred gold resource of 250 000 t of ore with a grade of 2 g/t. The company also noted that additional drilling results were still being assessed (Zephyr Minerals N.L. 1996). Anomalous values of zinc were also report by the company in earlier reports (Zephyr Minerals N.L. 1995).

2.2.2 Bonang Goldfield

The Bonang Goldfield is narrow and elongate, trending north north-east for a distance of over 20 km to the State border. Whilst there is no observed structural feature coincident with the alignment of the Bonang goldfield, locally reef gold appears to be associated with faulting. The northern section of the Bonang goldfield around Roaring Camp is dissected by the McLaughlin Creek Fault Zone, but the Pioneer and Cambrian mines occur along the inferred Bonanza Gully Fault. Both these faults have shown significant strike-slip and/or dip-slip movement in the Middle Devonian and could have provided pathways for mineralisation (VandenBerg et al. 1992).

On a regional scale the Bonang Goldfield occurs close to the intersection of the northeast trending Yalmy-McLauclan Creek Fault zones with the northwesterly trending Deddick River Fault.

The Bonang Goldfield includes the largest number of mines in the area, including the largest producer, the Rising Sun mine. This reef was worked to a depth of 150 m. It has the deepest workings and is the largest producer in the East Gippsland region, with a recorded production of 183.1 kg of gold. The reef was variously reported to increase in width with increasing depth and vary from 0.3 to 3.0 m wide. It returned an average grade of 33 g/t (VandenBerg et al. 1992).

Other reefs worked in the past include Duke of Westminster, Bonanza, Clancy's and Croesus. The reefs within these mines are described as dipping steeply east or west and striking predominantly north to northeast. Host rocks to the reefs are generally metamorphosed sediments but the Clancy's reef was in a granitic intrusive. Total recorded reef production for the Bonang Goldfield (Table 1) is about 290 kg (VandenBerg et al. 1995).

2.2.3 Clarkeville Goldfield

The Clarkeville Goldfield is narrow and elongate, comprising at least ten worked reefs aligned in a north-easterly direction for over 2 kilometres. It lies on the north-western limb of a regional north-east trending anticline. Vandenberg et al. (1992) state that `In most cases the reefs are sub-parallel to the strata which generally dip north-west. The reefs were noted as being "disturbed and shattered" occurring in very faulted and "broken country"'. From this description it appears that the emplacement of the Clarkeville reefs was fault-controlled, although outcrop on this part of the Errinundra Plateau is very poor and consequently no structure could be discerned (VandenBerg et al. 1992). The Clarkeville reefs occur in close proximity to the fold hinge and may be attributed to regional tectonics, with gold deposition by migrating fluids.

On a regional scale the goldfield lies adjacent to north-east trending structures.

The main gold workings were New Discovery, Sunbeam and Waggra and total recorded production from reefs is about 35 kg (VandenBerg et al. 1995).

2.2.4 Club Terrace

Several steeply dipping reefs up to 0.6 m wide have been worked in the area. Although production statistics are incomplete, the Birthday Reef was noted as one of the larger workings with 1740 tonnes of quartz producing 52.7 kg of gold (Buckley et al. 1994).

2.2.5 Boulder Mine

The Boulder Mine, north of Club Terrace, is different from other gold reefs in the area, being situated within the Kuark Metamorphics. The reefs are boudinaged from extension after introduction of the quartz, indicating that the gold was deposited before the end of the Middle Silurian metamorphic event (Buckley et al. 1994). VandenBerg et al. (1992) describe the mine workings as revealing several generations of quartz veins, some of which are highly deformed. The Boulder reef had an average grade of 55 g/t and an average width of 1.2 m. The strike of the main reef was north-east and it dipped gently to the south-east. The reef was worked by four separate adits, but the lowermost adits revealed relatively little gold (VandenBerg et al. 1992).

2.2.6 BA Creek Reefs

These reefs include the Mount Lyell, Mountain Maid, Reward and White Star and were only prospected to shallow depths. No production was recorded from these reefs (VandenBerg et al. 1992).

2.3.7 Tara Goldfield

Gold in this part of the East Gippsland CRA, occurs as primary deposits hosted by quartz veins in Ordovician metasediments (Pinnak Sandstone) as well as epigenetic veins and disseminated pyrite in the Snowy River Volcanics (VandenBerg et al. 1996). Total recorded primary gold production is about 34 kg (Buckley et al. 1994).

2.3 Epithermal gold, silver mineralisation

Low temperature quartz vein gold-silver deposits with variable base metal mineralisation have been recognised in the Snowy River Volcanics (Orth et al. 1995). Silicification, clay-sericite-chlorite alteration and brecciation, characteristic of epithermal deposits are typically developed. These deposits are considered likely to have formed during the waning stages of the Early Devonian igneous activity. Deposits with typical epithermal alteration are Glen Shiel silver mine (Ag), W-Tree Creek prospect (Au), Pyramid Mountain prospect (Au) and Halls Peninsula prospect (Cu,Au) (Buckley et al 1994).

2.4 Volcanic hosted massive sulphide base metal mineralisation

Stratabound base metal deposition in volcanic rocks in the East Gippsland CRA took place during two periods of volcanic activity.

The first period of base metal mineralisation was in the Late Silurian when volcanic hosted massive sulphide base type base metal deposits were formed in Gibsons Folly Formation along the northwestern margin of the Limestone Graben just outside the northwestern corner of the East Gippsland CRA. These deposits include Wilga (3.00 million tonnes of resource at 2.7% Cu, 0.5% Pb, and 6.2% Zn (Caluzzi 1995)) and Currawong (8.84 million tonnes at 1.9% Cu, 0.7% Pb, 4% Zn and 38 g/t Ag and 0.8 g/t Au (Wilkinson 1995)). Mining of the Wilga deposit commenced in 1992.

The south-eastern margin of the Limestone Graben occurs within the East Gippsland CRA, but the Gibsons Folly Formation is not known to occur along this margin.

The second period of stratabound base metal deposition in volcanic rocks took place in Early Devonian and is associated with volcaniclastic members in the upper part of the Snowy River Volcanics and in volcaniclastics in the basal unit of the Buchan Group. These volcaniclastics frequently contain stratiform base metal mineralisation and include the Blue Bullocks Creek, New Guinea and Shaw's Gully prospects. Detrital sphalerite and galena together with enriched manganese, barium and silver values occur within waterlain tuffs, pyritic shales and intraformational breccias (Buckley et al 1994).

Oxidation along specific stratigraphic horizons of the Snowy River Volcanics has resulted in the formation of the iron-manganese deposits at Oxide and Iron Mask Mines. Minor associated Cu-Pb-Zn-Ag-Ba mineralisation has also been noted at these deposits.

2.5 Stratabound base metal mineralisation in carbonate rocks (Irish-style base metal mineralisation)

Several small stratabound lead-zinc deposits are hosted by basal dolomites and dolomitic limestones of the Buchan Group. Typical examples include the Hume Park, Pyramids and Back Creek mines which were first worked at around 1870, and the Neils prospect. There is evidence of at least minor contemporaneous volcanic activity during the initial stages of limestone deposition (Orth et al. 1995).

These deposits have similar settings and styles to the Irish carbonate hosted stratabound lead-zinc deposits. They are generally stratabound, and show varying mineralisation styles from syndiagenetic (replacement and cavity fill) to locally syngenetic (exhalative) and epigenetic (breccia type). There are also geochemical similarities between the two provinces, with the Irish deposits also showing enrichment in iron and silver and occurring in dolomitised host rocks.

Remobilisation of the Buchan limestone-hosted mineralisation into fractures and bedding plane slips probably took place during the Tabberabberan Deformation when the rocks were gently folded.

Oxidation of stratiform/stratabound pyrite lenses in interbedded limestone and tuffaceous beds has produced the iron deposits of Cocks Limonite, McRaes Limonite and Gilbert Road Ironstone. These deposits were most likely associated with minor volcanism during the formation of the Buchan Caves Limestone. Accessory Cu, Pb, Zn, Ag and Ba has been identified this mineralisation (Buckley et al. 1994).

In the Boulder Flat Graben, stratabound base metal mineralisation has been located in the basal sections of the Boulder Flat Limestone (Errinundra Group) where the Boulder Flat 1 and 2, Zinc Hill, Gibson Creek and possibly Crabhole prospects occur. Mineralised outcrops mainly comprise galena and sphalerite in gossanous material or within lenses and veins of barite. The mineralised zone is 15-30 metres wide and has been traced discontinuously for more than 3 km. Limestone, extensively veined with barite occurs both above and below the more concentrated baritic zone and copper mineralisation is observed in the southern section of the limestone sequence (Buckley et al. 1994, VandenBerg et al. 1992).

2.6 Epigenetic vein mineralisation

This style of mineralisation is generally associated with structurally controlled dacite-rhyolite porphyry dyke swarms belonging to the Snowy River Volcanics which suggest an Early Devonian mineralising event (Buckley et al. 1994).

Typical prospects include Tiger Creek, Red Steer and Scorpion Creek where copper is associated with variable amounts of molybdenum and gold; the quartz-gold lodes of the Mount Tara area and the barite veins of Balley Hooley Hill, Glen Shiel and Tulloch Ard. Other deposits include the Deddick silver-lead field and Campbell's Knob copper-lead-zinc field. The mineralisation is generally associated with fracture systems, veinlets or disseminations through the host rock. Host rocks include granitoids as well as the adjacent country rock, but the fracture systems and the hydrothermal mineralisation are significantly younger than the granitic intrusions (Buckley et al. 1994, Orth et al. 1995). Near Tubbut, quartz reefs with minor copper mineralisation occur in granodiorite and are considered to be produced by hydrothermal action associated with the Snowy River Volcanics (VandenBerg et al. 1992).

2.7 Mineralisation associated with igneous rocks - Porphyry copper, gold, molybdenum

Porphyry copper mineralisation is associated with granitic intrusions following the Quidongan phase of the Benambran deformation. Several porphyry systems have been identified in the eastern part of the East Gippsland CRA. These include the Sunday Creek, Double Bull Creek, Dogwood, and Mount Buck prospects and the Booths Fancy Mine. Porphyry copper type alteration has been identified in the Mount Elizabeth area east of the East Gippsland CRA, but no significant mineralisation has been located to date. These prospects are associated with multiphase, magnetic I-type granite to diorite stocks, sills and dykes with associated quartz-sericite-kaolin-chlorite-epidote hydrothermal alteration. Pyrite and copper minerals are general disseminated through the intrusion and adjacent fractured country rock as well as occurring within quartz veinlets, brecciated zones and shears. Minor molybdenum and gold mineralisation has also been identified in these porphyry systems but the potential for gold has in such systems in the East Gippsland CRA has not been fully explored (Buckley et al. 1994; VandenBerg et al. 1996).

Porphyry copper style mineralisation also occurs in Ordovician metasediments as at Pinnak, Paradise Ridge, Goanna and Little Yalmy prospects.

2.8 Other mineralisation associated with igneous rocks

This style of mineralisation includes occurrences and minor deposits of molybdenum and tungsten thought to be derived from granitic rocks.

This style of mineralisation occurs at the Bendoc wolfram mine which recorded a production of 840 kg of wolframite from 52 tonnes of ore. The wolframite occurs within a series of sub-parallel quartz veins in Ordovician metasediments and hornfels. Bismuth is also present at this prospect. The mineralisation occurs on Mt Bendoc which is a hill of hornfels and is presumed to overlie a granitoid stock at shallow depth. Tungsten mineralisation is thought to have occurred through late-stage magmatic fluids emanating from this intrusion (VandenBerg et al. 1992).

Molybdenite-bearing quartz veins near Wangarabell were worked in 1920 to a maximum depth of 24 m. Mineralisation within this lode includes molybdenite, iron pyrites and muscovite. The lode is associated with an adjacent granitoid body which contains smaller molybdenum-bearing quartz veins. Specks of free molybdenum were observed on the face of the granite (VandenBerg et al. 1995).

Narrow quartz ± copper ± tungsten ± molybdenum ± bismuth veins associated with granitoid intrusions have been identified at various other locations throughout the Mallacoota map sheet area. These include Mt Cavell (bismuth), Cabbage Tree Creek (molybdenum), Mangan Creek (molybdenum and tungsten) and Genoa Peak (tungsten and molybdenum). Extensions of this narrow vein mineralisation have not been fully investigated by modern exploration methods (VandenBerg et al. 1995).

2.9 Iron

The iron ore at the Two, Five, Six and Seven Mile deposits at Nowa Nowa occur as replacement deposits in ignimbrite. Recent field investigations indicate that the hematite in these deposits is of replacement origin, mostly within a single volcanic unit, the Tomato Creek Ignimbrite of the Snowy River Volcanics.

The Two Mile deposit consists of micaceous hematite with varying amounts of magnetite, limonite, jasper, quartz and rare pyrite. A test batch of 300 t of ore extracted from an open cut assayed 62.1% $Fe2O3$. Iron ore resources of the deposit were calculated at between 11 000 and 50 000 t (VandenBerg et al. 1996).

The Five Mile deposit has a very strong aeromagnetic anomaly and the deposit occurs as a massive siliceous magnetite-hematite body in a fault bounded wedge. Mineral assemblages consist of magnetite, micaceous hematite, minor pyrite and traces of chalcopyrite. It was considered that the presence of a lenticular zone of significant copper mineralisation may indicate that base metal accumulations are close to the magnetite-haematite bodies in the host sequence. The total mineable resources have been estimated as 4.69 Mt at a grade of 52% iron from the southern deposit and 0.5 Mt at 52.6% iron from the northern deposit (VandenBerg et al. 1996).

The Six Mile deposit consists of magnetite and micaceous haematite and lies close to the Kanni Fault.

The Seven Mile deposit has a strong aeromagnetic and consist of limonite, micaceous hematite and magnetite with an auriferous gossan developed over the eastern boundary. Estimated the total mineable resources have been estimated as 0.93 Mt at a grade of 48.9% iron (VandenBerg et al. 1996).

Previously these deposits were variously interpreted as being skarn type deposits formed by hydrothermal fluids from intrusives interacting with limestones; or as representing volcanic related deposits. Small scale patchy replacement is pervasive in the region, but there is no evidence that this is related to the presence of limestone, which is only known to occur in the Five Mile deposit (VandenBerg et al. 1996).

Minor iron occurrences are associated with oxidised stratabound and syngenetic pyrite lenses in the Buchan Caves Limestone. Iron minerals include magnetite, specular hematite, pyrite and limonite. Minor gold and copper values have also been reported.

2.10 Barite

In the eastern part of the East Gippsland CRA barite is widespread in the Snowy River Volcanics and in the overlying Buchan Caves Limestone of the Buchan Group. Most of the barite occurrences have elevated base metal values in barite-quartz-sulphide mineralisation. The association of these occurrences with hydrothermally altered and partly brecciated host rocks suggest that mineralisation was derived from late stage volcanic activity as at Bally Hooley Hill and Tulloch Ard (Orth et al. 1995). Barite also occurs in Snowy River Volcanics at Kanni Creek and has been reported at Iron Mask as blocks in ironstone and as separate veinlets. It has also been reported as a gangue mineral in silver-lead-copper mines and prospects in the Buchan area including the Good Hope, Neils Creek and Back Creek areas and McRae's Limonite quarry (VandenBerg et al. 1996).

In the Boulder Flat Graben, limestone-hosted barite mineralisation is associated with stratabound base metals at Boulder Flat prospect 1. A few hundred tonnes of barite was mined during 1982-86 for use in drilling muds for the Bass Strait oil fields (Buckley et al. 1994). About 20 tonnes of barite were mined at Glen Shiel around 1920.

2.11 Limestone

Large resources of high grade limestone occur within the Buchan Caves Limestone and the Murrindal Limestone of the Buchan Group. Teichert and Talent (1958) documented about fifteen outcrop areas of massive, high grade limestone that may be suitable for quarrying. Such deposits have not been tested in detail, and the siting of new quarries would have to take into account environmental considerations and the possible presence of caves.

The lower formation, the Buchan Caves Limestone consists of almost pure limestone and dolomitic limestone 180-210 m thick (Teichert and Talent 1958). Most of the limestone is a calcarenite, with pure dolomite and dolomitic limestone occur at the base of this formation. This limestone is of considerable economic importance because of the relative high purity and extent of outcrop. The calcarenite has the greatest potential for industrial use, as it is relatively free of insolubles, muddy intercalations, quartz sand and carbonaceous matter (McHaffie and Buckley 1995).

Hard crystalline limestone has been quarried from Cameron's and Heath's quarries at Buchan South and at Rocky Camp, 5 km north of Buchan, and used as dimension stone in building, construction and monumental industries. High quality limestone from Buchan South has also been used in paper manufacture. The Rocky Camp Limestone is currently quarried for production of quicklime, flux, stock feed, paper manufacture and agricultural purposes. Geochemical testing also indicates this unit is suitable for use in polymers, but the high iron content may preclude its use in paper and paint. Parts of the Buchan Caves Limestone may reach sufficiently high grade for use as lower grade general fillers where brightness is not important (Buckley et al. 1994).

A limestone of Tertiary age occurs between Bairnsdale and Orbost. It forms a continuous sub-surface sheet, and to the north the limestone grades into sand and gravel. The higher purity limestone is a soft, porous, earthy, highly fossiliferous, yellow-orange coloured rock which grades laterally and vertically into impure calcarenite and marl. As of June 1995, three commercial operations intermittently extract Tertiary limestone for agricultural purposes and there are many other disused pits scattered throughout the area (VandenBerg et al. 1996).

2.12 Dolomite

The dolomitic basal part of the Buchan Cave Limestone crops out at Buchan East where a very pure dolomite several metres thick passes upwards into normal limestones by a progressive decrease in the proportion of dolomite (Teichert and Talent 1958). Sporadic dolomitisation also occurs at higher levels in the limestone (McHaffie 1976). Dolomite, depending on its chemical properties, is used for aggregates, construction materials, agriculture, chemical and metallurgical purposes, glassmaking and fillers (McHaffie and Buckley 1995). Commercial grades of dolomite contain 20 to 45% MgO. An analysis of dolomite from the basal beds of the Buchan Caves Limestone shows 54% $CaCO3$, 43.6% $MgCO3$, 0.7% $SiO2$ and 1.9% $Al2O3$ & $Fe2O3$ (VandenBerg et al. 1996).

2.13 Heavy mineral sands

Several thin and discontinuous seams of heavy mineral sand occur at Point Pearl, Cape Conran, Betka River and Point Hicks. Average grades of 16.7% (0.45% $CrO2$) and 1.9% (0.15% $CrO2$) occur at Point Pearl and Cape Conran, respectively. Overall, the heavy mineral fraction is dominated by ilmenite, with minor zircon and rutile. These strand line accumulations occur on beaches and dunes near the headlands and are very localised. Ancient shorelines, inland from the present coastline, can be detected inland on airborne radiometric images, possibly due to monazite. Heavy mineral concentrations may be associated with these inland shorelines.

Copland (in Vandenberg et al. 1992) describes a thin layer of monazite sand, containing 0.02 % monazite grading to 6% thorium, overlying bedrock at 1.5 and 2.7 m depth at the headwaters of Pinch Swamp Creek. This occurrence is thought to be derived from the Bonang Granodiorite aureole (VandenBerg et al. 1992).

2.14 Dimension stone

An outcrop of medium grained, feldspar rich, pink granite is observed at Cann River. Exposed faces of this granite reveals close jointing which makes it unsuitable for use as a dimension stone. The granite has been intermittently quarried for use as beaching stone for bank reconstruction of the Cann River by the East Gippsland River Management Board between 1978 and 1991. However, joint patterns within this granite vary and further exploration may reveal suitable regions of the granite for use dimension stone.

The Orbost Trondhjemite has been quarried and used as the base course of the now demolished Commonwealth Bank (Collins Street) in Melbourne 1923. The original quarry, north of Princes Highway, has been expanded for roadworks and the granite shows considerable jointing which, together with inclusions of other rocks, reduces its attraction as a dimension stone (VandenBerg et al. 1996).

The Bete Belong and Double Bull granites may have a limited potential as a dimension stone. The best exposures in the Snowy River consist of rectangular tors 2 m high and 1 m wide, in medium to coarse grained pale coloured granite with a weak porphyritic texture and rare inclusions of other rocks (VandenBerg et al. 1996).

According to VandenBerg et al. (1992), the Wibenduck Limestone in the Sardine Creek Graben contains a small deposit of marble which has the potential to yield attractive monumental stone.

2.15 Pyrophyllite

The Snowy River Volcanics have the potential for economic deposits of pyrophyllite for which there has been no comprehensive exploration program yet (McHaffie and Buckley 1994). Pyrophyllite is a refractory mineral and is used in the steel making and ceramic industries as well as a filler and insecticide carrier. Generally the mineral is mainly found in acid volcanics, as a hydrothermal or metasomatic alteration product and is controlled by preferred solution pathways formed by faults or shears. Most of the Snowy River Volcanics have undergone some degree of devitrification and alteration. Detailed exploration work over gold prospects in the volcanics has identified some intense hydrothermal alteration zones at Nowa Nowa, Armistice, Monarch of Tara workings and the Blue Spur area centred on a major shear zone developed in Ordovician sediments. Shearing, silicification and pyritic and argillic alteration (alunite, kaolinite, pyrophyllite) occur along the Gilbert Fault especially, and elsewhere at the Blue Spur prospect and along the Carson Creek Fault(VandenBerg et al. 1996).

2.16 Construction materials

There has been extensive extraction of construction materials for road making purposes such as the construction, upgrading and maintenance of the Princes Highway. Ordovician and Silurian sandstone is widely used for minor road and track maintenance (Lands Conservation Council 1985). Douglas (1974) reported on the use of most rock types for road making purposes including granitic rocks, volcanics, dykes and Tertiary sands and gravels.

A single commercial hard rock quarry at Nowa Nowa operates under the ***Extractive Industries Act 1966***. The operation extracts ignimbrite for road base, sealing aggregate and railway ballast.

Pits and quarries also operate under provisions of the ***Forests Act 1958*** or the ***Land Act 1958*** on public land. The Department of Conservation and Natural Resources (DCNR) controls numerous operations under these Acts for the maintenance and construction of an extensive network of forest roads and tracks. Approximately 40 300 t of low grade gravel was extracted for this purpose in the financial year ending June 1994. Many of the extraction sites are used periodically depending on needs. There are no production records from most small gravel pits but the volumes involved are mostly insignificant (VandenBerg et al. 1996).

The quarrying of construction materials is also controlled by local municipalities under the ***Local Government Act 1989***. The Shire of Gippsland obtains its construction materials from commercial operations and from pits located on public land controlled by DCNR (VandenBerg et al. 1996).

Crushed rock and sand is currently extracted from many locations including Goongerah Creek, Boulder Flat, Pyramid Creek and Deddick Road and is used locally, primarily for road making (VandenBerg et al. 1992).

The demand for construction materials could increase dramatically it there is a new large-scale infrastructure project such as a new intercapital rail link (VandenBerg et al. 1992).**Table 2**

List of mineral occurrences, old mines and deposits in East Gippsland (Figures 14, 15 and 16)

LOCATION No.	LATITUDE	LONGITUDE	MINERAL LOCATION NAME	COMMODITIES
1	36.9254	148.1194	JAMES FLAT	Cu, Pb
2	36.896	148.0819	NATIVE DOG PLAIN	Cu
3	36.896	148.082	NATIVE DOG FLAT	Cu
4	37.03	148.746	CAMERONS (BLUE LINE)	Au
5	37.04	148.745	ROARING CAMP (LUCK OF ROARING CAMP)	Au
6	37.044	148.786	GOOD LUCK (COOLGARDIE)	Au
7	37.0511	148.1752	UPPER BUCHAN RIVER PYRITE	Fe
8	37.0534	148.7814	CAMBRIAN (CONFIDENCE)	Au
9	37.054	148.743	CHANCE (LAST CHANCE)	Au
10	37.0635	148.5095	DEDDICK RIVER	Ba
11	37.0649	148.7671	PIONEER (NEW PIONEER)	Au
12	37.0657	148.4083	MT BULLA BULLA*	Cu
13	37.0667	148.7407	BONANZA	Au, Pb
14	37.068	148.586	TUBBUT	Cu
15	37.0685	148.7396	SOUTH BONANZA	Au
16	37.0947	148.3953	DEDDICK SILVER-LEAD FIELD	Pb, Zn, Ag
17	37.098	148.7577	PINCH SWAMP CK MONAZITE	HMS
18	37.1	148.727	EXHIBiTION	Au
19	37.101	148.733	MARRIOTS	Au
20	37.1051	148.4979	ACCOMMODATION CREEK COPPER MINE	Cu
21	37.1054	148.7444	BONANG GOLDFIELD	Au
22	37.1073	148.911	DELEGATE HILL - TEAGUE'S TUNNEL	Au
23	37.11	148.911	DELEGATE HILL - SPENCE'S SHAFT	Au

24	37.1103	148.8908	DELEGATE HILL - WESTERN TUNNEL	Au
25	37.1129	148.7232	AUSTRALIAN	Au
26	37.113	148.731	LUCK AND LEISURE (VICTORIA)	Au
27	37.12	148.73	NEW CHUM	Au
28	37.135	148.728	WHO'D A THOUGHT IT (PRINCE OF WALES)	Au
29	37.1438	148.8849	BENDOC UNITED	Au
30	37.1453	148.7261	ALBERT (ROSEBUD)	Au
31	37.1457	148.8759	TUCKER	Au
32	37.1459	148.9784	DUNLOP (MULLOCKY REEF)	Au
33	37.1475	148.349	SNOWY RIVER*	Pb, Zn
34	37.1494	148.8692	COME LOVE	Au
35	37.1494	148.8737	MORNING STAR (EVENING STAR)	Au
36	37.1518	148.9459	MOUNT BENDOC	W
37	37.1518	148.9459	MT BENDOC WOLFRAM MINE	W, Bi
38	37.1556	148.8806	HOMEWARD BOUND	Au
39	37.16	148.87	BiSMARK	Au
40	37.162	148.791	DELEGATE RIVER	Au
41	37.1624	148.7907	CLARKEVILLE GOLDFIELD	Au
42	37.1649	148.971	JAMIESON'S IXL MINE	Au
43	37.1663	148.8865	BENDOC GOLDFIELD	Au
44	37.1699	148.7076	DAY DAWN (DAWN OF DAY)	Au
45	37.1699	148.8855	DETERMINATION WANDERER	Au
46	37.17	148.72	ARGYRE, MONARCH, ROSE OF THE VALLEY, VENUS	Au
47	37.17	148.95	LOWER BENDOC	Au
48	37.1738	148.4846	MOUNTAIN CREEK WEST*	Cu, Zn
49	37.1773	148.8733	ECLIPSE	Au

50	37.1799	148.7607	CRAESUS	Au
51	37.1854	148.878	GOLDEN EAGLE	Au
52	37.189	148.71	SUNFLOWER	Au
53	37.19	148.71	UNION	Au
54	37.19	148.88	VICTORY	Au
55	37.19	148.956	SPLITTERS CREEK	Au
56	37.1907	148.881	VICTORIA STAR (VICTORIA REEF	Au
57	37.1925	148.881	WELCOME STRANGER	Au
58	37.193	148.8793	STAR OF BENDOC	Au
59	37.1979	148.733	CLANCYS	Au
60	37.201	148.715	DUKE OF WESTMINISTER	Au
61	37.2044	148.5573	MONKEYTOP	Au
62	37.2086	148.3647	CAMPBELL'S KNOB LODES	Cu, Pb, Zn
63	37.2113	148.7119	RISING SUN	Au
64	37.215	148.712	SOUTH RISING SUN	Au
65	37.2261	148.8632	MOORES	Au
66	37.2262	148.4789	CAMP CREEK (WMC)*	Pb, Ag
67	37.23	148.699	GOOD HOPE	Au
68	37.231	148.8994	SUNBEAM	Au
69	37.2329	148.8916	NEW DISCOVERY (NEW NORTH DISCOVERY)	Au
70	37.2329	148.8938	JEWELLERS SHOP	Au
71	37.2343	148.4745	STAIRCASE*	Pb,Cu, Zn, Ag
72	37.2346	148.8973	VENSONS	Au
73	37.2355	148.8962	LITTLE WONDER	Au
74	37.2356	148.8917	PHOENIX	Au
75	37.236	148.85	NELSON	Au
76	37.2365	148.8917	SOUTH DISCOVERY	Au
77	37.2382	148.8996	DELEGATE RIVER	Au
78	37.2384	148.8872	WAGGRA (WELCOME FRIENDS)	Au

79	37.241	148.879	SNOWSTORM	Au
80	37.2413	148.8749	JUNGLE KING (JUNGLE KING EXTENDED)	Au
81	37.2421	149.1477	QUADRA & BULDAH CREEKS	Au
82	37.2527	148.7782	RESULT REEF	Au
83	37.2645	148.2789	GLEN SHIEL SILVER MINE	Ag, Au
84	37.2691	148.4279	MOONKAN*	Cu, Zn
85	37.2723	149.1446	BULDAH	Au
86	37.277	148.2893	GLEN SHIEL BARITE	Ba
87	37.2871	148.3571	TULLOCH ARD*	Pb, Zn
88	37.2879	148.197	GUMTOP*	Sn, Mo
89	37.2883	149.3707	GENOA RIVER BEDS	Cu
90	37.294	148.3809	BROADBENT'S*	Pb, Zn, Ba
91	37.3109	148.4783	EEL PROSPECT	Au
92	37.3164	148.3159	SPRINGS CREEK*	Pb, Zn
93	37.3192	148.4593	RODGER RIVER PROSPECT (WMC)	Au?
94	37.3194	148.3713	HOWITT*	Pb
95	37.3265	148.0215	TIGER CREEK PROSPECT	Cu, Mo
96	37.3531	149.0323	COMBIENBAR	Au
97	37.3556	148.3572	NEW GUINEA LEAD	Pb, Zn, Cu
98	37.3578	148.3968	RODGER RIVER (PREUSSAG)*	Pb, Zn
99	37.3601	148.2783	CAMP CREEK PROSPECT (PREUSSAG)	Pb,Zn, Ba
100	37.3642	148.7334	UNNAMED	Au
101	37.3672	148.7109	MT LYELL	Au
102	37.3677	149.4945	WANGARABELL (WANGRABELLE)	Mo
103	37.3768	148.0459	RED STEER PROSPECT	Cu, Mo
104	37.3797	148.2154	W-TREE CREEK PROSPECT	Au
105	37.381	148.6965	MOUNTAIN MAID	Au

106	37.3819	148.6965	REWARD	Au
107	37.3837	148.6966	B.A. CREEK	Au
108	37.3846	148.6921	WHITE STAR	Au
109	37.3874	148.6865	TREVASCAS AND MCDONNEL	Au
110	37.388	148.2765	TULLOCH ARD ROAD BARITE	Ba
111	37.3892	148.0743	SCORPION CREEK PROSPECT	Cu
112	37.3938	148.4054	PYRAMID MOUNTAIN PROSPECT	Au
113	37.3946	148.4856	LITTLE YALMY*	Cu, Mo, Zn
114	37.3965	148.0575	GIL GROGGIN GOLD MINE	Au?
115	37.3967	148.5365	SERPENTINE PROSPECT	Cu, Mo
116	37.3967	149.3554	THURRA RIVER	Au
117	37.397	148.537	PARISH WIBENDUCK	Cu
118	37.3978	149.0008	COBON CK	Au
119	37.4003	148.314	HACKETT CREEK PROSPECT	Pb, Zn
120	37.4011	148.3208	JACKSON'S CROSSING MANGANESE	Mn, Fe
121	37.4053	148.566	YALMY - PARADISE RIDGE	Au
122	37.4156	148.3097	RUNNING CREEK MANGANESE	Mn, Fe
123	37.4191	148.4748	SERPENTINE	Au
124	37.4213	148.5172	ELLERY	Cu Pb Zn
125	37.4294	148.5812	MARTINS CREEK	UNSPECIFIED
126	37.4311	148.293	BLUE BULLOCK CREEK PROSPECT	Pb, Zn
127	37.4349	148.3575	MOUNT TABBY*	Pb, Zn, Ba
128	37.4358	148.5768	ORBOST (MARTINS CK)	LS
129	37.4372	148.3158	WEST'S TRACK*	Cu
130	37.4398	148.9736	STUDENT'S GOSSAN	Cu, Pb
131	37.4419	148.3769	GOANNA*	Cu, Pb, Zn, Ba

132	37.4472	148.3035	HALLS PENINSULA PROSPECT	Cu, Au
133	37.4475	148.8868	BOULDER MINE	Au
134	37.4475	148.8868	BOULDER (BOLA)	Au
135	37.4501	149.4764	GENOA CREEK	Au
136	37.4505	148.9236	ZINC HILL Pb-Ag PROSPECT	Pb, Ag
137	37.4505	148.4822	PARADISE RIDGE*	Cu, Pb, Zn, Au
138	37.4535	148.2245	SHAW'S GULLY PROSPECT	Pb, Zn
139	37.4554	148.2109	PYRAMIDS LEAD MINE	Pb, Zn, Ag
140	37.4565	148.1996	BUCHAN	UNSPECIFIED
141	37.4579	148.9142	BOULDER FLAT Pb-Zn PROSPECT 2	Pb Zn
142	37.4582	148.2019	ROCKY CAMP (BUCHAN)	LS
143	37.4606	148.912	ERRINUNDRA (BOULDER FLAT)	LS
144	37.4618	149.3891	WINGAN RIVER	Au
145	37.4633	148.9143	BOULDER FLAT Pb-Zn PROSPECT 1	Pb, Zn
146	37.4735	148.4464	PINNAK PROSPECT	Cu, Mo, Au
147	37.4839	148.4828	BOOTH'S FANCY COPPER MINE (SARDINE CREEK) (COPPER CREEK)	Cu, Au
148	37.4843	148.8923	GIBSON CK	Cu
149	37.485	149.64	MANGAN CREEK (GYPSY POINT ROAD)	Mo, W
150	37.4895	148.2296	HUME PARK LEAD MINE	Pb, Zn, Ag
151	37.4919	148.2556	BALLY HOOLEY BARITE	Ba
152	37.5	148.18	BUCHAN	Fe
153	37.5036	149.8033	MALLACOOTA	Au
154	37.506	148.157	SPRING CREEK	Pb Cu
155	37.5093	149.8867	HOWE HILL	Cu
156	37.5093	148.231	BUCHAN EAST	DO
157	37.5131	148.3737	LOONGALAAT CREEK	Au

158	37.5136	148.2469	BACK CK	Pb, Cu, Ba, Ag, Zn, Sb, DO
159	37.514	148.5276	MURRUNGOWER	Cu Pb Zn
160	37.5203	148.212	COCKS LIMONITE	Fe
161	37.5206	148.7008	MT JACK	Au
162	37.523	148.488	SUNDAY CREEK	Cu
163	37.527	148.527	MCDOUGALLS LODE	Cu
164	37.5295	149.6402	GENOA PEAK	W Mo
165	37.53	149.346	MOUNT CAVELL	Bi
166	37.5331	148.1997	NEILS CK	Pb, Cu, Ba
167	37.5385	148.1964	OXIDE MINE	Fe, Mn, Pb, Zn, Ag
168	37.544	148.9356	CLUB TERRACE	Au
169	37.5535	148.1338	BUCHAN SOUTH (CAMERONS QUARRY)	DS, LS
170	37.5548	148.1876	TARA CROWN MINE	Cu, Pb, Au, Ag
171	37.5564	148.2941	BETE BELONG	DS
172	37.5568	148.1729	MCRAE'S LIMONITE QUARRY	Fe, Ba
173	37.5586	148.1707	BUCHAN SOUTH (HEATHS QUARRY)	DS, LS
174	37.561	148.1968	ARMISTICE MINE	Au, PP?
175	37.5629	149.9051	GABO ISLAND	DS
176	37.5647	148.8264	CRABHOLE CK	Pb Zn
177	37.5699	148.1709	GILBERT RD IRONSTONE	Fe, Mn, Pb, Zn, Ag
178	37.5711	148.1777	TARA QUEEN MINE	Au
179	37.5726	148.1619	MONARCH OF TARA MINE	Cu, Pb, Au, Ag, Ba, PP?
180	37.5736	148.0079	DOGWOOD	Cu, Mo
181	37.5751	148.317	DOUBLE BULL CK	Cu, Mo
182	37.5752	148.1732	ORBOST MINE	Au, Cu
183	37.5764	148.3612	CREAMY CREEK	Au
184	37.5766	148.175	LITTLE CASHBOX MINE	Au
185	37.5766	148.1738	MICAWBER MINE	Au
186	37.5766	148.1721	LADY TORR (TAEDATO) CREEK WORKINGS	Au

187	37.5779	148.1738	SUPRISE MINE	Au
188	37.5811	148.1779	TARA GOLDFIELD	Au
189	37.5811	149.7451	BETKA RIVER	HMS
190	37.5875	148.4826	MOUNT BUCK	Cu, Mo
191	37.5963	148.937	PODDY CK	Au
192	37.6026	148.0921	TALLATOOROOK (GOOD HOPE)	Pb Cu
193	37.6062	148.091	GOOD HOPE (TALLATOOROOK) MINE	Pb, Cu, Ba, Ag
194	37.6075	148.1471	IRON MASK	Fe, Mn, Au, Ba, Pb, Zn
195	37.6105	148.7165	MURRUNGOWER	HMS
196	37.6106	148.1058	KANNI (CANNI) CK	Fe, Ba
197	37.618	148.1739	DOMINION COPPER MINE	Cu, Pb, Ag
198	37.6201	148.1445	BLUE SPUR	PP
199	37.6265	148.8471	MCKENZIE RIVER GOLDFIELD	Au
200	37.6273	149.1248	CANN RIVER	DS
201	37.6367	148.7737	CABBAGE TREE CREEK	Mo
202	37.6528	148.1257	SEVEN MILE	Fe
203	37.6596	148.1263	SIX MILE	Fe
204	37.665	148.114	FIVE MILE	Fe, Cu
205	37.6655	148.1157	NOWA NOWA	LS
206	37.6773	148.0036	COLQUHOUN	DS
207	37.6917	148.7081	CABBAGE TREE CK	Au
208	37.7	148.496	ORBOST (YOUNGS CREEK)	UNSPECIFIED
209	37.7	148.4962	YOUNGS CREEK (ORBOST TRONDHJEMITE)	DS
210	37.7009	148.0901	TWO MILE	Fe
211	37.7014	148.1298	NOWA NOWA	PP?
212	37.712	148.599	MOUNT RAYMOND	FS
213	37.7155	148.9174	BEMM RIVER	Au
214	37.7172	148.0779	NOWA NOWA	GS
215	37.7582	150.0195	POINT PEARL	HMS

216	37.762	148.2011	TOSTAREE	LS
217	37.7847	149.8605	CAPE CONRAN	HMS
218	37.7992	149.2819	POINT HICKS	HMS

Ag	Silver	HMS	Heavy mineral sand
Au	Gold	LS	Limestone
Ba	Barium (Barite)	Mn	Manganese
Bi	Bismuth	Mo	Molybdenum
Cu	Copper	Pb	Lead
DS	Dimension Stone	PP	Pyrophyllite
Do	Dolomite	Sn	Tin
Fe	Iron	W	Tungsten
GS	Gravel, sand	Zn	Zinc

Appendix E - Mineral Resource Assessment and Mineral Deposit Models

Assessment of mineral resource potential in East Gippsland was carried out by delineating geological tracts favourable for the formation of specific types of mineral deposits. The tracts were delineated based on available geological, and geophysical information. The types of deposits, mineralisation and alteration styles present in the East Gippsland, the past and present exploration leases and the geochemical anomalies identified in the region were also taken into account for the assessment.

The descriptive models, for most of the deposit types, are taken from the mineral deposit models compiled by Cox and Singer (1986). For some deposit types, the available geological information was not sufficient to either draw upon a descriptive model from Cox and Singer (1986) or to compile a new model. These deposit types are: god associated with massive sulphide mineralisation in the Yalmy Group; the fissure-style copper-gold mineralisation in granites; and deposits of diamonds.

The papers cited by Cox and Singer (1986) are not included in the bibliography of this report and can be located in Cox and Singer (1986). Authors for the descriptions of all mineral deposit models (except Irish-style base metals) are listed in Cox and Singer (1986).

1 MODEL Au1: EPITHERMAL GOLD-SILVER DEPOSITS

(MODEL 25B OF COX AND SINGER 1986)

1.1 Model description

Description of the model after Dan L. Mosier, Takeo Sato, Norman J Page, Donald A. Singer, and Byron R. Berger in Cox and Singer (1986).

Approximate Synonym: Epithermal gold (quartz-adularia) alkali-chloride-type, polymetallic veins.

Description: Galena, sphalerite, chalcopyrite, sulfosalts, + tellurides + gold in quartz-carbonate veins hosted by felsic to intermediate volcanics. Older miogeosynclinal evaporites or rocks with trapped seawater are associated with these deposits.

General References: Buchanan (1980), Boyle (1979).

Geological Environment:

Rock types: Host rocks are andesite, dacite, quartz latite, rhyodacite, rhyolite, and associated sedimentary rocks. Mineralisation related to calc-alkaline or bimodal volcanism.

Textures: Porphyritic.

Age range: Mainly Tertiary (most are 29-4 Ma.).

Depositional environment: Bimodal and calc-alkaline volcanism. Deposits related to sources of saline fluids in prevolcanic basement such as evaporites or rocks with entrapped seawater.

Tectonic setting(s): Through-going fractures systems; major normal faults, fractures related to doming, ring fracture zones, joints associated with calderas. Underlying or nearby older rocks of continental shelf with evaporite basins, or island arcs that are rapidly uplifted.

Associated deposit types: Placer gold, epithermal quartz alunite Au, polymetallic replacement.

Deposit Description:

Mineralogy: Galena + sphalerite + chalcopyrite + copper sulfosalts + silver sulfosalts ± gold ± tellurides ± bornite ± arsenopyrite. Gangue minerals are quartz + chlorite ± calcite + pyrite + rhodochrosite + barite ± fluorite ± siderite ± ankerite ± sericite ± adularia ± kaolinite. Specularite and alunite may be present.

Texture/structure: Banded veins, open space filling, lamellar quartz, stockworks, colloform textures.

Alteration: Top to bottom: quartz ± kaolinite + montmorillonite ± zeolites ± barite ± calcite; quartz + illite; quartz + adularia ± illite; quartz + chlorite; presence of adularia is variable.

Ore controls: Through-going or anastomosing fracture systems. High-grade shoots where vein changes strike or dip and at intersections of veins. Hanging-wall fractures are particularly favourable.

Weathering: Bleached country rock, goethite, jarosite, alunite--supergene processes often important factor in increasing grade of deposit.

Geochemical signature: Higher in system Au + As + Sb + Hg; Au + Ag + Pb + Zn + Cu; Ag + Pb + Zn, Cu + Pb + Zn. Base metals generally higher grade in deposits with silver. W + Bi may be present.

Examples:

Creede, US (Steven and Eaton 1975, Barton and others 1977)

Pachuca, Mexico (Geyne and others 1963)

Toyoha, Japan (Yajima and Ohta 1979)

1.2 Known deposits and mineral prospects in the East Gippsland CRA

Most known occurrences of this style of mineralisation are associated with the Lower Devonian Snowy River Volcanics and are confined to the Buchan Rift. The most significant of these are: Glen Shiel Silver mine, W-Tree Creek prospect, Pyramid Mountain prospect, Halls Peninsula prospect, El prospect and Roger River prospect.

Epithermal mineralisation in these prospects is represented by silicified breccia zones, zones of quartz veins and associated stockworks, zones of chalcedony and massive quartz veins in rhyolitic to rhyodacitic volcanics. Quartz veins show typical epithermal textures such as chalcedony, colloform, crustiform, banded , comb and lattice or bladed. The veins often contain disseminated pyrite, with minor barite, specular and micaceous haematite, chalcopyrite and traces of galena, native silver and a silver sulphide. Apart from silicification the host rocks show propylitic, phyllic and argillic alterations. Fluid inclusion studies in the W-Tree prospect suggest temperatures of formation between 135° and 180°C from fluid with relatively high salinities of up to 14.3 wt% eq., which may reflect a magmatic component to the mineralisation.

In most prospects mineralisation is associated with faults and zones of brecciation. The Woongulmerang caldera in the northern part of the Buchan Rift is reported to have zones of weak alteration.

In the Mount Elizabeth area which is within 5 km from the boundary of East Gippsland alterations similar to porphyry and epithermal systems have also been recognised. Here the mineralisation is thought to be related to a caldera structure occupied by the Snowy River Volcanics and the I-type Tambo Crossing granodiorite.

1.3 Assessment criteria

1. Distribution of the Snowy River Volcanics which represents a predominantly subaerial complex of volcanic and volcaniclatics of silicic to mafic composition.
2. Presence of favourable structures such as caldera with ring fractures and zones of brecciation.
3. Presence of alterations such as: silicification, propylitic, chloritic, sericitic and argillic.
4. Presence of mineral prospects having features similar to epithermal precious-metal deposits.

1.4 Assessment:Tract Au1/H/C

The delineation of the tract is based on the distribution of the Snowy River Volcanics and consists of three areas. The main area within East Gippsland is confined to the Buchan Rift. A relatively small area is outlined in the central part of East Gippsland within the Boulder Flat Syncline which is inferred to be a remnant of a rift-like extension basin. The rocks in this basin are reported to correlate well with the sequence of Snowy River Volcanics and Buchan Group in the Buchan Rift, both in age and gross lithology. The third small area is outside the East Gippsland CRA but is within 5 km from the boundary of East Gippsland. This area comprises the Mount Elizabeth caldera occupied by the Snowy River Volcanics and Devonian granodioritic bodies.

This tract is occupied by the Lower Devonian Snowy River Volcanics (SRV) which comprise a complex sequence of ignimbritic rhyodacites and rhyolites with minor andesite, rhyolite lava and breccia, tuff, conglomerate, siltstone, tuffaceous sandstone, and with several intercalation of marine sandstone and siltstone.

The tract includes several prospects with epithermal style of gold-silver mineralisation. Vein quartz in them shows textures which are diagnostic of epithermal systems, most significant of which are the chalcedony, colloform-crustiform, banded and lattice or bladed textures. These prospects also show typical for epithermal systems wall-rock alterations such as, silicification, phyllic, argillic and propylitic.

The tract contains the Wulgulmerang caldera. It is marked by ring faults around ignimbrites, the main caldera infilling units. The caldera is intruded by feldspar-hornblende and pyroxene porphyry dykes and bodies of vitric lava along the ring faults. The rocks near the ring fault show weak phyllic alteration.

Although most significant epithermal deposits are of Tertiary age, mineral exploration in the last two decades has revealed equally significant mineralisation associated with Palaeozoic epithermal systems. Some of the most prominent of these are: Pajingo, Wirrilie and the Golden Plateau deposits in Queensland.

Generally mineralisation in epithermal systems is formed at shallow depths and do not extend more than 500 metres vertically. Hence many epithermal systems of Palaeozoic age are often eroded. However, in the tract delineated within the East Gippsland CRA the Snowy River Volcanics are protected from erosion within the downfaulted Buchan Rift and there are indications that not all epithermal systems have been eroded away. The strongest supporting factor is the presence of quartz with chalcedony and lattice or bladed textures. Quartz with these textures are known to occur in the upper parts of epithermal systems (Gyoui et al. 1995). The presence of argillic and clay alterations also indicates that the epithermal systems in the Buchan Rift were not deeply eroded.

Thus based on the available information it is concluded that the tract has a high potential for epithermal mineralisation with a certainty level of C.

Generally epithermal systems which form quartz-adularia type of mineralisation also generate acid-sulphate type of gold-silver mineralisation. This mineralisation is usually confined to the uppermost parts of the system. Hence it is possible that locally the tract contains this type of mineralisation.

In recent years detailed exploration of epithermal systems in Australia, Canada, Papua New Guinea and Philippines has revealed a transition of these systems at depth into porphyry systems with copper, gold and molybdenum mineralisation (Panteleyev, 1988). It is possible that the epithermal systems in the tract, particularly within calderas, might also contain porphyry systems at depths of a few kilometres.

1.5 Economic significance

Epithermal gold-silver deposits are important sources for gold and silver. Grade/tonnage model for deposits of this type (Cox and Singer, 1986) indicates that 90% deposits contain more than 0.065 million tonnes of ore, 50% more than 0.77 million tonnes and 10% contain more that 9.1 million tonnes. In 90% of these deposits ores have at least 2.0 grams per tonne gold and 10 grams per tonne silver. The ores in 50% of these deposits have at least 7.5 grams per tonne gold and 110 grams per tonne silver. In 10% of these deposits the ores have at least 27 grams per tonne gold and 1300 grams per tonne silver.

2 MODEL Au2: SLATE-BELT GOLD DEPOSITS

(MODEL 36A OF COX AND SINGER 1986)

2.1 Model description

Description of the model after Byron R. Berger in Cox and Singer (1986).

Approximate Synonyms: Mesothermal quartz veins, Mother Lode veins, Turbidite-hosted gold veins, Slate belt gold veins.

Description: Gold in massive persistent quartz veins mainly in regionally metamorphosed rocks.

Geological Environment:

Rock types: Greenstone belts; oceanic metasediments: regionally metamorphosed volcanic rocks, greywacke, chert, shale, and quartzite. Alpine gabbro and serpentine. Late granitic batholiths.

Age range: Precambrian to Tertiary.

Depositional environment: Continental margin mobile belts, accreted margins. The age of veins generally post-metamorphic and locally cut granitic rocks.

Tectonic setting(s): Fault and joint systems produced by regional compression.

Associated deposit types: Placer Au-PGE, Kuroko massive sulfide, Homestake gold.

Deposit Description:

Mineralogy: Quartz + native gold + pyrite + galena + sphalerite + chalcopyrite + arsenopyrite ± pyrrhotite. Locally tellurides ± scheelite ± bismuth ± tetrahedrite ± stibnite ± molybdenite ± fluorite. Productive quartz is greyish or bluish in many instances because of fine-grained sulphides. Carbonates of Ca, Mg, and Fe abundant.

Texture/structure: Saddle reefs, ribbon quartz, open-space filling textures commonly destroyed by vein deformation.

Alteration: Quartz + siderite and (or) ankerite + albite in veins with halo of carbonate alteration. Chromian mica + dolomite and talc + siderite in areas of ultramafic rocks. Sericite and disseminated arsenopyrite + rutile in granitic rocks.

Ore controls : Veins are persistent along regional high-angle faults, joint sets. Best deposits overall in areas with greenstone. High-grade ore shoots locally at metasediment-serpentine contacts. Disseminated ore bodies where veins cut granitic rocks.

Weathering: Abundant quartz chips in soil. Gold may be recovered from soil by panning.

Geochemical Signature: Arsenic best pathfinder in general; Ag, Pb, Zn, Cu.

Examples:

Grass Valley, US (Lindgren 1896)

Mother Lode, US (Knopf 1929)

Ballarat Goldfield, Victoria, Australia (Baragwanath 1953)

Goldfields of Nova Scotia, Canada (Malcolm 1929)

2.2 Known deposits and mineral prospects in East Gippsland

The area hosts a large number of gold prospects which are grouped into three main gold fields, the Bonang, Bendoc and Clarkeville (VandenBerg et al. 1992). These goldfields are narrow, elongate fields trending magnetic north, (Bendoc and Bonang) and northeast (Clarkeville). Gold bearing quartz reefs are hosted in Ordovician rocks.

The elongate distribution of the fields does not correspond to any photo-lineament or observed structural feature, although on a local scale some gold mineralisation is thought to be related to faults. For instance in the Bonang field gold workings lie along the McLauchlan Creek fault Zone (The Cameron and Roaring Camp workings) and along Bonanza Gully Fault Zone (The Pioneer and Cambrian workings). Similarly the Clarkeville reefs are also thought to be controlled by faults.

Because of lack of geological information about these reefs, which were amongst the earliest to be discovered and mined in East Gippsland, it is difficult to assess the role of lithology and structures in controlling gold mineralisation. However, elsewhere in Victoria most of the reefs are inferred to be structurally controlled (Ramsay and VandenBerg, 1990), emplaced along faults, within tension gashes or along fold crests as saddle and trough reefs. Most reefs are hosted by a sequence of turbiditic quartz sandstone and shales. Some reefs close to the eastern margin of the Melbourne gold province traverse dykes of the Woods Point Dyke Swarm. In the Tabberabbera Zone greasy, carbonaceous pyritic slate has been described as an ideal host of mineralisation. Similarly in the Ballarat East goldfield it is suggested that mineralisation is often localised by the presence of "indicator beds" (O'Shea et al. 1994).

The timing of gold mineralisation of reefs in East Gippsland is as difficult to assess as in other gold fields in Victoria. Generally, it is believed that gold in Victorian deposits was introduced during or immediately after major deformational episodes (Ramsay and VandenBerg 1990). According to VandenBerg et al. (1994) in the goldfields within East Gippsland, the earliest gold mineralisation was formed during the Early to Middle Silurian Benambran deformation, after the most severe folding had taken place. However, mineralisation is thought to extend through to the Middle Devonian. It is generally considered that hydrothermal fluids responsible for this type of mineralisation are related to the process of low-grade metamorphism of rocks.

2.3 Assessment criteria

1. Distribution of Ordovician rocks (turbidites and their metamorphic equivalents).
2. Presence of carbonaceous sedimentary or metasedimentary rocks.
3. Presence of fault zones.
4. Intensive deformation of rocks and their metamorphism with signs of retrograde metamorphism.
5. Presence of primary and/or alluvial gold deposits and prospects.

2.4 Assessment: Tract Au2/M-H/C

A major part of the tract delineated in East Gippsland is occupied by Ordovician turbiditic rocks which comprise a lower, sandstone-dominated sequence (Pinnak Sandstone, Broadbent River Formation) and an upper, mudstone-dominated sequence (Bendoc Group). The sandstone-dominated portion also includes green slaty mudstone and dark siltstone. Within Bendoc Group the lower, Warbisco Shale consist of black shales with minor interbedded quartzose sandstone. The shale is made up of fine-grained quartz with small amounts of finely disseminated pyrite and carbonaceous material. The Sunlight Creek Mudstone Member which underlies the Warbisco Shale also contains dark grey, almost black siltstone alternating with dark green siltstone and pale grey or white sandstone. Although any of these Ordovician rocks can be a host of gold mineralisation, the presence of rocks with carbonaceous material may constitute a more favourable environment.

Ordovician sediments in the tract have undergone two episodes of deformation. During Early and Middle Silurian, Benambran deformation the sedimentary rocks, east to the Yalmy Fault Zone were folded into tight, isoclinal folds. This deformation was accompanied by regional metamorphism and intrusion of I-type granitoids. The metamorphism led to the formation of the Kuark Metamorphic Complex that comprises biotite and spotted schists. Granites outside the Kuark Metamorphic belt generated contact-metamorphic aureoles of normal hornfels. Thus Ordovician rocks in the tract have undergone intense deformation and metamorphism which is part of the environment in which the gold-forming fluids could have been generated and structurally favourable sites could also have been produced. The presence of several fault zones, most prominent of which are the Yalmy and McLauchlan Fault Zones can also provide structures to serve as fluid channel ways.

The experience shows that localising factors for slate belt gold deposits vary from area to area and more detailed geological studies can reveal factors specific to the tract. It needs to be stressed that although gold deposits in the tract were one of the earliest deposits to be discovered and mined in the area, there has been little detailed exploration for this style of gold deposits after mining essentially ceased earlier this century. It was mentioned earlier that for this type of deposits, low-grade metamorphism is a favourable factor in generating gold forming fluids. The available information indicates that the rocks only underwent relatively high-grade metamorphism.

Thus based on the above information it is concluded that the tract has moderate to high potential for this type of gold deposits, with a certainty level of C.

It has been suggested that Ordovician rocks in the tract might host fine-grained disseminated gold mineralisation over-looked by early explorers. This mineralisation might be attractive for large tonnage, low-grade operations (VandenBerg et al. 1995). However the available geological information does not allow to make an assessment of the mineral potential of this type of mineralisation. More detailed information on structure and tectonics, such as the presence of detachment faults is essential for the assessment of this type of deposit.

2.5 Economic significance

The slate belt type of gold deposits are one of the largest type of gold deposits and are important source of gold and silver. According to the grade/tonnage models for the low-sulphide gold-quartz veins (Cox and Singer, 1986) 90% of these deposits contain at least 0.001 million tonnes of ore; 50% contain at least 0.03 million tonnes and 10% contain at least 0.91 million tonnes. In 90% of these deposits ores contain at least 6 g/t gold; 50% contain at least 15 g/t gold and 10% contain 43 g/t gold.

3 MODEL Au3: GOLD ASSOCIATED WITH MASSIVE SULPHIDE MINERALISATION

No descriptive model for this type of mineralisation is included in the report because of lack of precise information on the nature of mineralisation in the rocks of the Yalmy Group.

3.1 Known deposits and mineral prospects in East Gippsland

The tract is reported to contain several mineral occurrences of base metals and gold. Some of these occurrences are known to have stockwork zones of pyrite with anomalous values for gold (personal communication, Mr T Dickson, Victorian Geological Survey) The other base metal and gold occurrences in the tract are Accommodation Creek, Mountain Creek West, Monkey Top and Moonkan.

3.2 Assessment criteria

1. Distribution of rocks belonging to the Yalmy Group.
2. Presence of intermediate to felsic volcanism.
3. Presence of granitoid intrusives.
4. Presence of mineral occurrences.

3.3 Assessment: Tract Au3/M-H/B

The tract has been delineated based on the distribution of rocks of the Yalmy Group and the presence of mineral occurrences.

The rocks of the Yalmy Group consists of sandstones and siltstones deposited in relatively deep marine conditions. They are thought to be equivalent to the Towonga Sandstone which underlie the Cowombat Siltstone and the Thorkidaan Volcanics in the Limestone Creek and the Reedy Creek Outlier in the north-west part of the East Gippsland. As was mentioned earlier the Gibsons Folly Formation and the Cowombat Siltstone host a number of volcanic hosted massive sulphide deposits such as Wilga and Currawong. The Yalmy Group is not reported to contain any volcanics. However, a thin unit of silicic volcanics has been mapped in the Tombong Beds which overlie the Yalmy Group rocks. The Seldom Seen Formation which underlies the Towonga Sandstone is also reported to contain intermediate acid volcanics. Thus although volcanics have not been recorded in the Yalmy Group there are indications that some volcanic activity (intermediate to felsic) was going on if not strictly contemporaneously then closely before or after the formation of these rocks.

It is possible that the gold mineralisation associated with massive pyrite in the Yalmy Group could be related to distal type of volcanic massive sulphide mineralisation.

Alternatively this could also represent some porphyry related gold mineralisation. The Yalmy Group is known to be intruded by a number of Silurian Granitoids such as the Cabanandra Granodiorite (biotite granodiorite) and the Postman Spur Granodiorite (biotite granodiorite). The tract might also contain a porphyry dykes cogenetic with the Snowy River Volcanics which also have a potential for the porphyry related gold mineralisation. It needs to be stressed that there is a large overlap between this tract and the tract for the porphyry copper-gold mineralisation (Figure 9).

Based on the above information it is concluded that the tract has moderate to high potential for gold mineralisation associated with massive sulphide with a certainty level of B.

4 MODEL Cu-Au2: FISSURE STYLE COPPER GOLD DEPOSITS

No descriptive model for this type of mineralisation is included in the report because of lack of precise information on the nature of mineralisation. However it is possible that this type of mineralisation is similar to that found in association with porphyry copper-gold deposits.

4.1 Known deposits and mineral prospects in East Gippsland

The area hosts a number of mineral occurrences located within or close to granitoids. There is no detailed description of these occurrences but at Howe Hill and Wangarabell prospects the mineralisation is described as fissure quartz veins with sulphides. The granitoids and the surrounding rocks are reported to contain several occurrences of copper and gold.

4.2 Assessment criteria

1. Distribution of granitoids.
2. Distribution of mineral occurrences.
3. Presence of geochemical anomalies.

4.3 Assessment: Tract Cu-Au2/L-M/B

The tract has been delineated based on the distribution of granitoids and mineral occurrences of copper and gold.

The tract and the surrounding area have been targeted for exploration for granite related copper and gold mineralisation (VandenBerg et al. 1995). In the Wangarabell area quartz reefs in the vicinity of Genoa Peak have been assayed to contain 3.0 g/t gold and 2.5 g/t silver (VandenBerg et al. 1995).

Based on the available information it is concluded that the tract has low to moderate potential for fissure style copper-gold deposits type of mineralisation at the certainty level of B.

5 MODEL BM1: VOLCANIC HOSTED MASSIVE SULPHIDE DEPOSITS

(MODEL 28A OF COX AND SINGER 1986)

5.1 Model description

Description of the model modified after Donald A. Singer, in Cox and Singer (1986).

Approximate Synonym: Noranda type, volcanogenic massive sulfide, felsic to intermediate volcanic type.

Description: Copper- and zinc-bearing massive sulfide deposits in marine volcanic rocks of intermediate to felsic composition.

General References: Ishihara (1974), Franklin and others (1981), Hutchinson and others (1982), Ohmoto and Skinner (1983), Large (1992); Allen and Barr (1990).

Geological Environment:

Rock types: Marine rhyolite, dacite, and subordinate basalt and associated sediments, principally organic-rich mudstone or shale. Pyritic, siliceous shale. Some basalt.

Textures: Flows, tuffs, pyroclastics, breccias, bedded sediment, and in some cases felsic domes.

Age range: Archaean through Cainozoic.

Depositional environment: Hot springs related to marine volcanism, probably with anoxic marine conditions. Lead-rich deposits associated with abundant fine-grained volcanogenic sediments.

Tectonic setting(s): Island arc. Local extensional tectonic activity, faults, or fractures. Archaean greenstone belt.

Associated deposit types: Epithermal quartz-adularia veins in Japan are regionally associated but younger than Kuroko deposits. Volcanogenic Mn, Algoma Fe.

Deposit Description:

Mineralogy: Upper stratiform massive zone (black ore)-pyrite + sphalerite + chalcopyrite ± pyrrhotite ± galena ± barite ± tetrahedrite - tennantite ± bornite; lower stratiform massive zone (yellow ore)-pyrite + chalcopyrite ± sphalerite ± pyrrhotite ± magnetite; stringer (stockwork) zone-pyrite + chalcopyrite (gold and silver). Gahnite in metamorphosed deposits. Gypsum/anhydrite present in some deposits.

Texture/structure: Massive (>60 percent sulphides); in some cases, an underlying zone of ore stockwork, stringers or disseminated sulphides or sulfide-matrix breccia. Also slumped and redeposited ore with graded bedding.

Alteration: Adjacent to and blanketing massive sulfide in some deposits - zeolites, montmorillonite (and chlorite?); stringer (stockwork) zone - silica, chlorite, and sericite; below stringer - chlorite and albite. Cordierite and anthophyllite in footwall of metamorphosed deposits, graphitic schist in hanging wall.

Ore controls: Toward the more felsic top of volcanic or volcanic-sedimentary sequence. Near center of felsic volcanism. May be locally brecciated or have felsic dome nearby. Pyritic siliceous rock (exhalite) may mark horizon at which deposits occur. Proximity to deposits may be indicated by sulfide clasts in volcanic breccias. Some deposits may be gravity-transported and deposited in paleo depressions in the seafloor. In Japan, best deposits have mudstone in hanging wall.

Weathering: Yellow, red, and brown gossans. Gahnite in stream sediments near some deposits.

Gossan may be high in Pb and typically Au is present. Adjacent to deposit - enriched in Mg and Zn, depleted in Na. Within deposits - Cu, Zn, Pb, Ba, As, Ag, Au, Se, Sn, Bi, Fe.

Examples:

Kidd Creek, Canada (Walker and others 1975)

Mt. Lyell, Australia (Corbett 1981)

Brittania, Canada (Payne and others 1980)

Buchans, Canada (Swanson and others 1981)

5.2 Known deposits and mineral prospects in East Gippsland

The two largest deposits of this type, Wilga and Currawong, are located outside the East Gippsland CRA but are within a few kilometres from the boundary. These deposits are located within the Limestone Creek Graben which is one of the two remnants of the Cowombat Rift of

Silurian age. Mineralisation in these deposits is located at the base of the Gibsons Folly Formation which consists of dacitic, andesitic and basaltic units with minor Porphyritic rhyolite bodies, and enclosed within turbiditic sediments. These rocks are inferred to have formed in relatively deep marine environment. The underlying Cowombat Siltstone is thought to belong to a shallow marine basin-slope facies. The Thorkidaan Volcanics, underlying the Cowombat Siltstone consists of marine volcanics of rhyolitic and dacitic compositions and are inferred to have been formed in a mixture of shallow water, deep water and sub-aerial conditions.

The James Flat prospect is located within East Gippsland but is hosted by the Lower Silurian Towonga Sandstone which underlies the Thorkidaan Volcanics. In this prospect minor base metal mineralisation is recorded within quartz veins which infills cavities. The mineralisation is thought to be of Upper Silurian age (Oppy et al. 1995). Within the area mineral exploration has recorded anomalous soil values of lead and zinc.

5.3 Assessment criteria

1. Distribution of rocks belonging to marine volcanic and sedimentary sequence.
2. Distribution of known base metal deposits and mineral occurrences.

5.4 Assessment: Tract BM1a / M-H / B

This tract encloses two areas where volcanic rocks were deposited in submarine conditions. The larger one of these areas is in the central and southern parts of the Buchan Rift where the Snowy River Volcanics are reported to be deposited in shallow marine environment.

The volcaniclastics of the upper member of the Snowy River Volcanics, and the basal unit of the Buchan Caves Limestone frequently contain base metal mineralisation of volcanic exhalative origin. Mineral prospects of this type include the Shaw's Gully, Blue Bullocks Creek and Hackett Creek prospects and New Guinea lead occurrences. Detrital sphalerite and galena together with enriched manganese, barium and silver values with waterlain tuffs, pyritic shales and intraformational breccias point at the volcanic massive sulphide nature of mineralisation in these prospects.

The second area is relatively small and is delineated based on the presence of volcanic and sedimentary rocks formed within the Boulder Flat Graben and interpreted to be equivalent to the Snowy River Volcanics in age as well as gross lithology. The Boulder Flat Syncline is inferred to be the structural remnant of a rift-like extensional basin, in which felsic volcanics were deposited in shallow marine environment (VandenBerg et al. 1995). There a number of base metal prospects reported in this area but the available information is not sufficient to conclude if any of these are volcanic hosted massive sulphide deposits.

On the available information there is a moderate to high potential for volcanic hosted massive sulphide deposits within the southern part of the Buchan Rift, with a certainty level of B.

5.5 Assessment: Tract BM1b / M-H / C

The tract is delineated based on the distribution of marine volcanic and sedimentary rocks which fill the Limestone Creek graben and extend into the East Gippsland CRA. They belong to the Thorkidaan Volcanics and the underlying Lower Silurian Towanga Sandstones. The tract also contains the a small graben to the east of the main Limestone Graben, called the Reedy Creek Outlier (Allen and Barr, 1990). More detailed mapping in the area shows the presence of rocks belonging to the Cowombat Siltstone. The Cowombat Siltstone, outside but within a few kilometres of the East Gippsland CRA is known to contains several massive sulphide base metal prospects in the Limestone Creek Graben.

The distribution of volcanic-hosted massive sulphide deposits in geologically similar areas shows that they are generally confined to one or maximum two stratigraphic levels. For instance in Noranda area (Canada) a large proportion of the deposits occur close to a single stratigraphical horizon(Lydon, 1988). Similarly, in Australia, there are five volcanic belts with known volcanic hosted massive sulphide deposits, in which only one mineralised horizon has been recognised. However, in another two belts in Australia, the Mount Read Volcanics (Tasmania) and the Mount Windsor Volcanics (Queensland) there are at least two important stratigraphic levels of mineralisation (Large 1992).

In East Gippsland the Gibsons Folly Formation is not reported but the tract contains the Reedy Creek Outlier which is reported to have rocks belonging to the Cowombat Siltstone and the Thorkidaan Volcanics underlying the Gibsons Folly Formation. It is possible that the second horizon of massive sulphide mineralisation could have been generated in either the rocks belonging to the Cowombat Siltstone or of the underlying Thorkidaan Volcanics.

It was mentioned earlier that the James Flat prospect within East Gippsland is hosted in the Towanga Sandstone and is thought to be of Upper Silurian age. The lack of information does not allow, at this stage, to assess the role of the late Silurian Bindian deformation which could have deformed, metamorphosed and remobilised the volcanic massive sulphide mineralisation.

Hence, based on the available information the tract is thought to have moderate to high potential for the volcanic hosted massive sulphide deposits with a certainty level of B.

5.6 Economic significance

Volcanic-hosted massive sulphide deposits are significant source for copper, lead and zinc. Some of these deposits can have a few tens of parts per million of gold and few hundreds of parts per million of silver. Global grade/tonnage models for this type of deposits indicate that 90% of these deposits have more than 0.12 million tonnes of ores, 50% have more that 1.5 million tonnes and 10% have more than 18 million tonnes. Similarly 90% of these deposits the ores have more than 0.45% copper, 50 % have more than 1.3% copper and 2.0% zinc and 10% have more than 3.5% copper, 8.7% zinc and 1.9% lead.

6 MODEL BM2: IRISH-STYLE CARBONATE HOSTED BASE METAL DEPOSITS (MODEL 31A OF COX AND SINGER 1986)

6.1 Model description

Cox and Singer (1986) include the Irish-style base metal deposits in the model for the Sedimentary-exhalative (Sedex) Zn-Pb deposits. Although Irish-style deposits have several similarities with sedimentary-exhalative deposits, they also have features which are similar to the Mississippi-valley type (MVT) deposits. Keeping this in view a descriptive model for the Irish-style deposit is thought necessary. The descriptive model is compiled based on a review by Hitzman and Large (1986).

Approximate Synonyms: Carbonate hosted stratabound deposits.

Description: Stratabound and cross-cutting accumulations of sulphide and sulphate minerals within sequence of carbonate and clastic rock.

General Reference: Hitzman and Large (1986)

Geological Environment:

Rock types: Mixed siliciclastic and carbonate rocks and locally evaporitic sediments in shallow marine, moderate to high oxidising shelf environment. The sequence succeeded by the deposition of shallow water shelf limestones and deeper water carbonates and argillite. Volcanic rocks of bimodal composition are locally present.

Textures: Host rocks are commonly micritic, oolitic, pelloidal or slightly sandy carbonate beds.

Age range: Commonly Palaeozoic. Deposits in Ireland are hosted in Lower Carboniferous rocks. The mineralisation is suggested to be formed in a short span of 7 million years during the latest Courceya (approximately 353 my) and the Early Arundian (approximately 345 my). The latest Courceyan to Arundian corresponds to a period of tectonic activity including limited bimodal Volcanism in Central Ireland.

Depositional environment: Shallow marine shelf environment.

Tectonic setting: Overall tectonic environment setting is similar to that of both Selwyn Basin in Canada (which hosts the Sedex deposits) and the German Hercynian Basin (contains Meggen and Rammelsberg deposits). In all three areas large prisms of clastic sediments appear to have sharply abutted against well-developed carbonate shelves. Host rocks are formed during periods of limited volcanism, extensional tectonics followed by compression of one basin margin.

Associated deposit Types: Bedded barite deposits.

Deposit Description:

Mineralogy: Sphalerite, galena, pyrite, marcasite, chalcopyrite, barite and carbonates. Minor to trace amounts of arsenopyrite, bornite, chalcocite, covellite, tennantite, semseyite, bournonite, freibergite, pyrargyrite, boulangerite, cylindrite, frankeite, agryrodite, jordanite, gratonite, enargite, geocronite, native antimony, and fluorite and gypsum.

Texture/structure: Sulphides occur as inter-porosity fill, vein, irregular colloform bands replacing earlier bands of carbonates or sulphides and sulphates, coarse vug fillings, stylolites, and massive laminated bands. In cross-cutting closed to the feeder mineralisation, sulphides form stockwork of veins, breccia fillings and massive replacement zones.

Alteration: Dolomitisation (often ferroan dolomite) and minor and local silicification. Alteration is lithologically controlled and argillaceous rocks are poorly dolomitised. Dolomitisation follows diagenetic infill cements by calcite. It is followed the precipitation of sulphides and carbonate material. Minor carbonate followed mineralisation.

Ore controls: Lithologically stratabound mineralisation is consistently restricted to non-argillaceous units and is generally best developed within micritic, oolitic, pelloidal or slightly sandy carbonate beds. Highest grade mineralisation occurs commonly within porous and permeable (?) oolitic, pelloidal or slightly sandy pakstones and wackstones adjacent to less (?) permeable argillaceous carbonates, fine-grained calsiltites or micrites. mineralisation adjacent to feeder structures cross cuts stratigraphy. The majority of mineral deposits are adjacent to structures (generally normal faults) that were active during mineralisation.

Geophysical signatures: IP anomalies used for exploration

Geochemical Signatures: Zinc and lead Geochemical anomalies in soil and stream sediments.

Examples:

Navan Ireland (Ashton et al 1986)

Silvermines Ireland (Andrew 1986)

Tynagh Ireland (Banks 1986)

6.2 Known deposits and mineral prospects in East Gippsland

The Irish-Style base metal occurrences in the study area are concentrated in two regions: in Murrindal Syncline in the Buchan Rift and in the Boulder Flat Graben. In Murrindal Syncline more than 40 base metal prospects showing features similar to the Irish-Style base metal deposits have been recorded. Important prospect of this type are: the Hume Lead and Pyramids Lead Mine, the Back Creek, Good Hope, Spring Creek and Neils Creek mines. Mineralisation in these prospects is located within basal dolomitic limestones. Recent work confirmed that these deposits display similarities with epigenetic zones of the Irish-style base metal deposits (VandenBerg et al. 1996, in press). Geochemical similarities between the Irish and Buchan provinces have also been reported (VandenBerg et al. 1996, in press). However, temperature of formation (160°C to 210°C) are slightly lower than those for the Irish-style deposits, although they do indicate that a direct primary volcanic source is unlikely.

The Boulder Flat Graben also contains a number of base metal prospects. They are: The Boulder Flat lead-zinc prospect-1 and 2, the Zinc Hill lead-silver prospect and the Gibson Creek copper prospect. The stratabound barite mineralisation in the Boulder Flat prospect is also thought to have features similar to the Irish-style deposits. The four prospects occur within the Boulder Flat Limestone, generally towards its base. The Boulder Flat lead-zinc prospect -1 is reported to contain subeconomic lead-zinc-silver mineralisation. Mapping also revealed the presence of five separate barite lenses in variably silicified and dolomitised limestone. In the Boulder Flat lead-zinc prospect-2 several continuous and discontinuous stratiform lead and zinc anomalous zones are recorded in dominantly impure limestone and siltstone with minor volcaniclastics. Minor sphalerite is also noted in late stage calcite-dolomite-quartz veins. Barite and dolomite with traces of fluorite and galena are commonly associated with zinc mineralisation. Silver values are low but increase with the appearance of silver-antimony sulphides. The Zinc Hill lead-silver prospect is reported to be occurring in the basal part of the Boulder Flat Limestone. Exploration uncovered a barite-galena with silver. In the Gibson Creek Copper prospect, drilling intersected disseminated chalcopyrite in clastics marking the boundary with volcaniclastics.

6.3 Assessment criteria

1. Distribution of rocks of the Buchan and or Errinundra Groups formed in extensional related setting where limestones and clastics were deposited in shallow marine and shelf environment.
2. Geological setting characterised by active tectonism with possible concurrent volcanic activity.
3. Distribution of occurrences similar to the Irish-style base metal deposits.

6.4 Assessment: Tract BM2/H/C

The tract is delineated based on the distribution of rocks belonging to the Buchan Group within the Buchan Rift and rocks of the Errinundra Groups occupying the Boulder Flat Graben.

The Buchan Caves Limestone, which is the lowest member of the Buchan Groups is thought to be formed in shallow marine environment (shallow sloping carbonate shelf) after the initiation of marine transgression in the southern part of the Buchan Rift. There is some evidence that volcanism on minor scale continued well after the onset of limestone deposition. As described above the area contains several prospects that have features similar to the Irish-style base metal deposits.

The Boulder Flat Graben also represents a similar extensional rift-like structure where clastic sediments and volcanics are overlain by limestone and shale of the Boulder Flat Limestone. As in Buchan Rift, marine sedimentation continued after volcanism ceased.The rocks within the graben are inferred to have formed in shallow marine environment. This area also contains stratabound base metal and barite mineralisation hosted in limestones.

Based on the available information it is concluded that the tract has a high potential for the Irish-style base metal deposits with a certainty level of C.

6.5 Economic significance

Irish-style base metal deposits are important sources of base metals as important as large volcanic-hosted massive sulphide deposits. The Navan deposit in Ireland has 90 million tonnes of ore with 2.3% Lead and 10% Zinc (Cox and Singer, 1986). The other two deposits are comparatively smaller (Silvermines: 18 million tonnes with 2.8% Lead and 7.4% Zinc; and Tynagh: 12 million tonnes with 0.4% Copper, 4.9% Lead and 4.5% Zinc).

7 MODEL Cu-Au1: PORPHYRY COPPER-GOLD DEPOSITS

(MODEL 20C OF COX AND SINGER 1986)

7.1 Model description

Description of the model after Dennis P. Cox, in Cox and Singer (1986).

Description: This generalised model includes various subtypes all of which contain chalcopyrite in stockwork veinlets in hydrothermally altered porphyry and adjacent country rock.

General Reference: Titley (1982).

Geological Environment:

Rock types: Tonalite to monzogranite or syenitic porphyry intruding granitic, volcanic, calcareous sedimentary, and other rocks.

Textures: Porphyry has closely spaced phenocrysts and microaplitic quartz-feldspar groundmass.

Age range: Mainly Mesozoic and Cainozoic, but may be any age.

Depositional environment: High-level intrusive rocks contemporaneous with abundant dikes, breccia pipes, faults. Also cupolas of batholiths.

Tectonic setting(s): Rift zones contemporaneous with Andean or island-arc volcanism along convergent plate boundaries. Uplift and erosion to expose subvolcanic rocks.

Associated deposit types: Base-metal skarn, epithermal veins, polymetallic replacement, volcanic hosted massive replacement, Porphyry Cu-skarn related, porphyry Cu-Mo, and porphyry Cu-Au.

Deposit Description:

Mineralogy: Chalcopyrite + pyrite ± molybdenite; chalcopyrite + magnetite ± bornite ± Cu; assemblages may be superposed. Quartz + K-feldspar + biotite + anhydrite; quartz + sericite + clay minerals. Late veins of enargite, tetrahedrite, galena, sphalerite, and barite in some deposits.

Texture/structure: Stockwork veinlets and disseminated sulfide grains.

Alteration: From bottom, innermost zones outward: sodic-calcic, potassic, phyllic, and argillic to propylitic. High-alumina alteration in upper part of some deposits. See table 3. Propylitic or phyllic alteration may overprint early potassic assemblage.

Ore controls: Stockwork veins in porphyry, along porphyry contact, and in favourable country rocks such as carbonate rocks, mafic igneous rocks, and older granitic plutons.

Weathering: Green and blue Cu carbonates and silicates in weathered outcrops, or where leaching is intense, barren outcrops remain after Cu is leached, transported downward, and deposited as secondary sulphides at water table or paleowater table. Fractures in leached outcrops are coated with hematitic limonite having bright red streak. Deposits of secondary sulphides contain chalcocite and other Cu_2S minerals replacing pyrite and chalcopyrite. Residual soils overlying deposits may contain anomalous amounts of rutile.

Geochemical Signature: Cu + Mo + Au + Ag + W + B + Sr center, Pb, Zn, Au, As, Sb, Se, Te, Mn, Co, Ba, and Rb outer. Locally Bi and Sn form most distal anomalies. High S in all zones. Some deposits have weak U anomalies.

Examples:

Bingham, US (Lanier and others 1978)

San Manuel, US (Lowell and Guilbert 1970)

El Salvador, Chile (Gustafson and Hunt 1975)

7.2 Known deposits and mineral prospects in East Gippsland

Several porphyry copper systems have been identified in East Gippsland. These include the Sunday Creek, Double Bull Creek, "Dogwood", and Mount Buck prospects.

These prospects are reported to be associated with multiphase magnetic I-type granite or diorite stocks, sills and dykes with alterations typical of porphyry systems. Pyrite and chalcopyrite are generally disseminated through the intrusion and adjacent country rocks, as well as coating joints and occurring in quartz veins. Breccia zones and shears also host copper mineralisation. Some prospects are reported to have minor molybdenum and gold mineralisation. Often the prospects are capped with zones of supergene enrichment with highest grades of mineralisation. These prospects are inferred to be related to the granitic intrusions following the Quidongan phase of Benambran deformation.

East Gippsland also hosts mineralisation which similar to the copper porphyry systems but related to granitoids and porphyry dykes associated with the Lower Devonian Snowy River Volcanism. These include the Accommodation Creek copper mine, Deddick silver-lead field, Booth's Fancy copper mine, Pinnak, Tiger Creek, Red Steer and Scorpion Creek prospects and the Tubbut copper lodes. Most of these prospects are hosted in granitoids or in the surrounding hornfelsed rocks but are not thought to be genetically related to the granitoids. Instead a swarm of dykes (feldspar porphyry, dacite porphyry, rhyolite, and rhyolite porphyry) showing affinity to the Snowy River Volcanics is thought to be related to the mineralising event which is interpreted to be Early Devonian. Mineralogically these prospects show differences from typical porphyry copper mineralisation. However, the presence of feldspar porphyry dykes and the zones of silicification, sericitisation, chloritization and possibly agrillic alteration in these prospects indicates links with porphyry systems. Often minor molybdenum, gold and silver mineralisation is associated with them.

Porphyry copper type alteration has also been identified in the Mount Elizabeth area which is within five kilometres. from the boundary of East Gippsland. here the mineralisation is thought to be related to a caldera structured occupied by the Snowy River Volcanics and the I-type Tambo Crossing granodiorite.

7.3 Assessment criteria

1. Presence of mineral prospects having features similar to porphyry copper deposits
2. Distribution of Siluro-Devonian and Devonian granitoids.
3. Distribution of porphyry dykes, thought to be cogenetic with the Early Devonian Snowy River Volcanics.

4. Presence of caldera structure.
5. Presence of porphyry-related wall-rock alterations.
6. Magnetic lows on the aeromagnetic map.
7. Presence of geochemical anomalies.

7.4 Assessment: Tract Cu-Au1 / M-H / C

The tract Cu-Au1 has been delineated using the above assessment criteria. The areas has several Siluro-Devonian granitoids. Aeromagnetic survey reveals the that a large part of East Gippsland is occupied by these granitoids at shallow depths.

The area has been intruded by Silurian granitoids during Quidongan phase of Benambran Deformation which are inferred to have generated copper porphyry systems.

A significant part of the tract is covered by the Snowy River Volcanics which infilled the Early Devonian rifting. Volcanic rocks in this N-S trending rift are intruded by several porphyry dykes and granitoids capable of generating porphyry style hydrothermal systems.

Northern part of the tract contains a favourable structure in the form of Woongulmerang caldera highlighted by the presence of ring dykes and zones of week wall-rock alteration. A similar caldera in the Mount Elizabeth area is reported to have alteration similar to porphyry†systems.

The tract also contains several copper, copper-molybdenum, copper-molybdenum-gold and copper-gold prospects with features similar to copper porphyry systems. It also contains the Pinnak, Serpentine and 'Student's Gossan' prospects where several stream and soil geochemical anomalies (copper, lead, zinc, molybdenum) have been identified by exploration companies and are inferred to be related to subsurface copper porphyry style mineralisation.

Based on the above information the tract is inferred to have Moderate to High potential for porphyry copper deposits with a certainty level of C.

7.5 Mineral potential for other deposits associated with porphyry systems

Often copper porphyry systems generate hydrothermal activity which is capable of forming several types of associated deposits. Most common of these are: base-metal skarn, copper skarn, epithermal veins, polymetallic replacement, and volcanic hosted massive replacement deposits. The assessment of mineral potential for these associated deposits needs more detailed work and needs to be undertaken at a later stage.

7.5.1 Epithermal deposits

The mineral potential for epithermal gold and silver deposits was assessed separately. The tract was delineated based on the distribution of the Snowy Rive Volcanics. The tract for copper porphyry system partially overlaps with it. Often there exists a transition between porphyry and epithermal systems. Such transitional systems have been recognised in Mount Leyshon and Kidston in North Queensland, Philippines and in Canada. The British Columbia Epithermal Model (Panteleyev 1988) summarises the relation between porphyry Cu, Mo and epithermal systems. Thus, it is possible that the copper porphyry systems generated by Silurian and Siluro-Devonian granitoids were also capable of forming epithermal mineralisation. The potential for such type of mineralisation exists in particular for those granitoids which are not outcropping but are located at shallow depths and are recorded by magnetic highs.

Based on the above information it is inferred that the delineated tract has an unknown potential for epithermal gold deposits. This event of mineralisation is separate from the main epithermal event which is inferred to be related with the Snowy River Volcanics.

7.5.2 Skarn deposits

In the southern part of the tract near Nowa Nowa, Silurian limestone is reported to occur at the Five Mile iron ore deposit, with features similar to skarn type of deposits. It is possible that if such limestones are intruded by granitoids in the tract, skarn mineralisation could be generated. The potential for such skarn deposits in the tract is unknown.

7.6 Economic significance

Porphyry copper-gold deposits are important sources of copper and gold. The grade/tonnage model (Cox and Singer, 1986) for porphyry copper-gold deposits indicate that 90% of these deposits contain at least 25 million tonnes of ores, 50% contain at least 100 million tonnes and 10% contain at least 400 million tonnes. In 10% of these deposits ores contain at least 0.35 wt% copper and 0.2 parts per million gold, in 50% of the deposits ores have at least 0.5 wt% copper and 0.38 parts per million gold and in 10% of the deposits the ores contain at least 0.72 wt% copper and 0.72 parts per million gold. One of the deposits of this type is the Goonumbla group of deposits in NSW which contains 30 million tonnes of ore with 0.91 wt% copper and 0.63 parts per million gold (Heithersay et al. 1990)

8 MODEL W1: TUNGSTEN-MOLYBDENUM VEINS

(MODEL 15A, COX AND SINGER 1986)

8.1 Model description

Description of the model after Dennis P. Cox and William C. Bagby in Cox and Singer (1986).

Approximate Synonym: Quartz-wolframite veins (Kelly and Rye 1979).

Description: Wolframite, molybdenite, and minor base-metal sulphides in quartz veins

Geological Environment:

Rock types: Monzogranite to granite stocks intruding sandstone, shale, and metamorphic equivalents.

Textures: Phanerocrystalline igneous rocks, minor pegmatitic bodies, and porphyroaphanitic dikes.

Age range: Paleozoic to late Tertiary.

Depositional environment : Tensional fractures in epizonal granitic plutons and their wallrocks.

Tectonic setting(s): Belts of granitic plutons derived from remelting of continental crust. Country rocks are metamorphosed to greenschist facies.

Associated deposit types: Sn-W veins, pegmatites.

Deposit Description:

Mineralogy: Wolframite, molybdenite, bismuthinite, pyrite, pyrrhotite, arsenopyrite, bornite, chalcopyrite, scheelite, cassiterite, beryl, fluorite; also at Pasto Bueno, tetrahedrite-tennantite, sphalerite, galena, and minor enargite.

Texture/structure: Massive quartz veins with minor vugs, parallel walls, local breccia.

Alteration: Deepest zones, pervasive albitization; higher pervasive to vein-selvage pink K-feldspar replacement with minor disseminated REE minerals; upper zones, vein selvages of dark-Gary muscovite or zinnwaldite (greisen). Chloritization. Widespread tourmaline alteration at Isla de Pinos.

Ore controls: Swarms of parallel veins cutting granitic rocks or sedimentary rocks near igneous contacts.

Weathering: Wolframite persists in soils and stream sediments. Stolzite and tungstite may be weathering products.

Geochemical signature: W, Mo, Sn, Bi, As, Cu, Pb, Zn, Be, F.

Examples:

Pasto Bueno, Peru (Landis and Rye 1974)

Xihuashan, China (Hsu 1943, Giuliani 1985)

Isla de Pinos, Cuba (Page and McAllister 1944)

Hamme District, US (Foose and others 1980)

Round Mountain, US (Shawe and others 1984)

Chicote Grande, Bolivia

8.2 Known deposits and mineral prospects in East Gippsland

Granitoids are an important constituent of East Gippsland. Aeromagnetic survey reveals that some granitoids are much more extensive at shallow depths. Although the dating suggest a considerable age range of granites field evidence suggests that apart from the Ellery Adamellite (386±3Ma) granites are approximately of the same age (VandenBerg et al. 1995). They intrude rocks as young as Early Silurian and most were unroofed prior to the deposition of the Snowy River Volcanics. This constraints the time of their intrusion to between the (late?) Early Silurian and the (middle?) Early Devonian (Orth et al. 1995).

The 'I/S' line coincides with Yalmy-McLauchlan Fault zone in East Gippsland. The granitoids to the west of the this line are inferred to be I- and/or S-type whereas those to the east are type.

There are a number of tungsten, molybdenum and bismuth prospects associated with these granitoids. In the Mount Bendoc wolfram mine, a series of quartz-wolframite veins cross-cut Ordovician metasediments. The veins contain native bismuth and bismuthinite. The deposit is hosted in hornfels which are presumed to overlie a granite stock.

In Wangarabell molybdenum mine, quartz veins containing molybdenite, pyrite and muscovite is thought to be associated with an adjacent granitoid (Bega batholith). Granites belonging to the same batholith also host the Genoa Peak, and the Mangan Creek vein-type tungsten-molybdenum prospects. The Mount Cavell bismuth prospects is inferred to be associated with the granitoids of the Berridale batholith.

8.3 Assessment criteria

1. Distribution of syngenetic to late orogenic, I-type and/or S-type fractionated granitoids.
2. Distribution of tungsten, molybdenum and bismuth prospects.

8.4 Assessment: Tract W1/M/C

The tract has been delineated based on the distribution of Siluro-Devonian granitoids in East Gippsland. The tract contains both I- and S-type granites with a few A-type granites. Most granitic bodies are part of large meridional Bega and Berridale batholiths, described to be made up of I-type, mafic and/or felsic and unfractionated granites (Chappell et al. 1991). Most of them produce aeromagnetic 'highs' and are extensive at shallow depth under Ordovician metasediments.

Granites in the tract belong to two granitic provinces recognised in the Lachlan fold belt. Granite to the east of the I/S line are part of the Bega province whereas those to the East belong to the Kosciusko province. The I-type granites in the Bega province are thought to have generated several known tungsten and molybdenum mineralisation. Similarly the I- and/or S-type of granites of the Kosciusko province are related to numerous mineral occurrences of tin, tungsten and molybdenum (Blevin and Chappell 1996). However most of the tin, molybdenum and tungsten occurrences of the Kosciusko provinces are outside East Gippsland.

The tract contains several tungsten, molybdenum and bismuth prospects. Mapping in the Bega provinces has revealed a number of tungsten and molybdenum vein and greisen prospects such as: the Whipstick, Blackrange and Cathcart prospects (Molybdenum, bismuth and minor gold) and the Creenah and the Hammond and Standens (Tungsten) prospects

It is believed that most the I-type granites in the Lachlan fold belt have not undergone significant fractionation and are neither strongly reduced or oxidised which limits their capacity to form large tungsten and molybdenum deposits of the type of scheelite skarns in the King Island (Tasmania).

Based on the above information it is concluded that it has a moderate potential for tungsten-molybdenum deposits with a certainty level of B.

8.5 Economic significance

Apart from the tungsten vein deposits the granitoids in the assessment area have the potential to host tungsten-skarn deposits. Often these granitoids can also form tungsten-molybdenum pipes hosted within granitic bodies. However, based on available geological information it is difficult to assess their mineral potential.

According to grade/tonnage models for tungsten deposits, 90% deposits contain at least 0.045 million tonnes of ore, 50% at least 0.56 million tonnes and 10% at least 7 million tonnes. In these type s of deposits, 90% contain at least 0.6 wt% WO_3, 50% at least 0.9 wt% WO_3 and 10% at least 1.4 wt% WO_3 (Cox and Singer 1986).

9 MODEL MS1: DESCRIPTIVE MODEL OF SHORELINE PLACER TI (MODEL 39C OF COX AND SINGER 1986)

9.1 Model description

Description of the model modified after Eric R. Force in Cox and Singer (1986).

Description: Ilmenite, rutile, zircon, leucoxene, magnetite, monazite and other heavy minerals (garnet, xenotime, cassiterite and gold) concentrated by beach processes.

Geological Environment:

Rock types: Well-sorted medium to fine grained sand in dune, beach and inlet deposits commonly overlying shallow marine deposits.

Age range: Commonly Late Tertiary (Miocene) to Quaternary (Holocene) but could be any age range.

Depositional environment: Stable coastal region with efficient sorting and winnowing, receiving sediment from deeply weathered metamorphic terranes of sillimanite or higher grade.

Tectonic setting: Margin of craton. Crustal stability during deposition and preservation of deposits.

Deposit Description:

Structure: Elongate 'shoestring' deposits parallel to coastal dunes and beaches.

Ore controls: Ultimately a high-grade metamorphic source but may include sediments and metasediments as source rocks in which heavy minerals were trapped during an earlier depositional cycle and subsequently eroded; stable coastline with efficient sorting and winnowing. Heavy mineral concentrations are formed by wave and wind action and include beach placer, beach ridge, and sand dune deposits.

Weathering: Leaching of iron from ilmenite and destruction of labile heavy minerals results in residual enrichment of deposits.

Geochemical and geophysical signatures: High Ti, Zr, Th, U, rare earth elements; anomalously high concentrations of heavy minerals; gamma radiometric anomalies due to monazite content; induced polarisation anomalies due to ilmenite.

Examples:

Numerous heavy mineral concentrations of rutile and ilmenite along the current and ancient inland shorelines in Northern New South Wales and southern Queensland (Wallis and Oakes 1990).

Heavy mineral concentrations of ilmenite and rutile along ancient shorelines inland from the present coastline in southwest of Western Australia at Yoganup (Masters 1990) and Eneabba (Shepherd 1990).

9.2 Known deposits and mineral prospects in East Gippsland

Small concentrations of heavy mineral sands occur at Point Pearl, Cape Conran, Betka River and Point Hicks. These heavy mineral concentrations are dominated by ilmenite, with minor zircon and rutile. There is one reported occurrence of heavy minerals at Murrungower in alluvial sand and gravel north of the coastal plain. Monazite is also known to occur further north in a small alluvial deposit at Pinch Swamp Creek. The sources for these heavy minerals are probably the igneous rocks in East Gippsland but they could also have been derived from heavy minerals previously held in sediments and metasediments but subsequently released by erosion.

In addition to heavy mineral deposits dominated by ilmenite and rutile, there are also primary gold occurrences and old workings near and outcropping through the sediments on the coastal plain. Gold is known to occur Cabbage Tree Creek, McKenzie River, Bemm River, Genoa Creek, and Mallacoota.

9.3 Assessment criteria

1.Appropriate coastal deposits of sand along current or ancient inland beach and dune sands.

2.Known occurrences of heavy minerals.

3.The presence of alluvial heavy mineral, alluvial gold and primary gold occurrences cropping out through the sediments on the coastal plain, or present upstream to the north of the coastal plain.

4.Presence of lineaments on radiometric images from airborne radiometric surveys.

9.4 Assessment: Tract MS1a/L-M/B

This tract-includes present day beach and dune sands and also includes older dune and swamp deposits on the coastal plain. These sediments have not been mapped in detail but may extend up to 7 kilometres inland. According to VandenBerg et al (1995), the inland dunes are probably of Quaternary age (about 1.8Ma) and extend further inland than shown on the current maps. Heavy mineral occurrences are present along the coast and heavy minerals may also be present in the older dune sand and possibly beach deposits inland. The presence of heavy minerals sands at Pinch Swamp Creek and Murrungower shows that heavy minerals are being derived from the inland sources.

It also possible that erosion of primary gold to the north of the coastal plain and underlying the sediments on the coastal plain may have been transported by streams and reworked into placers together with other heavy minerals on ancient shorelines along the Quaternary dune sand system.

On available information there is a low to moderate potential, with a certainty of B, for heavy mineral concentrations of sufficient size to be of economic interest. Such deposits may contain some gold and may occur largely within the older dune and possible shoreline sediments.

9.5 Assessment: Tract MS1b/Un

This tract lies over the Late Tertiary (about 5Ma) sediments on the coastal plain. Image analyses of airborne radiometric surveys show east-west lineaments which may represent monazite in old shore lines developed in the Late Tertiary. Another possibility is that the lineaments represent younger Quaternary sediments which have not been mapped. According to published reports, the dominant lithology in some parts of the coastal plain are limestones which do not represent a favourable environment for deposition of heavy mineral sands. The distribution of the lithologies in this sequence has not been mapped in detail and the potential for the presence of heavy mineral concentrations in this tract is unknown. As in Tract 1a, if heavy mineral concentrations are present in Tract MS1b, they may contain significant amounts of gold.

9.6 Economic significance

Based on data on 61 deposits worldwide, shoreline placer deposits have a median ore tonnage of 11 million tonnes (Cox and Singer, 1986). Both beach and dune sand deposits are included in this sample. About 90 percent of these deposits contain at least 11 million tonnes of ore and 10 percent contain at least 690 million tonnes. The median grades for these deposits are 1.3 percent TiO_2 for ilmenite and 0.15 percent TiO_2 for rutile.

The economic viability of shoreline deposits is determined by the constituent mineralogy and size of the deposit. The limited extent of the beach and dune sand deposits in East Gippsland suggest that the size of heavy mineral deposits, if present, is likely to be restricted to the lower range of tonnages for these deposits.

10 MODEL Au4: ALLUVIAL PLACER GOLD

(MODEL 39a OF COX AND SINGER 1986)

10.1 Model description

Modified after W. E. Yeend in Cox and Singer (1986).

Description: Elemental gold and platinum-group alloys in grains and (rarely) nuggets in gravel, sand, silt, and clay, and their consolidated equivalents, in alluvial, beach, aeolian, and (rarely) glacial deposits.

General references: Boyle (1979), Wells (1973), Lindgren (1911).

Geological environment:

Rock types: Alluvial gravel and conglomerate with white quartz clasts. Sand and sandstone of secondary importance.

Textures: Coarse clastic.

Age range: Cainozoic. Older deposits may have been formed but their preservation is unlikely.

Depositional environment: High-energy alluvial where gradients flatten and river velocities lessen, as at the inside of meanders, below rapids and falls, beneath boulders, and in vegetation mats. Winnowing action of surf caused Au concentrations in raised, present, and submerged beaches.

Tectonic setting(s): Tertiary conglomerates along major fault zones, shield areas where erosion has proceeded for a long time producing multicycle sediments; high-level terrace gravels.

Associated Deposit Types: Black sands (magnetite, ilmenite, chromite); yellow sands (zircon, monazite). Au placers commonly derive from various Au vein-type deposits as well as porphyry copper, Cu skarn, and polymetallic replacement deposits.

Deposit description:

Mineralogy: Au, platinum-iron alloys, osmium-iridium alloys; gold commonly with attached quartz, magnetite, or ilmenite.

Texture/structure: Flattened, rounded edges, flaky, flour gold extremely fine grained flakes; very rarely equidimensional nuggets.

Ore controls: Highest Au values at base of gravel deposits in various gold "traps" such as natural riffles in floor of river or stream, fractured bedrock, slate, schist, phyllite, dikes, bedding planes, all structures trending transverse to direction of water flow. Au concentrations also occur within gravel deposits above clay layers that constrain the downward migration of Au particles.

Geochemical signature: Anomalous high amounts of Ag, As, Hg, Sb, Cu, Fe, S, and heavy minerals magnetite, chromite, ilmenite, hematite, pyrite, zircon, garnet, rutile. Au nuggets have decreasing Ag content with distance from source.

Examples:

Sierra Nevada, US (Lindgren 1911, Yeend 1974)

Victoria, Australia (Knight 1975)

10.2 Known deposits and mineral deposits in East Gippsland CRA

Alluvial gold has been worked at numerous locations in the region and include the Bendoc, Bonang, BA Creek, Cabbage Tree Creek and MacKenzie Creek goldfields.

Primary gold occurs in the basement under these sediments at Cabbage Tree Creek, McKenzie River, Bemm River, Genoa Creek and Mallacoota and other occurrences of primary gold could well be concealed below the sediments. Past alluvial gold workings are reported to have been widely distributed over the floodplain areas and rarely concentrated in drainage channels. Worked deposits reveal 'immature quartz washes, including sub-angular slate and sandstones clasts' (Vandenberg et al. 1992).

10.3 Assessment criteria

1. Gold bearing source rocks.

2. Distribution of alluvial sediments.

3. Known alluvial workings.

10.4 Assessment: Tract Au4/M-H/B

Sediments of Late Tertiary and Quaternary age (about 5Ma to present) are widespread along the foothills and the coastal plain of East Gippsland CRA. Although the region has been prospected for alluvial gold deposits in the past, it still has a moderate to high potential for further concealed alluvial gold deposits.

Alluvial gold has been recovered from the Tertiary and Quaternary sediments in East Gippsland, and more deposits of alluvial gold are probably present in such sediments, particularly deeply buried alluvial deposits in areas where Tertiary and Quaternary sediments have not been mapped in detail. On the available information, the potential for alluvial gold deposits is moderate to high with a certainty level of B. This tract also has a moderate potential, with a certainty level of B, for primary gold deposits (e.g. slate-belt gold) in the basement rocks underlying the Tertiary and Quaternary sediments.

10.5 Economic significance

Alluvial gold production in East Gippsland was generally not recorded. According to the Victorian Geological survey, if a ratio of alluvial/reef gold production, similar to that in other areas of the State, is used for the East Gippsland region then alluvial production of at least 2000 kg is likely.

11 SEDIMENT HOSTED COPPER AND URANIUM DEPOSITS (MODELS 30b and 30c OF COX AND SINGER 1986)

11.1 Description of model 30b - descriptive model of sediment - hosted copper

Modified after Dennis P. Cox (in Cox and Singer 1986)

Approximate synonym: Sandstone Cu, includes Cu-shale (Lindsey 1982).

Description: Stratabound, disseminated copper sulphides in reduced beds of redbed sequences.

General references: Tourtelot and Vine (1976), Gustafson and Williams (1981).

Geological environment:

Rock types: Red-bed sequence containing green or Gary shale, siltstone, and sandstone. Thinly laminated carbonate and evaporite beds. Local channel conglomerate. Some deposits in thinly laminated silty dolomite.

Textures: Algal mat structures, mudcracks, crossbedding and scour-and-fill structures. Fossil wood in channels.

Age range: Middle Proterozoic and Permian and early Mesozoic. Other Phanerozoic ages possible.

Depositional environment: Epicontinental shallow-marine basin near paleo-equator. Sabkhas. High evaporation rate. Sediments highly permeable.

Tectonic setting(s): Intracontinental rift or aulacogen-failed arm of triple junction of plate spreading. Passive continental margin. Major growth faults.

Associated deposit types: Halite, sylvite, gypsum, anhydrite. Sandstone uranium, basalt copper, and Kipushi Cu-Pb-Zn.

Deposit description:

Mineralogy: Chalcocite and other Cu2S minerals + pyrite ± bornite ± native silver. Cu2S replacement of early fine-grained pyrite is common. Deposits may be zoned with centers of chalcocite ± bornite, rims of chalcopyrite, and peripheral galena + sphalerite. Some deposits contain carrollite and Co-pyrite and Ge minerals.

Texture/Structure: Fine disseminated, stratabound, locally stratiform. Framboidal or colloform pyrite. Cu minerals replace pyrite and cluster around carbonaceous clots or fragments.

Alteration: Green, white, or Gary (reduced) colour in red beds. Regionally metamorphosed red beds may have purple colour.

Ore Controls: Reducing low-pH environment such as fossil wood, algal mat. Abundant biogenic sulfur. Pyritic sediments. Petroleum in paleoaquifers. High permeability of footwall sediments is critical. Boundaries between oxidized and reduced sediments.

Weathering: Surface exposures may be completely leached. Secondary chalcocite enrichment down dip is common.

Geochemical Signature: Cu, Ag, Pb, Zn (Mo, V, U) (Co, Ge). Au is low. Weak radioactivity in some deposits.

Examples:

Kupferschiefer, Germany (Wedepohl 1971)

White Pine, US (Brown 1971)

Western Montana (Belt), US (Harrison 1972, 1982)

Kamoto, Zaire (Bartholome and others 1976)

11.2 Description of model 30c - descriptive model of sandstone uranium deposits

Modified after Christine E. Turner Peterson and Carroll A. Hodges

Approximate synonyms: Tabular U ore, roll front U.

Description: Microcrystalline uranium oxides and silicates deposited during diagenesis in localised reduced environments within fine to medium-grained sandstone beds; some uranium oxides also deposited during redistribution by ground water at interface between oxidised and reduced ground.

General reference: Turner-Peterson and Fishman (1986), Granger and Warren (1969).

Geological environment:

Rock types: Host rocks are feldspathic or tuffaceous sandstone. Pyroclastic material is felsic in composition. Mudstone or shale commonly above and/or below sandstones hosting diagenetic ores).

Textures: Permeable-medium to coarse grained; highly permeable at time of mineralisation, subsequently restricted by cementation and alteration.

Age range: Most deposits are Devonian and younger. Secondary roll-front deposits mainly Tertiary.

Depositional environment: Continental-basin margins, fluvial channels, braided stream deposits, stable coastal plain. Contemporaneous felsic volcanism or eroding felsic plutons are sources of U. In tabular ore, source rocks for ore-related fluids are commonly in overlying or underlying mud-flat facies sediments.

Tectonic setting(s): Stable platform or foreland-interior basin, shelf margin; adjacent major uplifts provide favourable topographic conditions.

Associated Deposit Types: Sediment-hosted V may be intimately associated with U. Sediment-hosted Cu may be in similar host rocks and may contain U.

Deposit description:

Mineralogy: Uraninite, coffinite, pyrite in organic-rich horizons. Chlorite common.

Texture/structure: Stratabound deposits. Tabular U-intimately admixed with pore-filling humin in tabular lenses suspended within reduced sandstone. Replacement of wood and other carbonaceous material. Roll front U-in crescentic lens that cuts across bedding, at interface between oxidised and reduced ground.

Alteration: Tabular-Humic acid mineralising fluids leach iron from detrital magnetite-ilmenite leaving relict TiO2 minerals in diagenetic ores. Roll front-Oxidised iron minerals in rock updip, reduced iron minerals in rock downdip from redox interface.

Ore Controls : Permeability. Tabular-Humin or carbonaceous material the main concentrator of U. Roll front-S species, "sour" gas, FeS2. Bedding sequences with low dips; felsic plutons or felsic tuffaceous sediments adjacent to or above host rock are favourable source for U. Regional redox interface marks locus of ore deposition.

Weathering : Oxidation of primary uraninite or coffinite to a variety of minerals, notably yellow carnotite as bloom in V-rich ores.

Geochemical and Geophysical Signature : U, V, Mo, Se, locally Cu, Ag. Anomalous radioactivity from daughter products of U. Low magnetic susceptibility in and near tabular ores.

Examples:

Colorado Plateau (Fischer 1974)

Grants, US (Turner-Peterson and Fishman 1986)

Texas Gulf Coast (Reynolds and Goldhaber 1983)

Wyoming, US (Granger and Warren 1969)

11.3 Assessment Criteria

1. Presence of red-bed sequence.

2. Presence of rift structures.

3. Presence of outcrop of rhyolite lava near Combienbar (Ramsay and VandenBerg 1986; also on 1:100 000 scale Bendoc map sheet (VandenBerg 1992) suggest that prior to erosion felsic volcanic rocks may have been present to provide a source for uranium.

11.4 Assessment: Tract Cu and U

Red bed clastic sediments of the Combyingbar Formation crop out in three areas in East Gippsland (Map 6 and Figure 15). Elsewhere in Australia and in the world, copper mineralisation is known to occur in reduced sediments within red bed sequences and uranium mineralisation also occurs in reduced sediments near interfaces of reducing and oxidising environments. Sandstone uranium occurs in reduced sediments at Beverley and Honeymoon in South Australia and such deposits are extensive in Colorado Plateau in US (Cox and Singer 1986). Sediment hosted copper is known to occur in Zambia and Zaire (southern Africa), Kupferschiefer (Germany) and Montana Belt (US).

Near Mansfield, 36 occurrences of copper mineralisation have been recorded in locally reduced rocks rocks in red beds in the Mansfield Basin, about 150 km west of East Gippsland. Anomalous uranium values were also recorded at six localities in these rocks (Nott 1988).

Although the red beds of the Combyingbar Formation could represent a permissive environment for sediment-hosted copper and sandstone type uranium deposits, only one occurrence of copper at Genoa River Beds prospect has been recorded in one of the red bed tracts. No details are known about this occurrence and the host is not known. No uranium has been recorded in these sediments. The limited areas of outcrop further restricts the potential for the occurrence of such deposits. On the available information there is a low to moderate potential for the presence of such deposits with a certainty level of B.

11.5 Economic significance

Elsewhere in the world, sediment-hosted copper and sandstone type uranium deposits represent major sources for copper and uranium respectively.

Based on data from 57 deposits worldwide, sediment-hosted copper deposits have a median ore tonnage of 22 million tonnes. About 90% of these deposits contain more than 1.5 million tonnes of ore. The median grade of these deposits is 2.1% copper (Cox and Singer 1986).

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Appendix F - Minerals Metadata Sheets

AUSTRALIA: MINERAL OCCURRENCE DATABASE (MINLOC)

Organisation: Mineral Resources and Energy Branch, Bureau of Resource Sciences

Abstract: Compilation of data for the MINLOC database began in 1989 and now contains information on about 50 000 mineral occurrences and deposits. Information for each location includes location co-ordinates, name of occurrence, and commodity(ies) of economic interest. The information in the database covers about 94% of the Australian continent.

Contents:

Citation Information

Data Set Title: Mineral occurrence database (MINLOC)

Data Set Short Title: MINLOC

Jurisdiction: Australia

Custodian: Bureau of Resource Sciences (BRS)

Publication Date:

Acknowledgements: Mineral Resources and Energy Branch (MREB)

References:

Dataset Description

Abstract: Compilation of data for the MINLOC database began in 1989 and now contains information on about 50 000 mineral occurrences and deposits. Information for each location includes location co-ordinates, name of occurrence, and commodity(ies) of economic interest. The information in the database covers about 94% of the Australian continent.

Search Words: MINERALS Mineral Deposits, MINERALS Mine Sites

Location Description: Australia

Spatial Domain

Bounding Coordinates: 154.0, -44.0, 112.5, -9.5

Bounding Polygon:

Attribute List: MINLOC ID; name locality; coord latitude; coord longitude; map ID or reference; accuracy code; 100K map sheet code; name of 100K map sheet; original number on map; state name abbreviated; comments; ID for method of location; abreviated commodity name; ID for commodity order if more than one commodity.

Dataset Currency and Status

Beginning Date: 1989

Ending Date: '19--'

Progress: In Progress

Maintenance and Update Frequency: 2-3 times per year

Dataset Storage and Format

Stored Data Format: Digital - Point

Output Data Format: Hardcopy - Printed Map; Hardcopy - Other

Native Data Format: Oracle - RDBMS (Relational Database)

Access Constraints: No Access Constraints

Dataset Quality

Lineage Summary: Each datapoint has reference to the source

Scale: 250 000

Resolution:

Cell Size:

Positional Accuracy: 3 Grades of accuracy: 10 to 100 metres; 100 to 1000 metres; 1 to 10 kilometres.

Attribute Accuracy: Each data point is tagged with precision

Logical Consistency: Crosschecking of datasets, Overlays of maps, User feedback

Completeness: 94% of Australia was covered on first pass basis

Additional Information:

VICMINE DATABASE

Organisation: Department of Natural Resources and Environment Minerals and Petroleum Victoria.

Abstract: The VicMine database contains information on mines, prospects and mineral occurrences in Victoria.

Contents:

Citation Information

Data Set Title: VicMine Database

Data Set Short Title: VicMine

Jurisdiction: Victoria

Custodian: DNRE, MPV

Publication Date: Dec 1995

Acknowledgements:

References:

Dataset Description

Abstract: The VicMine database provides information on location, geology, production and resources of mines, prospects and mineral occurrences in Victoria.

Search Words: Minerals, Mineral Deposits

Location Description: East Gippsland

Spatial Domain

Bounding Coordinates: 154.0, -44.0, 112.5, -9.5

Bounding Polygon:

Attribute List: See attached list

Dataset Currency and Status

Beginning Date: 1990

Ending Date: 1996

Progress: In progress

Maintenance and Update Frequency: Irregular

Dataset Storage and Format

Stored Data Format: Digital - DXF

Output Data Format: Digital - ASCII, Digital-DXF, Digital-MapInfo;

Hardcopy - report

Native Data Format: Digital - Point

Access Constraints: Crown copyright

Dataset Quality

Lineage Summary: Data derived from literature with minor field checks.

Scale: 25 000 to 100 000

Resolution: 25 to 100 metres

Cell Size:

Positional Accuracy: Varies according to source, ± 1 km to ± 25 m.

Attribute Accuracy: As derived from literature review and geological appraisal from minor field checks.

Logical Consistency: Data compiled to best of ability given available resources.

Completeness: Dependent on available data in literature.

Additional Information:

Attribute list

ID: Every minerals occurrence has a unique identifying code for each MINE/PROSPECT. The identifier code consists of the commodities produced (listed in order of importance), followed by a unique number. For example the Golconda Mine, which was primarily a gold producer with secondary copper production, is identified as AuCu31. To simplify the presentation of the mineral occurrences, the symbol used to identify the mine on the MapInfo screen is based only on the primary ore type - e.g. in this case the Golconda mine is represented by a yellow circle (for a primary gold deposit).

PRODUCT: Gives the commodities produced.

ORE TYPE: Indicates if the deposit is a primary or an alluvial deposit.

FIELD: The field in which the deposit lies. Field names are base upon predefined fields as discussed in Weston (1992) with new names based upon prominent geographic feature. A locality map is presented as Figure 4 in VIMP Report 10, available separately from the Department.

MINE PROSPECT NAME: Specifies the name of either mine/prospect/workings (incorporated into the name of proprietors) or that of reefs/alluvial areas being worked by proprietors.

LOCATION (EASTING, NORTHING AND ACCURACY):

Location of mine/prospect/workings in AMG co-ordinates.

PRODUCTION (ORE MINED, CONCENTRATE PRODUCED AND PRODUCTION YEARS): Production is recorded as ore-mined and final production, during a specified interval in years.

MINERALISATION (METALLICS AND NON METALLICS):

Mineralisation is described within the data base columns of **METALLICS, NON-METALLICS, HOST, HOST ORIENTATION, HOST LITHOLOGY, ASSOCIATED LITHOLOGY and STRUCTURE.**

METALLICS encompasses both metallic minerals and metals derived from unspecified mineral sources.

HOST is the structural or stratigraphic feature described by **METALLICS** and/or **NON-METALLICS** (i.e. gangue), which hosts mineralisation and occurs within the **HOST LITHOLOGY.**

HOST ORIENTATION describes the orientation of HOST and is presented as dip & direction/strike. e.g. 60W/360 - dip 60o west and a strike of 360o.

HOST LITHOLOGY is the stratigraphic host of mineralisation. The orientation of the **HOST LITHOLOGY** is sometimes recorded in the **COMMENTS** column.

ASSOCIATED LITHOLOGY is a lithology which is spatially and possibly genetically related to the **HOST LITHOLOGY**.

STRUCTURE - the structural elements of shearing and faulting (representing ductile to brittle deformation) are often not recorded (from the original data) in the strictest sense and the terms used are often interchangeable.

GENESIS - mineralisation has two broad origins, forming either primary hydrothermal deposits or secondary placer/alluvial deposits. The genesis of mineralisation is often contentious and contrasting alternative origins are recorded together, depending upon interpretations within the recorded literature.

FIELD DISCOVERY - the discovery date of mineral fields.

REFERENCES - all the references have been coded with a GEDIS number (Energy & Minerals of Victoria data base reference system). A complete list of references used in compiling this data base is contained within minref.doc and minref.txt (ASCII version).

COMMENTS - additional information has been provided regarding depth of workings, reasons for mine closures, alternative ore/product estimation, etc.

VIC: GEOLOGICAL MAPS DATABASE

Organisation Department of Natural Resources and Environment

Minerals and Petroleum Victoria

Abstract: The geological maps database is a digital version of the 1: 250 000 scale geological maps of Victoria.

Contents:

Citation Information

Data Set Title: Victorian 1: 250 000 Geological maps database

Data Set Short Title: Vic GEOL.

Jurisdiction: Victoria

Custodian: Department of Natural Resources and Environment, Minerals and Petroleum Victoria

Publication Date: Dec 1995

Acknowledgements:

References:

Dataset Description

Abstract: The Geological Maps Database is a digital version of the 1: 250 000 scale geological maps of Victoria that were compiled during the 1970s and 1980s. Some areas have been updated from more recent 1: 100 000 scale mapping.

Search Words: Geosciences, Geology

Location Description: East Gippsland, Victoria

Spatial Domain

Bounding Coordinates: 154.0, -44.0, 112.5, -9.5

Bounding Polygon:

Attribute List: See attached listing

Dataset Currency and Status

Beginning Date: 1970

Ending Date: 1992

Progress: In progress

Maintenance and Update Frequency: Irregular

Dataset Storage and Format

Stored Data Format: Digital - polygon, Hardcopy - Maps

Output Data Format: Digital - polygon, Hardcopy - Maps

Native Data Format: Available in Genemap, MapInfo or ArcView formats

Access Constraints: Data is Crown Copyright

Dataset Quality

Lineage Summary: Derived from 1: 250 000 scale geological maps

Scale: 250 000

Resolution: 250

Cell Size:

Positional Accuracy: $\pm$ 250 m

Attribute Accuracy: Data is accurate at time of map compilation to the best knowledge of the people compiling the map, given the state of geological knowledge.

Logical Consistency: Data identified from field mapping and aerial photography interpretation at 1: 250 000 scale.

Completeness: As above

Additional Information:

Attribute List: - see attached listing

Attribute List:

Unit: The abbreviated formal rock unit id. code (e.g. Emv)

Unit No.: Used only for granitoid plutons. The number quoted is that defined by White et. al., Petrology of Igneous Rocks. In J.G. Douglas & J. A. Ferguson, (eds) *Geology of Victoria*. Geological Society of Australia, Victoria Division. Melbourne, pp. 427-451.

Name : The formal name fo the rock unit/formation/member.

Description & Description 1: A brief description of the unit.

VIC: MINING TENEMENTS

Organisation: Department of Natural Resources and Environment Minerals and Petroleum Victoria

Abstract: The mining tenements database provides information and location of both current and expired exploration licences and mining licences in Victoria.

Contents:

Citation Information

Data Set Title: Victorian Mining and Exploration Tenements

Data Set Short Title: VICEL

Jurisdiction: Victoria

Custodian: Department of Natural Resources and Environment, Minerals and Petroleum Victoria

Publication Date: 20th October 1995

Acknowledgements:

References:

Dataset Description

Abstract: The VICEL data set is derived from the corporate GEDIS system, and as such represents a snapshot in time of continually changing data. The data base provides an outline of current and expired Exploration Licences and Mining Licences together with information on dates held and licences.

Search Words: Minerals Mining and Exploration Leases

Location Description: East Gippsland, Victoria

Spatial Domain

Bounding Coordinates: 154.0, -44.0, 112.5, -9.5

Bounding Polygon:

Attribute List: See attached listing

Dataset Currency and Status

Beginning Date: Oct 1995

Ending Date:

Progress: Complete

Maintenance and Update Frequency: Daily (source dataset) Not planned (this dataset)

Dataset Storage and Format

Stored Data Format: Digital - Polygon, Digital-Database

Output Data Format: Digital - Polygon, Digital - database, hard copy - maps; hard copy - reports

Native Data Format: Distributed Via CD or disk or on-line for subscribers

Access Constraints: Crown copyright reserved

Dataset Quality

Lineage Summary: Sourced from accurate topographic maps

Scale: 25000

Resolution: 25

Cell Size:

Positional Accuracy: ± 25 metres

Attribute Accuracy: All information is accurate as far as Mineral and Petroleum Victoria is concerned.

Logical Consistency:

Completeness: Complete for State of Victoria

Additional Information:

Attribute List

elcurr. These files include the location and details of current Exploration titles (as at 20th October, 1995).

Number The Exploration Licence title number.

Type The title type (El. for Exploration Licence, MP for an area excluded from title applications during the Moratorium period).

No. Renewed The number of times the title has been renewed.

Applicant The name of the title applicant.

Priority The title priority date.

Granted Date the title was granted.

Expiry Date the title is due for renewal/expiry.

Moratorium Date the moratorium period expires.

Area The area of the title in square kilometres.

Municipality The municipal shire in which the title lies.

Status The status fo the title (CURRE for current, RENEW for under renewal, APPLI for under application).

DCNR. Region The Department of Conservation and Natural Resources region in which the title lies.

elhist

Title The Exploration Licence title number

Applicant The name of the title applicant.

Granted Date the title was granted.

Expiry Date the title is due for renewal/expiry.

Renewed The number of times the title has been renewed.

Area sq. km The area of the title in square kilometres.

Municipality The municipal shire in which the title lies.

Commodity target The commodity target.

Expenditure The amount of exploration expenditure reported to the Department. Exploration expenditure figures in square brackets ([]) indicate expenditure was jointly reported with several Exploration Licences not listed. CONFID: appears where the details fo the report are still confidential.

Mapping, Ground geophysics, Air geophysics, Lit survey, Drilling

Indicates if mapping, ground geophysical surveys, air-born geophysical surveys, geochemical sampling surveys, literature surveys or drilling was recorded in the exploration activities.

Target (cont-cont2) Brief description of the commodities and style of mineralisation sought.

micurr: This file contains data giving an image of the currently held Mining titles (as of 20th October, 1995). Details of the titles can be viewed by opening the mlcurr.tab file (if not already opened), choosing the Info tool button in the Main Button Pad and clicking within the title you wish to inquire.

The information displayed is:

Number The Mining title number.

Type The title type (DL for Development Lease, ESP for Extractive Search Permit, LIC for Extractive Industry Licence, LSE for Extractive Industry Lease, MAL for Mining Area Licence, MIN for Mining Licence, ML for Mining Lease, MRC for Miners Right Claim and TRL for Tailings Removal Licence).

No. Renewed The number of times the title has been renewed.

Applicant The name of the title applicant.

Priority The title priority date.

Granted Date the title was granted.

Expiry Date the title is due for renewal/expiry.

Area The area of the title in hectares.

Municipality The municipal shire in which the title lies.

Status The status of the title (CURRE for current, RENEW for under renewal, APPLI for under application).

DCNR Region The Department of Conservation and Natural Resources region in which the title lies.

VIC: MAGNETICS DATABASE

Organisation: Department of Natural Resources and Environment

Minerals and Petroleum Victoria

Abstract: Magnetic data over the Eastern Highland is the latest high resolution data. Based in magnetic minerals distribution the data provide detailed information about surface and subsurface lithology and structure. The dataset s of Orbost, Mallacoota and Murrindal surveys data.

Contents:

Dataset Quality

Citation Information

Data Set Title: Eastern Highlands magnetic data

Data Set Short Title:

Custodian: Department of Natural Resources and Environment, Minerals and Petroleum Victoria

Publication Date: ORBOST - June 1994; Mallacoota - May 1995; Murrindal - August 1995

Acknowledgements: To CRAE and BHP contributed to ORBOST survey.

References:

Dataset Description

Abstract: Magnetic data over the Eastern Highlands is the high resolution data collected in 1994-1996. The helicopter surveys were flown at 80 metres above the ground with 200 metres line spacing. The data-set provides detailed information about surface and subsurface lithology and structure.

Search Words: Minerals, Geophysics

Location Description: Eastern Highlands, Victoria

Spatial Domain

Bounding Coordinates: 154.0, -44.0, 112.5, -9.5

Bounding Polygon:

Attribute List:

Dataset Currency and Status

Beginning Date: ORBOST - February 1994

Mallacoota - November 1994

Murrindal - November 1995

Ending Date: ORBOST - April 1994

Mallacoota - May 1995

Murrindal - January 1996

Progress: ORBOST and Mallacoota - complete

Murrindal in progress (data processing) will be released in August 1996**.**

Maintenance and Update Frequency:

Dataset Storage and Format

Stored Data Format: Digital - Database; Hardcopy - Maps, Reports

Output Data Format: Digital: Mapinfo, ERMapper, TIFF, DS ASCII: Hardcopy: Plotted maps, Report, Transparence

Native Data Format: none

Access Constraints: Crown copyright reserved

Dataset Quality

Lineage Summary:

Scale: 1: 25 000

Resolution: 100 (magnetic data were collected every ~ 0.1 sec, ~ 3 metres)

Cell Size: 50 metres (gridded data)

Positional Accuracy: The navigation data were provided by the Satellite Global Positioning System (GPS) with accuracy of ± 10 metres.

Attribute Accuracy: The measurements were taken with resolution of 0.01 nT for ORBOST and 0.01nT in Mallacoota

Logical Consistency: Two ground base magnetometers were set up during the acquisition to record diurnal variation. During the data processing diurnal variation and the International Geomagnetic Reference Field (IGRF) have been recovered. The data have been tie-line levelled and microlevelling was applied.

Completeness: The data have not been collected over towns (Buchan, Cann River, Mallacoota) due to flight regulations.

Additional Information:

VIC: RADIOMETRICS

Organisation: Department of Natural Resources and Environment

Minerals and Petroleum Victoria

Abstract: Radiometric data over the Eastern Highlands provides surface geochemical information, allow lithological boundaries to be identified. The data-set consists of ORBOST, MALLACOOTA and MURRINDAL surveys data.

Contents:

Dataset Storage and Format

Dataset Quality

Citation Information

Data Set Title: Eastern Highlands radiometric data

Data Set Short Title:

Jurisdiction: Victoria

Custodian: Department of Natural Resources and Environment, Minerals and Petroleum Victoria

Publication Date: ORBOST - June 1994, Mallacoota May 1995, Murrindal - August 1996

Acknowledgements: To CRAE and BHP contributed to the ORBOST survey.

References:

Dataset Description

Abstract: Radiometric data reflect the surface and near surface (20-50 cm depth) distribution of natural radioelements (potassium, thorium, uranium). The data is presented in RBB format showing potassium in red, thorium in green and uranium in blue. Variations in the colour represent changes in lithology at the surface.

Search Words: Minerals, Geophysics

Location Description: Eastern Highlands, Victoria

Spatial Domain

North Bounding Coordinate: -37.0

East Bounding Coordinate: 150.0

South Bounding Coordinate: -38.0

West Bounding Coordinate: 148.0

Bounding Polygon:

Attribute List:

Dataset Currency and Status

Beginning Date: ORBOST - February 1994; MALLACOOTA - November 1994; MURRINDAL - November 1995

Ending Date: ORBOST - April 1994; MALLACOOTA - May 1995; MURRUNDAL - January 1996

Progress: ORBOST & MALLACOOTA - complete; MURRINDAL - in progress (data processing)

Maintenance and Update Frequency Not planned

Dataset Storage and Format Digital - Database; Hardcopy: Maps, Reports

Stored Data Format:

Output Data Format: Digital: Mapinfo, ERMapper, TIFF, ASCII; Hardcopy: Plotted MRB Report, Transparency

Native Data Format: none

Access Constraints: Crown copyright reserved

Dataset Quality

Lineage Summary:

Scale: 1: 25 000

Resolution: 100 (No radiometric data were recorded every 1.0 sec, ~ 30 metres)

Cell Size: 50 metres grid (gridded data)

Positional Accuracy: The navigation data were provided by the satellite Global Positioning System (GPS) with accuracy of ±10 metres.

Attribute Accuracy:

Logical Consistency:

Completeness: The measurements were collected in CPS (counts per second) and then recalculated to % of ground equivalent for K, and ppm for Th and U.

Additional Information: The data have not been collected over towns (Buchan, Cann River, Mallacoota) due to flight regulations Logical Consistency:

- Pre and post flight checks of stability were undertaken.
- Flight calibration was made before and following each day's surveying. Corrections have been applied for instrument deadtime, cosmic and aircraft background. The influence of radon has been minimised by the application of long wavelength spatial filtering.

Appendix G - Forest Metadata Sheets

VICTORIA: Hydrology at 1:100 000

Organisation: Victorian Department of Natural Resources and Environment

Abstract: This layer contains line and point features delineating streams and boundaries and point sources of water bodies such as lakes, reservoirs and farm dams.

Contents:

Citation Information

Data Set Title: Hydrology at 1:100 000

Data Set Short Title: HYDRO100

Jurisdiction: Victoria

Custodian: Victorian Department of Natural Resources and Environment

Publication Date: 12 Sept 1994

Acknowledgements: Australian Army, CNR Water Resource Management Branch (WRMB) Stream and Catchment References for Environmental Data (SACRED)

References: Wilson, P. & Nason, S. (1991) (SACRED) "Stream and Catchment References for Environmental Data, A stream Numbering System for Victoria", Department of Conservation and Environment, Victoria.

Dataset Description

Abstract: This layer contains line and point features delineating streams and boundaries and point sources of water bodies such as lakes, reservoirs and farm dams. All features are identified and coded according to the Australian Standard Geographic Information Systems - Geographic Data - Interchange of feature-coded digital mapping data AS2482 - 1989.

Feature of major importance are identified. Addtionally linear features are identified using CNR's Water Resource Management Branch (WRMB) hierarchical stream numbering scheme, which is based on Australian Water Resource Council basins.

This scheme enables features to be classified by hydrology basin and includes a further classification scheme for hydrological features.

Search Words: WATER

Location Description: Australia

Spatial Domain

Bounding Coordinates: -32.75,-40.25,150.75,140.00

Bounding Polygon:

Attribute List: HYDRO100.AAT (ARC FEATURES)

AS2482 Australian Standard AS2482 - 1989

Template Highlights major features and those

features shared in LANDMMT100 layer

AWRC Riverbasin AWRC basin number

WRMB Stream number AWRC Stream number

WRMB Reach number WRMB SACRED stream number

WRMB Reach number WRMB SACRED reach number

WRMB Feature code WRMB SACRED feature code

Digital source Digital source

Analog Source Analog source

Version Major revision number applied

to features modified

HYDRO100.PAT (POINT FEATURES)

AS2482 Australian Standard AS2482 - 1989

Digital source Digital source

Analog source Analog source

Version Major revision number applied

to features modified

HYDRO100.NAT (NODE FEATURES)

AS2482 Australian Standard AS2482 - 1989

Digital source Digital source

Analog source Analog source

Version Major revision number applied

to all features modified

Dataset Currency and Status

Beginning Date: 1989

Ending Date: 1994

Progress: Complete

Maintenance and Update Frequency: As Required

Metadata Reviewed: 24 Oct 1994

Dataset Storage and Format

Stored Data Format: Digital - point, line poly,database

Output Data Format:

Native Data Format: Digital - ARC/INFO

Additional Format info: ARC/INFO coverages and associated .LUTs

Access Constraints:

Dataset Quality

Lineage Summary: AUSLIG 1:100,000 digital topographic base map; AUSLIG 1:100,000 topographic base map (CNR digitised); ARMY 1:100,000 topographic base map (CNR digitised); CNR Water Resource Management Branch (WRMB) Stream and Catchment References for Environmental Data (SACRED) received in AS2482 format for each 1:100,000 tile.

During importation, prior to insertion in the library, the following processes were conducted: translate to ARC/INFO format; subtract 6,000,000 from the y-co-ords; Split into themes (e.g. roads, hydrology, topography, utilitiesd, remaining); generalize (fuzzy 0.05 to 0.4); unsplit on AS2482. Additional processing including topology fixing and AS2482 validation were applied to features on each mapsheet. In some cases, a clean may have been performed with a fuzzy of 0.01. On completion the version item of features were upgraded from -9 (unvalidated) to a version greater than 0. Clipped (fuzzy 0.05).

Scale: 100 000

Positional Accuracy: ARMY data; 90% within +/- 50m horiz. +/- 10m vert. AUSLIG data; +/- 25m horiz. +/- 5m vert. Digital; departure from source will not exceed 50m or RMS of 0.12mm Determination; survey controlled with 8 points/sheet residual error < 10m

Attribute Accuracy: AS2482 coding on all features is validtaed against the printed 1:100,000 map (ARMY or AUSLIG). Major features are identified (template 1 or 2). The WRMB numbering classification scheme isapplied using a number of attributes such as wr_basin, wr_no, wr_reach and wr_feat. This classification scheme has only been applied to those features that WRMB have numbered. In future the remaining streams may be classified.

Logical consistancy: All coverages go through a checking procedure that includes; item validation (AS2482, template, wr_basin, wr_no, wr_reach, wr_feat, sourced, sourcea, and version), node errors, intersect errors.

Completeness: All 1:100 000 mapsheets that fall completely within Victoria (including those along the coast) will have a complete coverage of hydrology data according to the 1:100 000 printed maps. Those mapsheets that fall across interstate borders and that CNR had to digitize due to their unavailability will have all hydrology features that fall within Victoria and major hydrology features only interstate.

Additional information:

VICTORIA: Hydrology polygons at 1:100 000

Organisation: Victorian Department of Natural Resources and Environment

Abstract: This layer is a totally derived layer that contains polygonized hydrological features.

Contents:

Citation Information

Data Set Title: Hydrology polygons at 1:100 000

Data Set Short Title: HYDROP100

Jurisdiction: Victoria

Custodian: Victorian Department of Natural Resources and Environment

Publication Date: 16 Nov 1995

Acknowledgements: ARMY, CNR Water Resource Management Branch (WRMB) Stream and Catchment References for Environmental Data (SACRED)

References:

Dataset Description

Abstract: This layer is a totally derived layer that contains polygonized hydrological features. All features are identified and coded according to the Australian Standard Geographic Information Systems - Geographic Data - Interchange of feature-coded digital mapping data AS2482 - 1989.

Search word: WATER

Location Description: Victoria

Spatial Domain

Bounding Coordinates: -32.75, -40.25, 150.75, 140.00

Bounding Polygon:

Attribute List: HYROP100.AAT (ARC FEATURES)

AS2482 Australian Standard AS2482 - 1989

Template Highlights major features and those features shared in LANDMMT100 layer

Digital source Digital source

Analog Source Analog source

Version Major revision number applied to features modified

HYDROP100.PAT (POLYGON FEATURES)

AS2482 Australian Standard AS2482 - 1989

Name Name of feature

Digital source SOURCED.LUT Digital source

Analog source SOURCEA.LUT Analog source

Version Major revision number applied to features modified

Data Currency and Status

Beginning Date: 1991

Ending Date: 1994

Progress: Complete

Maintenance and Update Frequency: As Required

Metadata reviewed: 16 Nov 1995

Data Storage and Format

Stored Data Format: Digital - line,poly,database

Output Data Format:

Native Data Format: Digital - ARC/INFO

Additional Format info: ARC/INFO coverages and associated .LUTs

Access Constraints:

Dataset Quality

Lineage: AUSLIG 1:100,000 digital topographic base map; AUSLIG 1:100,000 topographic base map (CNR digitised); ARMY 1:100,000 topographic base map (CNR digitised). Using the parent coverage, HYDRO100, features were selected according to theirAS2482. Those features that contained polygon arcs were copied to HYDROP100 and then built fo polygon.

Scale: 100 000

Resolution: 50

Positional Accuracy: ARMY data; 90% within +/- 50m horiz. +/- 10m vert. AUSLIG data; +/- 25m horiz. +/- 5m vert. Digital; departure from source will not exceed 50m or RMS of 0.12mm Determination; survey controlled with 8 points/sheet residual error < 10m

Attribute accuracy: AS2482 coding on all features is validtaed against the printed 1:100,000 map (ARMY or AUSLIG).

Logical consistancy: All coverages go through a checking procedure that includes; item validation (AS2482, sourced, sourcea and version)

intersect errors

label errors

Completeness: All coverages that fall completely within Victoria (including those along the coast) will have a complete derived coverage of hydrology polygons. Those mapsheets that fall across interstate borders and that CNR had to digitize (sourced = 29) will all hydrology polygons that fall within Victoria and major hydrology polygons only interstate. There are a number of mapsheets that do not have any hydrology polygon information on them due to natural factors rather than incomplete information.

Additional Information:

VICTORIA: Land Management at 1:100 000

Organisation: Victorian Department of Natural Resources and Environment

Abstract: This layer contains polygons delineating the current legal status of land or Government Act under which land is managed, government management recommendations and the current management of land.

Contents:

<u>Citation Information</u>

Citation Information

Data Set Title: Land Management at 1:100 000

Data Set Short Title: LANDMMT1OO

Jurisdiction: Victoria

Custodian: Victorian Deptartment of Natural Resources and Environment

Publication Date: 16 Nov 1994

Acknowledgements:

References:

Dataset Description

Abstract: This layer contains polygons delineating the current legal status of land or Government Act under which land is managed, government management recommendations and the current management of land.

Also included are Reference Areas, Wilderness Zones and Remote Natural Areas, and where possible, boundaries delineating land owned or vested with other authorities, local government and the Commonwealth.

The layer includes an identifier for land or water and whether or not the land contributes to the Fire Protected Area and the marginal 1.5km strip.

Search word: LAND Ownership, LAND Cadastre

Location Description: Australia

Spatial Domain

Bounding Coordinates: -32.75,-40.25,150.75,140.00

Bounding Polygon:

Attribute List: LANDMMT100.AAT (ARC FEATURES)

AS2482 Feature coding according to Australian Standard AS2482 - 1989

Fire Protected Area Identifies arcs forming marginal 1.5km strip of fire protected area

Digital source Digital source

Analog Source Analog source

Version Revision number applied to features modified during major revisions to the layer. A single record should be present for each version

LANDMMT100.PAT (POLYGON FEATURES)

Dataset Name of polygon

Land Status Legal status or Government Act under which land is managed

NP ACT Relevant Part Numbers of the National Parks Act Schedules

Management Management recommendations (LCC recommendations other Government recommendations)

Management Status Current management of the land

Reference Area Unique number assigned to provide link to reference area database

Wilderness Zone Relevant part No's of Wilderness Zones & Remote Natural Areas (Schedule's 5 & 6 of the NP Act)

Fire protected area Contribution or otherwise to fire protected area

Land Type Land or water

Version Major Revision number applied to features modified

NP code Combines LAND_STATUS and NP_ACT items. NP_CODE uniquely identifies any public land polygon with an Act number

Data Currency and Status

Beginning Date: 1989

Ending Date: present

Progress: In Progress

Maintenance and Update Frequency: As Required

Metadata reviewed: 7 Feb 1995

Dataset Storage and Format

Stored Data Format: Digital - point,line,poly,database

Output Data Format:

Available Formats Type(s): Digital - ARC/INFO

Additional Format Info: ARC/INFO coverages and associated .LUTs

Access Constraints:

Dataset Quality

Lineage: Data Collection Method; Certified Plans, Parish Plans, maps, Government Gazettes

Data Set Source: To establish the legal status of the land a copy of the current record Parish Plan was made at the Central Plan Office (CPO). Public land information was identified on this copy and then reduced via omnigraph or photocopier to 1:100, 000. Cadastral boundaries were interpreted onto a matte film copy of the existing topographic base (digital preferably, printed map if not available).

Park boundaries are interpreted from the Certified Plans and Dedication Schedules - that is, if the boundary follows a ridge then the ridge is prepped, if the boundary follows a road then the road is copied from the ROAD100 layer. Where possible the prepped information was sent to the former regional planners to verify public land prior to digitising.

For management recommendations, the original source maps for the relevant Land Conservation Council (LCC) study area Final Recommendations are borrowed from the LCC and reduced to 1:100 000. The boundaries again are interpreted from this information and the relevant feature is copied from the base layer. Where other Government recommendations supercede the LCC recommendations, these are adopted.In future forest management and park management recommendations may be incorporated.

Data Set Processing Details: Minimal processing performed on LANDMMT100, that is , the coverages are always built and not cleaned or clipped if at all possible. If a clean is performed the tolerances are set to 0.1.

Scale: 100 000

Positional Accuracy: 1mm at map scale (100 metres) for prep and digitising where base features (ie. roads) exist to tie cadastre to. Derived layers as per parent coverage.

Attribute Accuracy: All arcs copied from another layer are validated within that layer prior to being copied into LANDMMT100. The majority of these attributes are maintained. All arc features are AS2482 coded.

Coding of labels for polygons is restricted to those codes that are contained within the relevant lookup tables for each attribute.

Logical Consistancy: Features from base layers are checked to ensure that the length of hydrology, road and utility arcs coded to be land management boundaries will be within 1% of the aggregate length of the same arcs in LANDMMT100.

All coverages go through a validation process that includes item validation, labelerrors, edgematching of both arcs and labels.

Completeness: All 1:100 000 mapsheets are coded with the legal status of the land (LAND_STATUS). Presently some mapsheets are not attributed for management recommendation, their attributing will be completed under a user pays approach.

Additional Information:

VICTORIA: Named locations at 1:100 000

Organisation: Victorian Department of Natural Resources and Environment

Abstract: Named locations desribed in this layer include town names, buildings/structures and place names in general.

Contents:

Citation Information

Data Set Title: Named locations

Data Set Short Title: LOCN100

Jurisdiction: Victoria

Custodian: Victorian Department of Natural Resources and Environment

Publication Date:

Acknowledgements: Division of Survey and Mapping Place Names Register

References:

Dataset Description

Abstract: Named locations desribed in this layer include town names, buildings/structures and place names in general. These locations are stored as named points and are classified according to the Australian Standard Geographic Information Systems - Geographic Data - Interchange of feature-coded digital mapping data AS2482 standard. Point names will in future be stored as annotation appropriate for various outputs with linkages to the original point location. The layers primary function is to support production of map annotation and as a general reference for localities.

Search word: HUMAN ENVIRONMENT Structure and Facilities

Location Description: Australia

Spatial Domain

Bounding Coordinates: -32.75,-40.25,150.75,140.00

Bounding Polygon:

Attribute List: LOCN100.PAT (POINT FEATURES)

Feature Reference Code Unique point reference code

AS2482 Australian Standard AS2482 - 1989

Feature Reference Name Name of feature

Digital source Digital source

Analog source Analog source

Edit Version Edit history

Feature Class Feature Class

TATLOCN100 (ANNOTATION FEATURES)

Feature Reference Code Unique point reference code

(This table is a provision for future annotation)

Data Currency

Beginning Date: 1993

Ending Date: 1993

Progress: Unknown

Maintenance and Update Frequency: As Required

Metadata reviewed: 24 Oct 1994

Dataset Status

Stored Data Format: Digital - point,database

Output Data Format:

Native Data Format: Digital - ARC/INFO

Additional Format info: ARC/INFO coverages and associated .LUTs

Access Constraints:

Dataset Quality

Lineage: Data was derived initially from the Division of Survey and Mapping Place Names Register (dbase3 based). Substantial data rectification was required and additional intelligence applied to the data by the Drafting Services Section. Future additions/enhancements will be coordinated by the Drafting Services Section.

Data Set Processing Details: The original data from DSM was in dBase 3 format and contained the following information: DSM classification code (eg. PEAK, BANK); AMG easting (eg. 599200); AMG northing (eg. 6210900); ZONE (eg. 54); TILE-NO (eg. 7423-4-3); NAME (eg. 19TH STREET). This information was then put into one ARC/INFO lookup table and processing occurred. Any non-sensical or duplicate (within 1km) records were removed.

Features were grouped according to a new classification scheme that is not as specific as the one used by DSM. Unique codes (locn_code) were assigned and features were AS2482 coded.

Australian Bureau Statistics data was linked to get population figures for towns. CNR significance was then added for workcentres, area offices, etc. The 1:100,000 mapsheet where the feature falls was derived from the co-ordinates provided.

Scale: 100 000

Positional accuracy: 10 to 100 metres depending on source data

Attribute accuracy: All information provided in the original dataset has been maintained. The accuracy of the attributes may vary according to the classification. The name of the feature and the classification according to LOCN_CODE should have an accuracy of greater than 95%. The CNR significance is accurate to June 1993 when the the current departmental map of Areas was produced.

Logical consistancy: Any non-sensical data was removed (i.e. points that fell in Bass Strait) and duplicate records were also removed.

Completeness: Unknown

VICTORIA: Roads at 1:100 000

Organisation: Victorian Department of Natural Resources and Environment

Abstract: This layer contains line and point features delineating streams and boundaries and point sources of water bodies such as lakes, reservoirs and farm dams.

Contents:

Citation Information

Data Set Title: Roads at 1:100 000

Data Set Short Title: ROAD100

Jurisdiction: Victoria

Custodian: Victorian Department of Natural Resources and Environment

Publication Date: 16 Nov 1994

Acknowledgements: AUSLIG, ARMY

References:

Dataset Description

Abstract: This layer contains line and point features delineating roads and related features. All features are identified and coded according to the Australian Standard Geographic Information Systems - Geographic Data - Interchange of feature-coded digital mapping data AS2482 - 1989. Major road networks are identified and numbered according to a unique numbering system.

Search word: TRANSPORTATION Land

Location Description: Australia

Spatial Domain

Bounding Coordinates: -32.75,-40.25,150.75,140.00

Attribute List: ROAD100.AAT (ARC FEATURES)

AS2482 Australian Standard AS2482 - 1989

Speed Rating Speed Rating

Road Name Name of feature

Road Number Road number assigned by NRS

Template Highlights major features and those features shared in LANDMMT100 layer

Digital source Digital source

Analog Analog source

Version Major revision number applied to features modified

ROAD100.PAT (POINT FEATURES)

AS2482 ROAD_AS2482.LUT Australian Standard AS2482 - 1989

Name Name of feature

Digital source Digital source

Analog source Analog source

Version Major revision number applied to features modified

ROAD100.NAT (NODE FEATURES)

AS2482 Australian Standard AS2482 - 1989

Digital source Digital source

Analog source Analog source

Version Major revision number applied to all features modified

Data Currency and Status

Beginning Date: 1989

Ending Date: 1994

Progress: In Progress

Maintenance and Update frequency: As Required

Metadata reviewed: 24 May 1995

Data Storage and Format

Stored Data Format: Digital - point,line,database

Output Data Format:

Native Data Format: Digital - ARC/INFO

Additional Format info: ARC/INFO coverages and associated .LUTs

Access Constraints:

Dataset Quality

Lineage Summary: AUSLIG 1:100 000 digital topographic map base

AUSLIG 1:100 000 topographic map base (CNR digitized)

ARMY 1:100 000 topographic map base (CNR digitized)

Division of Survey and Mapping 1:25 000 digital topographic map base (limited to East Gippsland area only)

Data Set Processing Details: The data was received in AS2482 format for each 1:100 000 tile and prior to insertion in the library underwent the following processes during importation: translate into arc/info format; subtract 6 million from the y co-ords; split into themes (e.g. roads, hydrology, topography, utilities, remaining); generalize (fuzzy 0.05 to 0.4); unsplit on AS2482; clip (fuzzy 0.05); set version = -9.

Additional processing including topology fixing and AS2482 validation were applied to fatures on each mapsheet. In some cases, a clean may have been performed with a fuzzy of 0.01. On completion the version item of features were upgraded from -9 (unvalidated) to a version greateer than 0.

Scale: 100 000

Positional Accuracy: ARMY data; 90% within +/- 50m horiz. +/- 10m vert. AUSLIG data; +/- 25m horiz. +/- 5m vert. Digital; departure from source will not exceed 50m or RMS of 0.12mm Determination; survey controlled with 8 points/sheet residual error < 10m

Attribute Accuracy: AS2482 coding on major features (template 1 or 2) is validated against the VICROADS Directory. Major features (template 1 or 2) are identified and a unique number identifier assigned to these features during this validation process.

Logical Consistancy: All coverages go through a checking procedure that includes item validation (AS2482, template, roadnum, sourced, sourcea, and version), node errors, intersect errors.

Completeness: All 1:100 000 mapsheets that fall completely within Victoria (including those along the coast) will have a complete coverage of road data according to the 1:100 000 printed maps. Those mapsheets that fall across interstate borders and that CNR had to digitize will have all roads that fall within Victoria and major roads only interstate.

Additional Information:

VICTORIA: Utilities at 1:25 000

Organisation: Victorian Department of Natural Resources and Environment

Abstract: This layer contains line and point features delineating streams and boundaries and point sources of water bodies such as lakes, reservoirs and farm dams.

Contents:

Citation Information

Data Set Title: Utilities at 1:25 000

Data Set Short Title: UTIL25

Jurisdiction: Victoria

Custodian: Victorian Department of Natural Resources and Environment

Publication Date: 17 Feb 1995

Acknowledgements: Survey and Mapping Victoria

References:

Dataset Description

Abstract: This layer contains line and point features for utilities such as railway lines, gas and oil pipelines, transmission lines, fences, etc. All features are identified and coded according to the Australian Standard Geographic Information Systems - Geographic Data - Interchange of feature-coded digital mapping data AS2482 - 1989.

Search word: HUMAN ENVIRONMENT Utilities

Location Description: Australia

Spatial Domain

Bounding Coordinates: -32.75,-40.25,150.75,140.00

Bounding Polygon:

Attribute list: UTIL25.AAT (ARC FEATURES)

AS2482 Australian Standard AS2482 - 1989

Name Name of feature

Template Highlights major features and those

features shared in LANDMMT100 layer

Digital Digital source

Analog Source Analog source

Version Major revision number applied to features modified

UTIL25.PAT (POINT FEATURES)

AS2482 UTIL_AS2482.LUT Australian Standard AS2482 - 1989

Name Name of feature

Digital source Digital source

Analog source Analog source

Version Major revision number applied

to features modified

UTIL25.NAT (NODE FEATURES)

AS2482 Australian Standard AS2482 - 1989

Digital source Digital source

Analog source Analog source

Version Major revision number applied to all features modified. Minor CNR Area amendments

Data Currency and Status

Beginning Date: 1989

Ending Date: 1996

Progress: In Progress

Maintenance and Update Frequency: As Required

Metadata reviwed: 28 Oct 1994

Data Storage and Format

Stored Data Format: Digital - point, line ,database

Output Data Format:

Native Data Format: Digital - ARC/INFO

Additional Format info: ARC/INFO coverages and associated .LUTs

Access Contraints:

Dataset Quality

Lineage: Survey and Mapping Victoria 1:25 000 digital topographic map base. Minor CNR Area amendments

Data Set Processing Details: The data was received in AS2482 format for each 1:25 000 tile and prior to insertion in the library underwent the following processes during importation: translate into arc/info format; subtract 6 million from the y co-ords; split into themes (e.g. roads, hydrology, topography, utilities, remaining); generalize (fuzzy 0.05 to 0.4); unsplit on AS2482; clip (fuzzy 0.05). Note that sheets that are printed as double format or 1:50 000 double format are supplied as one double format file but in importing is split into the two single format mapsheets for library insertion. Additional processing including topology fixing and AS2482 validation may be applied to features on each mapsheet. In some cases, a clean may have been performed with a fuzzy of 0.01. On completion the version item of features will be upgraded from -9 (unvalidated) to a version greater than 0.

Scale: 25 000

Positional Accuracy: 90% well defined points with +/- 12.5m of location 90% elevations within +/- 10 or 20 m. Digital data within 0.5mm of source with RMS < 0.12mm. 38 sub-standard mapsheets (location out by up to +/- 50m).

Attribute Accuracy: If the version number is greater than 0 then the AS2482 coding on all features is validated against the printed 1:25 000 map.

Logical Consistancy: All coverages go through a checking procedure that includes item validation (AS2482, template, sourced, sourcea, and version), node errors, intersect errors.

Completeness: Approximately 20% of the state is covered with data in the Corporate Library.

Additional Information:

List of Maps

East Gippsland

Comprehensive Regional Assessment

LAND TENURE AND STATE FOREST MANAGEMENT ZONES

LEGEND

5 0 5 10 15 20 25 Kilometres

Parks and reserves

STATE FOREST

No logging

Logging with special conditions

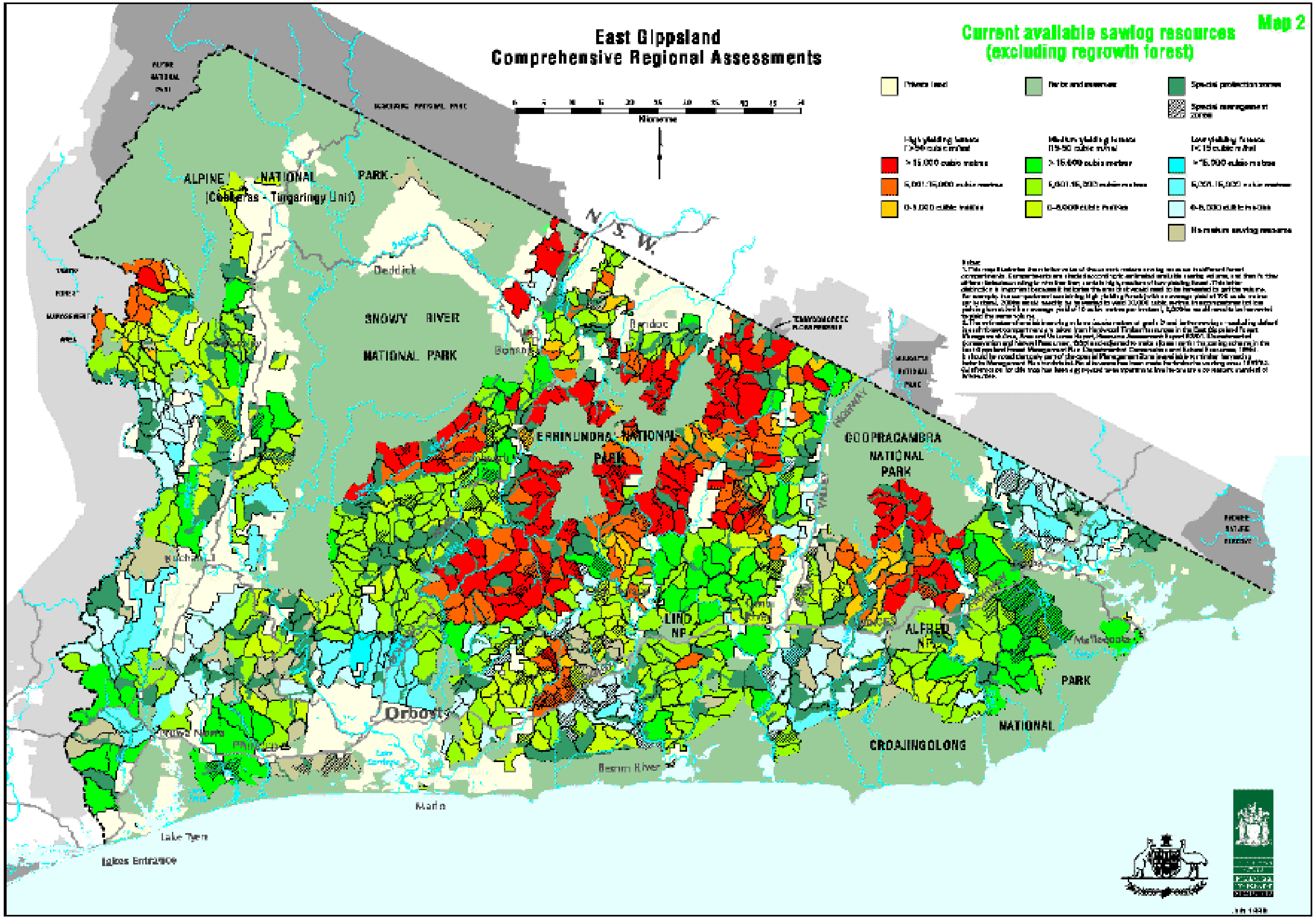
Logging with general conditions

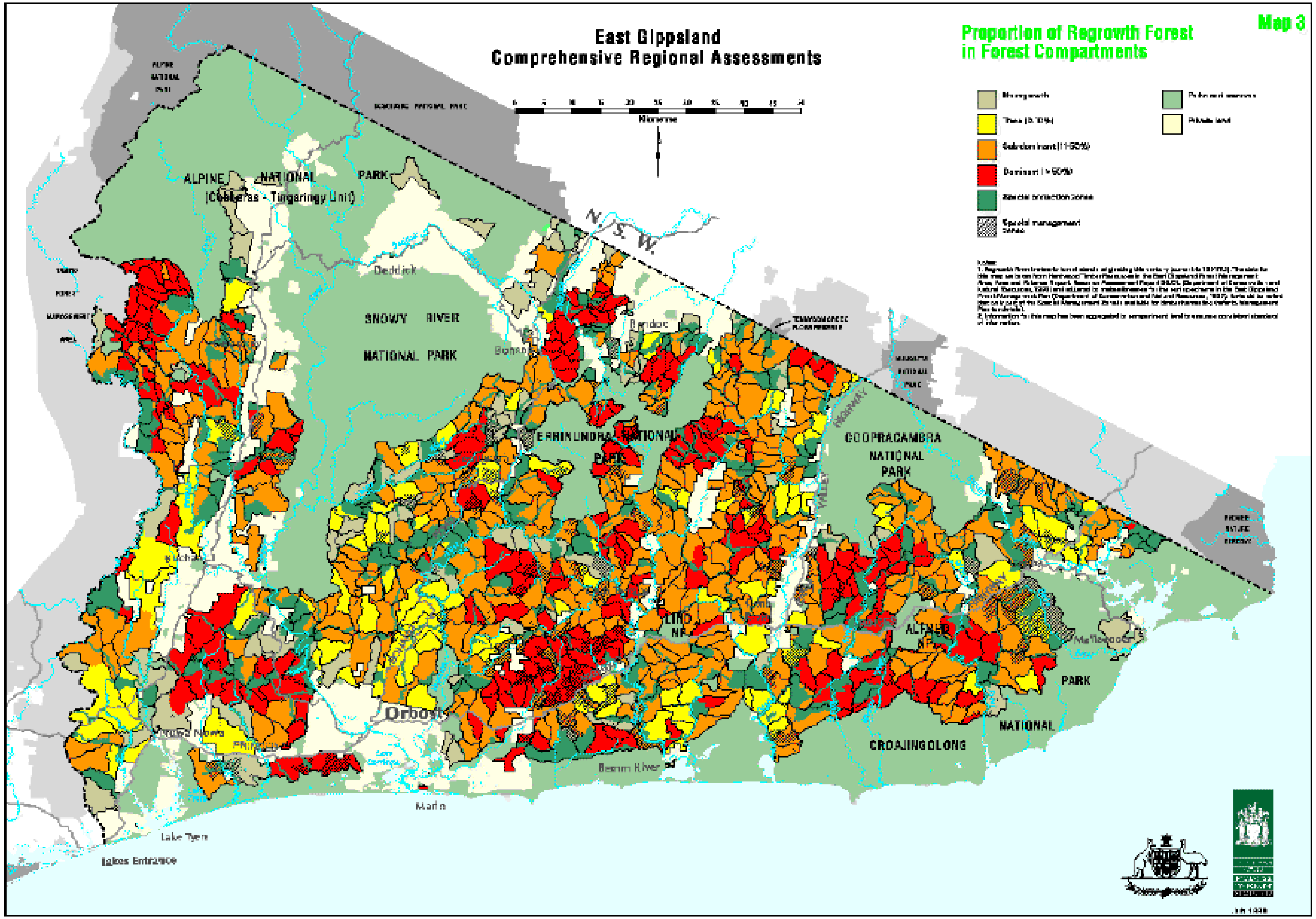
Other reserves and public land

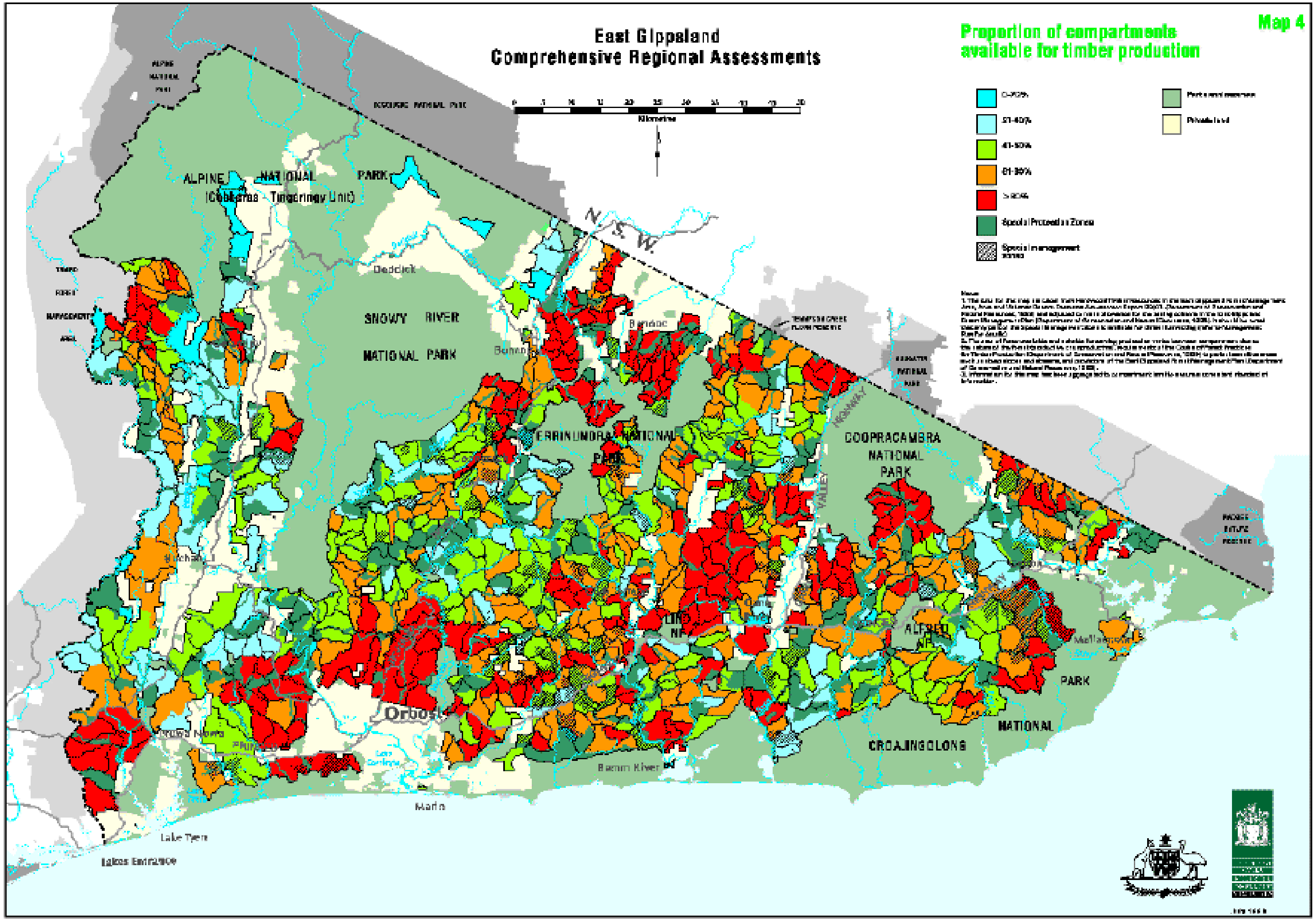
Conservation reserves outside study area

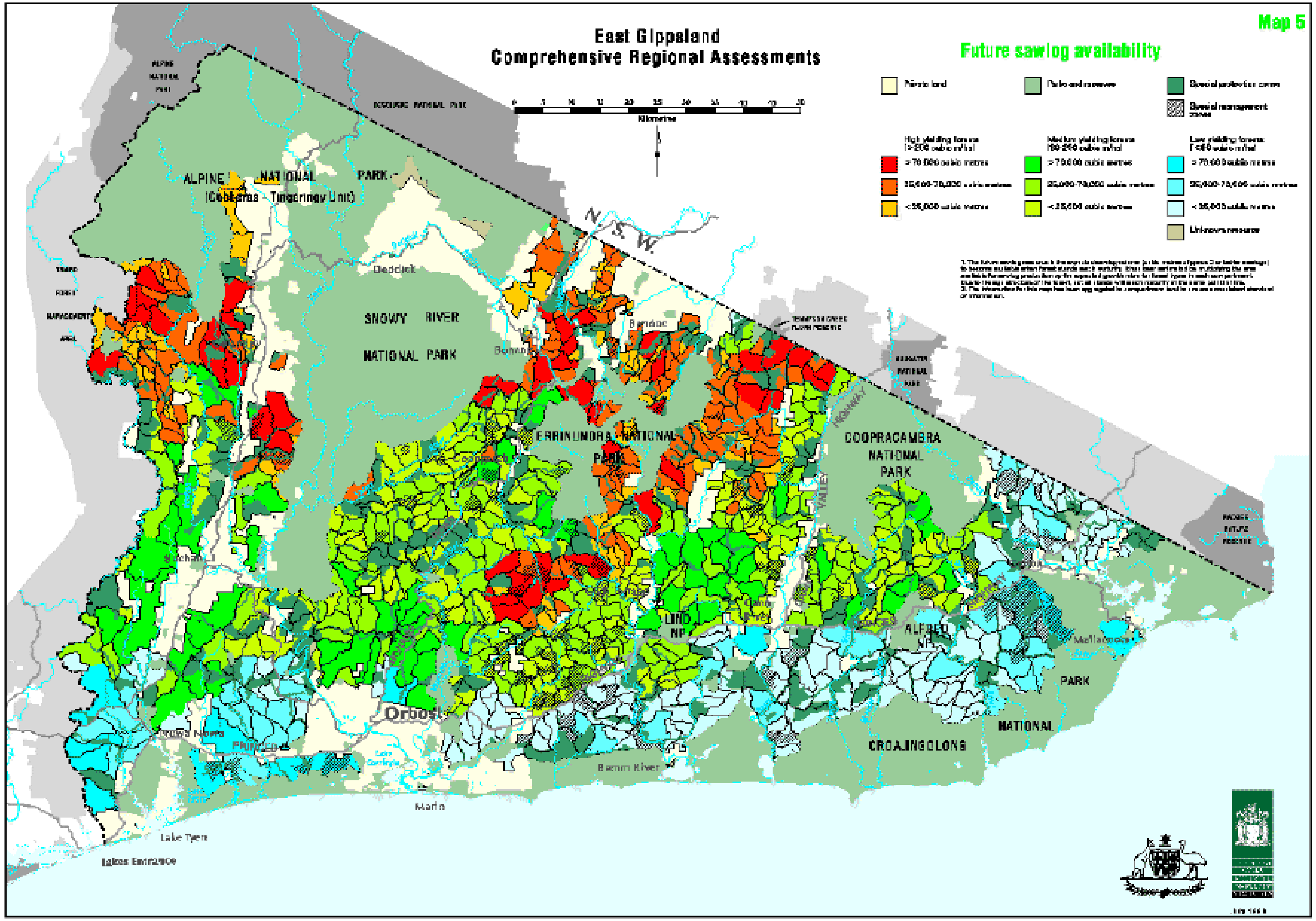
Other public land outside study area

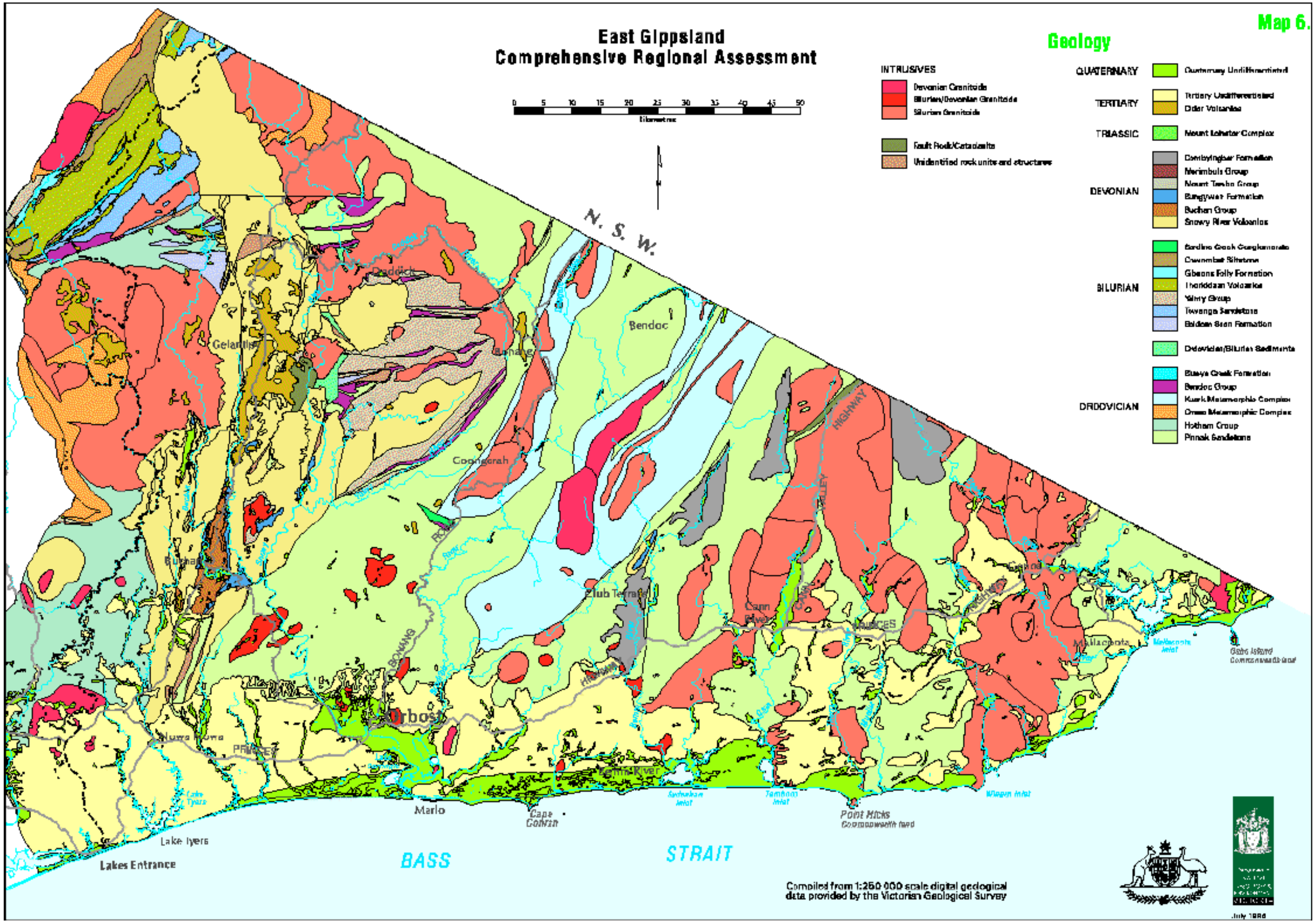
Private land

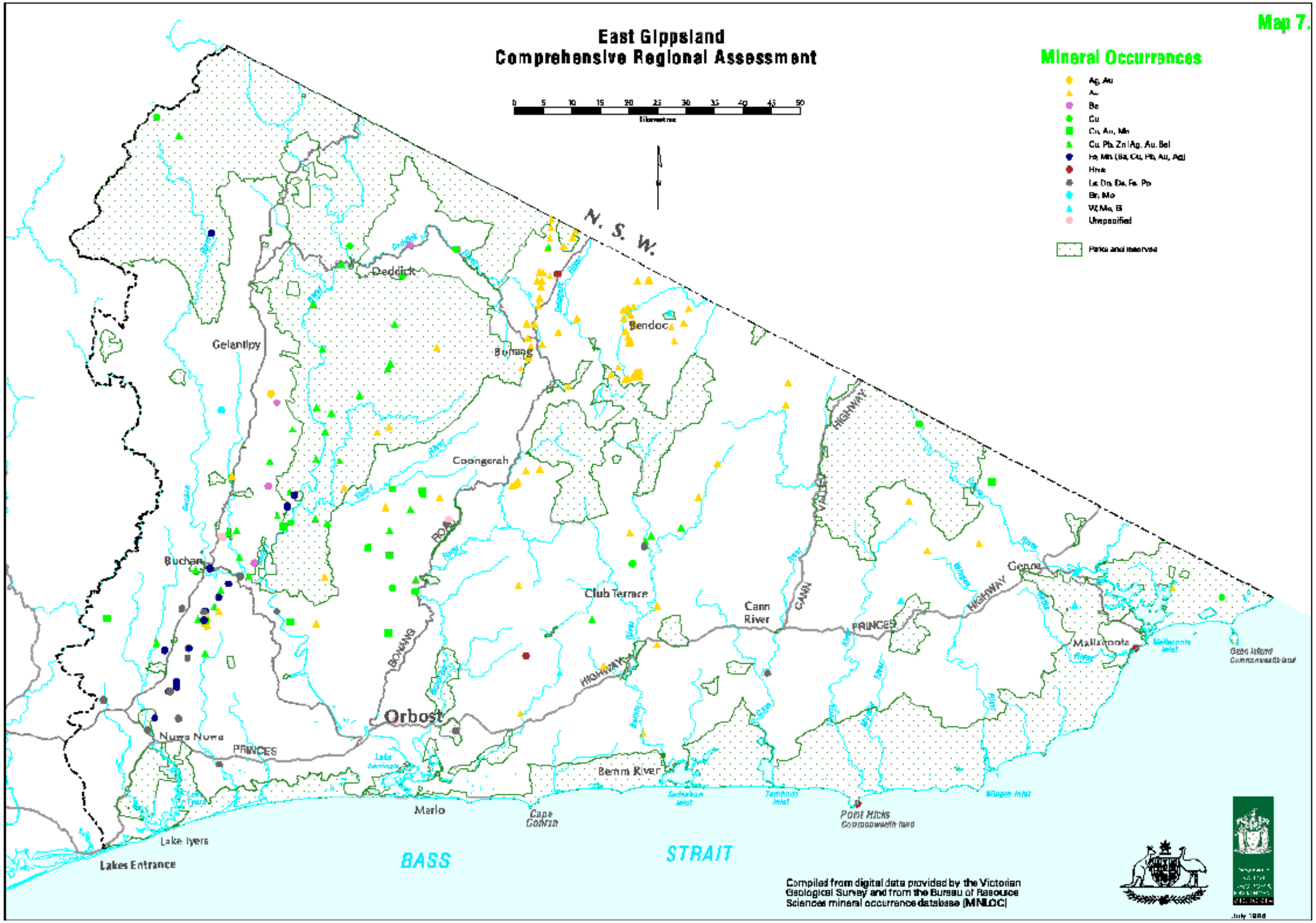

East Gippsland
Comprehensive Regional Assessments
Current available sawlog resources
(excluding regrowth forest)
Map 2
Private land
Parks and reserves
Special protection zones
Special management zones
> 15,000 cubic metres
ALPINE NATIONAL PARK
(Cobberas - Tingaringy Unit)
SNOWY RIVER NATIONAL PARK
ERRINUNDRA NATIONAL PARK
COOPRACAMBRA NATIONAL PARK
CROAJINGOLONG NATIONAL PARK
ALFRED NP
LIND NP
N. S. W.
Deddick
Bendoc
Orbost
Buchan
Mallacoota
Bemm River
Marlo
Lake Tyers
Lakes Entrance

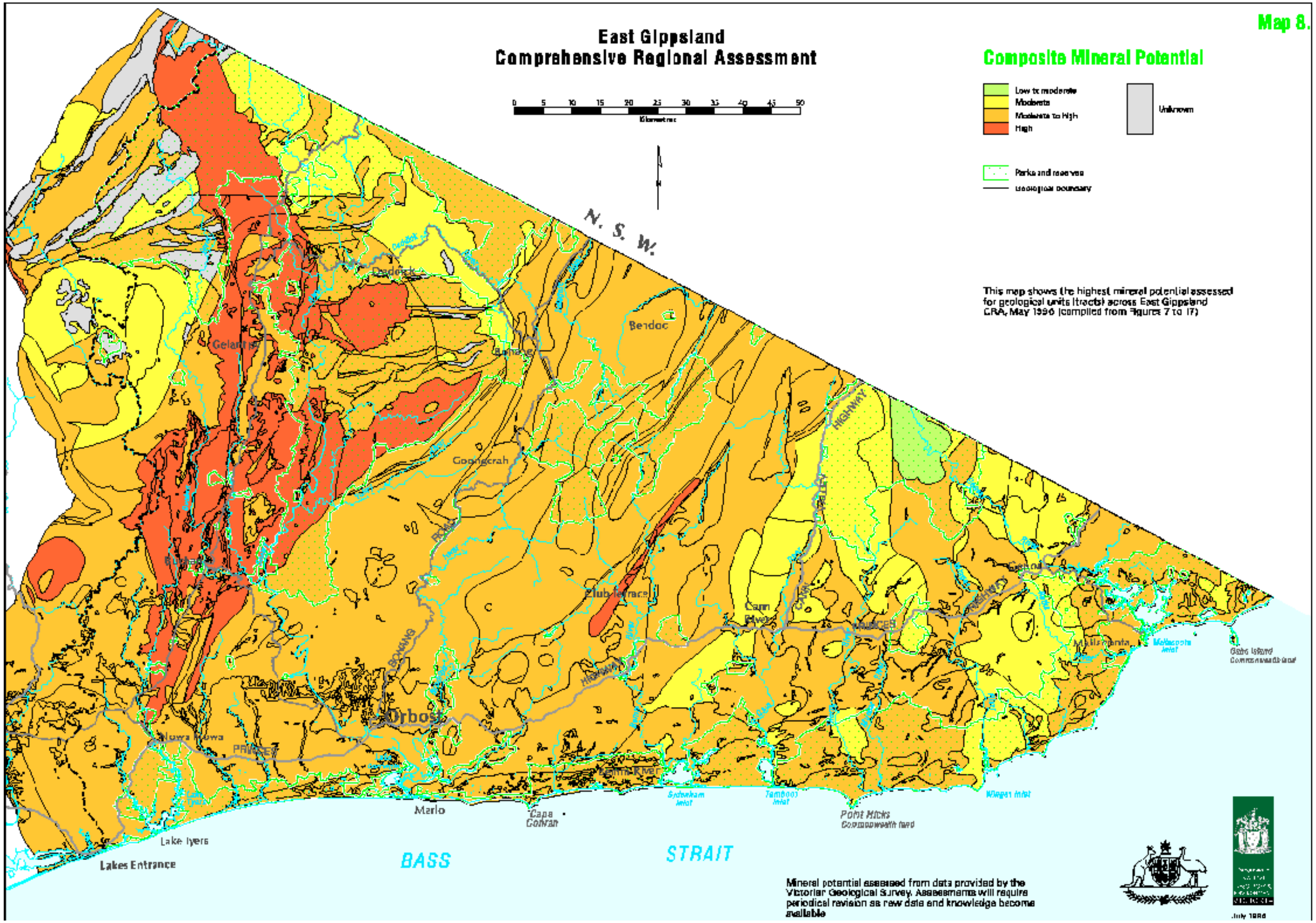

Map 3
East Gippsland
Comprehensive Regional Assessments
Proportion of Regrowth Forest
in Forest Compartments
Kilometres
Subdominant (11-50%)
Dominant (>50%)
Private land
N. S. W.
ALPINE NATIONAL PARK
(Cobberas - Tingaringy Unit)
SNOWY RIVER
NATIONAL PARK
Deddick
Bonang
Bendoc
ERRINUNDRA NATIONAL PARK
COOPRACAMBRA
NATIONAL
PARK
CROAJINGOLONG
NATIONAL
PARK
Orbost
Marlo
Bemm River
Lake Tyers
Lakes Entrance
Mallacoota


Map 4
East Gippsland
Comprehensive Regional Assessments
Proportion of compartments
available for timber production
0-20%
21-40%
41-60%
61-80%
>80%
Special Protection Zones
Special management zones
Permanent reserves
Private land
Kilometres
N.S.W.
ALPINE NATIONAL PARK
(Cobberas - Tingaringy Unit)
SNOWY RIVER
NATIONAL PARK
ERRINUNDRA NATIONAL PARK
COOPRACAMBRA
NATIONAL
PARK
ALFRED
NP
CROAJINGOLONG
NATIONAL
PARK
Deddick
Bonang
Bendoc
Orbost
Marlo
Buchan
Lake Tyers
Lakes Entrance
Bemm River
Mallacoota

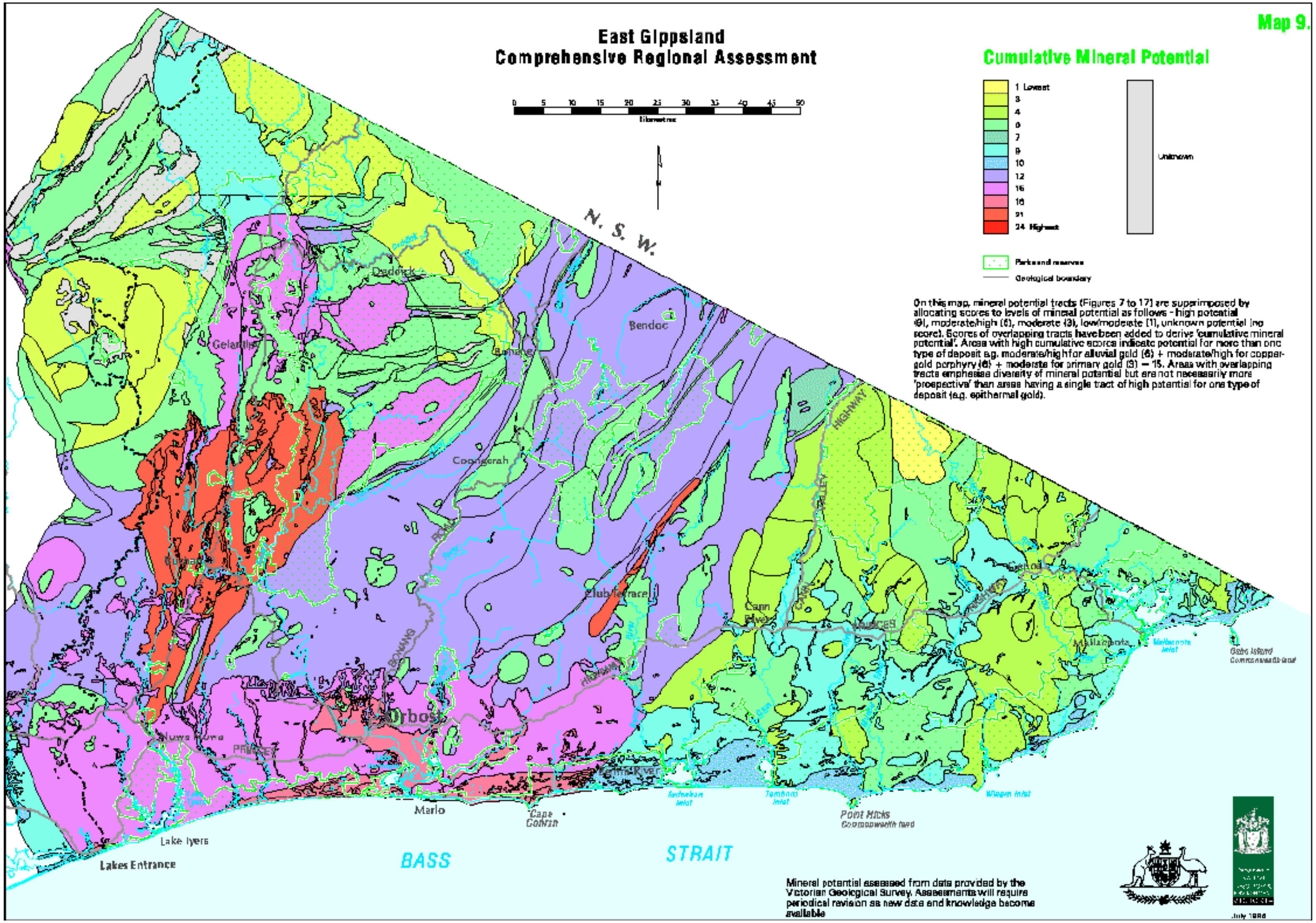

Map 5
East Gippsland
Comprehensive Regional Assessments
Future sawlog availability
Private land
Parks and reserves
Special protection zones
Special management zones
High yielding forests (>200 cubic m/ha)
> 70,000 cubic metres
35,000-70,000 cubic metres
< 35,000 cubic metres
Medium yielding forests (80-200 cubic m/ha)
> 70,000 cubic metres
35,000-70,000 cubic metres
< 35,000 cubic metres
Low yielding forests (<80 cubic m/ha)
> 70,000 cubic metres
35,000-70,000 cubic metres
< 35,000 cubic metres
Unknown resource
Kilometres
N. S. W.
ALPINE NATIONAL PARK
(Cobberas - Tingaringy Unit)
Deddick
SNOWY RIVER
NATIONAL PARK
Bonang
Bendoc
ERRINUNDRA NATIONAL PARK
COOPRACAMBRA NATIONAL PARK
LIND NP
ALFRED NP
Mallacoota
CROAJINGOLONG NATIONAL PARK
Orbost
Cann River
Bemm River
Marlo
Lake Tyers
Lakes Entrance
Buchan


Map 6.
East Gippsland
Comprehensive Regional Assessment
Geology
INTRUSIVES
Devonian Granitoids
Silurian/Devonian Granitoids
Silurian Granitoids
Fault Rock/Cataclasite
Unidentified rock units and structures
QUATERNARY
Quaternary Undifferentiated
TERTIARY
Tertiary Undifferentiated
Older Volcanics
TRIASSIC
Mount Leinster Complex
DEVONIAN
Combyingbar Formation
Merimbula Group
Mount Tambo Group
Bungywarr Formation
Buchan Group
Snowy River Volcanics
SILURIAN
Cowombat Siltstone
Gibsons Folly Formation
Yalmy Group
Towanga Sandstone
ORDOVICIAN
Bendoc Group
Hotham Group
Pinnak Sandstone
Kilometres
N. S. W.
Bendoc
Gelantipy
Combienbar
Orbost
Marlo
Cape Conran
Point Hicks
Mallacoota
Lakes Entrance
Lake Tyers
BASS
STRAIT
HIGHWAY
PRINCES
Compiled from 1:250 000 scale digital geological data provided by the Victorian Geological Survey


Map 7.
East Gippsland
Comprehensive Regional Assessment
0 5 10 15 20 25 30 35 40 45 50
Mineral Occurrences
Ag, Au
Au
Ba
Cu
Cu, Au, Mn
Cu, Pb, Zn (Ag, Au, Ba)
Fe, Mn (Ba, Cu, Pb, Au, Ag)
Hm
Unspecified
Parks and reserves
N. S. W.
Deddick
Gelantipy
Bendoc
Bonang
Coongerah
Buchan
Club Terrace
Cann River
Genoa
Mallacoota
Orbost
Nowa Nowa
PRINCES
HIGHWAY
BONANG
CANN
VALLEY
Lake Tyers
Lakes Entrance
Marlo
Cape Conran
Bemm River
Point Hicks
BASS
STRAIT
Compiled from digital data provided by the Victorian Geological Survey and from the Bureau of Resource Sciences mineral occurrence database (MINLOC)



Map 8.
East Gippsland
Comprehensive Regional Assessment
0 5 10 15 20 25 30 35 40 45 50
Kilometres
Composite Mineral Potential
Low to moderate
Moderate
Moderate to High
High
Unknown
Parks and reserves
Geological boundary
This map shows the highest mineral potential assessed for geological units (tracts) across East Gippsland CRA, May 1996 (compiled from Figures 7 to 17)
N. S. W.
Bendoc
Goongerah
Gelantipy
Club Terrace
Cann River
Genoa
Mallacoota
Mallacoota Inlet
Gabo Island Commonwealth land
Orbost
Nowa Nowa
Marlo
Cape Conran
Lake Tyers
Lakes Entrance
Sydenham Inlet
Tamboon Inlet
Point Hicks Commonwealth land
Wingan Inlet
BASS
STRAIT
HIGHWAY
PRINCES
BONANG
Mineral potential assessed from data provided by the Victorian Geological Survey. Assessments will require periodical revision as new data and knowledge become available
July 1996


Map 9.
East Gippsland
Comprehensive Regional Assessment
0 5 10 15 20 25 30 35 40 45 50
Kilometres
Cumulative Mineral Potential
1 Lowest
3
4
6
7
9
10
12
16
18
21
24 Highest
Unknown
Parks and reserves
Geological boundary
On this map, mineral potential tracts (Figures 7 to 17) are superimposed by allocating scores to levels of mineral potential as follows - high potential (9), moderate/high (6), moderate (3), low/moderate (1), unknown potential (no score). Scores of overlapping tracts have been added to derive 'cumulative mineral potential'. Areas with high cumulative scores indicate potential for more than one type of deposit e.g. moderate/high for alluvial gold (6) + moderate/high for copper-gold porphyry (6) + moderate for primary gold (3) = 15. Areas with overlapping tracts emphasise diversity of mineral potential but are not necessarily more 'prospective' than areas having a single tract of high potential for one type of deposit (e.g. epithermal gold).
N. S. W.
Bendoc
Dadderick
Gelantipy
Bonang
Combienbar
Cooongerah
Club Terrace
Cann River
Genoa
Mallacoota
Orbost
Nowa Nowa
Buchan
HIGHWAY
PRINCES
BONANG
Marlo
Cape Conran
Lake Tyers
Lakes Entrance
BASS
STRAIT
Sydenham Inlet
Tamboon Inlet
Wingan Inlet
Mallacoota Inlet
Point Hicks
Gabo Island
Mineral potential assessed from data provided by the Victorian Geological Survey. Assessments will require periodical revision as new data and knowledge become available
July 1996