Tasmania Social and Economic Report

Acknowledgements

We would like to acknowledge the active participation of all individuals, groups, organisations and agencies who undertook to give us detailed contributions in the form of discussions, workshops, surveys and other written material as part of this assessment.

We would also like to thank those residents in each case study area who assisted in the preparation and provision of the community workshops and collection of the community infrastructure data, and those who gave their valuable time to attend.

Section 7 of this chapter, "Profile of the wider community", was commissioned to be undertaken by *Environment and Behaviour Consultants*, Townsville Queensland.

Executive Summary

The report provides an assessment of the social baseline conditions which exist within selected municipalities and townships within the State. Data has been collected on a number of assessment criteria including economic viability and labour force characteristics, socio-demographic structure, community infrastructure, historical response to change, community vitality, social well-being, community visions and aspirations and community attitudes towards forest use within the region.

The methodology employed in the Tasmanian social assessment is based on social assessment theory and has involved detailed scoping and profiling work. A multi-method approach to data collection was adopted using survey, interview, focus group, workshop and participant observation techniques. Public involvement is an integral part of any social assessment process and thus the community was actively involved in the process of data collection.

A range of stakeholders at the State, regional and local level have been involved in the social assessment process. Groups involved in forest activities such as logging, transport, apiary, seed and firewood collecting, boat building, craft and speciality timbers, furniture makers, tourism, recreation, private forestry and other forest uses have been interviewed and surveyed. A random telephone survey of the Tasmanian community was also conducted to assess community values relating to forest use and recreational use of forested areas.

Furthermore, a representative sample of case study communities was selected. These communities differed in terms of the diversity of their local economy. Some communities were viewed as more dependent on forest industries, such as those in the Circular Head, Glamorgan/Spring Bay, Dorset, Huon and Derwent Valley municipalities. Several communities in the West Coast municipality were considered more dependent on mining while other areas such as the Meander Valley, Northern Midlands and George Town municipalities had a more diverse economic base.

It is evident that people hold a variety of values in relation to the use and management of Tasmania's forests. Key industry groups believe that forests within Tasmania are currently being managed on a sustainable basis and that further access to resource should be maintained. Conservationists argue that the current practices fail to adequately protect biodiversity, wilderness and old growth values, and believe that further logging of native forest areas threaten existence values and intergenerational equity.

Those residents living in communities which were highly dependent upon forest industry were concerned about employment for themselves and their children. Furthermore, such communities were afraid that any further reduction in key industry sectors would impact detrimentally on physical and social infrastructure in their area. The traditional nature of communities has sometimes made it difficult for them to effectively respond to change. Many commented on how the nature of their communities was changing, resulting in tension between traditional and new residents. In the face of externally imposed change, many communities have historically relied on government assistance or the major employer of their area. During times of crisis however, rural communities displayed the ability to work together and mobilise their local resources.

Case study communities exhibited a strong sense of community with a high level of commitment to the region. Participation in voluntary groups was high and provided the opportunity for social interaction and enhanced well-being. Despite communities' access to political structures, many residents did not feel that they had an effective voice in decision making. Furthermore, considerable diversity existed in the visionary capacity of Tasmanian communities. Community vision and aspirations were influenced by the type of community leadership, degree of stability and economic wealth of the area. Communities with strong leadership, a diverse economic base and the potential for further economic development were more able to develop long term and holistic visions for their regions.

A diverse range of views were presented by the wider community. These ranged from those wishing to see a reduction in the degree of regulation over forestry activities to those wishing to see an increase in the level of legislative control over native forests. In relation to recreational use a large proportion of the Tasmanian population had visited native forests within the last year, and a third of the sample visited areas at least once a month to undertake activities such as bushwalking, picnicking and sightseeing. A main issue raised in regard to the use of state reserves/national parks forest areas was the impact of overuse by visitors.

For other forest users, dependence upon forests varied from those with an economic dependence (eg. apiarists, sawmillers, craftwood users) to those with a non commercial dependence such as the recreationists and traditional land users. The major issue for both these groups was access to native forests. While roads provide access to forested areas, the main purpose of these roads is to provide access for forestry activities, which impact directly upon these other forest uses. In addition, aboriginal communities are concerned with the possibility of damage to aboriginal sites and water quality through logging activities.

The mining industry is concerned about obtaining access to land with mineral potential as previous debates over land use have resulted in a loss of resource. It was outlined that flexibility was required to plan for multiple use of forests.

It is evident that communities hold a range of values on the use and management of Tasmania's forests. However, many believe there is a need to both protect forest areas but also use them as a source of employment. While forestry was seen to be an industry which could further develop through value adding opportunities, tourism was raised as the preferred type of industry development across all regional sectors by the general public. Many of those involved in the tourism industry believe there is further potential in nature-based tourism within Tasmania.

The experience of an individual, group or community shapes the way in which events are perceived. What is important to one group or community may not be considered important to someone outside of that domain. It is important to acknowledge and consider values, social dynamics and beliefs of all groups, but particularly those groups that may be immediately affected by events in order to minimise social disruption and to maximise the positive community potential within the outcomes of the Regional Forest Agreement for Tasmania.

It is evident that for most groups, which depend upon forest activities, the timber industry is important to the economy of their region.

Tasmanian communities expressed the wish to have a voice in determining how future forest resources are used and managed. They believe these views must be seriously considered if an optimal solution to the Regional Forest Agreement is to be achieved.

List of maps

The following A3 maps, which accompany the three volumes of the Social and Economic report, are available for downloading from this site's map download facility:

- CRA 1.1 Tenure and land status
- S&E 4.1 Forest resource types
- S&E 4.2 Forest plantations
- S&E 4.3 Importance of state forest for commercial wood production
- S&E 4.4 Current eucalypt sawlog volume
- S&E 4.5 Special species timber
- S&E 4.6 Native forest eucalypt height potential
- S&E 4.7 Wood supply zones
- S&E 5.1 Generalised geology (Stratotectonic element map)
- S&E 5.2 Mineral deposits and occurrences
- S&E 5.3 Composite mineral potential
- S&E 5.4 Cumulative mineral potential
- S&E 5.6 to 5.43 Mineral potential tracts
- S&E 6.1 Leatherwood and apiculture hive sites
- S&E 6.2 AWRC river basins

Reference maps

The following five large maps are printed at 1:250,000 scale and are available for downloading from the map download facility or for inspection at Public Land Use Commission reference centres:

- Forest resource types
- Current eucalypt sawlog volume
- Native forest eucalypt height potential
- Mineral deposits and occurrences
- Composite mineral potential

The following four large maps are printed at 1:100,000, 1:250,000, and 1:500,000 scale and are available for downloading from the map download facility or for inspection at the Public Land Use Commission reference centres:

- Data reliability (mineral resources)
- Time/space diagram of geological and mineralising events
- Sub-parmeener geology
- Composite geological interpretation coverage of northwest forests airborne geophysical survey

The following three maps are A3 size and are available for downloading from the map download facility or for inspection at the Public Land Use Commission reference centres:

- Effect of rainfall on plantation potential
- Effect of average annual temperature on plantation potential
- Effect of geology on plantation potential

Contributors

The Social and Economic Technical Committee thanks the following individuals and organisations for their contribution and expertise in the writing and assembling this report.

Staff of Tasmanian Government agencies

Department of Education

Department of Environment and Land Management

Department of Primary Industries and Fisheries

Department of Tourism

Department of Premier and Cabinet

Forests and Forest Industry Council

Forestry Tasmania

Private Forests Tasmania

Tasmania Development and Resources

Mineral Resources Tasmania

Staff of Commonwealth Government agencies

Australian Bureau of Agricultural and Resource Economics

Bureau of Resource Sciences

Department of the Environment Sport and Territories

Department of Primary Industries and Energy

Department of the Prime Minister and Cabinet

Other organisations

Australian Manufacturing Workers Union

Australian Newsprint Mills

Australian Workers Union

Construction Forestry Mining and Energy Union

Forest Industries Association of Tasmania

Forest Protection Society

Landcare Tasmania

LA Newnham

Light Manufacturing Industries Training Board

Municipality residents, staff and representatives from:

- Circular Head
- Derwent Valley
- Dorset
- George Town
- Glamorgan/Spring Bay
- Huon Valley
- Meander Valley
- Northern Midlands
- West Coast

Native Forest Network

Southern Forests Community Group

Tasmanian Farmers and Graziers Association

Tasmanian Beekeepers Association

Tasmanian Conservation Trust

Tasmanian Country Sawmillers Federation

Tasmanian Logging Association

Tasmanian Minerals Council

Tasmanian Recreational Land Users Federation

Transport Workers Union

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Chapter 3 Social Assessment Report

Introduction: What is social assessment?

Social assessment is a tool to predict the future effects of policy decisions upon people, their physical and psychological health, well-being and welfare, their traditions, lifestyles, institutions and interpersonal relationships (D'Amore, 1978). Social assessment methodology is used to highlight value choices, increase public involvement and efficacy, and give more democratic direction to the decision making process.

Public involvement is an integral part of the social assessment process as it is essential that communities play a legitimate role in the decision making process. Those who may be affected by new policies have a right to know how they may be affected and how decisions are made. In any social assessment there will be a variety of community groups with different concerns. These groups have local knowledge which can help decision makers predict impacts and develop impact management plans. Good public involvement informs decision makers and ultimately leads to more effective decision making and a greater acceptance of decisions by all parties.

The cumulative nature of impacts should also be acknowledged. Attention should be paid to the interrelated effects of a number of changes in a region over a period of time, as the combined effects are likely to be greater than those considered separately. A community that has been psychologically buffeted by a succession of impacts, or has been relocated or reconstituted involuntarily, has different adaptive potential compared to one that has had a relatively undisturbed life (Carley and Bustelo, 1984).

Social assessment must also empower communities to participate effectively in land use decision making. Impact analyses are likely to be inaccurate if they discount the affected people's values, social dynamics, and beliefs about events. The people directly affected are in the best position to say how they actually experience events. In predicting the potential impacts of forthcoming policies, the people's own predictions, in the form of optimism and fears, are a significant component of people's behaviour and hence of impacts (Ross, 1990).

3.1.2 The social impact assessment process

The social impact assessment process has three distinct phases (Burdge & Vanclay, 1995). These include:

- assessment and prediction
- mitigation and monitoring
- audit and analysis.

The assessment phase refers to the determination of the potential impacts of change before the change has actually taken place. This involves documenting the social baseline conditions for the relevant human environment in order to develop an understanding of the relationships between the social and biophysical environment; the historical background of the area; contemporary issues; political and social structures; culture; attitudes; social-psychological conditions; and basic population statistics.

Having collected this information, the prediction phase then involves identifying the full range of possible impacts that may result from change. This may be achieved through a variety of means including discussions or interviews with those who have the potential to be affected, and community workshops. These impacts are then evaluated to determine the most probable impacts and the importance of these impacts to the affected public. It is also necessary to consider the flow-on effects of change, including the second, third and other higher order impacts that may result. It is at this point that alternative options for change can be recommended and an estimate made of the consequences of such options.

The second task of social impact assessment is to develop and implement mitigation plans which seek to avoid impacts, minimise unavoidable impacts and utilise compensation mechanisms and alternative programs. It is also necessary to develop and implement a monitoring program that is capable of identifying deviations from the proposed action and documenting any important unanticipated impacts that may arise. Both decision making authorities and communities need to play an ongoing role in this process.

The assessment phase relies heavily on prediction techniques and therefore it is important that the methods used are audited to ensure reliability and validity of predictions. One way of assessing prediction methods is to analyse the social impacts of past actions and compare these to the current assessment work. Given similar resource projects or proposals and pre-change conditions, the social impacts of a project in one community can be generalised and used to predict what may result in another.

The present report contains the data collected as part of the assessment phase of the social impact assessment process only. Prediction of impacts and the development of mitigative plans will be undertaken in the integration phase of the regional forest agreement process.

Literature review

Forestry and mining have been at the centre of public debate over the use of public land in Tasmania for many years. In this time, there have been numerous reports produced that detail the economic, heritage and environmental significance of Tasmania's wilderness and forested areas. A much smaller number of reports or studies have made reference to social aspects, although this situation does appear to be changing. The following review provides an outline of past forest related studies that have addressed social implications, and more recent studies that place cultural meanings and social impacts at the centre of analysis.

In 1985, at the direction of the Commonwealth Government, the Tasmanian woodchip export industry and the Tasmanian Forestry Commission compiled an environmental impact statement to determine the basis for the continuation of woodchip exports after 1988. The environment impact statement makes reference to both social and economic impacts; the detail of these impacts is contained in a background paper 'Tasmania's Socio-Economic Environment' (Dianco 1985). This paper is primarily a statistical profile in socio-economic and demographic terms, providing an outline of Tasmania's population, employment levels, recreational opportunities and economy. The paper is focused at a state level and does not comment on social implications for local communities.

In 1993, the socio-economic aspects of the export woodchip industry were examined in further detail by Hoysted and McCuaig (1993). The study provides an overview of the development of the woodchip industry in Tasmania. This overview is supplemented by a more detailed examination of two case studies - the municipalities of Esperance (Southern Region) and Spring Bay (East Coast). The case study areas are profiled in terms of their historical development and their present socio-demographic structure. The significance of the woodchip industry to the local communities is discussed.

At a regional level, the study revealed differences in the communities of Esperance and Spring Bay. In Esperance, the woodchip industry filled an employment gap resulting from the collapse of 'box' sawmilling. Jobs were re-distributed within the municipality rather than created. Esperance remained a strong cohesive inward looking community. In Spring Bay, the establishment of the woodchip industry created new forest related job opportunities that attracted an influx of workers and their families to the area. Newcomers in Spring Bay helped stabilise the age structure of the community and contributed to the local economy. Despite community-wide support for the woodchip industry, new residents expressed more concern over the environmental impacts of the industry.

More recently, the Department of Primary Industries and Energy produced a report on the social impact of closure of 399 coupes to woodchipping (1995). Although the report presents a national profile of the timber industry, Tasmania is examined as a case study. The report is based on secondary data and interviews with community leaders. The report documents employment impacts, income impacts, insecurity and uncertainty impacts, impacts in terms of small business debt and contractual agreements, social and community issues, and social adjustment impacts. It highlights the limited alternative employment options available to forestry workers, the insecurity of the present industry, the loss of purpose and self-esteem felt by communities, and the reduction in local businesses, services and community groups. The report is able to make some general recommendations regarding the need for structural adjustment programs, but lacks any detailed assessment of Tasmania's small timber towns and regional economies.

Beyond the woodchip specific reports reviewed above, there have also been several key inquiries that have changed forestry and land use policy in Tasmania. In 1988, an inquiry into the Lemonthyme and Southern Forests (known as the Helsham inquiry) was commissioned in order to identify areas of world heritage value and report their existence. The inquiry included consideration of the economic and environmental effects of discontinuing logging operations in such areas. The Commission received submissions from participants and reports from consultants.

Whilst a number of submissions outlined economic factors at a state level, the Tasmanian Forest Workers Taskforce's report, 'The Economic Impact of Resource Withdrawal Upon Tasmanian Communities', detailed employment issues at a local community level. The submission discussed economic issues in a local social context. Seven case study areas were profiled: Deloraine, Kentish and Westbury, Bothwell and Green Ponds, Hamilton, New Norfolk, Huon and Port Cygnet, and Esperance. The studies were based on census data and interviews with forest industry representatives, forest workers, local government representatives and local business people (Damos Consultancy, 1987).

The submission concluded that local communities, such as Esperance, New Norfolk, Hamilton and Deloraine, which have a high dependence on forestry resources, would be most negatively affected by a withdrawal of such resources. A criticism of the economic claims put forward by the Tasmanian Forest Workers Taskforce and others by the Commission was that they had not given weight to the potential for forest dependent industries to adapt to change.

In 1990, following the Helsham Inquiry, the Forests and Forest Industry Council was established in an attempt to settle divisive land use issues and to develop a Forests and Forest Industry Strategy. The final report 'Secure Futures For Forests and People' was based on technical information and public submissions (Forests and Forest Industry Council of Tasmania, 1990).

The vision outlined in the Forest and Forest Industry Strategy referred to the responsible and sensitive management of Tasmania's forests. The aims of the strategy included: protecting and conserving environmental values; providing long-term job security and additional job opportunities for employees; providing long-term security of resource for industry; and providing long-term prospects for competitive markets for Crown and private forest products. The Forest and Forest Industry Strategy also made reference to social implications in its inclusion of 'People Issues'. However, people issues were defined in terms of jobs and forest worker safety, rather than social impacts on local communities.

Information on issues affecting local communities was obtained through a public consultation mechanism. Submissions were received from Regional Advisory Groups and their associated districts. Districts included: West Coast, Smithton, Burnie, Devonport, Deloraine, West Tamar, Launceston, Scottsdale, Fingal, Triabunna, Tasman/ Forestier, Derwent (including Lower Midlands), Southern (including Geeveston, Huon, Bruny Island), and Hobart. The submissions provided a sketch of the priorities in different areas. For example, on the West Coast the public expressed concern over: resource and job security; the extension of world heritage areas/ National Parks (preferred multiple use rather than a 'lock up' approach); the future of the special timber industry; and the exploration for minerals in National Parks. In the Southern region the public expressed concern over environmental issues, such as the logging of old growth forests; protection of minor species and the use of poisons; the inappropriateness of clearfelling and regeneration to the area; worker safety and union membership; and the needs of apiarists.

In 1990, a Public Land Use Commission was appointed to investigate key aspects of public land use in Tasmania. The Public Land Use Commission produced five reports, one of which focused on the recreational use of public land. It was the first time social and cultural meanings were seriously considered in relation to land use (Public Land Use Commission, 1990). A recent anthropological study of traditional practices in world heritage areas by Dr Joan Knowles has pursued these themes further. This research shows that the involvement of local communities in the landscape plays an important role in social reproduction (Knowles, 1996). The Public Land Use Commission reports have also been followed by a more extensive cultural mapping project conducted by the Community Arts Network of Tasmania in 1996. This project provides a detailed picture of the local culture of 16 municipalities. Variables such as sense of community, community involvement, community attitudes, local concerns and community vision are mapped for each municipality.

Although the above reports indicate some appreciation of social and community issues there remains very few examples of a comprehensive social assessment within Tasmania. Of the four social assessment studies that have been conducted, two have involved specific projects: ANM's Light Weight Coated Paper Project and the Copper Mines of Tasmania Project. A third is an academic working paper produced by the Centre for Resource and Environmental Studies in Canberra, while the fourth is basically a precursor to the comprehensive regional assessments that are currently being undertaken.

In 1990, McLennan and Magosanik Associates prepared a social economic community impact statement in relation to ANM's light weight coated project. The social impact analysis focused on changes in relation to New Norfolk's population structure, accommodation, health, education, emergency services, community support services and recreational facilities. It detailed the disruption to the community and potential adjustments resulting from the project. The report concluded that it was unlikely that the community would experience any significant negative effects in relation to social infrastructure, and that any disadvantages would be offset by the advantages of increased populations in the small townships of the Derwent Valley (McLennan and Magosanik, 1990).

Neil and Lea's 1991 paper 'Wind-down and closure: Local economic development and governance options in the mining towns of Western Tasmania' utilised data from a 1986 CSIRO survey conducted on the West Coast. This survey explored the relationship between development options and the attitudes of families employed in the mining industry within the region.

In 1995, Wise, Lord and Ferguson (1995) assessed social and community issues in relation to the Copper Mines of Tasmania Project - the opening of Mt Lyell. This informed the Sustainable Development Advisory Council's assessment of the Copper Mines of Tasmania project. The study is based on a series of focus groups and interviews, and a survey of Queenstown and Strahan residents. It provides some background information on the range of services presently available, and outlines the attitudes, concerns and priorities of Queenstown and Strahan residents. The report highlights the Queenstown community's high level of dependence on mining and the negative impacts that have resulted due to the closure of Mt Lyell in 1994. It concludes with a summary of possible scenarios for Queenstown's future.

In 1995, a report entitled 'Social Impacts of Deferred Forest Assessments' (ERM Mitchell McCotter, 1995) was produced for the Interim Forest Assessment to protect forest areas pending completion of a Regional Forest Agreement. Five areas of assessment were identified: impacts on the local economy; impacts on employment; impacts on individuals and families; impacts on community services; and impacts on community vitality.

The report profiled four case studies, one of which was the Huon Valley in Tasmania. The report concluded that the local communities in the Huon Valley were likely to be significantly affected by reduced logging operations. Potential impacts included: the closure of some mills, employment loss in the forest industry without alternative job opportunities to absorb the retrenched labour force; a loss of income to local business; increased stress on community and family relationships caused by high unemployment; some rationalisation of services caused by depopulation of townships; and a decrease in community morale and vitality. Continued growth in the aquaculture industry in Dover and the community's willingness to work together to cope with change, as demonstrated in the past, was expected to cushion to some degree the above impacts. Across all the four case study areas, the potential for the timber industry to adapt to change was recognised as important in off-setting negative impacts such as employment loss and business failure.

The above studies indicate that social impacts have only been given limited attention in the Tasmanian land use debate to date. Despite this lack of attention, it is clear that forestry and mining play a central role. In rural communities across Tasmania there is a strong dependence on timber and/or mining for employment and economic growth. This dependence varies across localities. While most regions rely in some way on forest and/or mining industry, those communities with a diverse economic base have demonstrated greater resilience in managing change.

Methodology

3.3.1 Background

The social assessment methodology draws upon the social assessment work of Dale and Lane (1994), Taylor, Bryan and Goodrich (1990) and Wildman and Baker (1985). The approach adopted recognises that social assessment is part of a value-laden decision making process and that there is a need to ensure that the methodology employed considers the historical view of development and impacts; methods of public participation; and methods of grounding social assessment in social contexts.

3.3.2 Research design

The research design employed in the current social assessment is of a cross-sectional nature, whereby a sample of the population is selected and information is collected from this sample at one point in time. The focus of a cross-sectional design is one of description, whereby the characteristics of a population or the differences between two or more populations are documented.

Methodological and data triangulation has also been adopted. That is, data from different sources has been collected and a variety of methods used to collect information about the same phenomena. Methods employed in the social assessment work included:

- participant observation
- surveys
- interviews
- focus groups
- community workshops.

3.3.3 Methodology

The methodology employed in the Tasmanian social assessment involved two key phases:-

Scoping phase

This phase involved identifying all stakeholders in the Commonwealth/State Regional Forest Agreement process using a networking approach. The process begins with key stakeholders and then 'snowballs' throughout the wider community, a process commonly referred to as snowball sampling.

Key variables and initial descriptions of likely areas of impact and boundaries were selected using predominantly secondary data. Such data is useful in:

- producing demographic profiles
- preparing historical backgrounds of areas under assessment
- examining the state of the economy and
- assessing the availability of infrastructure and social services.

Nine case study areas, based on local government areas were selected for detailed social assessment. Key stakeholders and communities were consulted during this phase. The aim was to obtain consensus on the selection of case study areas and to ensure that a range of communities were selected which represented the diversity of Tasmania. The communities sampled differed in terms of the diversity of their local economies. Communities ranged from those with a high dependence on forestry (percentage of workforce employed in agriculture and forestry and manufacturing) to those with a more diverse economic base.

The case study areas selected for more detailed assessment are outlined in the table below.

Table 3.1: Case study areas selected for detailed profiling

Municipality	Townships	Main industries
Huon Valley	Geeveston	Undergoing structural adjustment in forestry and agriculture
Derwent Valley	New Norfolk	Forestry, timber processing and tourism
West Coast	Zeehan Strahan	Mining, forestry , agriculture and tourism
Circular Head	Smithton Stanley	Forestry, agriculture, tourism and mining exploration
Meander Valley	Deloraine	Forestry, agriculture and tourism
Dorset	Scottsdale	Plantation forestry, agriculture
George Town	George Town	Agriculture, timber processing, and mineral processing
Northern Midlands	Campbell Town	Agriculture, private forestry
Glamorgan/Spring Bay	Triabunna Swansea	Forestry, timber processing, tourism and agriculture

Profiling phase

The profiling phase involved collecting detailed primary data and secondary data relating to:

- local economic viability
- employment and labour force characteristics
- socio-demographic structure of community
- community infrastructure
- historical response to change
- community vitality
- social well-being
- community vision/aspirations
- community attitudes towards changes in forest use.

This information is outlined in detail in each of the separate municipality profile reports.

Data collection methods

As highlighted above, a variety of methods have been employed in the social assessment process. These methods are outlined below.

Participant observation

Participant observation involves both systematically observing and participating in the day-to-day life of communities, organisations and groups. Social distance is minimised through face-to-face relationships with individuals and a qualitative understanding of complex social phenomena can be developed.

Cross-sectional survey method

A number of surveys are used to sample relevant industry groups that use and value forests as well as the wider community.

Survey of forest users: Surveys have been developed for the following groups:

1. forest and forest product workers
2. logging and transport contractors
3. private forest growers
4. tourist operators
5. other forest users (apiarists, firewood collectors, seed collectors, specialty timbers, craftwood, tree ferns, fence post contractors, graziers).

Survey of the wider community: A random telephone survey was conducted to obtain the views and attitudes of a cross-section of the Tasmania community.

Survey of forest industry service providers: A survey has also been commissioned to describe the dependency of service industries on forest based activity across case study areas. This survey will examine the linkages between industries directly reliant on access to forested land and businesses that service forest communities.

Interviews, focus groups and community workshops

The interview method

The interview method affords the interviewer the freedom to explore, probe and ask questions freely on a specified number of topics and issues. The greatest strength of such an approach is that the interviewer is given the liberty to develop a conversational style which in turn enables individual perspectives and experiences to emerge. An interview guide approach was undertaken with stakeholders at state, regional and local levels.

The focus group method

The focus group method is a discussion based interview that produces a particular type of qualitative data. It involves the simultaneous use of multiple respondents to generate data that is focused and relatively staged, and it is this method that separates the technique from other group interviewing strategies (Millward, 1995).

Structured focus groups were conducted with groups within the community who have the potential to be most affected by change. These groups included youth, the elderly and women with young children. Participants were asked a number of questions relating to their community and their perception of the impact of changes in forest use on their community.

Community workshops

Community workshops provide a good forum to generate a 'group product' such as lists of issues, conceptual alternatives, impacts, or mutually acceptable plans of action. Workshops are best used when there is a specific problem or issue which needs to be addressed or solved. Techniques which may be employed in the workshop process include: brainstorming, nominal group process and subgroups. Following the identification of issues, similar techniques can be used to weight or rank the issues and investigate ways in which such issues can be addressed.

The strengths of the workshop process include allowing maximum flow of information and allowing the exploration of solutions. To gain a better appreciation of how individuals viewed their communities, community workshops were conducted at a central location within each of the following case study areas: Geeveston, New Norfolk, Zeehan, Strahan, Smithton, Stanley, Deloraine, George Town, Scottsdale, Campbell Town, Swansea and Triabunna.

Representatives from a range of sectors within each case study area were invited to attend the workshops. The sectors from which representatives were invited are listed in the table below.

Table 3.2: Sectors of the community from which workshop participants were selected

Industry	Apiarists Contractors/Subcontractors Mill workers Mill management Unions Forest agencies Seed collectors Firewood collectors Tourist operators Other forest users
Conservation	Local environmental groups

Community infrastructure	Commerce/Finance Education Health Religion Housing Recreation and tourism Transport Communications Emergency services Retail and trade services Other local services/businesses Shire
Indigenous communities	Land councils Local residents
Landholders	Local farmers Landcare

The workshop forum was used to address three key questions:

1. What have been the significant events in your community since 1980 and how has the community managed these events?
2. How do you feel about the community in which you live?
3. What are the visions for your community?

Workshop participants were divided into subgroups to address each of the questions outlined. Each group had a trained facilitator and scribe. The outcomes of each discussion were recorded on butcher's paper and then brought back to the group to be discussed in a plenary session.

Participants were required to complete an evaluation form on the completion of the workshop. It was agreed that the results obtained in the workshop would be fed back to participants through the Forest Community Coordinator.

Collection of community infrastructure data

The methodological approach adopted in the collection of data in the community infrastructure sections of the report was based on a participatory action research method. Many of the issues which need to be addressed in relation to the social infrastructure which exists within local communities can only be documented through direct consultation with the community. The term **community** in this context is used in a broad sense and includes not only residents in the district, but also service providers, local, state and Commonwealth government authorities, local community groups, and other organisations and individuals who have significant expertise or local knowledge of the physical and social infrastructure of an area.

The action research method affords the community ownership of their data and allows active participation in the assessment process. The information collected is then cross-validated using existing secondary data such as community service directories and local government plans and profiles.

Social indicators

Social indicators are measures of community and social well-being, such as crime rate and unemployment, and are measured at regular intervals, enabling the determination of trends or fluctuations. Social indicators may also be descriptive measures of social conditions or analytical measures of social well-being with specific interrelationships. Social indicators are often used to monitor the impact of large-scale social change on the quality of life of residents. In the present assessment, census data and other community datasets were examined to identify key social indicator variables within Tasmania as a whole and the specific case study areas selected.

Data analysis and modelling

Quantitative data analysis

Quantitative data collected during the course of the social assessment was coded and then analysed using the Statistical Package for the Social Sciences. A variety of statistical analyses were performed. These included: frequency analysis, multiple response analysis, cross tabulations and other inferential statistics.

Qualitative data analysis

There are a variety of analytic techniques which can be used to analyse qualitative information collected through interview methods or open-ended survey items. The techniques employed in this assessment included:

- *Content/theme analysis:* a technique that creates a classification scheme for qualitative information and reduces data into manageable proportions. The analysis comprises both a mechanical and an interpretative component. Emphasis is placed on meaning within the data and a descriptive overview of data themes are presented. Quotations are used to illustrate particular themes or strands of meaning.
- *Analytic Induction:* a model of reasoning where general principles or conceptions are developed from specific observations. This form of analysis provides a means of looking at available community data and formulating a framework to account for the numeric and qualitative data obtained.

Data collected in the assessment phase will be used to model the impacts of changes in resource use as Regional Forest Agreement options are developed. This analysis will assess community attitudes, assess critical service impacts and develop measures for impact mitigation and management.

Feedback

Results of the data collection throughout the social assessment process will be fed back at regular intervals to key stakeholders and communities involved in the process. This will be carried out by the Forest Community Coordinator Department of Primary Industries & Energy and members of the Tasmanian government social and economic assessment team.

Expert reference group

A reference group of social assessment experts has been established to evaluate and validate the approaches adopted in the social assessment for Tasmania. This panel of experts has been used as a technical reference group to provide technical expertise relating to the methodology and approaches adopted by the unit in the course of its work. This group has met regularly with the Social Assessment Unit throughout the Tasmanian assessment process to verify the methods employed and monitor the social assessment process.

Membership of the panel includes representatives from the scientific and academic sectors:

Dr Geoff Syme

Senior Scientist

Australian Centre for Water in Society

Division of Water Resources, CSIRO

Floreat, Western Australia.

Ms Mary Lane

Senior Lecturer

Department of Social Work and Social Policy

University of Sydney, NSW

Dr Jacqui Tracey

Senior Project Officer

Industry Development

Forestry Structural Adjustment Unit

Department of Land and Water Conservation - Sydney, NSW

Dr Brian Bishop

Senior Lecturer

School of Psychology

Curtin University of Technology

Perth, Western Australia.

State profile

The data used in this and following sections has been drawn from the Australian Bureau of Statistics Census of Population and Housing for 1991 and the 1996 Tasmanian Year Book.

3.4.1 Geographic description

Tasmania, Australia's only island state, covers an area of 67,800 square kilometres, has a coastline of 3000 kilometres and occupies 0.88% of Australia. It is 314 km from east to west and slightly more from north to south.

3.4.2 History

Tasmania has been home to Aboriginal people for at least 35,000 years. Some 12,000 years ago Tasmania became separated from the Australian mainland isolating the Tasmanian tribes. At the time of European settlement Tasmanian tribes numbered between 5,000 and 10,000 individuals. Although the Dutch were the first to visit and explore the Tasmanian coastline, it was an Englishman, Lt. John Bowen, who established the first European settlement at Risdon Cove in 1803, a site now part of greater Hobart. A second settlement was established in the North at Port Dalrymple, later moved to the area which has become known as the City of Launceston.

Both settlements grew steadily and gradually established the institutions and infrastructure of a British colony. These included a Supreme Court and newspapers were published in both settlements by 1824. In 1833, the Legislative Council sessions were opened to the public and an elected parliament was established in 1854. It was at this time that the original name of Van Diemen's Land was changed to Tasmania. Van Diemen's Land was originally a penal colony, with settlements operating at Sarah Island from 1822 to 1833, and at Port Arthur from 1833 to 1877 for a further 24 years after the cessation of transportation in 1853.

The late 1820s and early 1830s saw strong moves by European settlers against the Tasmanian Aboriginal people. This culminated in the large scale transportation of Aborigines to the Bass Strait Islands and a rapid decline in the health of the race. A strong Aboriginal community still exists in Tasmania. In 1986, 20,000 year old Aboriginal rock paintings were discovered in caves in the southwest of the state and in 1996 a number of key cultural areas, including the original site of Bowen's landing at Risdon Cove, were handed back to the Tasmanian Aboriginal people.

Figure 3.1: **Municipal areas of Tasmania**

Payable gold was first discovered in 1852 at Fingal. However, it was not until 1871 when world-class tin deposits were discovered at Mt Bishoff that the West Coast mining industry was born. This industry still forms much of the backbone of the Tasmanian economy. The oldest mine is the Mt Lyell copper mine which opened in 1892 and operated continuously for 103 years before closing briefly in 1995. It was reopened under new ownership in 1996.

Education was an early priority in Tasmania, with a council of education established in 1858, compulsory primary education introduced in 1868 and a university established in 1890.

The collapse of the Van Diemen's Land Bank in 1891 triggered a deep depression from which the state emerged slowly in the early 1900s before being plunged into another depression in 1929. 1914 saw the formation of the Hydro Electric Commission and the beginning of a policy of encouraging large high-energy-use industry, an approach which continued to be the major focus of Tasmanian economic policy up until the 1980s. The first of these industries was the Electrolytic Zinc works at Risdon which opened in 1917 and which is still in operation. The Hydro Electric Commission opened the first of its many hydro power schemes at Waddamana in 1922 and the most recent, the Pieman scheme, in 1996. It would be difficult to overestimate the impact of the Hydro Electric Commission on Tasmanian economic and social life. The 1983 decision by the High Court that stopped the Gordon-below-Franklin scheme effectively ended the dominant era of the Hydro Electric Commission.

It is Bass Strait, the stretch of water which divides Tasmania from the rest of Australia, that has most impact on the Tasmanian economy and psyche. In 1936 a submarine cable provided telecommunication linkage across the strait, in 1961 the William Holyman entered the cargo trade. The first of four roll-on roll-off ferries, the *Princess of Tasmania* commenced the Devonport to Melbourne run, opening up a large market for 'sail-drive' tourism. This ship was subsequently replaced by the increasingly larger and more luxurious, *Empress of Australia, Abel Tasman* and *Spirit of Tasmania* (the present ship) Freight rates have always constituted an extra burden for both Tasmanian consumers and exporters. The *Tasmanian Freight Equalisation Scheme* was introduced in 1976 and although it is constantly under threat of revision it continues to underpin Tasmanian export industries. The 1996 election of a Coalition Federal government has also seen a subsidy introduced for the *Spirit of Tasmania* crossing, designed to boost the local economy and to bring the cost of the Bass Strait crossing into parity with road linkages between other states.

Fire has also played a large part in Tasmanian history. Bushfires have repeatedly ravaged European settlement from the major fires in 1887 to the bushfires which resulted in the loss of 62 lives and 1000 homes in 1967. In contrast, massive flood destroyed large parts of Launceston in 1929.

The 1990s have been a difficult period for Tasmania with the loss and threatened loss of many industries and jobs and a very high budget deficit driving significant cuts to the public sector. 1993 saw unemployment reach 13.4% and although this has now dropped below 10%, the Tasmanian figure is consistently higher than the national average. Environmental and development issues continue to produce debate, dissent and community division.

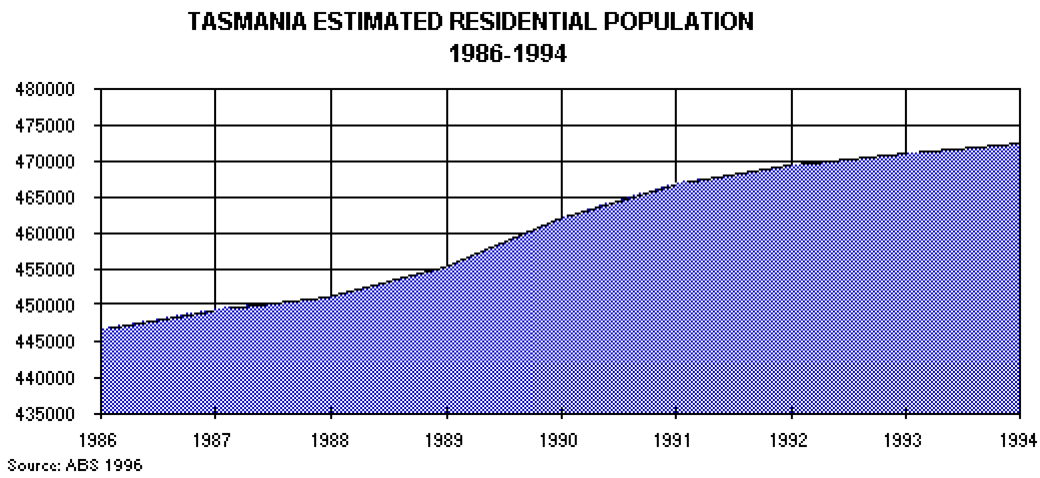
3.4.3 Socio-demographic profile

The Tasmanian population has experienced rapid changes over the past 150 years. Until the mid 19th century Tasmania experienced a fairly rapid build up of population, however in the early 1850s, this increase slumped considerably. This decline was due to two major factors: the discovery of gold in Victoria in 1851, and the ending of transportation in 1853. In the early 1870s, the population increased once again due to a growth in mainland markets for Tasmanian primary products as well as significant tin and gold discoveries on the West Coast of the state.

The post World War II baby boom and gains from overseas immigration resulted in an annual population increase of 1.5% from 1945 to 1980 - more than double the pre-war rate. However, Tasmania still lagged behind the population growth in mainland States. In the same period, the Australian rate of growth was 2% and as a result the proportion of the total Australian population living in Tasmania decreased from 3.4% in 1945 to 2.7% in 1992. In the period from 1971 to 1994, Tasmania's resident population was the lowest in Australia falling below 1% of the total Australian population. The 1993-94 population growth rate for Australia was over five times that for Tasmania.

In 1994 the resident population of Tasmania was estimated at 472,357, with 48.2% residing in the Greater Hobart-Southern Region, 28.2% in the Northern Region and 23.7% in the Mersey-Lyell region. The municipalities with the largest percentage increase since were Sorell, Kingborough and Meander. The largest percentage decrease since 1986 was recorded in the West Coast Municipality. In relation to population distribution, Tasmania is the most decentralised state with almost 60% of the population living outside the capital city. The population is concentrated in four urban centres: Hobart, Launceston, Burnie and Devonport. Population density is 6.97 persons per square kilometre.

Figure 3.2



Population mobility in Tasmania is relatively low with 57% of Tasmanian residents living in the same dwelling for the last five years from 1986-91. Of those Tasmanians who had changed address, 78.5% (123,500) remained in Tasmania.

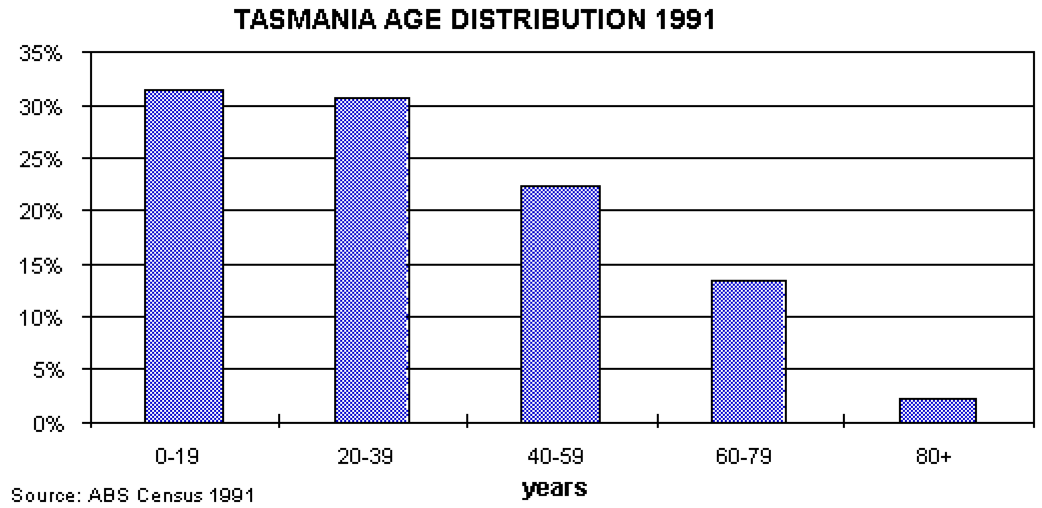
Estimates of internal migration indicate that Victoria is the main source and destination of permanent and long-term Tasmanian interstate movements.

According to census figures, 8,885 Aboriginal people and Torres Strait Islanders lived in Tasmania in 1991, comprising approximately 1.9% of the total population. The majority of those aged 15 years and over were employed in the wholesale and retail trade sector, 442 persons (18.4%), and the manufacturing sector, 376 persons (15.6%). A total of 188 (7.8%) Aboriginal and Torres Strait Islander people were employed in Agriculture, Forestry and Fishing industries. Most people were employed as labourers and trades persons.

Tasmania, like Australia, has an ageing population. In 1994 the median age was 37.7 years, 3.2 years higher than in 1986 and 4.9 years higher than in 1981. This figure is higher than the median age for all Australians which was 33.4 years in 1994. The age distribution within Tasmania has also changed markedly. In 1901, 48% of the population were aged under 20 years. This has steadily decreased since 1986 from 33% to 29.8% in 1994. In 1994 there were an estimated 3901 more females than males. This excess of females is largely concentrated in the 65 and over age group.

In 1991, 35.6% of Tasmanian population 15 years and over had a qualification. Participation rates of full time students aged 15 to 19 in Tasmania in 1995 are close to the national average of 48.4%. Retention rates to Year 12, however, are significantly lower at 59.7% in Tasmania than for Australia as a whole, 72.2%.

Figure 3.3



3.4.4 Economic Profile

The largest employers of Tasmanian workers are mostly in the tertiary sector, community services (30.8%), the wholesale and retail trade (19.1%), finance property and business services (7.9%) and public administration and defence (6.8%).

Figure 3.4 **Highest level of qualification attained of persons aged 15 years and over 1991**

The largest occupational groups were trades and sales-persons. Employment figures however say little about the importance of Tasmanian industries to the state economy. The largest revenue producing industry sector in Tasmania is manufacturing and energy production with a turnover in 1991-92 of $3904 million. This is followed by mining and metallurgical production ($995 million), agriculture ($525 million), tourism ($420 million) and fishing and aquaculture ($187.8m). The revenue figures for forestry are not provided in the Australian Bureau of Statistics reference with a total log usage in 1993-94 of 4.3 million cubic metres and a Crown forest profit of $5.1 million. However, the forest industry does rank among the principal industries in the state. In 1991 the median family income per year was $28,810, 13.5% of people aged over 15 years were unemployed.

Figure 3.5 **Occupation of persons employed aged 15 years and over 1991**

Figure 3.6 **Family income 1991**

Table 3.3. Employment by Industry 1991-1996

Industry	1991	1992	1993	1994	1995	1996
Agriculture	12,400	11,800	12,300	12,100	11,000	12,200
Services to agriculture; hunting and trapping	1,000	700	400	900	400	1,100
Forestry and logging	1,500	1,500	2,300	2,400	2,700	2,600
Commercial fishing	1,500	900	1,800	1,400	1,800	2,000
Mining	3,100	2,500	2,300	1,600	1,300	2,100
Manufacturing	27,100	26,600	20,700	24,700	23,400	23,900
Electricity, gas and water supply	3,800	3,300	3,200	2,600	2,500	1,700
Construction	10,600	12,600	12,800	16,600	12,000	13,700
Wholesale trade	10,900	9,700	10,100	10,200	11,100	10,100
Retail trade	26,600	27,700	30,300	30,100	31,100	32,300
Accommodation, cafes and restaurants	n.a	n.a.	10,400	10,700	10,300	9,300
Transport and storage	8,400	6,700	7,900	6,100	7,700	7,700
Communication services	3,200	3,600	3,900	2,800	3,200	2,500
Finance and insurance	8,100	6,200	7,200	4,600	6,500	4,800
Property and business Services	11,400	9,700	9,800	11,200	12,800	11,900
Government administration and defence	9,700	11,500	11,100	13,200	14,000	14,900
Education	15,000	13,100	15,200	16,900	16,500	14,900
Health and community services	20,900	21,300	19,700	17,800	20,000	21,700
Cultural and recreational services	3,900	4,100	3,900	3,100	4,800	4,700

Personal and other services	7,100	7,600	7,800	7,700	8,500	6,700
Total	188,191	183,092	195,093	198,694	203,595	202,796

Source: ABS 1996

Manufacturing and energy production

Although there has been a steady decline in manufacturing employment since the 1970s and an actual fall in turnover since 1990-91, the manufacturing industry continues to yield the largest number of jobs and the largest volume of production. It is those divisions which rely on natural primary resources such as food, beverages and tobacco (not grown in Tasmania) and paper, paper products, printing and publishing which dominate turnover figures. Very significant contributions also come from the wood, wood products and furniture subdivision, fabricated metal products, and transport equipment. It is large industry which provides the greatest proportion of production and jobs in these areas.

For instance Cadbury Schweppes (confectionery and softdrinks), breweries (Cascade and J. Boag and Sons), milk and cheese processors (UMT and Lactos) and large vegetable processors such as McCains and Edgell-Birds Eye are responsible for the bulk of the employment in the manufacturing of food and beverages. The outputs of Australian Paper Tasmania on the North West Coast and Australian Newsprint Mills at Boyer are principally responsible for the large paper and paper products figures. Comalco (Aluminium), TEMCO (ferro-alloys) and Pasminco-Metals-EZ (zinc) are world standard and world scale metal processors. The Hydro Electric Commission remains the state's largest business with an annual income of $486 million. INCAT Tasmania is the world's largest producer of aluminium catamaran fast ferries and is the fastest growing business in the state and a major export earner.

Mining and metallurgical production

The mining industry is particularly vulnerable to movements in the global economy and this results in a relatively volatile industry climate. Despite this, mining has a 100 year history of being one of the vital contributors to the state's economy, based primarily on the rich and diverse mineralisation of the West Coast region. Although mineral production increased slightly in 1994 (to $350 million) the value to the state fell almost 16% between 1992-93 and 1993-94. More worrying has been a slump in expenditure on mineral exploration and development in the late 1980s, although this trend appears to be reversing. There have been a number of 'good news' stories for the state from the mining sector in the last two to three years. The Mt Lyell copper mine at Queenstown has resumed production for Copper Mines of Tasmania, Renison Limited has started production from the deep shaft Rendeep, Aberfoyle Resources has installed new extraction equipment and begun deep drilling at their Hellyer mine, new or reworked gold mines have opened at Henty and Beaconsfield, and the state government is optimistic about signing a new operator for the soon-to-be-closed Savage River iron ore mine.

Agriculture

Commercial agriculture occupies almost 29% of Tasmania's land area producing a turnover of $525.8 million in 1992-93, a rise of 9.2% over the previous year. The sector is dominated by large concerns with only 11.8% of the 4,500 establishments providing 42.3% of the turnover. Approximately 60% of agricultural turnover comes from livestock and livestock products, in particular cattle for meat production, dairying, and sheep and wool production. Wool production and prices have suffered a steep decline in recent seasons falling from first to third in regard toturnover. The other major agricultural contributor is cropping, with the largest contributor in this sector being vegetable production, especially potatoes. Overall the gross value of vegetable production in 1993-94 was $118.3 million. Lagging well behind was the former Tasmanian icon of orcharding with $38.9 million in production. Tasmania has a small but growing investment in a range of alternative agricultural products such as wine grapes ($2.1 million), cut flowers ($7.44 million) and essential oils. The early 1990s were a time of severe drought for much of Tasmania's agricultural industries, however this has broken in the 1995-96 seasons.

Tourism

During 1994 Tasmania had 456,408 arrivals who spent at least one night in the state, an increase of 24.5% over 1990 figures. These visitors spent $420 million in the state, making tourism Tasmania's third or fourth largest income earner and providing an estimated 17,290 jobs. While 90,000 of these visitors came for business and conventions, it is Tasmania's popularity as a holiday destination which sustains the industry. The state's natural beauty and heritage sites serve as the major attractions with Port Arthur, Launceston's Cataract Gorge, Sullivan's Cove, Mt Wellington and the Gordon River the most visited sites. There has been a steady increase in participation in close-to-nature or eco-tourism activities. The 1995 tourist season was an extremely disappointing one for local operators.

Fishing and aquaculture

Whilst declining stocks in traditional wild fisheries in Tasmanian waters have put pressure on the profitability of professional fishing, the aquaculture industry has been growing strongly. Despite declining stocks in wild fisheries, the overall turnover still increased between 1992-93 and 1993-94, driven entirely by a 45% growth in earnings from export abalone (from $50.1 million in 1992-93 to $73.1 million in 1993-94). In the same period the value of aquaculture increased from $65.7 million to $74.8 million principally from salmon culture.

Forestry

Wood is harvested in Tasmania from public land managed by Forestry Tasmania, the Department of Environment and Land Management, and from private forests. Production includes timber grown in plantation and from native forest.

The tables below outline the number of employees working in Forestry Tasmania, a government trading enterprise, and the number of employees in Private Forests Tasmania, a government agency that provides advice on forest management and services to private forest owners.

Table 3.4: Forestry Tasmania employees by forest district

Forestry Tasmania District	Number of employees in forestry and associated activities
Derwent	48

Bass	54
Murchison	44
Circular Head	53
Eastern Tiers	54
Huon	79
Mersey	79
Hobart Office	184
Launceston Office	11
Total	**606**

Source: Forestry Tasmania, October 1996

Table 3.5: Persons employed by Private Forests Tasmania by Office

Private Forests Tasmania Office	Number of employees
Hobart	3
Burnie	4
Launceston	11
Total	**18**

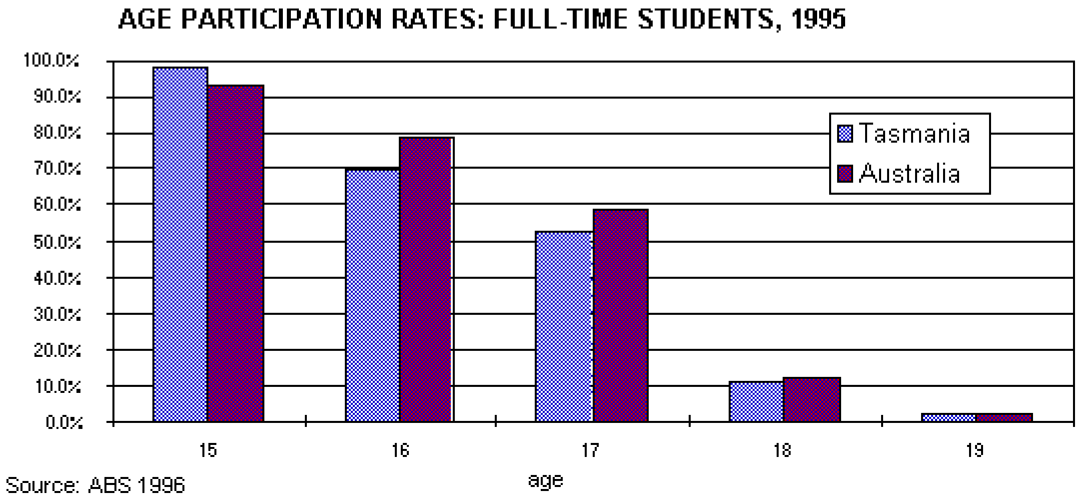
Source: Private Forests Tasmania

3.4.5 Infrastructure

Education

There are 316 school sites within Tasmania which include kindergarten, primary, District High Schools (P-10), secondary (7-10), senior secondary college (11-12) and special and early special schools. Of these, 82 are non-government schools consisting of 10 Kindergartens, 63 primary and 9 secondary schools. The table below illustrates that full time student retention rates in Tasmania from age 16 onwards are below the Australian average.

Figure 3.7



The Tasmanian government education system is divided into seven administrative districts. The number of schools by district and type of school are presented in the table below

Table 3.6 Number of schools by district and type of school

District	Unlinked Kinder-garten	Primary	District High	Secondary	Senior Secondary College	Special	Early Special	**Total**
Arthur	0	24	4	5	1	1	1	**36**
Barrington	0	19	1	5	1	1	1	**28**
Bowen	0	19	7	4	1	1	0	**32**
Derwent	0	23	3	5	1	2	0	**34**
Forester	0	23	5	5	1	3	0	**37**
Hartz	0	23	4	5	2	1	1	**36**
Macquarie	1	19	2	5	1	2	1	**31**
TOTAL	**1**	**150**	**26**	**34**	**8**	**11**	**4**	**234**

Source: Department of Education, Community and Cultural Development, Tasmania.

Health and community services

The changing demographic structure of the Tasmanian community (including an increasingly ageing population) and changes in the workforce (including the demand for more skilled workers and the participation of more women) are changing the demands on the community as a whole. Currently, Tasmania has one of the highest unemployment rates and thus, dependence on social welfare and community services is high.

The Federal Government provides almost all income maintenance payments and a large proportion of the funding for state government welfare programs. The Department of Community and Health Services operates eight programs administered throughout three regions - North, South and North West. The following five programs are operated on a regional basis:

- Aged and Disability Support Services
- Acute Care Services
- Mental Health Services
- Child, Family and Community Support Services
- Housing Services

Aged and disability support services aim to meet the needs of people who are aged and/or have a disability to enable them to live safely and independently in communities of their choice. Services provided include: accommodation, community access, home support, aged care assessment, advocacy and community education, and the seniors bureau.

The acute care program, in association with the state's public hospitals, provides an important link with community and residential care services. The focus is moving towards providing care for people after they leave hospital.

A wide range of psychiatric services is available on a regional basis. Services range from secure, close management of severely mentally ill people to the clinical management of children and adolescents with varying degrees of emotional or behavioural problems. The Royal Derwent Hospital offers residential, medical and nursing care in the specialist streams of acute, rehabilitation and long-term support, and psychogeriatric and secure services.

Child, family and community support services include: health assessment and management services for infants, children, adolescents and their parents; community-based health services which address needs related to dental health and alcohol and drug abuse; child protection and placement for children without safe adult care; services for young offenders; and community education.

Housing services are delivered on a regional basis through local outlets within each region. Services include the provision of rental housing, asset management, tenancy management, tenant assistance, special needs housing, community housing and home ownership assistance.

The Department of Community and Health Services coordinates and directs the development of all ambulance organisations and services throughout the State. Both road and air ambulance networks are available which are serviced by professional and volunteer officers in two operational regions.

The Department of Community Health and Services also attempts to improve the health of the Tasmanian population by addressing public health and safety needs, targeting programs for specific population groups, planning and developing policies, promoting health, and regulating, co-ordinating and advocating.

Health and community services are also provided through a variety of volunteer agencies. These agencies are often able to respond quickly to emerging community needs as well as providing significant support to government funded services, especially in times of recession. In October 1993 there were about 117,000 people in Tasmania involved in some form of volunteer activity contributing approximately 11 million hours of service. In addition, many churches provide a range of social welfare services for the wider community.

Tasmania has a total of approximately 39 hospitals, with eight located in Hobart, four in Launceston and 27 located in rural townships. In 1991-92 Tasmania had 3.75 public hospital beds per 1000 population, a little above the 3.68 beds recorded for Australia. In relation to private hospitals 1.17 hospital beds were available, almost the same as the national average. In the public hospital sector, Tasmania has the lowest separation rate of all states and the second highest separation rate from private hospitals. The average length of stay in Tasmanian hospitals is approximately 5.9 days. The longest length of stay being in the public sector (7.1 days) with the shortest in the private sector (3.7 days). The average occupancy rate for all hospitals is 76.7%. Health services are also provided through community health centres in local townships.

Emergency services

Police, fire, state emergency service, and ambulance services are provided statewide. There are: 130 police stations; 29 state emergency service unit managers; 4 professional and 238 volunteer fire brigades; and 6 ambulance headquarters, 10 branch stations, and 27 volunteer or independent stations.

Sport and recreation

Approximately 28 national sport and physical recreation events were held in Tasmania during 1993-94. The sport and recreation industry consists of state, regional and local sport and recreation groups, facility providers, commercial operators and both state and local government bodies. Volunteer groups provide many sport and recreational activities, the most popular activities include walking, fishing and swimming.

Recreational activities within Tasmania are becoming more popular. In 1993-94 figures produced from the household expenditure survey showed that the average weekly expenditure on recreation was $75/week and expenditure on sport and recreation as a whole was in the order of $490-590 million. A broad range of strategies have been employed by state government departments to improve opportunities for recreation for women, older adults, Aboriginal people and Torres Strait Islanders and people with disabilities.

Profiles of Forest Users

A survey was developed to sample the views of relevant industry groups that use and value forests. These groups were selected according to one of Colfer's (1995) dimensions, dependency, which refers to the reliance of groups upon forested land for a range of goods and services. The quantitative and qualitative results of these surveys are outlined below.

The following groups were sampled:

- Forest and forest product workers
- Logging and transport contractors
- Private forest growers
- Tourist operators
- Other forest users (including apiarists, collectors of firewood, seed, specialty timbers, craftwood, tree ferns and graziers)
- Mining Employees

Table 3.8 outlines the number of questionnaires given to each group.

Table 3.8: Forest users surveys administered

Organisations / associations	No. surveys administered
Country Sawmillers (members)	282
Country Sawmillers (non-members)	262
Tasmanian Logging Association	807
Transport Workers Union	1183
Logging contractors (non-affiliated)	22
Forest workers (non-affiliated)	56
Australian Paper Mills	1000
Australian Newsprint Mills	500
CFMEU	1000
Forest Industries Association (FIAT)	2700
Other forest users (apiarists, graziers, firewood and seed collectors, furniture makers, boat builders, craft and specialty timbers, tree ferns)	1600
Mining employees	1004*
Tourist operators	187
Private forest growers	1175
Forestry Tasmania field workers	500
Total	12,278

***Only one survey was returned from mining employees. As a result no analysis has been conducted for this particular group.**

Lists of respondents were obtained through industry associations such as the Tasmanian Logging Association, Tasmanian Country Sawmillers' Federation, Forest Industry Association of Tasmania, Tasmanian Minerals Council, Construction Forestry Mining and Energy Union, Tasmanian Bee Keepers Association, and the Tasmanian Farmers and Graziers Association. Other mailing lists were obtained from organisations such as Private Forests Tasmania (private forest growers), Forestry Tasmania (licence holders of crown sawmills, grazing leases, firewood collectors, tourist operators and purchasers of specialty timbers), Forest Protection Society (logging contractors and industry employees), and Department of Tourism, Sport and Recreation (tourist operators).

Forest and forest product workers

A total of 7,554 forest and forest product workers were contacted and asked whether they would complete a survey. Of these, 12.6% responded of which 90.1% were male and 9.9% female. Most respondents were married (66.2%) with an average age of 38 years. One fifth of the sample were single. Of those that were married, 41.7% had partners who were also employed. Of those sampled, 71% had children. The average number of children was two with an average of one child living at home. Children's ages ranged from one to 32 years. Most of the sample (92.9%) had no other dependents living at home. In relation to education, most children attended their local primary or secondary schools.

Employment

Table 3.9 outlines the occupational groupings of those forest and forest product workers who responded to the survey. Occupational categories have been largely based on the Australian Bureau of Statistics categories.

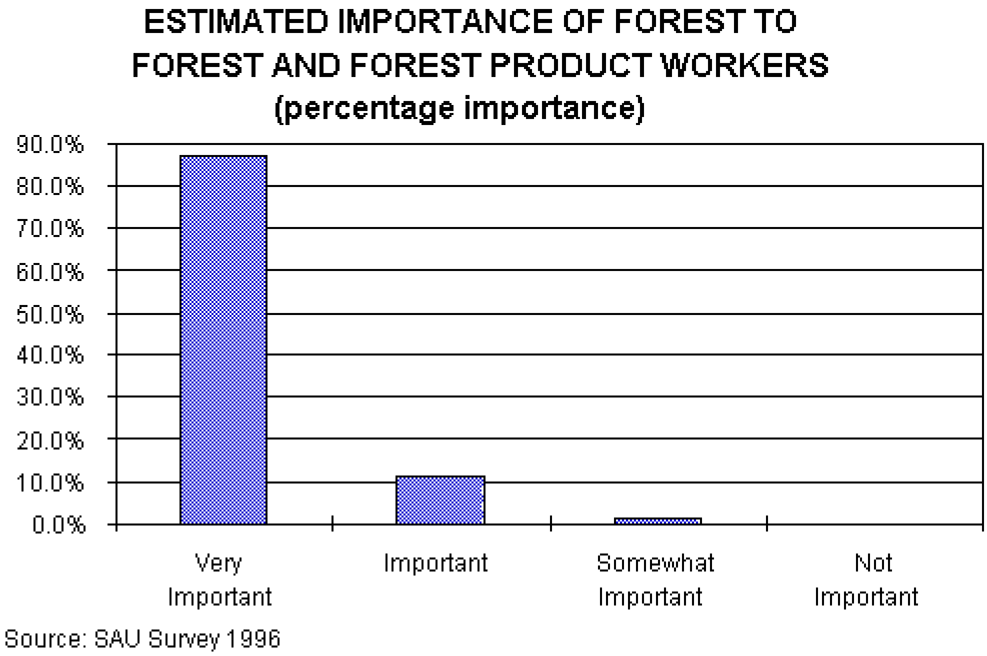
Table 3.9: Respondent forest and forest product workers by occupation

Occupational category	*Proportion of total respondents (%)*
Managers/administrators	*16.2*
Professionals	*2.3*
Tradespersons	*5.2*
Clerks	*7.9*
Salespersons and personal service workers	*3.3*
Plant and machinery operators and drivers	*48.4*
Transport drivers	*4.9*
Labourers and related workers	*11.8*
Total	*100*

Source: SAU Survey 1996

Respondents had been working in their current job from one to 45 years, with an average of 9 years of service. Of those sampled, 94.3% were employed full time, with a further 5.8% employed on a part time or casual basis. On average workers had been employed in the timber industry for 14 and a half years, and 49% of respondents had family members also employed in this industry. 14% of respondents had moved township on average 2.4 times to maintain employment within the forest sector. When asked how important they felt the timber industry was to their local economy, 86.9% responded that the industry was very important and 11.5% important. Only 1.8% felt the industry was somewhat important or not important at all.

Figure 3.8:



Educational qualifications and experience in other industries

Approximately 85.6% of those sampled had not received any formal qualifications in the form of degrees or diplomas.

However, many workers were highly skilled in relation to vocational qualifications such as trade certificates and tickets. Vocational qualifications obtained include certificates/tickets in electrical fitting, fitting and turning, machining, loader/skidder driving, crane operations, log handling and classification, tree felling, welding, secretarial work and engineering. Of those sampled, 64.7% had experience in industries other than forestry, generally in processing and manufacturing industries, primary industry and trade service areas.

Occupational health and safety

Respondents were asked to outline whether they had ever been injured at work, the nature of this injury and whether the injury could prevent them from obtaining other employment. Of those sampled, 36% stated that they had received an injury at work. Generally, these injuries were back injuries or muscle strains, injuries to appendages such as fingers, hands or wrists, or minor cuts or sprains to knees, ankles etc. Of those who had suffered an injury, only a small proportion (10.2%) believed that the injury could prevent them from gaining alternative employment. Reasons for this included decreased mobility and limited capability.

Place of residence in relation to place of work

Most workers travel to work from their home base daily (95.8%). Only a small proportion of those sampled travel from a base other than home (6.3%). Respondents' places of residence and places of work are illustrated in Figures 3.9 and 3.10.

Of those sampled, 43% were paying off a mortgage, 20.6% were renting and 36.4% owned their own homes. For those who owned their property or were paying it off, property values ranged from $5,800 to $500,000, with an average property value of $119,189. Just over half of the sample (57.7%) were paying off a loan or loans, with 45% of people paying between 25 and 50% of their household income to meet these costs. A further 46.8% were paying less than a quarter of their income to meet loan repayments.

On average, respondents had lived at their current address for ten years, and in the area 22 years. 65.2% also had family living in their area and of those that were married or living with a partner, 42.9% had their partner's family also residing within their locality. These findings indicate that strong familial networks exist in relation to these particular occupational groups.

Quality of life

Respondents were asked to comment on what they liked most about living in their particular area. Respondents predominantly mentioned the people in the area, whether that be family, friends and others in the community (12.7%), as well as the peace and quiet (12.1%), lifestyle (10.6%), and country atmosphere (7.9%). Other reasons included proximity to work (6.1%), easy access to recreational pursuits (5.4%) and areas such as beaches and rivers (3.8%), and the clean healthy environment of the area (5.2%).

Figure 3.12

Count of Forestry Tasmania Employees at Town of Residence

- 1 - 2
- 3 - 4
- 5 - 7
- 8 - 10
- 11 - 14

N

When asked what they liked least, the weather (23.7%), the lack of employment prospects (11.6%), the lack of services (7.5%), and the remoteness and isolation of many communities (7.1%) were commonly mentioned. Other factors such as lack of entertainment activities, cost of travel, distance to educational facilities for children and reduced local economic viability were also raised.

Potential improvements for forestry workers

When asked how the present situation for workers within the forestry industry might be improved, respondents emphasised resource security. The call for stability and long-term decision making was reiterated by respondents from a cross-section of occupational groups.

> "Long term security of resource."
>
> "More stable industry."
>
> "I would like to see science rather than emotion rule the debate as this would result in outcomes that provide resource job security."

Not only was stability an issue, but also the further development of an economically viable forestry industry. Respondents expressed support for the establishment of a pulp mill in Tasmania and a relaxation of present woodchip regulations.

> "Build a pulp mill in Tasmania. Open up more forest areas."
>
> "More export chip licences."
>
> "Increase export licences to 10 years."

Other visions for the future of the industry related to the establishment of more plantations and an increased emphasis on downstream processing.

> "More incentives for plantation development."
>
> "Increase plantation timber reserves."
>
> "Increased down stream processing. Rather than export woodchipping."
>
> "Guaranteed access to forests. Down stream processing."

For scientists working in the forestry industry, research was viewed as a basis for a more sustainable approach.

Comments on the forestry debate

The forestry debate was viewed by many respondents as being 'too political', 'emotive' and based on 'misinformation'. Criticisms were directed at the emotional arguments employed by radical greens and the one-sided nature of the media.

> "Keep the politics out of it, this area badly needs the employment and economic benefits that down streaming would provide."
>
> "Let foresters have more say. Keep politics out of it."
>
> "Too much misinformation about forest practices such as logs being chipped. Forests are a renewable resource. The debate is too one-sided and controlled by environmentalists."
>
> "The debate appears to be mainly an emotional one from the conservationists' side, with motivation being mainly generated for political purposes which have little to do with forestry practice."
>
> "Greens get all the media attention."

"It is indeed unfortunate that various politicians have chosen to use the forest industries and issues as political bargaining chips, with political gain the objective rather than development of a sustainable environmentally responsible industry policy. Furthermore, when scientific forest management issues are diminished by emotive non-factual arguments by a media more interested in 'colourful' images and sounds, the value of any outcome of such a debate is very little."

There was also a feeling that the forestry debate was being controlled by outsiders who did not appreciate or understand the issues involved.

"A rural issue dominated by urban voters totally ignorant of the facts."

"Forest industry must promote the industry to educate the public in the major city environments."

A number of respondents called for more public awareness as a means for redressing the present imbalance in the forestry debate.

"Not everyone knows the full story about forestry debate."

"People should be more aware of logging operations."

Impact of political arguments on individuals, families and the community

At a personal level, respondents were most affected by job insecurity and reduced work opportunities in the forestry industry. While some expressed this through concern over the future, frustration and stress, for others the impact was more immediate involving actual job loss.

"They have left me feeling insecure about my position to support my family."

"I have doubts about my future employment."

"Will I have a job next week or will I be unemployed?"

"Worry about job insecurity."

Some respondents had become more cynical about the political process.

"Leaves you very insecure and makes you wonder about the political decision making process - what a joke."

"Loss of credibility in politicians' ability to understand scientific issues. They make decisions based on votes/emotions rather than science."

"Loss of income. Undue stress about employment. Divisive arguments affecting personal relationships."

"Uncertainty about the future of forestry and therefore job security for ourselves and our friends."

Other effects on families included reduced income and relocation in order to find work.

"Destabilising effect due to relocation to obtain new skills to maintain employment opportunities."

"Just about sent them broke."

"Loss of income and livelihood."

Some respondents also expressed concern for their children's employment prospects in the forestry industry.

> "If there were more jobs in the industry my youngest boy might have a better job."
>
> "They [political arguments] have drawn us together, but [we are] also concerned for our children's future."

A further issue raised by respondents was the 'sneering' comments of people in social situations when forestry arguments are raised.

> "We are generally unwilling to discuss 'what I do for a living' type questions in a social situation because they invariably create unpleasant discussions which one can never 'win', or even be allowed to present a rational, reasoned argument."

At a community level, forest workers surveyed indicated that past and present policies had led to division within the community.

> "Caused some division and investment instability."
>
> "Split the community."
>
> "It divided a community."

Respondents also commented on the impact of forest policy on local economies and the future outlook for their particular communities.

> "Our community is on its knees. We need some security."
>
> "Always puts a scare through the community. No mill - no town."
>
> "Might stop businesses from expanding due to uncertainty."
>
> "All businesses in the local community seem to be affected when the forest industry is quiet."

"Businesses have closed or reduced opening hours as less cash coming into the community has in general reduced cash spent in the area. Circular Head relies a lot on the logging industry and if cut-backs continue it will reduce members of Circular Head."

District employees of Forestry Tasmania

Surveys were also administered to district employees of Forestry Tasmania. A total of 500 surveys were administered and a sample of 14% responded. Of this 14%, 88.6% were male and 11.4% female. Respondents were generally married (58%), however, a relatively high proportion were also single (26.1%). Age of employees ranged from 16 to 60 years with an average age of 38 years. Of those who were married, 54.3% had partners who were also employed. 69.7% of respondents had children. The average number of children was 2.5 with an average of one child living at home. Only 8.8% of the sample had dependents, other than children living at home. In relation to educational facilities, most children attended their local primary or secondary schools.

Employment

The occupational groupings of those sampled include district forester, technical forester, forest planner, forest manager, tree feller and other forest work. Of the respondents, 97.1% were employed full time and 2.9% were employed on a part time basis. Employees had been in their current positions from one to 42 years, with an average of ten years service. On average, employees had worked in the timber industry for approximately 16 years. Of those sampled, 56% had, on average, seven family members also employed in the timber industry in some capacity. Employees worked in a range of townships outside the metropolitan areas including the townships of Devonport, Fingal, Bicheno, Perth, Smithton, Tarraleah, Triabunna, Scottsdale and South Arthur. When asked how important they perceived the timber industry to be to the economy of their local area, 78.6% believed the industry to be very important, 14.3% important, 5.7% somewhat important and 1.4% not important at all.

Figure 3.11:

Figure 3.10
Count of Forest Products Workers
Place of Work

- 1 - 4
- 5 - 17
- 18 - 57
- 58 - 117
- 118 - 181

N

Educational qualifications and experience in other industries

Of those sampled, 25.7% had formal qualifications, 10% had TAFE qualifications or equivalent and a further 25% had reached Year 12.

Almost half (48.6%) of the employees sampled had experience in other industries. These industries included other government areas such as education, health, local government, and public works. Others had experience in processing and manufacturing industries (food, newspapers, engineering), primary industries (fishing, farming, mining, fruit growing) and other areas such as insurance, energy, hospitality, construction and retail. 42.9% of respondents had moved township for employment purposes, on average two or three times.

Occupational health and safety

Of those employees sampled, 38.6% had been injured in some way. Injuries ranged from minor cuts, lacerations, to more severe sprains, back injuries and loss of limbs. Most employees (96.9%), however, did not believe that injuries would prevent them from their obtaining employment elsewhere.

Place of residence in relation to place of work

Almost all (97.1%) employees sampled traveled to work from their home base each day. Township of residence of employees is illustrated in Figure 3.12. The majority of those sampled were paying off a mortgage (52.2%) which required 25 to 50% of their household income. 28.4% owned their own home and a further 19.4% were renting. Values of property ranged from $15,000 to $300,000 with an average value of $108,037.

In regard to length of residence, most employees had been at their current address for on average nine years, and had been living in the area on average 19 years. Half the respondents had family who also lived in their area and of those who were married or attached, 32.9% had their partner's family also living nearby. Once again familial connections appeared strong with respondents families and their partner's families living in their localities for an average of 45 years each.

Quality of life

Respondents appeared to be active in their respective communities, participating on average in approximately two community groups or organisations. When asked what they liked most about living in their area, respondents indicated that country living and the environment (14.9%) were a distinct advantage, followed by the friendliness and closeness of rural people (8.3%). Access to sport and recreational pursuits and employment was also an advantage. Disadvantages identified by respondents included the lack of services (16.7%), the climate and weather (16.7%) and isolation from main centres (8.3%).

Potential improvements for forestry workers

Resource security was again identified by these respondents as the most important way of improving their present situation.

> "5 to 10 year rolling periods of resource security to industry, allowing certainty of supply and a degree of stability in the industry which would allow longer term planning and good forest management to proceed rather than the ad hoc planning which has been a result of constant political interference."
>
> "Long-term planning and security of the industry."

"Security of employment which is related to security of resource."

Other action which respondents suggested might lead to improvements included: allocation of more money to enable better service provision; an end to government inquiries; raising public awareness of how forests are managed; and development of down-stream processing.

Comments on the forest debate

The district foresters surveyed raised similar issues to the forest workers. They expressed some despair at the politicised nature of the forestry debate and the extreme position of greenies.

> "Highly politicised - no middle ground. People are perceived as 'greenies' or 'not caring loggers'."
>
> "Very political and tends to be one sided. Driven by media."

There was some concern that too much emphasis had been placed on emotive issues without regard to the scientific facts.

> "There is a lot of misinformation (and lies) being spread by various conservation groups which have no or little scientific credibility. The debate is being run by a minority."
>
> "Greens and conservationists are losing credibility due to lack of scientific approach. The emotive issues raised (by greens) are not convincing the general public that our forests are not being managed to 'world's best practice'."

Some expressed the need for greater public awareness of the forestry industry and its economic value.

> "Conservationists don't use real facts. They make up stories and the media promote the green views too much. Forestry industry should increase public awareness."
>
> "Practical solutions at the political level need to be made so as to encourage foreign investment in Australia which will increase downstream processing here. The economic value of our forests also needs to be publicly recognised."

Impact of political arguments on individuals, families and the community

Most respondents felt that political arguments had affected them personally. Their main concern was that industry insecurity had led to additional planning difficulties, extra work and stress.

> "It has made my planning job much more stressful particularly as more land has been locked up for other purposes."
>
> "Uncertainty, insecurity, stress, additional work loads."
>
> "Additional planning responsibilities. Change in tactical and strategic plans at short notice. General uncertainty in industry leads to increased stress."

Other impacts at an individual level included: frustration at the distortion of facts by extremists; personal vilification from either being perceived as a 'greenie' at the pub or from conservationists who oppose forestry practices; and an increased capacity to see 'both sides of the story'.

Political dispute had also led to personal stress which in turn had affected their families. Others related how family members had been drawn into political arguments.

Respondents also identified job insecurity as a source of anxiety for themselves and their families.

> "The uncertainty of long-term work."
>
> "Doubts about continuity of employment, stability of location, and future outlook."

As with the forest workers, Forestry Tasmania employees felt that the main impact of forest policy was division within the community.

> "It has polarised and divided the community. Both the pro and anti sides of the debate have gone overboard in their trying to get the story across."
>
> "Divided the community - either for or against logging."
>
> "A few loud people are using the debate to polarise the community to think like them."

Also of concern was the loss of employment opportunities and associated flow-ons to the community.

> "Uncertainty. Lack of development. Population leaving area. Increased unemployment. Cynical attitude to government and decision makers."
>
> "People leaving the district to find work. Young people moving away. Very few young people stay in the area because there is no work."

Logging and transport contractors

A total of 280 contractors were also contacted and asked to complete a survey. The survey asked for detailed information on their contracting business and their use of a range of services. A total of 13% responded and the following results were obtained.

On average contractors employed 7.8 people full time and 1.7 part time. In addition, approximately 2.6 full time employees were family members and 1.1 part time. Employees resided in a number of different townships across the state as illustrated in Figure 3.13.

When asked about their type of forest activity, 42% of the logging contractors sampled were involved in logging activities, 30.4% in felling and a further 27.5% in snigging. Other activities included loading, log grading, debarking and splitting, and tree farming. Half of the contractors harvested between 20 and 40,000 tonnes of logs on average per annum, 32.1% between 40 and 60,000. Only a small percentage of contractors harvested less than 10,000 (7.1%) or greater than 60,000 tonnes (10.7%).

Contractors were also asked to specify the areas of forest on which their business relied. Specifically, they were asked to outline the percentage of their operation dependent upon each forest area (see table below) and the forest districts in which they were currently operating.

Table 3.10: Forest contractors dependence on forest areas

Forest Area	*Mean percentage of operation dependent upon forest area*
Public Native Forest	***77.56***
Private Native Forest	***62.92***
Private Pine Plantation	***55.00***
Public Pine Plantation	***75.00***
Private Native Species Plantation	***100.00***

Source: SAU Survey 1996

Most transport contractors were involved in the transport of logs from the forest to either the sawmill (38.8%) or the chipmill (36.3%). A smaller number of transport contractors were involved in carting logs from the forest to veneer mills (15%) or to pulp and paper mills (10%). Other transport activities included carting of minor species to craftyards or small sawmills. In relation to sawn timber, approximately 50% of the sample transported sawlogs from the sawmill to the market, and 50% from green mills to the market. Woodchips were largely transported from sawmills to chipmills (57.1%) and from the sawmill to pulp and paper mills (42.9%). Of those sampled, 64% subcontracted work to other people. The type of work subcontracted included: log haulage/cartage, tree felling, dozer operations, mechanics and some logging activity. On average, 50% of transport contractors transported between 20 and 40,000 tonnes of logs per annum, 23.3% between 40 and 60,000 tonnes and 13.3% above 60,000. Again, only a small proportion of the sample transported less than 10,000 tonnes per annum (13.3%).

Contractors were also asked to comment on their annual operating costs, gross business income, business debt and spending, and capital invested.

The following figures outline the responses obtained. With regard to operating costs, most contractors spent between $250,000 and $500,000.

Figure 3.14

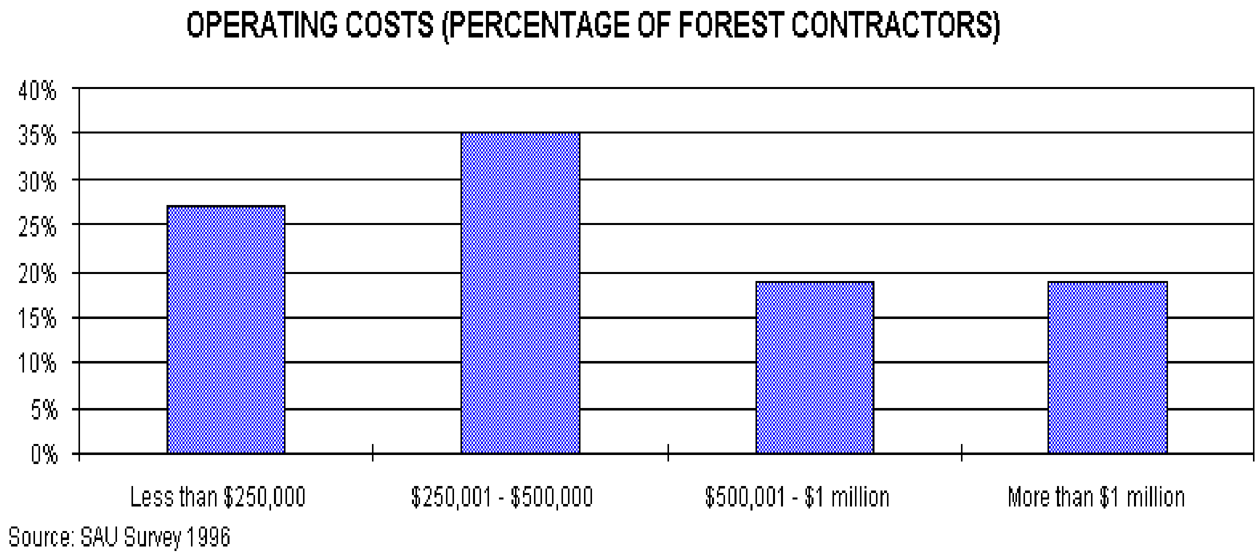
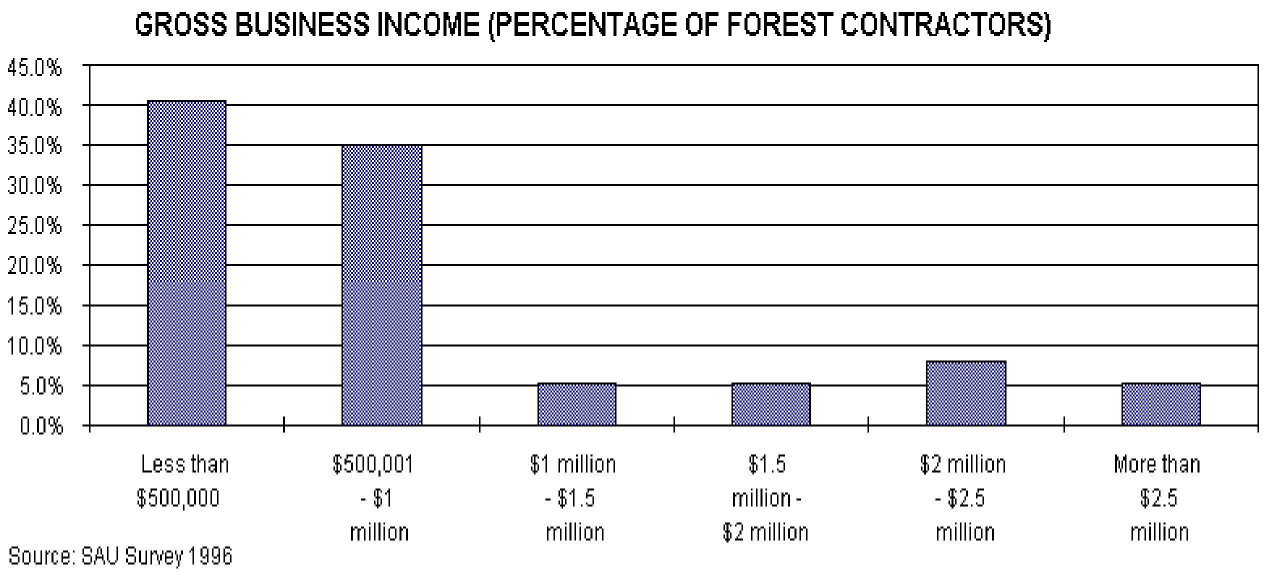
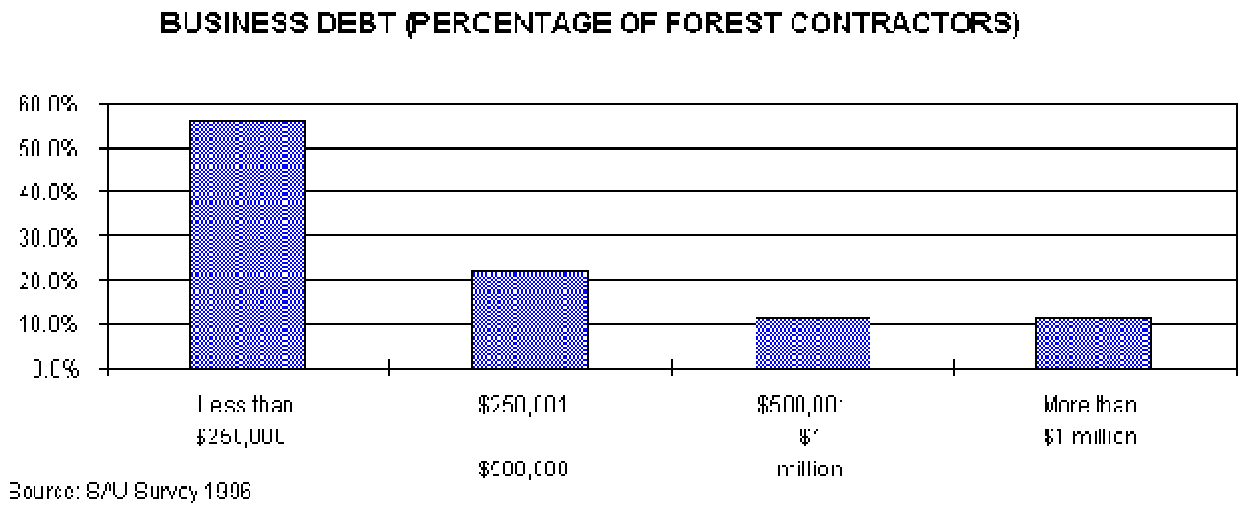


Figure 3.15



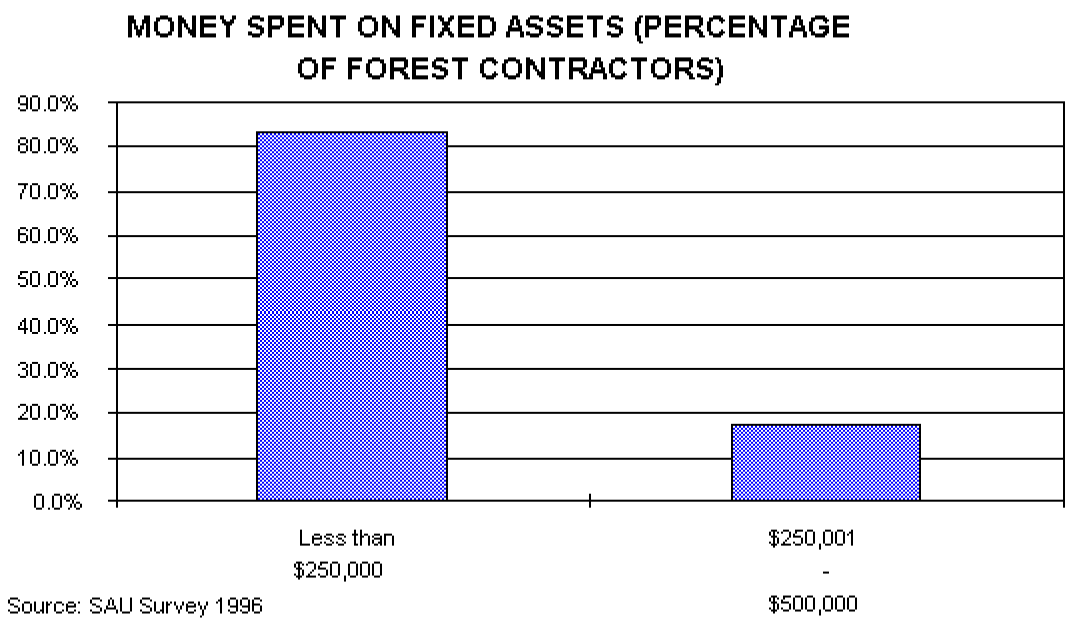
Most contractors had a gross business income of less than $1 million.

Figure 3.16



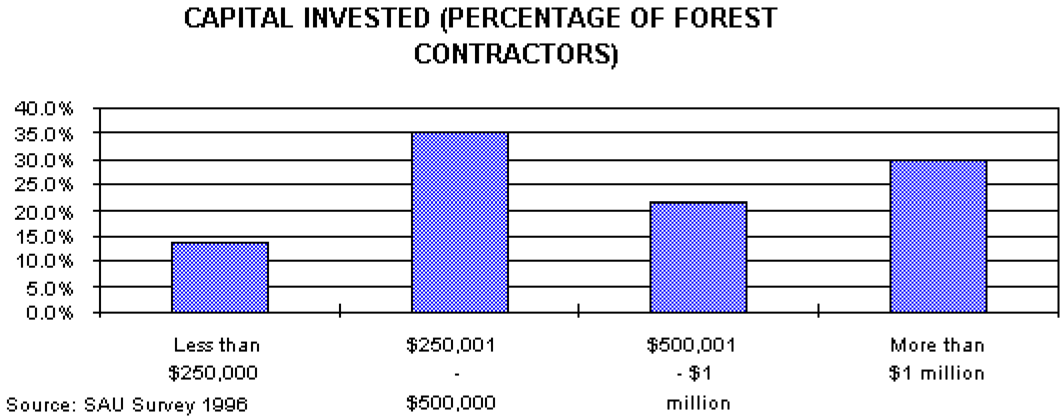
For most contractors, business debt was less than $250,000, with only a small proportion of those sampled in the higher debt categories.

Figure 3.17



Money spent on fixed assets varied from less than $250,000 to up to $500,000.

Figure 3.18



Capital invested by contractors varied considerably. Most contractors were in the $250,000-500,000 and more than $1 million categories.

Contractors were also asked to indicate where they accessed services for the purchase of fuel, tyres, machinery, mechanics, finance, legal matters, accountancy and insurance. The locations where each of these services are purchased are illustrated in the table below.

Table 3.11: Forest contractors purchase of services by type and area

Service	Township	Percent of response
Fuel	Burnie	13.5
	Launceston	13.5
	Triabunna	13.5
	Hobart	8.1
	Smithton	8.1
Tyres	Hobart	25.7
	Launceston	25.7
	Burnie	11.4
	Scottsdale	11.4
	Smithton	8.6
Machinery	Launceston	54.1
	Hobart	24.3
Machinery services	Launceston	33.3
	Burnie	21.2

	Hobart	15.2
	Triabunna	12.1
Financial services	Launceston	37.8
	Hobart	13.5
	Smithton	13.5
	Burnie	8.1
Legal services	Launceston	34.3
	Hobart	25.7
	Burnie	11.4
	Smithton	11.4
Insurance services	Launceston	62.9
	Hobart	28.6
Accountancy services	Launceston	37.1
	Hobart	25.7
	Burnie	14.3
	Smithton	11.4

Source: SAU Survey 1996

Launceston and Hobart are the key areas where services are accessed. However, services in other centres such as Triabunna, Smithton and Burnie are also regularly used.

Private forest growers

A total of 1,175 private forest growers across Tasmania were contacted and asked to respond to a survey. A total sample of 20% was obtained. On average private forest growers across the state had owned private land for approximately 25 years. Of those sampled, 94.8% were male and only 5.2% female, with an average age of 52 years. Respondents were predominantly married (86.1%) and of these 41.5% had partners employed in running the property, 29.9% had partners employed in work off the property and 19.6% had partners that were not employed at all. Off-property employment for partners included teaching/lecturing (22.6%), nursing (16.1%), administrative positions (11.3%), accountancy (6.5%), beekeeping (4.8%) and library work (3.2%). Other work included legal work, journalism, hairdressing, child caring, cleaning, retail, community service sectors.

In relation to education, 34.1% had reached Year 10 and 35.5% had obtained formal qualifications. Other educational achievements included trade and apprenticeship certificates, commercial pilot's licences, technical forestry certificates and two people had obtained masters degrees in wood science.

Of those sampled, 89.5% had children, and their ages varied from one to 26 years. On average respondents had three children with one or two currently living at home.

The private forest growers sampled had lived at their current addresses on average for 24 years. The townships of residence of private forest growers are illustrated in Figure 3.19. Some respondents had lived at their address for up to 79 years. Residence in the area was also high at 33 and a half years on average. 61% of respondents had their family living in the area, and 19.1% had their partner's family. Family residence in the area was very high with an average of 63 years. The majority of people sampled owned their own home (74.1%), and 22.7% were currently paying off a mortgage. The average property value was $452,755. Of those sampled, 52.3% were paying off loans of some kind, with the majority of people putting less than 25% of their income towards these costs (60.5%).

When asked what they liked most about living in their area, respondents referred to the peace and quiet afforded by their location (11.9%), the open spaces of country living (10.1%), their proximity to services and main centres (9.2%), the climate (9.5%), the friendliness of local people (8.0%), and the beautiful surrounding scenery (6.5%). Other factors included: privacy, good rainfall, quality soil, and a healthy and clean environment. Participation in community groups ranged from no participation to membership of 14 groups with average participation in approximately two groups across the sample.

Disadvantages of location included limited services and facilities (9.3%), the cold climate in winter (10.2%), the cost of travel to access services such as educational facilities (5.6%), lack of control over government decisions whether local, state or federal (5.1%), and roading issues (4.7%).

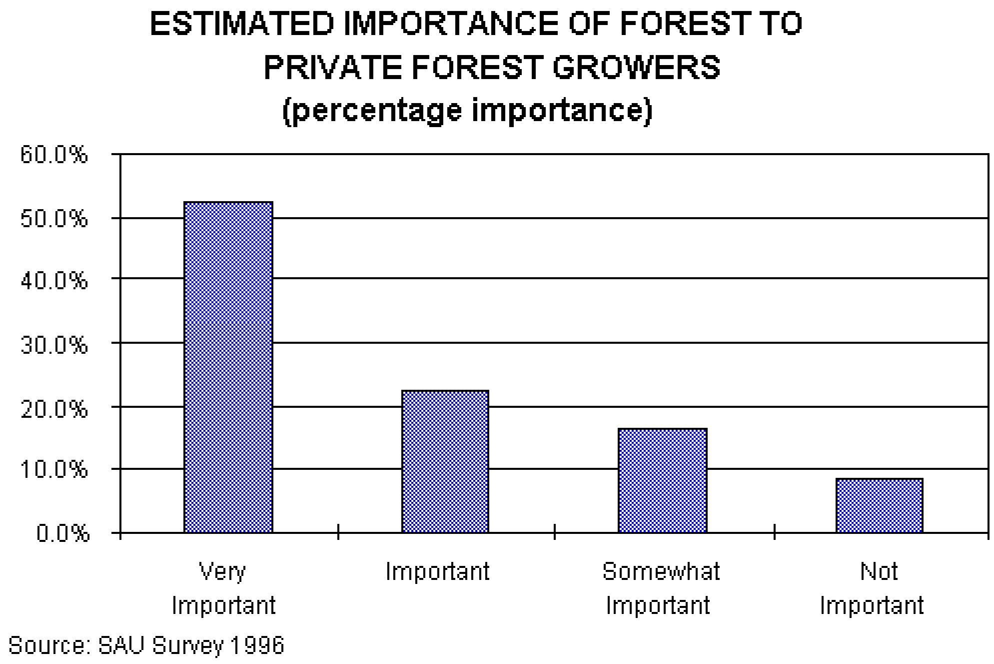
The approximate area of forest located on private properties ranged from one to 10,000 hectares, with an average of 453.25 hectares of forested land. The private forest growers sampled were involved in a range of economic activities on their properties including wool production (12.5%), cattle (17.5%), raising sheep for meat (10.6%), cereals/grains (6%), vegetables (6%) and dairying (3.8%).

In relation to the use of forested land on their properties, 9.5% of growers were involved in commercial timber production for plantation pulp, 8.4% for native forest sawlog, 8% for native forest pulp, 6.9% for plantation sawlog and 6.6% for native forest timber for firewood. Time spent in forest related activities on their properties ranged from zero to 100% with an average of 17.15%. The greatest amount of time was spent in orcharding (average of 41.62%) and wool production (average of 30.18%).

Of those sampled, 48.7% had employees, with an average of 2.7 full time and 2.7 part time. Townships of residence for these employees are illustrated in Figure 3.20. Growers had on average 1.5 full time family employees and 1.4 part time family employees. Of those sampled, 51% had worked in other industries, predominantly education, construction, mining, engineering and transport.

When asked how important timber production from private land was to the economy of their local area, respondents felt that it was very important (52.5%) or important (22.4%). 16.6% felt that it was somewhat important and 8.5% not important at all.

Figure 3.21



Respondents were also asked whether they intended to draw income from on-farm forestry over the next 10 to 20 years. A total of 74.7% responded that they would be drawing income from this resource in years to come.

Financial reasons for depending upon the resource included superannuation/pension for future years (44.5%), increased current income (22.8%), working capital for farm operations or debt servicing (11.1%) and to support children's education (6.3%).

Of those who were not drawing income from on-farm forestry, reasons presented included: the need to regenerate forested areas (30.7%); that trees on their property were not suitable for harvesting (13.5%); that codes of practice for harvesting were too stringent (3.8%); and that the resource was being kept for future generations (3.8%). Other respondents were located in areas where the land was not suitable for forestry as it was too dry.

Approximately 57.7% of respondents were spending less than 25% of their income to service their current debts, 30.3% were spending between 25 and 50% of their incomes. The percentage of farm income for 1995-96 derived from on-farm forestry enterprises was less than 25% for 89.6% of respondents. Only 3.8% of respondents were deriving more than half of their income from farm forestry enterprises.

Comments on the forest use debate

There was widespread support amongst the private forest owners sampled for an economically viable and environmentally sustainable forestry industry. Private forest owners emphasised their own role in managing forests in a knowledgeable and responsible manner and they tended to take the pragmatic view that forestry was a crop that could be managed.

> "Farmers should be able to sell timber as they want to, with proper regards to streams and the environment."
>
> "Trees are just another crop - but they take longer to mature."
>
> "When interests are more concerned for the resource security of big logging companies that will trash whatever they can get from anywhere in the world then move on - not having to live with the effects of the damage done - and local sawmillers who have worked in these mountains for years (without ruining them) are hard pressed to get access to logs even though they employ more people due to the scale of the process and get a higher percentage of quality timber out of each log, there is something very wrong happening."

Accordingly, there was considerable frustration with bureaucratic interference and the demands of extreme conservationists. Of particular concern was the lack of certainty created by unresolved forest use policy.

> "Too many controls being imposed on private land."
>
> "I strongly agree with sustainable and environmentally sound land management, however, there is a section of the community that is intent on halting any forestry activities."
>
> "Thoroughly fed up with constant 'extreme green' agenda of locking up more and more state resources and their destroying of investment incentives from forestry. They are constantly causing uncertainty to our selective logging operations - which are strictly sustainable for future generations. We are hesitant of how much investment to make in forestry while the 'green agenda' is constantly changing."
>
> "[W]e are still not sure how government will rule or whether we will be allowed to log this plantation for commercial use. I would like to see a 100% guarantee that in 20 years we will be able to log this plantation."

There was some optimism that tree farming would play a more significant role in the timber industry if resource security was assured and if there were adequate market based incentives.

> "With the downturn in wool and beef prices farmers are diversifying where possible. There would be a great opportunity for farm forestry if this resource could be assured of a stable future."
>
> "Forestry and farming are vital to each other and for our future."
>
> "We have been urged and encouraged to 'grow trees' - we need a fair price for our efforts."
>
> "Should be more emphasis put on plantations for renewable resource and the 'old growth' forests left alone."
>
> "I think eventually native forest logging will be phased out and the timber industry will need to be plantation and regrowth based. To this end policy makers need to encourage plantation establishment primarily by changing taxation regimes."

For some, enthusiasm for tree farming was qualified by the need for continued access to native forest resources.

> "Farm forestry particularly private hardwood and softwood plantations are very important to the future economy of this area, however, these plantations cannot sustain the demand for timber production and pulp wood on their own. Access to sustainably managed native forests are also vital to the diverse timber industry and this community."

A further issue raised by respondents was compensation. There was a feeling that private forest owners should be compensated for economic losses incurred through government decisions and provided with financial support to participate in decision making.

> "Compensation has got to be addressed immediately. Not only money that I am currently missing out on, but if my bush is to be set aside forever then something must be done about missing income from future timber harvests. I had banked on this money and it has been taken away from me."
>
> "Minority groups seem to be able to obtain government funding to oppose forestry production - i.e. forest harvesting. Private forest owner groups are unable to receive similar funding to defend themselves from a torrent of ill informed misinformation."

Impact of the past and current forest policy on individuals, families and the community

The private forest owners identified a range of impacts arising from forest policy. At an individual level, major concerns related to economic impacts such as lost revenue, lost value of resource and reduced property values.

> "Lowered economic activity has adversely affected my ability to earn and invest in my profession."
>
> "It is probably decreasing the potential worth of my forestry investment."

Resource security was again identified as a key issue.

> Uncertainty of knowing what our tree farm investment will bring and what guarantees we have on their future sale."
>
> "Estate planning has been postponed. Contractor stopped from working because of unmarked 'endangered species'. Delays."

Respondents made specific reference to the impact of decisions relating to the woodchip industry.

> "Hard to sell this chip."
>
> "Tiresome restrictions and frustrations. Difficulty in selling low grade timber for woodchips."
>
> "Past - haven't been able to sell timber because multi-nationals have been chip driven and had too much say. Present - improved."

Respondents also noted that participation in forest policy decision-making had had a considerable impact in terms of their time and commitment.

> "An increasing amount of unpaid time is spent attending and traveling to meetings in relation to the forest debate, making submissions, reading correspondence and articles on the forest issues. There seems to be no end to it."

While many of the private forest owners surveyed felt that forest policy had had little impact on their families, others pointed to the loss of income and employment, and associated stress.

> "It has meant financial hardships and stopped us realising our investment and further investment has been restricted."
>
> "Lowered family income and lifestyle."
>
> "Concern at possible loss of superannuation for parents."
>
> "Stress in the family."

These effects were felt most strongly by those who anticipated employment opportunities for family members.

> "Creation of uncertainty for family forestry enterprises, e.g. seed collection."
>
> "My father has passed away, but the policies in place at the moment would make him angry. We bought and paid for the property, but can't do anything with it."
>
> "[Family] live interstate because the jobs are not here. Too many trees chipped and not replaced."

The private forest owners surveyed felt that forest policy had had a considerable impact on the local economy and employment, with small sawmill businesses being the hardest hit.

> "Decisions which disrupt logging activities impact unfavourably on the local economy. This in turn affects just about everybody."
>
> "[There were] eight sawmills in our locality. None left. Say no more."

> "To my knowledge the main effect has been to close our local sawmills. So I would say disastrous."

> "It has restricted the growth and reasonable potential of an industry vital to this area."

> "It has meant idle forests, idle land, and migration of young people because of a lack of local jobs."

Economic impact on the local community was not the only concern. Respondents also indicated that forest policy had led to division within the community.

> "It has polarised views which reduces the ability for sensible dialogue within the community."

> "Divisiveness, unemployment, uncertainty."

Although the divisive nature of forest debate was a common sentiment, there were exceptions.

> "Neither the greenies not the loggers in this area want to see clear felling on crown land. We are being brought together by a sentiment of not wanting something precious to us in many ways (not just economic) ruined by someone far away making an arbitrary decision based on extremely short-term economics and favouring big multinationals over the local people."

Other impacts at a community level related to the landscape and the environment. Respondents who raised these issues were concerned primarily with erosion and water quality.

Tourist operators

A total of 32 tourist operators (20%) responded to the survey from a total of 187. Of these, 18 were male and 12 were female. Respondents were aged from 27 to 62 years with an average age of 41 years. Of those sampled, 65% were married, 20.7% were single and the remainder were either in a defacto relationship (10.3%) or divorced (3.4%). 70% of respondents had partners who were employed either as business partners (30%), as managers/assistant managers (15%), in self-employment (10%) or as transport drivers (10%). Other occupations included consultants, builders, cleaners and nurses. 83% of respondents had children, whose ages varied between one and 22 years. Most people had an average of two children, and an average of one child living at home.

Of those sampled, 44.8% had received a degree or diploma, 37.9% had reached Year 10 and 10.3% had graduated from Year 12. Those with vocational qualifications had obtained certificates in the areas of fitting and machining, fire fighting and voluntary ambulance service, dental assistance and first aid, electrical fitting, boiler attendant, earth sciences, tourism management, saddling, and horse-back tour guiding.

Of those sampled, 14.3% resided in the Meander Valley Municipality, 43% in the Huon Valley, 10.8% in Hobart and surrounding suburbs, 10.8% on the West Coast, 10.7% in the Derwent Valley, 7.2% in Glamorgan/Spring Bay, Break O'Day and Central Coast respectively, and 3.6% in Dorset and in Launceston. The townships of residence of tourist operators are illustrated in Figure 3.22. Residents had been living at their current address for between one and 62 years with an average of 13 years, and in the area on average 18 years. 26.7% of respondents had their family also living in the area and 13.3% their partner's family.

When asked what they liked most about living in the area, people identified the peace and quiet, and clean and healthy environment. In addition, lifestyle and employment opportunities were raised along with access to recreation, natural forests and bushland, and the local community spirit.

When asked what they disliked about living in the locality, 16.2% of respondents referred to the lack of facilities and support services. 10.8% of respondents also disliked the cold weather or felt remote or isolated (8.1%).

In regard to personal finance, 51.9% of respondents owned their own home and 33.3% were paying off a mortgage. Of these respondents the value of property owned or being purchased ranged from $35,000 to $500,000. The average value of a property was $165,636. 82% of respondents were paying off some form of loan with 91% using 50% or less of their household income to cover these loans.

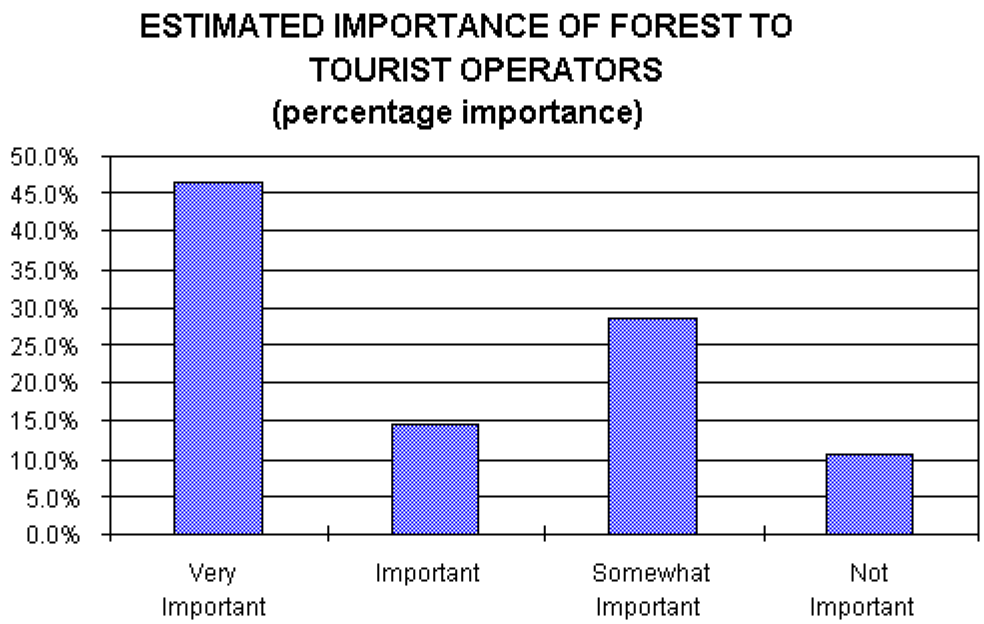
Respondents were also asked to comment on their business enterprise. Most operators were involved in outdoor tour operations and tourist accommodation in the form of holiday flats, units and houses, hotel/motels, bed and breakfasts, or guest houses/lodges. Fewer were involved in tourist transport such as cruises, coach tours and so on, however some operated tourist shops, galleries, cafes or restaurants. On average operators employed two full time employees and five part time employees. Approximately two family members full time and one or two family members part time were also employed on average. Employees resided in a number of townships as shown in Figure 3.23. Tourist operations utilised a wide range of areas including State Forest Reserves, World Heritage areas, river areas, waterfalls and parks.

Of the operators sampled, 83.3% had previous experience in a number of other sectors, namely education (16.7%), the public service sector (12.5%), farming, heavy industry, manufacturing, the defence forces (8.3% respectively), as well as building, mining, fruit farming, retail, dairy farming and fishing (4.2% respectively). Length of service ranged from one to 50 years experience.

In regard to finance, 44.8% of operators had annual operating costs of less than $20,000, 24.1% between $20 and 50,000 and 13.8% above $200,000. 31% of operators had a gross business income of less than $10,000, 20.7% between $25 and 50,000 and 24.1% above $100,000. The majority of the operators owed less than $10,000 on their businesses (53.6%), with 21.4% owing between $10 and 25,000. Business spending on fixed assets was also relatively low with 60.7% of operators spending between zero and $10,000, and only 10.7% more than $100,000. Capital invested ranged from less than $100,000 (66.7%) to more than $1 million for 11.1% of the sample.

When asked to comment on how important tourism was to the local economy of their area, 73.3% of the sample believed the industry to be very important and a further 20% important. In relation to the forest/timber industry the response of operators was still relatively high, 46.4% suggesting that the industry was very important, 14.3% important and 28.6% somewhat important. 10.7% felt the timber industry was not important at all.

Figure 3.24



Source: SAU Survey 1996

Comments on the forest use debate

For the most part, tourist operators valued forests as an important resource and favoured sustainable forest management.

"The forest should be harvested in a responsible manner."

"I am happy with multiple use policies."

"I believe in the value of pristine old growth wilderness and believe in preserving what's left. As such plantation forestry should be pursued."

Although tourist operators were generally supportive of well managed working forests, the visual impact of forestry practices was a major issue. Tourist operators expressed opposition to clear felling of old growth areas and were critical of the lack of buffers along tourist routes.

"If the forest is harvested, a buffer zone of trees along tourist routes should be left standing."

"Tasmania has yet to reach its potential for ecotourism activities. Slash and burn forestry activities are defacing the landscape and putting visitors off."

"Our company believes that all forestry operations in old growth and high conservation value forests in Tasmania must cease to enable the development of an economically viable and environmentally sustainable nature tour industry."

"As a nature tour operator we consider old growth and high conservation value forests as a priceless and irreplaceable resource. The future potential of the nature tour industry is being compromised by forestry operations in old growth and high conservation value forests."

Other issues concerning respondents included the conversion from mixed forest to monoculture, the use of poisons, restrictions on public access to forests, the need for downstream processing and the importance of nature based eco-tourism.

Impact of the past and current forest policy on individuals, families and the community

The impact of forest policy on tourist operators varied according to individual circumstances. While a number felt there had been little or no impact at a personal level, others referred to job loss or job insecurity, increased numbers of log trucks on the roads, increased possum culling due to displacement of wildlife, increased difficulties in obtaining firewood, loss of historically significant sites, more 'red tape' to deal with, and improved forest access for tourists.

Several recalled the 'shocked' response of tourists to clear felled areas.

"Seeing denuded forest is a shock to most tourists."

"Visitors are disappointed to see clear felling and pine plantations."

"Past forest policies are offensive to look at when traveling around Tasmania."

Many tourist operators felt that forest policy had had a minimal impact on their families. Of those who did identify effects, the reduced opportunity for employment was of major concern.

> "Members of my family rely on timber resources for their livelihood."
>
> "No hope of work in forestry industry for local community including me and my family."
>
> "Other statewide forest debacles at different times have led to both my sons leaving the state to find employment elsewhere."

At a local community level, tourist operators surveyed identified two key effects. The first was the loss of employment.

> "Devastating to the local morale, and unless some stability is instilled in local industry then the crumbling effect will continue."
>
> "The local community was heavily dependent on old growth logging and suffered huge loss of employment when Australian Newsprint Mills changed the pulping inputs to regrowth in 1988."

The second was division within the community.

> "Divided it and soured many people towards conservationists."
>
> "Politicking and 'rigged' review systems have divided the community so that many who can no longer work in forestry are actually supporting the companies who have robbed their resource."

Other forest users

A survey was also developed and sent to a number of different groups which use forests. These groups included apiarists, graziers, firewood collectors, craftwood and specialty timbers, furniture makers, boat builders, tree fern collectors and seed collectors. A total of 1,600 surveys were administered and a total of 189 returned (11.8%). The townships of residence of other forest users and their employees are illustrated in Figures 3.25 and 3.26. Data collected on each of the groups is presented below.

Apiarists

A total of 35 apiarists responded to the survey of which 92.1% were male and 7.9% female. The average age was 53 years. The majority of the sample were married (78.9%). Of those sampled, 38% had a partner who was also employed. Partner occupations included business partner, teacher, career, administrative officer or retailer. Of those sampled, 15.8% were single. 86.1% of the sample had children, whose ages varied from two to 26 years. The average number of children totaled three and the average number of children currently at home was 1.5. Children of school age attended the local primary or secondary schools in their area.

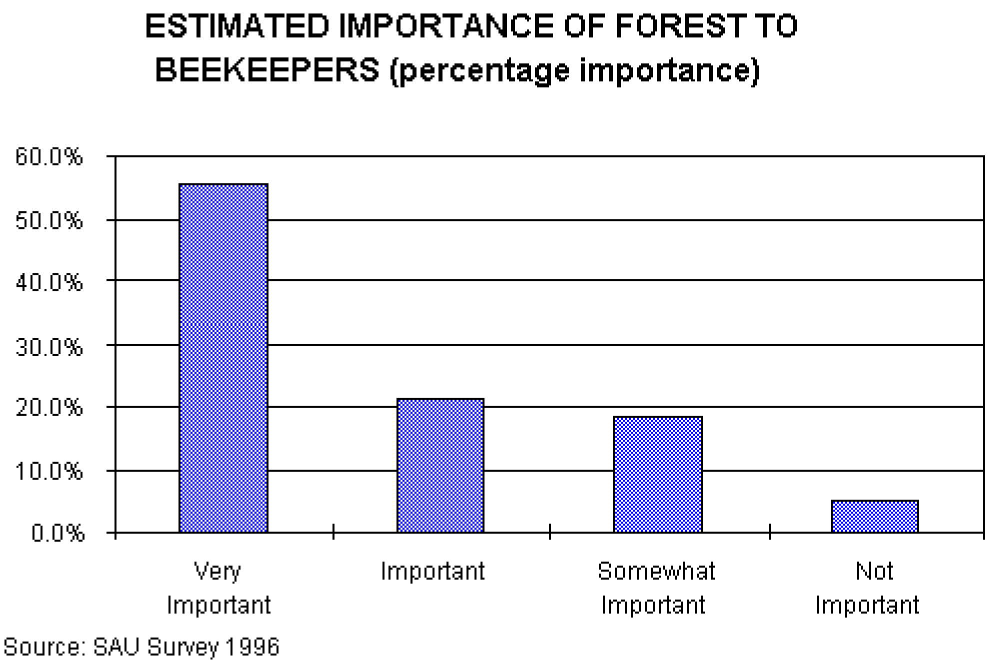
In relation to education, 40.5% of those sampled had reached Year 10, only 18.9% had formal qualifications in the form of a degree or diploma. Of those sampled, 85.7% had experience in industries other than apiary. These industries included farming, forestry, construction, nursing and food processing. Other areas included education, hospitality, automotive industry, government, fishing, manufacturing, horticulture, law and landscaping.

Of the respondents, 56.8% travelled to work from their home base daily. However, the remaining 43.2% travelled from other locations due to the seasonal nature of their work. More than half of those sampled (57.1%) travelled distances of more than 100 kilometres to work. 80% of respondents owned their own home, 11.1% were paying off a mortgage and 8.3% were renting. The average value of property for those buying or owning homes was $138,483. Of those 35.1% paying off some form of loan, less than a quarter of household income was being used to pay these costs (52.9%) and 41.2% were paying between 25 and 50% of their household income on these costs.

In relation to their business enterprise, only 36.8% of apiarists sampled had employees. The number of full time employees ranged from one to 12 with an average of 2.5. The number of part time employees ranged from one to 10 with an average of 1.9. The average number of family members employed full time was 1.7 and the number of part time family members was 1.6. For the majority of respondents the average annual operating costs were between zero and $20,000 (70.6%), 11.8% of respondents were between $20 and 50,000, and only 17.6% above $50,000. Gross business income varied from zero to $10,000 (39.4%) to greater than $100,000 for 21.2% of the sample. 18.2% earned between $10 and 25,000 and 15.2% between $25 and 50,000. Most apiarists had relatively low business debt, owing between zero and $10,000 (70%), 13.3% owed between $10 and 25,000 and a further 13.3% owed more than $100,000. Once again money spent on fixed assets was low, 81.3% of those sampled spent between zero and $10,000. 58.8% of the sample had less than $100,000 worth of capital invested, 20.6% between $100 and 250,000 and 11.8% between $500,000 and $1 million.

With regard to use of forested land, respondents used predominantly public native forest areas (46.4%) and private native forest (17.4%). However, it was evident that apiarists also used unforested land (23.2%). When asked how important the timber industry was to the economy of their local area, 55.3% of respondents believed it to be very important, 21.1% important, 18.4% somewhat important and only 5.3% not important at all. Only 6.1% of those sampled had family members who were employed in the timber industry in some capacity within Tasmania.

Figure 3.27



On average, respondents had been living at their current address for 22 years and in the area for 31 years. Of those sampled, 57.9% had their family also living in the area and 27.8% their partner's family. When asked what they liked most about living in the area a range of factors were identified.

These included: the beauty of the natural environment (15.4%), the centrality to employment and recreational interests (15.4%), the clean air for beekeeping (12.8%) and the peace and quiet (12.8%). Other factors included privacy, good people and having family in the area.

When asked what were the disadvantages or costs respondents mentioned the cold climate in winter (16.7%), lack of services and facilities due to remoteness (12.5%) and crime in their area (8.3%).

Comments on the forest debate

The main issue raised by the apiarists surveyed was protection of leatherwood, the resource on which the honey industry relies. Respondents were concerned that indiscriminate logging had led to considerable depletion of leatherwood and expressed strong support for protection and management of this resource.

> "There should be no logging in leatherwood forests."
>
> "As a beekeeper I have sympathy for the timber industry but my business is completely dependent on the availability of leatherwood honey resource, not only for direct income, but also to maintain hives through winter - loss of the leatherwood resource would mean the loss of my business."
>
> "For the past 50 years the beekeeping industry has been totally ignored with no resources put aside for them and as a result we are at the end of the leatherwood forests in the south of the state. Any further reduction in the amount of forest available will result in a reduction of the honey industry and hive numbers. If continued all committed beekeepers will leave the industry because it will not be viable, leaving insufficient hives for seed and fruit crops."

Some respondents also wanted increased access to leatherwood stands.

> "Need to get more access to new bee sites so that I can expand and increase production."

Impact of the past and current forest policy on individuals, families and the community

In relation to the impacts of forest policy, respondents were most concerned with how the depletion of leatherwood would reduce the viability of their businesses.

> "The destruction of forests containing leatherwood. Trees have been clear felled and converted to plantations making it much more difficult to expand my business to a sustainable/viable operation."

Some highlighted how apiarists have both benefited and lost from forestry operations.

> "Forest operations have meant that some resource has been lost, but new roading has also made new resources available."

When asked about impacts on their families, the apiarists surveyed were pessimistic about the option of expanding their family businesses and were hesitant to encourage their children into the industry.

> "Due to the uncertainty of the leatherwood supply in future years the family business is unable to expand the way we would have liked."

Some mentioned that the reduced level of honey production meant that apiarists had to travel longer distances to more hive sites.

> "I am away from home for longer periods and have to work harder to obtain an income to sustain my family - this is due to the fact that the hives on some sites don't bring in as much honey as what they would have done prior to being heavily logged."

Graziers

A total of 27 graziers responded to the survey, of which 96.3% were male and 3.7% female. The average age was 48 years. The majority of the sample were married (70.4%), and 21.7% had a partner who was also employed. Partners predominantly worked in Hobart (66.7%). Of the respondents, 11.1% were single and 11.1% were living in a defacto relationship. Most of the sample had children (88%) from 1 to 27 years old. The average number of children totaled 2.5 and the average number of children currently at home was 1.6. Children of school age attended the local schools in their area.

In relation to education, 44.4% of those sampled had reached Year 10. Only 18.5% had formal qualifications in the form of a degree of diploma. Of those who responded, 87% had experience in industries such as agriculture, forestry, construction, accountancy, fishing, transport and hospitality.

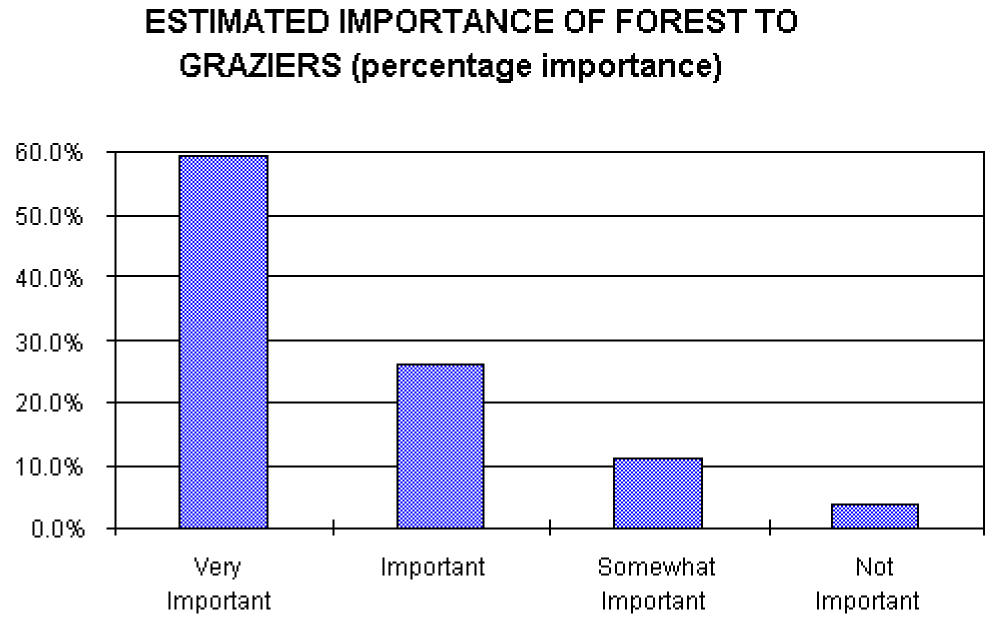
Of those sampled, 41.7% of graziers travelled to work from their home base daily. Distances travelled to work varied from 10 to 20 kilometres (40% of respondents), 20 to 50 kilometres (26.7% of respondents) to greater than 100 kilometres (13.3% of respondents). 73.1% of respondents owned their own home, 19.2% were paying off a mortgage and only 7.7% were renting. Of those 44% paying off some form of loan, less than 25% of household income was being used to pay these costs for 46.7% of respondents and 33.3% were paying between 25 and 50% of their household income on these costs.

In relation to their business enterprise or activity, only 33.3% of graziers had employees. Number of full time employees ranged from one to 17 with an average of three, the number of part time employees from one to ten with an average of 2.5. The average number of family members employed full time was 1.8 and the number of part time family members was 1.5.

For half of the respondents the average annual operating costs were between zero and $20,000, for 18.2% of respondents costs were between $20 and 50,000, for 13.6% of respondents costs were between $50 and 100,000 and for 13.6% of respondents costs were above $200,000. Gross business income varied from zero and $10,000 (26.1%) to greater than $100,000 for 34.8% of the sample. 17.4% earned between $10 and 25,000 and 13% between $25 and 50,000. Amount of business debt varied considerably with 50% owing less than $10,000, 5% owing between $10 and 25,000, 15% between $25 and 50,000, and a quarter owing more than $100,000. Money spent on fixed assets was also low, 59.1% of those sampled spent between zero and $10,000, a further 18.2% spent between $25 and 50,000. Of those sampled, 47.6% had less than $100,000 worth of capital invested, 23.8% between $100 and 250,000, 14.3% between $250 and 500,000 and 14.3% above $500,000.

With regard to use of forested land, respondents used predominantly private native forest areas (48.8%), public native forest (17.1%) and unforested land (14.6%). When asked how important the timber industry was to the economy of their local area, 59.3% of respondents believed it to be very important, 25.9% important, 11.1% somewhat important and only 3.7% not important at all. Of those sampled, 21.7% had family members who were employed in the timber industry in some capacity within Tasmania.

Figure 3.28



Source: SAU Survey 1996

On average, respondents had been living at their current address for 20.5 years and in the area for on average 33 years. 70.4% had their family also living in the area and 25% their partner's family. When asked what they liked most about living in their area a range of factors were identified.

These included: peace and quiet (16.7%), open spaces and the beauty of the natural environment (20%), the ability to own their own property and work in the area (13.3%), the privacy of a rural setting (10%), and the scenic quality of the area (10%). Other factors included lifestyle, people, low population density and having family in the area.

When asked what were the disadvantages respondents mentioned the cold climate in winter and the winds (15%), lack of services due to remoteness (7.4%) and poor roading (7.4%). Respondents also mentioned the existence of alternative lifestyle people within their communities.

Respondents participated actively in their local community being involved in between zero and 8 groups. On average, respondents participated in two community groups.

Key issues

In general, the graziers surveyed were supportive of the timber industry. They were most critical of the restrictions on their own farming operations.

> "It means when I clear some of my present forest for farm use I have got no alternative but to burn the timber where I am not going to reforest."
>
> "Because of forest types we cannot woodchip."

> "Most properties have a whole farm plan. If land owners cannot forest particular areas it affects the whole plan through lost income and reforesting and therefore future income. It also affects our local logging contractors."

> Restrictions on grazing access in State forests was a concern specific to this group.

> "Forestry Tasmania need to take a broad view of State forest from just that of timber management and harvesting - everything else seems barely tolerated or of nuisance value. For example, some employees of Forestry Tasmania have publicly stated that they would like to get rid of grazing in State forest. They don't seem to be aware of multiple use possibilities or to work towards a mutually beneficial sharing of land resource."

Other issues raised by respondents included the lack of wildfire prevention and difficulties controlling wildlife numbers.

Firewood collectors

A total of 103 firewood collectors responded to the survey of which 96.9% were male and 3.1% female. The average age was 44 years. The majority of the sample were married (62.9%), and 21.8% had a partner who was also employed. Partner occupations included business partner, beekeeping, nursing, administrative officer, accountant, waiter/waitress, groundsman, kitchenhand, florist, nursery attendant and timber worker. 33.3% of partners worked in Hobart. 16.5% of the sample were single. Of those sampled, 86.3% had children, whose ages varied from one to 27 years. The average number of children was two and the average number of children living at home was also two. Children of school age attended the local primary or secondary schools in their area.

In relation to education, 52.1% of those sampled had reached Year 10, 17% had reached Year 12 and only 13.8% had formal qualifications in the form of a degree of diploma. Of those who responded, 78.4% had experience in other industries such as included agriculture, mining, food processing, forestry and communications.

Of the respondents, 62.2% travelled to work from their home base daily. Distances travelled to work varied from 10 to 20 kilometres (29.7% of respondents), 20 to 50 kilometres (32.8% of respondents), 50 to 80 kilometres (10.9% of respondents) to greater than 100 kilometres (17.2% of respondents). 44.2% of respondents owned their own home, 25.3% were paying off a mortgage and a high proportion of respondents were renting (30.5%). Of those 50% of respondents paying off some form of loan, less than a quarter of household income was being used to pay these costs for 42.9% of respondents; 37.5% were paying between 25 and 50% of their household income on these costs.

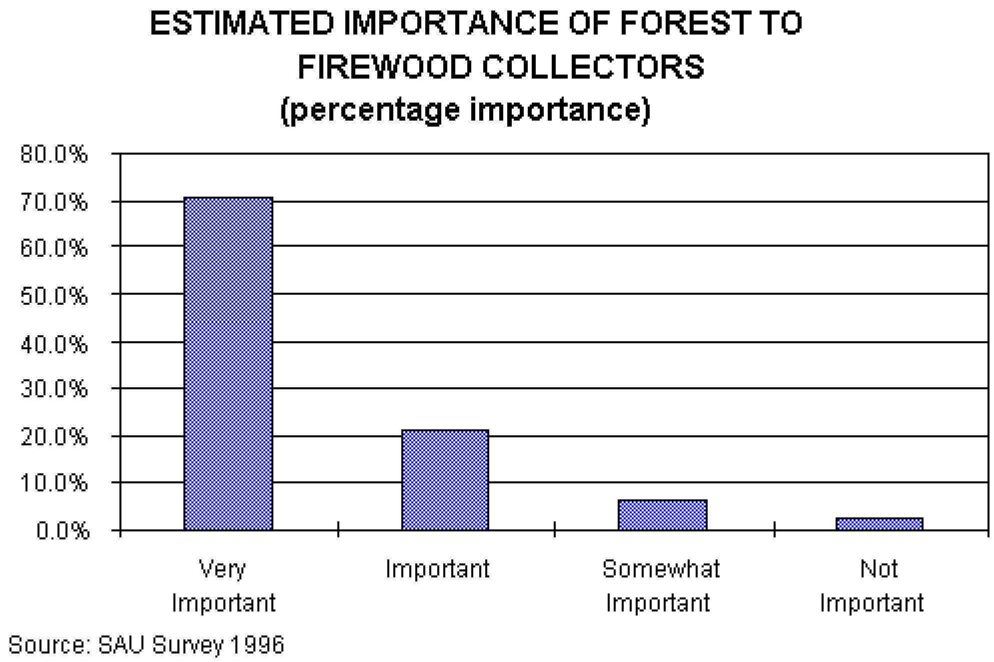
In relation to their business enterprise or activity, only 18.2% of firewood collectors had employees. The average number of full time employees was five and the average number of part time employees was 1.8. The average number of family members employed full time was 1.5 and the number of part time family members was 1.3.

For the majority of respondents the average annual operating costs were between zero and $20,000 (72.5%). Only 10.1% of respondents had costs above

$200,000. Gross business income varied from zero to $10,000 (59%) to greater than $100,000 for only 18% of the sample. Amount of business debt varied considerably with 67.9% owing between $10 and 25,000, again only 14.3% owed more than $100,000. Money spent on fixed assets was also relatively low, 69% of those sampled spent between zero and $10,000, a further 10.3% spent between $10 and 25,000 and 12,1% between $25 and 50,000. Of those sampled, 66.7% had less than $100,000 worth of capital invested. Some of the firewood collectors were also involved in other activities such as apiary, timber harvesting, clearing of land and production of timber products. Collectors also outlined that some firewood collected was for their own domestic or personal use.

With regard to use of forested land, respondents used predominantly public (41.1%) and private (30.2%) native forest areas to collect firewood. When asked how important the timber industry was to the economy of their local area, 70.5% of respondents believed it to be very important, 21.1% important, 6.3% somewhat important and only 2.1% not important at all. Of those sampled, 17% had family members who were employed in the timber industry in some capacity within Tasmania.

Figure 3.29



On average, respondents had been living at their current address for 14 years and in the area for on average 25 years. Of the respondents, 58.8% had their family also living in the area and 32.6% their partner's family.

For those with family in the area, these families had lived in the area from three to 150 years with an average of 53 years. When asked what they liked most about living in their area a range of factors were identified. These included: peace and quiet (18.6%), the natural environment (11.9%), centrality to work and interests (11.9%), the people (6.8%), the clean air (6.8%) and lifestyle (5.9%). Other reasons were scenic beauty, ability to work own property and recreational opportunities such as fishing.

When asked what were the disadvantages, respondents mentioned the lack of services due to remoteness (9.9%), increased crime in the area (6.2%) and limited employment (6.2%). Other disadvantages included the climate, especially in winter, government controls on way of life and too much development.

Respondents participated in zero to 8 groups. On average, respondents participated in at least 1 community group.

Key issues

Above all, firewood cutters expressed a desire for access to more firewood areas.

> "We need more wood cutting areas made available to us."
>
> "More areas closer to town should be open for firewood use."
>
> "Forestry needs to open more firewood areas so people like myself and sons can become self-employed."
>
> "There should be more areas open to woodcutting from here to Derwent Bridge. More wood leases to woodcutters like us instead of commercial cutters who charge high rates."

In terms of impacts, respondents were most dissatisfied with the expense and time involved in collecting firewood due to a lack of firewood areas close to the main urban centres.

> "I pay around $20 a month to collect firewood for home use and have to travel further every time, sometimes 30 minutes into the forest making it very expensive to collect and even more time."
>
> "I find that it is getting harder to find wood close to Devonport and have to drive further away to get it."

While for some collectors the lack of firewood access had caused inconvenience through longer distance, for others this had led to unemployment.

> "Put me out of firewood industry."
>
> "Unable to get a firewood area from Forestry so am unemployed."

Firewood cutters raised two further issues: the wastage they observed when out cutting and problems with illegal cutters;

> "It should be used to its fullest potential not abused."
>
> "Defected trees should be allowed to be fallen for firewood."
>
> "Too much timber left laying around could be used for chips."
>
> "Where logging is done more time should be allowed for household woodcutting before burning."
>
> "Weekenders coming from Hobart getting forest produce without a licence and four wheel drivers making the track a muddy disgrace."

> "I find that with people who go out and take wood without a licence, it makes it hard for people like me to be able to find wood."

> "A lot of people cut wood where they're not meant to be as there is not enough wood in the areas allotted to chopping."

Seed collectors

A total of ten seed collectors responded to the survey, of which nine were male and one female. The average age was 44 years. Half of the sample were married. 30% of these respondents had a partner who was also employed as either nurses, business partners or administrative officers. Of the sample, 40 % were single and 10% were separated. 70% of the sample had children, whose ages varied from one to 20 years. The average number of children and the number of children currently at home was two.

Of those sampled, 40% had reached Year 10, 20% Year 12 and a further 40% had formal qualifications in the form of a degree of diploma. Of those who responded, 80% had work experience in other areas such as the automotive industry, agriculture and forestry. Most travelled to work from their home base daily (80%), the remaining respondents travelled from a variety of different locational bases. Distances travelled were largely greater than 100 kilometres (55.6% of respondents) or between 20 and 50 kilometres (22.2%).

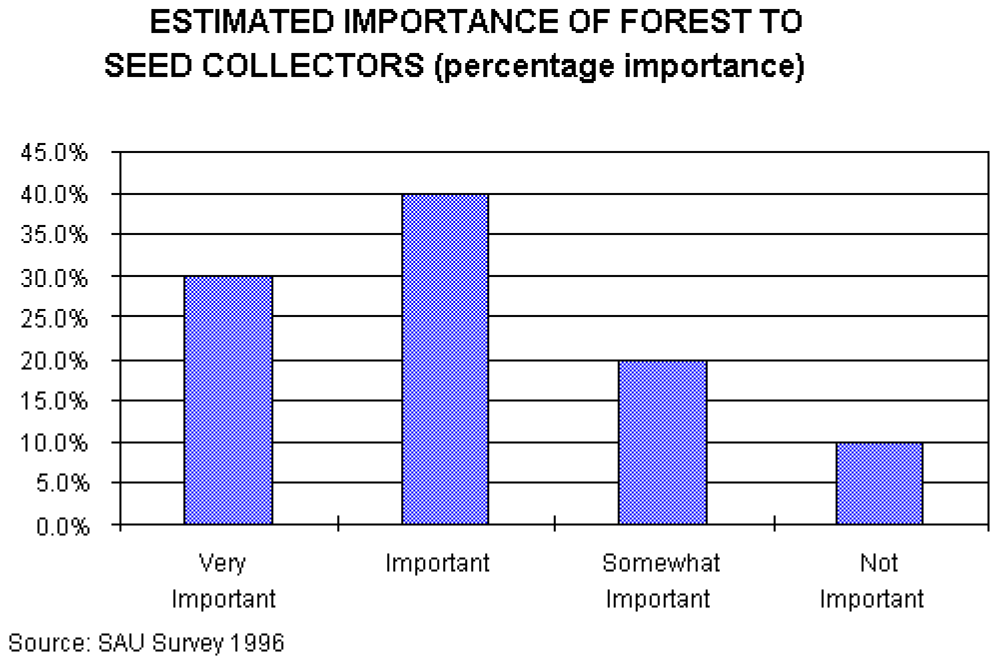
Of the respondents, 70 % owned their own home, 20% were paying off a mortgage and 10% were renting. 70% were paying off some form of loan with predominantly 25 and 50% of their household income being used to pay these costs.

In relation to their business enterprise or activity, 70% of seed collectors sampled employed staff. The average number of full time employees was 14 and part time employees 2.8. The average number of family members employed full time was two and the number of part time family members was one.

For half of the respondents the average annual operating costs were between zero and $20,000 (50%) with a further 20% between $150 and 200,000. Gross business income varied from zero and $10,000 (20%) to greater than $100,000 for 40% of the sample. Of those sampled, 30% earned between $10 and 25,000 and 10% between $50 and 100,000. Amount of business debt was either low or high with 44.4% owing less than $10,000 and 33.3% owing more than $100,000. Money spent on fixed assets was also relatively low. Half of those sampled spent between zero and $10,000, a further 30% spent between $10 and 25,000, and 20% spent greater than $100,000. Of those sampled, 66.7% had less than $100,000 worth of capital invested, 22.2% between $250 and 500,000 and 11.1% above $1 million.

With regard to use of forested land, respondents used predominantly private (40.9% response) and public (40.9% response) native forest areas. When asked how important the timber industry was to the economy of their local area, 30% of respondents believed it to be very important, 40% important, 20% somewhat important and 10% not important at all. Of those sampled, 10% had family members who were employed in the timber industry in some capacity within Tasmania.

Figure 3.30



On average, respondents had been living at their current address for 13 years and in the area for on average 22 years; 50% had their family also living in the area. When asked what they liked most about living in their area, responses such as lifestyle, proximity to work and peace and quiet were frequently mentioned (15.4% response respectively).

When asked what were the disadvantages respondents mentioned the lack of services due to remoteness (20%) and too much development (20%).

Respondents participated actively in their local community being involved in between zero and seven groups. On average, respondents participated in one to two community groups.

Key issues

The seed collectors identified few impacts specific to their occupation. They did, however, emphasise the need for sustainably managed forests and were particularly concerned about wastage.

> "I think areas clear felled at present should be cleared of firewood and craft wood. Too much is being wasted...I know a lot of mistakes have been made in the past but now people have changed things around and the farming and forest industries have a brighter future."

> "I feel very strongly that we have to reduce our waste of timber products, hence the reduction and final elimination of the clear felling of old growth."

Some respondents expressed concern over the conversion from native forest to pine plantation.

The impact of forest policy on employment was not uniformly felt. Some seed collectors had experienced job loss, while others spoke of increased job opportunities.

Furniture makers

A total of 15 furniture makers responded to the survey, of which 14 were male and one was female. The average age was 39 years. The majority of respondents were married (71.4%), and 42.9% had a partner who was also employed. Partner occupations included teachers, child carers, designers, public service workers and social workers. Partners predominantly worked in Hobart (33.3%) and Launceston (33.3%). One respondent was single and two were separated. Thirteen respondents had children, whose ages varied from two to 22 years of age. The average number of children was two and the average number of children currently at home was also two.

In relation to education, a relatively large number of those sampled had formal qualifications (35.7%), 21.4% had reached Year 10 and 28.6% had TAFE qualifications. Of those who responded, 35.7% had experience in other industries. These industries included education, business, hospitality and architecture.

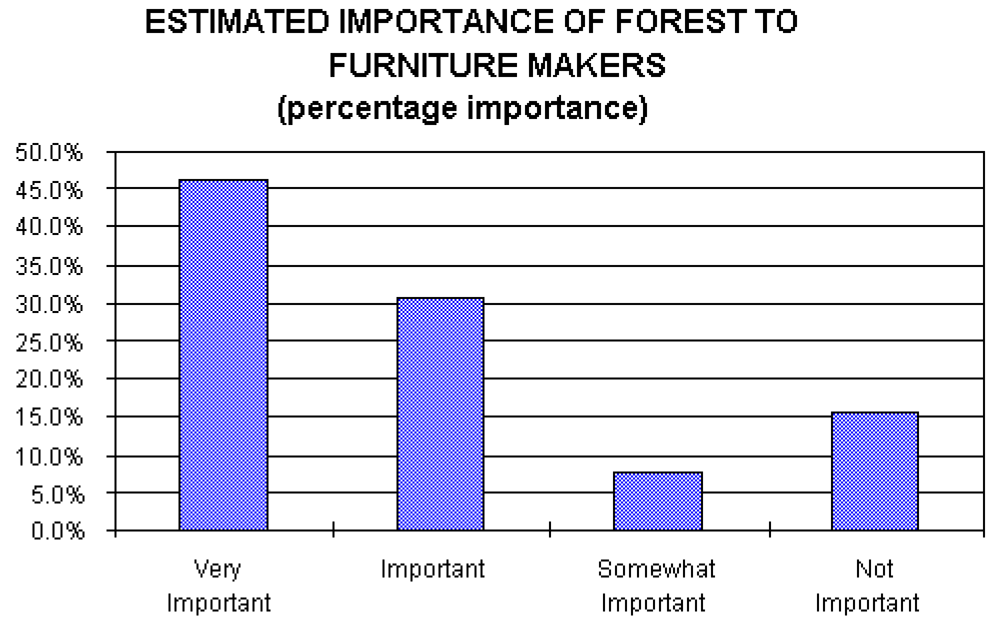
Of the respondents, 85.7% travelled to work from their home base daily. Distances travelled to work varied from 10 to 20 kilometres (33.3% of respondents) to greater than 100 kilometres (44.4% of respondents). Half the respondents owned their own home, 21.4% were paying off a mortgage and 28.6% were renting. Of those paying off some form of loan (69.2%), less than 25% of household income was being used to pay these costs for 62.5% of respondents and 25% of respondents were paying between 25 and 50% of their household income on these costs.

In relation to their business enterprise or activity, the majority of those employed staff (71.4%). The number of full time employees ranged from one to 90 with an average of 19. The number of part time employees ranged from one to nine with an average of 2.75. The average number of family members employed full time was relatively low at one and the number of part time family members was also one.

For the majority of respondents their average annual operating costs were above $200,000 (61.5%), 23.1% of respondents had lower operating costs between zero and $20,000. Gross business income was also high with 78.6% earning more than $100,000. Amount of business debt varied with 30.8% owing less than $10,000 and 46.2% owing more than $100,000. Money spent on fixed assets varied from zero to $10,000 for 21.4%, $10 to 25,000 for 50% and greater than $100,000 for 14.3%. In relation to capital invested in the business, 35.7% had less than $100,000 invested and 21.4% had between $100 and 250,000, $500 and 1 million and greater than $1 million respectively.

With regard to use of forested land, respondents used predominantly public native forest areas (29.6%), private native forest (14.8%) and public native species plantation (14.8%). Private pine plantation (11.1%), public pine plantation (11.1%) and private native species plantations (11.1%) were also used. When asked how important the timber industry was to the economy of their local area, 46.2% of respondents believed it to be very important, 30.8% important, 7.7% somewhat important and 15.4% not important at all. Of those sampled, 21.4% had family members who were employed in the timber industry in some capacity within Tasmania.

Figure 3.31



Source: SAU Survey 1996

On average, respondents had been living at their current address for seven years and in the area for on average 20 years. Of the respondents, 57.1% had their family also living in the area and 30.8% their partner's family living in the area.

When asked what they liked most about living in their area a range of factors were identified. These included the lifestyle (23.5%), the location in relation to employment and recreational interests (23.5%), the natural environment (11.8%) and the people (11.8%). Other factors outlined were clean air, peace and quiet, leisure activities, and the flora and fauna.

When asked the disadvantages, respondents mentioned the cold climate in winter (16.7%). Other disadvantages included travel time to major centres and difficulty in gaining employment.

Craft / speciality timbers

A total of 27 people working with craft/speciality timbers responded to the survey, of which 92.6% were male and 7.4% female. The average age was 40 years. The majority of the sample were married (66.7%) or separated (11.1%); 32% had a partner who was also employed. Partners worked in areas such as nursing, beekeeping, administration, design, public service or hospitality. Partners predominantly worked in Hobart (50%), a further 16.7% worked in Launceston. Of those sampled, 88% had children aged between two and 16 years of age. The average number of children totaled 2.5 and the average number of children currently at home was 1.7. Children of school age attended the local primary or secondary schools in their area. Of those sampled, 4.3% had other dependents living at home.

In relation to education, 33.3% of those sampled had reached Year 10, 25.9% Year 12 and 25.9% had formal qualifications in the form of a degree of diploma.

Of those who responded, 84.6% had work experience in other industries, namely farming, mining, fish farming, business, forestry, food and hospitality industries, automotive, architecture and landscape design.

Of the respondents, 64% travelled to work from their home base daily, others travelled from other bases mainly due to seasonal work. Distances travelled to work largely exceeded 100 kilometres (31.6% of respondents), 26.3% travelled between 20 and 50 kilometres and a further 21.1% between 80 and 100 kilometres.

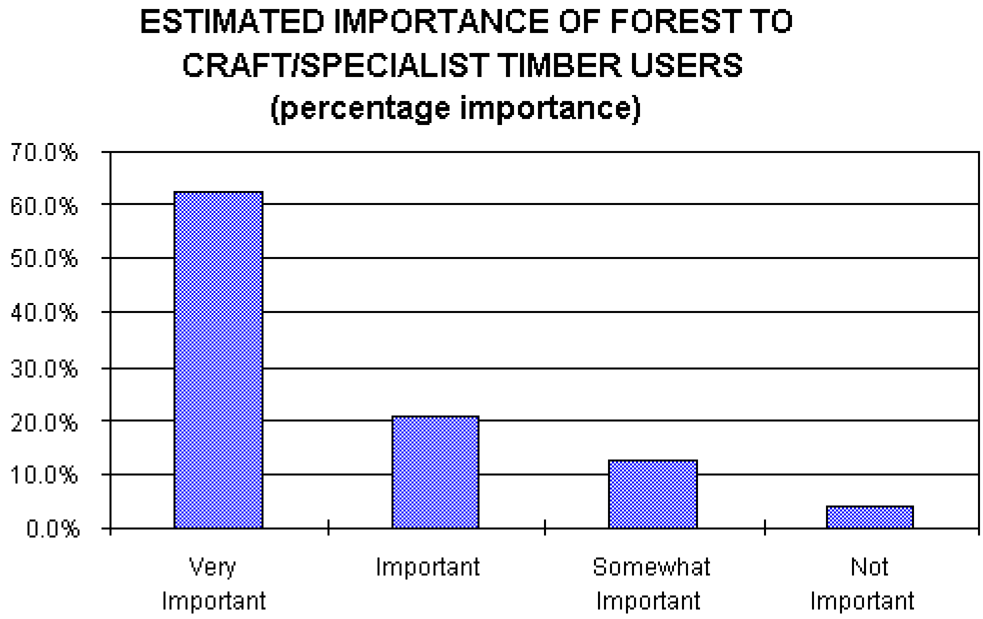
Half of the respondents owned their own home, 34.6% were paying off a mortgage and 15.4% were renting. Of the respondents, 70.8% were paying off some form of loan with approximately half of their household income being used to pay these costs in 77.8% of cases.

In relation to their business enterprise or activity, only 26.9% had employees. The average number of full time employees was 9 and the average number of part time employees was 1.7. The average number of family members employed full time was 1.3 and the number of family members employed part time was 1.4.

For half of the respondents the average annual operating costs were between zero and $20,000 (50%), 18.2% of respondents were between $20 and 50,000, 18.2% between $50 and 100,000 and a further 18.2% above $200,000. Gross business income varied from zero to $10,000 (38.1% of respondents) to $50 to 100,000 for 23.8% of people and greater than $100,000 for 28.6% of the sample. 17.4% earned between $10 and 25,000 and 13% between $25 and 50,000. Amount of business debt varied considerably with just under half of respondents owing less than $10,000 (47.4%), 5.3% owing between $10 and 25,000, 21.1% between $25 and 50,000 and 15.8% owing more than $100,000. In regard to money spent on fixed assets, 55% of those sampled spent between zero and $10,000, 25% between $10 and 25,000 and a further 15% spent over $100,000. Of the sample, 47.4% had less than $100,000 worth of capital invested, 26.3% between $100 and 250,000 and 10.5% respectively between $500,000 and $1 million and greater than $1 million.

With regard to use of forested land, respondents used predominantly private (24.5%) and public (35.8%) native forest to access craft and speciality timbers. 13.2% also accessed timber in private native species plantations. Public and private pine plantations were also used but to a lesser degree. When asked how important the timber industry was to the economy of their local area, 62.5% of respondents believed it to be very important, 20.8% important, 12.5% somewhat important and only 4.2% not important at all. Of those sampled, 41.7% had family members who were employed in the timber industry in some capacity within Tasmania.

Figure 3.32



Source: SAU Survey 1996

On average, respondents had been living at their current address for 13.5 years and in the area for an average of 22 years. Of those sampled, 51.9% had their family also living in the area and 19.2% their partner's family; these families had lived in the area from 5 to 150 years.

When asked what they liked most about living in their area a range of factors were identified. These included the natural environment (21.6%), the peace and quiet (10.8%), the lifestyle (10.8%) and the people (10.8%). Other factors mentioned were centrality to work and recreational interest, scenery and flora and fauna.

When asked the disadvantages, respondents mentioned the cold climate in winter (16.7%), lack of services due to remoteness (8.3%), government controls over way of life (8.3%) and the composition of community residents (8.3%).

Respondents participated actively in their local community being involved in between zero and 7 groups. On average, respondents participated in one to two community groups.

Boat builders

A total of four boatbuilders responded to the survey, of which all were male. The average age was 54 years. All were married and three had spouses who was also employed either as business partners, designers or accountants. Three of the sample had children, whose ages varied from one to seven years. The average number of children was two and these children attended their local primary schools.

In relation to education, half had reached Year 12 and half had formal qualifications in the form of a degree of diploma. All had previous experience in other industries, namely grazing, hospitality, transport and professional yachting.

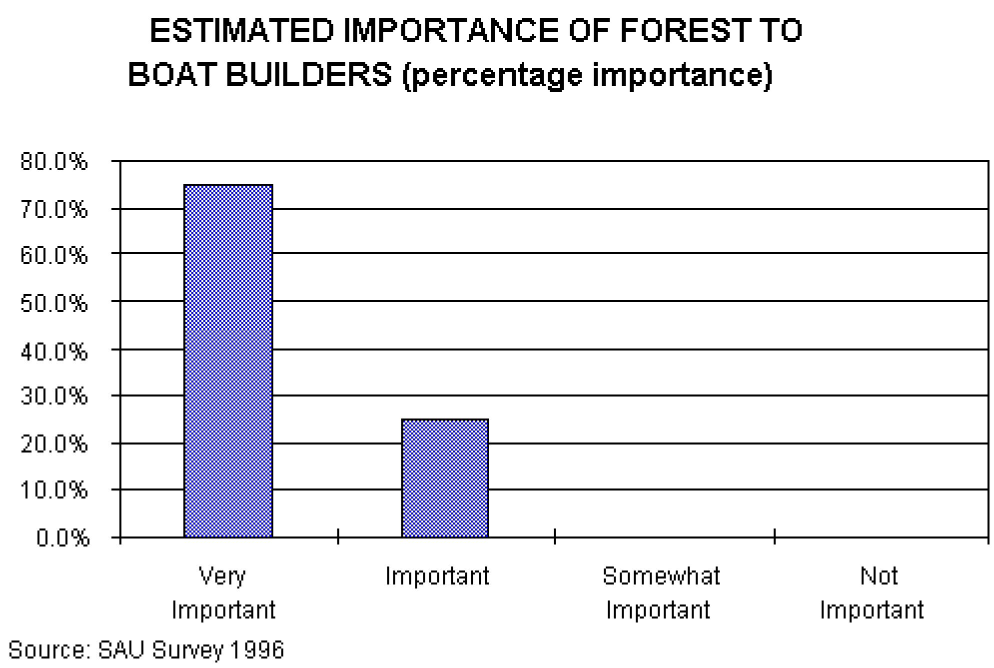
All respondents travelled to work from their home base daily. Distances travelled to work varied from 10 to 50 kilometres. All respondents owned their own homes.

In relation to their business enterprise or activity, three of the boatbuilders employed staff. The number of full time and part time employees ranged from one to six with an average of three. The number of full time and part time family employees ranged from one to two. Additional activities undertaken by some of the boatbuilders included teaching the art of boat building, supply of speciality timber and boat repairs.

In relation to business finance, annual operating costs ranged from $20,000 to above $200,000. Gross business income varied from $25,000 to above $100,000. Amount of business debt and money spent on fixed assets was predominantly under $10,000. Amount of capital invested in the business ranged from less than $100,000 to $1 million.

With regard to use of forested land, boatbuilders used predominantly public native forest areas (42.9%) and public native species plantation (28.6%). Private native forest and private native species plantations were used to a lesser extent. When asked how important the timber industry was to the economy of their local area, three of the respondents believed it to be very important and the remaining one believed it was important. Respondents did not have family members who were employed in the timber industry.

Figure 3.33



On average, respondents had been living at their current address and in the area for a total of 18 years. When asked what they liked most about living in their area a range of factors were identified.

These included the natural environment, the climate, the lifestyle, access to major centres, the waterways and the opportunities that their area could provide. Disadvantages included misguided development strategies, the ingrained attitude of local people and the cold winters experienced.

Respondents participated actively in their local community being involved in between zero and 3 groups. On average respondents participated in one to two community groups.

Tree fern collectors

A total of three tree fern collectors responded to the survey of which two were male and one female. The average age was 39 years. Respondents were either separated or divorced. All of those surveyed had children, whose ages varied from three to eight years. Children attended the local primary or secondary schools in their area.

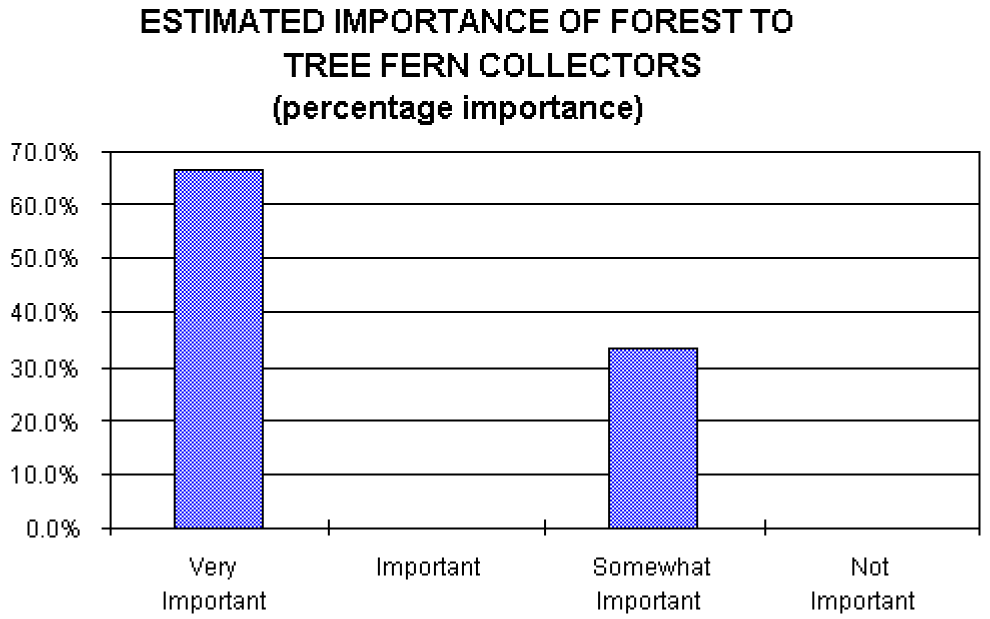
Of those sampled, one had reached Year 10, one Year 12 and one had formal qualifications in the form of a degree of diploma. Two had experience in other work areas. These areas included hospitality and silviculture. All respondents travelled to work from their home base daily. Distances travelled to work varied from 10 kilometres to greater than 100 kilometres.

One respondent owned their own home, one was paying off a mortgage and one was renting. All three were currently paying off some form of loan, with less than 75% of their income being used to pay these costs.

In relation to their business enterprise or activity, only one tree fern collector employed staff. Average annual operating costs varied from less than $20,000 to greater than $200,000. Gross business income from zero to greater than $100,000. Amount of business debt varied considerably between $25,000 to greater than $100,000. In relation to money spent on fixed assets, two collectors spent less than $10,000 while the other spent more than $100,000. Total capital invested also varied from less than $100,000 to $1 million.

With regard to use of forested land, respondents used predominantly private native forest areas, public native forest, private native species plantation and private pine plantations. When asked how important the timber industry was to the economy of their local area, two of the respondents believed it to be very important and the remaining one believed it was important. None of those sampled had family members who were employed in the timber industry.

Figure 3.34



Source: SAU Survey 1996

On average, respondents had been living at their current address and in the area for a total of 5 years; no respondents had family members in the area. When asked what they liked most about living in their area responses included the beauty of the natural environment, open spaces, the community, lifestyle and access to work.

Disadvantages included lack of services, poor roading, limited employment and high cost of living. Respondents participated on average in 2 community groups in their respective areas.

Key issues raised by the above groups

When asked to comment on the forest debate, respondents identified a diverse range of issues. However, there were some common themes shared by craftwood cutters and designers such as the availability of minor species, the present level of timber wastage and the need for resource security.

Availability, and access to, minor species was a priority for these groups.

> "The industry must become veneer driven and thought given to the replanting of minor species."
>
> "To cater for the needs of hundreds of woodcraft workers in Southern Tasmania, we need to have the remaining old growth forests managed on an ecologically sustainable basis...At the moment Forestry Tasmania wants to convert all old growth to eucalypt regrowth within 15 years."
>
> "Old growth forests need to be logged for furniture veneer etc."

A number of respondents were concerned with the wastage of timber resources and favoured value adding.

> "The resources from our forests should be used more efficiently, that is, maximising use of craft and specialty timbers and establish Tasmania as a world leader in design of furniture and craft, rather than 'cashing in' on a finite resource through practices such as woodchipping."
>
> "Stop chipping minor species!!!"
>
> "More use of regrowth forest especially for woodchips. Don't export chips - value add."
>
> "Minor species are being used for chipping instead of milling. Hence not allowing downstreaming of the industry in the form of crafts."

Some of the respondents comments pertained to forest management.

> "I think current forest practices are old fashion, stupid to the point of there being no future. We are left with no forest, no money and no jobs - what has gone on?"
>
> "There will be a forum at the [boat building] festival and a primary focus will be on the terrible management of special species timbers by Forestry Tasmania."

For those working in the specialty and craft timber industry, resource security was a critical issue.

> "Maintain jobs wherever possible. This will translate to security. This will translate to the community's willingness to spend and take risks (that is, mortgages)."

The key impacts for these groups were related to access and the difficulty in obtaining minor species and quality timber. Although most reported that forest policy had had minimal or no impacts on their families to date, the present lack of resource security was viewed by some as a potential threat to the viability of their family businesses. Some respondents also felt that, at a community level, this uncertainty could lead to unemployment and population loss.

In summary, it is evident that a variety of different groups use and value forests. These groups expressed a range of views in relation to their specific business enterprise as well as attitudes on forest use and management. In regard to the qualitative information, themes of resource security, adequate access to resource and employment opportunities were common. Furthermore, many groups were particularly concerned about present forest management practice and called for increased downstream processing, a refocus away from old growth forest to plantation and more efficient use of the current resource.

Municipality Profiles

Nine case study areas, based on local government areas were selected for detailed social assessment. The communities sampled differed in terms of the diversity of their local economies. Communities ranged from those with a high dependence on forestry (percentage of workforce employed in agriculture and forestry and manufacturing) to those with a more diverse economic base.

The case study areas selected for more detailed assessment are outlined below and include information on the socio-demographic structure of community, community infrastructure, historical response to change community vitality and social well-being, community vision/aspirations and community attitudes towards changes in forest use.

Separate reports for each municipality can be obtained from the Public Land Use Commission.

3.8.1 Circular Head Municipality

3.8.2 Meander Valley Municipality

3.8.3 George Town Municipality

3.8.4 Glamorgan-Spring Bay Municipality

3.8.5 Huon Valley Municipality

3.8.6 Northern Midlands Municipality

3.8.7 Derwent Valley Municipality

3.8.8 Dorset Valley Municipality

3.8.9 West Coast Municipality

Profiles of community groups most vulnerable to change

Social equity embraces notions of social justice, fairness and the more equal distribution of income and wealth. In addition, social equity implies equal access to the decision making and political processes for all. Analysing equity or distribution effects has always been a challenge for social impact assessors.

Equity can be conceived as either an intragenerational (short term) or an intergenerational (long term) goal. The latter implies a commitment to future generations. It embodies the idea that future generations should have access to at least the level of resources available to the present generation and should not have to bear the burdens of the present generation (Brundtland, 1987).

Social impact assessments must investigate effects in terms of equity for particular groups of people. A number of different methods can be employed to assess these effects. Qualitatively, the costs and benefits to particular groups can be identified or lists of impacts developed and presented in an equity matrix.

A series of focus group workshops were conducted in townships across each of the nine municipality areas selected for detailed profiling in the Tasmanian social assessment survey. The townships were chosen due to their dependence upon forest related industry, since these communities would be most severely affected by changes in forest based activity. As a result, workshops were conducted in the townships of Geeveston, Triabunna, Smithton and Zeehan. Groups invited to attend a workshop in these townships included young people, the elderly and young mothers. Previous social impact research has shown that structural adjustment is most likely to affect key groups within the community. Therefore, the effects of potential change on these groups must be documented.

The Forest Community Co-ordinator was responsible for liaising with key groups within the community. For example, in reaching young people contacts were made with local schools as well as local youth groups and organisations. A group of youth were selected and invited to attend a focus group session.

3.9.1 Young people

There are a number of issues consistently raised by young people across the townships. One of the most prominent of these is employment. There are few employment opportunities for young people living in the townships sampled and industry development, whether it be in the mining, tourism, forestry or aquaculture sectors, is required to facilitate the establishment of local jobs. Such development would expand and approve local services and enhance the viability of local economies.

Young people were clearly concerned by the lack of entertainment, increased crime and the prevalence of drugs in the community. They felt that there was little to keep them occupied and that they needed continual support and encouragement to see a future for themselves. While tertiary education was a possibility, the costs of traveling to the capital city or the mainland precluded this option for many families. Furthermore, since many of their peers leave school at an early age there was little incentive to remain at school and study.

In relation to the forestry debate, the young people interviewed expressed a desire to see the conflict resolved. Many expressed their concern over the environmental impact of logging, but also felt that the conservation movement had "taken the debate too far" and become too extreme.

It is evident from the information collected that there is little future for young people in the townships surveyed. Many young people, if given the choice, would remain in the areas in which they were brought up, however due to lack of employment in local areas, this is no longer an option. Even in mining communities, where jobs have characteristically been available in the past, the potential for employment, particularly for young women, is limited.

3.9.2 Senior Citizens

The issues arising from the focus groups with senior citizens somewhat varied. Many group participants had experienced considerable changes within their community and believed that things today were somewhat bleaker than in years past. In townships such as Geeveston, forestry had played a significant role in the life of the community. However due to adjustment in the industry the community has experienced a gradual decline in service provision, local business and community vitality. Participants believed that the township required new industry development, but recognised that new population increases would be required to service such developments.

The feelings from group participants in Triabunna were quite different to those participants in Geeveston. Triabunna participants indicated that while forestry had provided stability in the area in the past, the future of the area depended upon new development in industries such as farm forestry, plantations, aquaculture and forest based tourism. There was a strong feeling that future industry development should avoid environmental damage and that as a society we should be reducing our dependence upon our natural resources. Stricter harvesting regulations and the sustainable management of existing forests were seen as necessary. Participants did however express concern about future changes to the industry and employment prospects for young people.

The issues raised in the Zeehan focus group were characteristic of the experience in many mining communities. Although the mining company within the area has been seen to provide many positive benefits to the local township, it is evident that the evolving nature of the community with the mining presence has created tension between company and local residents. In recent times youth unemployment, lack of services and uncertainty are common problems. Also, due to Zeehan's geographic location, residents feel isolated.

As highlighted previously the sentiment common to all three groups was that the nature of the community is changing. Adjustment in mining and/or forest industries has changed their communities. These changes, and the community's reaction and adaptation to such change, had been witnessed by the older population. Some communities feel more able to adapt than others. Similarly, some elderly residents were themselves more inclined to embrace change while others preferred to remember the community as it once was. Changes in forest activity will indirectly affect this particular group more severely than other groups in the community. As reductions in industry occur, precious community services are lost and elderly residents are left most vulnerable.

3.9.3 Women

Two women's focus groups were conducted in the township of Smithton and the issues raised were relatively consistent. Participants highlighted the loss of boat and rail links to the area. However since these closures there had been extensive growth in the dairy industry which had increased local employment and population. Aside from dairying the area is seen to have a relatively high dependence on timber and further

employment is provided by the McCain's food processing plant. It was estimated that 50% of businesses are indirectly related to the timber industry and that further industry development would greatly benefit thecommunity. However it was noted that the environmental movement had been good in achieving better management and monitoring of forest practices and ensuring intergenerational equity.

The Smithton community appears to be strong and proud. It is currently working to enhance the aesthetic quality of the area by planting trees and developing local parks. Smithton has already been awarded the Tidy Towns Award and will be nominating for the Best Improvement Award in the year 2000. However, despite its strong commitment, participants in the focus group lamented their lack of political efficacy, that is, their inability to influence politicians. In one of the groups it also emerged that there was a considerable lack of local leadership with few people employed in a managerial capacity. This situation was exacerbated by young people leaving the area to obtain higher education skills but then not returning to professional positions due to a lack of career opportunities.

Services within the Smithton area seemed adequate and participants often travelled to Burnie for goods and services due to its accessibility. However, entertainment and recreational activities within the area were lacking.

In relation to vision, a number of proposals were put forward. Participants wished to see the development of a new marina to encourage large yachts to visit the area, the reopening of the waterway link between Stanley and Victoria and the development of the fishing industry, especially in regard to abalone and oysters. In addition, growth in the dairying industry was outlined due to export opportunities in Asia, mining of Smithton dolomite and further development of tourism, especially forest based tourist activity. The new road link to the area was seen to be able to provide increased access to tourists and subsidised ferry fares would also encourage visitors. It was acknowledged that the area did not have the infrastructure to encourage the development of this industry and therefore there was much work to be done developing tourist accommodation and other facilities. There was a strong view that the area needed to diversify its economic base in order to survive.

The mine's closure devastated the community and there remained limited opportunities for youth employment. Women were also concerned about health and educational services. For example, schools were having to combine grades to make up class numbers and there was a heavy reliance on the voluntary sector. In relation to health, social support services were limited but obviously needed to address the problems of stress and depression.

Overall, the women who participated in these focus groups appeared to be far more capable, than other groups, of dealing with the challenges facing their communities. They appeared very concerned about the future of the area in relation to opportunities for their children and families, and appeared to have many ideas as to how such change could be managed.

3.9.4 Summary

Analysis of the data collected using the focus group method yields some interesting information. Each group interviewed provided a unique perspective on the impact of changes, and clearly some groups are better able to adapt than others. For many focus group participants further changes to any significant industry within their area would result in hardship, either directly or indirectly. This is especially true for the younger and older people within the communities. A number of other groups may also be adversely affected by change; these include the unemployed, single parents, people with a disability, young children and people of lower socio-economic status.

Summary

The purpose of this report has been to provide a descriptive account of current social conditions in Tasmania and present social values in relation to forest use. Assessment criteria have been developed and assessed at both the regional and local level, where appropriate, to assist in the identification of communities most sensitive to change.

It is evident that in Tasmania few studies have seriously considered the social implications/impacts of changes in policy relating to the management of forest resources. Although some information is available, social effects change considerably over time and therefore a comprehensive review of current social issues in Tasmania was required.

There is a large number of stakeholder groups with a strong interest in the use and management of Tasmania's forests. It is evident that one of the key questions facing governments and stakeholders alike is how best to allocate forest resources for industry, recreation, environment and cultural heritage. Responses to this particular issue depend largely upon perspective. For example, industry groups believe that forests within Tasmania are currently being managed sustainably and that further access to resource should be maintained. Conservationists argue that the current practices fail to adequately protect biodiversity, wilderness and old growth values and believe that further logging of native forest areas threaten existence values and intergenerational equity.

Those people living within forest dependent communities are concerned about employment for themselves and their children and the wider public have a range of views relating to how forests should be used and managed. In relation to the mining sector, concerns have been raised regarding exploration rights on forested lands. The mining industry is concerned about obtaining access to land with mineral potential as previous debates over land use have resulted in a loss of resource. It was outlined that flexibility was required to plan for multiple use forests.

While there is no easy answer to the question posed, it is important that all values relating to forest use are documented and assessed in order for more informed decision making to take place. This section summarises, and identifies the salient themes which have emerged throughout the social assessment process in Tasmania.

3.10.1 Economic Viability and Labour Force Characteristics

The variation in dependence on forest industry across Tasmania has meant that past changes in forest policy and management practices have not been uniformly distributed. It is evident that some communities which have a greater dependence on forests have been continually buffeted by structural adjustment and change within the industry. While some of these communities have demonstrated a capacity to adapt to change through diversification and innovation, other communities have been less able to effectively deal with such change and as a result are currently experiencing a cycle of community decline. Communities with less dependence on the forest and mining industries are the least vulnerable to changes in forest and mining policy. These communities are characterised by a diverse economic base and as such have a greater capacity to accommodate structural change by developing alternative industries or attracting new economic opportunities. Greater diversity has also provided more stability in the economy which in turn has encouraged a more optimistic outlook.

Although the level of forest dependence provides some indication of the social sustainability of particular communities within Tasmania, there are additional factors which impact on local economic viability. For example, in small communities the viability of local business is highly interconnected. Changes in a key industry within a particular region or district may impact directly on other businesses within the area. It is evident, through discussion with business owners/managers, that many business enterprises within Tasmania are highly dependent on particular industry sectors and that any changes in these particular industries would result in a lack of business profitability and thus potential closure.

Social sustainability, however, is not simply tied to the economic fortunes of industry. The extent to which economic benefits flow back to the local community are equally as important as the capacity to attract profitable business. For example, some believe the economic and employment benefits of large companies to local communities can be overplayed. It was frequently outlined by residents that while large companies provide valuable economic activity, profits are often directed off-shore. Furthermore, increased mechanisation has reduced the need for people to participate in the production process. Although the flow of income into a local community is necessary to stimulate growth, a strong local community serves to keep economic activity, and jobs and income, in the local economy.

Relative to other Australian states, Tasmania has a very high level of unemployment. This is particularly pronounced in rural communities, with the exception of the West Coast, which continues to benefit from the presence of the mining sector. Of particular concern is the limited number of employment opportunities for rural youth, who are often forced to relocate in order to seek work. It is evident that once young people leave the area they rarely return and thus valuable skills are lost. However for those that remain, future opportunities are perceived as limited.

Although employees within the forest and mining sectors often lack formal qualifications, in the form of degrees or diplomas, these industries are highly specialised requiring particular work skills, mainly obtained through on the job training. Transferability to other industries is often limited due to employees' lack of formal education and training and experience in other industry areas. Forest and forest product workers are a relatively stable workforce and often live in close proximity to where they are employed. Forestry, in particular, has characteristically been an industry in which many generations of families have worked. Children of timber workers in local mills would often grow up to also work in the industry alongside their fathers. This trend is also apparent in small family logging and transport contracting firms.

In the particular case study areas selected, relatively high proportions of people work in agricultural, forestry and fishing industries. This was especially the case in areas such as Dorset (26.3%) and Circular Head (25.1%). Employment in manufacturing and mining was also high in Georgetown (39%) and the West Coast (29.5%) respectively, and people were largely employed as wage or salary earners rather than being self-employed.

All case study areas showed small proportions of people working in professional and sales occupations. Areas such as Dorset and Circular Head had relatively large numbers employed as managers/administrators, and the Huon Valley, George Town and the West Coast had high percentages of people employed as labourers and tradespersons.

3.10.2 Socio-Demographic Structure

A major concern of Tasmanians has been the high level of migration out of the state, particularly of youth and professionals. This trend is highlighted in a number of case study areas and most noticeably in the West Coast municipality due to restructuring of the mining industry.

People appear attached to their local areas due to high home ownership and the number of dwellings being purchased. However, in case study areas such as the West Coast and George Town, residence in rental accommodation was relatively high.

An examination of the socio-demographic statistics within the case study areas selected for the more detailed social assessment profiling work had relatively low educational qualifications compared to Tasmania. Areas such as the West Coast and Glamorgan/Spring Bay were an exception with relatively high proportions of people possessing formal qualifications in Glamorgan/Spring Bay and people with high level of vocational qualifications working in the mining industry on the West Coast.

Family incomes across case study areas were generally lower than the rest of the state. However once again areas such as the West Coast and George Town, which have a predominance of manufacturing and mining industries and a high proportion of young people, have relatively high median family incomes.

3.10.3 Community Infrastructure

It was evident from a number of different aspects of the assessment that rural communities in Tasmania are experiencing a contraction in the level of service provision due to the centralisation of many key services such as health and education. For example, the lack of education facilities in rural areas beyond Year 10 has presented a barrier to youth wishing to pursue post secondary education.

In many rural communities financial services are limited compared to larger urban centres. Recent removal of bank branches have particularly affected the elderly who find it difficult to adjust to electronic banking. In other townships, electronic banking facilities are not available or have been withdrawn. This has inconvenienced both local businesses and tourists wishing to access financial services after hours.

In relation to health provision, many district hospitals have been converted to aged care accommodation and emergency care facilities reduced. Residents thus have to travel further to access specialist health services. Furthermore, mental health service provision is limited in areas where the incidence of depression and stress are high. Increasing reliance is thus placed on the voluntary sector to fill critical service gaps.

For those communities which are closer to larger centres, the impact of service loss is less extreme. For example, townships which are located on major highway routes benefit from through traffic, enabling them to sustain infrastructure levels. For example, Campbell Town on the Midlands Highway is well positioned to take advantage of traffic flow between the two major urban centres and is relatively close to Launceston. However for more isolated communities, the effect of service loss is more pronounced.

Overall, the general level of community infrastructure and service provision to rural communities is limited and in a state of decline. While there are some communities that have been able to maintain their levels of infrastructure, most communities state they are having to continually defend and justify the need for services to be maintained. Once lost, such services are seldom replaced.

3.10.4 Historical Response to Change

Tasmanian communities have a history steeped in tradition. Many families have been living in their areas for a considerable number of years and as a result the density of networks is high. The traditional nature of communities sometimes makes it more difficult for these communities to respond to change. In some communities such as Deloraine, there has been considerable tension between traditional residents and new residents to the area. Many communities spoke of how things weren't the same as they used to be and how the nature of community was changing.

In many case study areas, there was an increasing identification with particular industries. For example, on the West Coast, there is a history of mining, whereas in areas such as the Huon Valley and the East Coast, forestry has been one of the main industries. Communities to date have largely relied on external sources, such as government, to support existing industry and attract new industry. Many major companies within Tasmania have also played an important role in the growth and development of townships. This is most evident in towns such as Zeehan, Maydena, Triabunna and New Norfolk where housing,

recreational and sporting facilities have been provided by the majoremployers within the district. This has made it more difficult for communities to draw on their own resources and initiative in response to change. Furthermore, a reliance on predominantly natural resource based industries has seen increasing fluctuations in relation to resource availability and market conditions. While many rural communities have the ability and capacity to work together and organise their resources in times of crisis, they are less able to cope with changes of greater magnitude which are often externally imposed.

3.10.5 Community Vitality and Social Well-being

A strong sense of community was evident across the majority of rural communities in Tasmania. Most communities are characterised by lengthy periods of residence and a low desire to relocate. The majority of communities take pride in their local area and have a strong commitment to the region.

Many communities have a high level of participation in voluntary community groups and organisations. These groups provide opportunities for social interaction and contribute to the social well-being of the community at large. As highlighted earlier, voluntary community groups play an essential role in meeting community social and welfare needs.

In terms of political efficacy, Tasmania's rural communities are relatively well served. Communities have easy access to local councilors and State government representatives. In fact, there is a perception by many that Tasmania is overgoverned. Despite this level of governance, many communities do not feel that they have an effective voice in decision making and would like to be more involved in decisions which affect them.

There is a strong perception that the level of crime has increased in many rural communities. This perception is supported by official Australian Bureau of Statistics figures which indicate that there has been an upward trend in the number of offences against property and against the person over the past five years (Tasmanian Year Book, ABS, 1996). Many residents and youth themselves spoke of a greater prevalence of drugs and a rise in suicide rates, particularly amongst young people in rural communities.

Like most Australian towns, the level of home ownership across Tasmania is high. The exception has been in company towns where affordable rental housing has been provided. This has changed in recent years as companies have begun to rationalise their operations and sell housing on the private market. In some communities there remain significant levels of public housing.

Community vitality and social well-being are also affected by changes at a statewide level. The rationalisation of health and educational services and structural adjustments in major industries have applied additional pressures to local communities. However, it was evident that the quality of life afforded by living in a rural area was clearly a major factor referred to by most of the groups sampled. The natural environment, the access to recreational and leisure pursuits and the people of the area were commonly mentioned.

3.10.6 Community Visions and Aspirations

The degree of community vision varies considerably between rural communities throughout Tasmania. A number of factors influence the type and nature of a community's visionary capacity. Those communities with a relatively stable local economy and diverse industry base tend to have well developed visions for the future. This relative security and wealth, enables communities to focus their attention on long term planning rather than having to expend energy defending their infrastructure. In some communities vision is centred around attracting a large new industry base to promote economic growth.

Leadership is an important factor that influences community vision and aspiration. For example, in the Dorset municipality the local council has played a strong stewardship role with a high degree of community input which has resulted in a well developed community vision for the area.

Despite the differences in vision across communities sampled, it was clear that many communities have well developed ideas as to future directions for their district or locality. Many people spoke of further development in the tourism industry as well as other small scale and large scale forestry initiatives. For example in the Huon Valley, the development of a boat building school is providing employment opportunities and training for local youth and is receiving recognition both nationally andinternationally. Other residents in the area are suggesting that new forest management practices be adopted to ensure that other forest users such as apiarist, crafts people, boat builders and users of speciality timbers are able to utilise and access all timber resource within the forest.

3.10.7 Community attitudes towards forest use

There is considerable variation in attitudes towards forest use across Tasmania. Such variation is evident both within and across different communities and occupational groups. Results obtained in focus groups, workshops and surveys suggest that the simplistic divide between industry and environmental groups is under challenge by a push towards more sustainable forest management regimes that benefit regional communities. For some communities, this attitudinal shift has been essential in enabling them to manage structural change within the forestry industry, ie. establishment of plantation based timber production. For other forest users such as apiarists, furniture makers, boat builders and users of craftwood and speciality timbers, this shift has been critical to their economic survival.

It is evident from the community survey that a range of values exist in relation to how forests should be used and managed. Due to the variation in social value systems ascribed to native forests, community attitudes reveal strong support for more consideration of local circumstances in the development of forest policy and a more regionally tailored or catchment based approach to forest management. Two core issues that the community perceived should be addressed in developing management plans included wildlife protection and conservation and the replanting and reforestation of forest areas. The latter issue was of more concern to residents in rural sectors of Tasmania, while the former was of concern to residents located in the major urban centres.

Approximately 55 percent of the Tasmanian population believed the area in which they lived to be very dependent upon the timber industry, 21 percent believed that protecting native forest would immediately threaten their opportunity for employment. Although there were mixed feelings about the management of native forests per se, 64 percent of the population believed that forest industries should have more of a say in how forests are managed. There was also strong support (54 percent) for allowing private forest growers to use and manage their own native forests in any way they see fit. In relation to legislative requirements, 65 percent of people believed that there was a need for better laws to protect the use of native forest. These views were largely represented in the metropolitan areas of the state.

It was apparent that 65 percent of the population had visited native forests within the last year and a third visited forest areas at least once a month.

The areas visited most frequently included areas of forest in close proximity to residential areas. These areas were used to undertake passive recreational activities such as bushwalking, picnics and sightseeing.

A number of respondents (30 percent) were particularly concerned about the human use of a number of specific areas within Tasmania. These included the Cradle Mountain Lake St Clair National Park and a number of localised forest areas. The main issues of concern were the overuse of these areas by visitors in the case of National Parks and the logging of particular forest areas. It was expressed that the latter issue could be addressed through better or selective logging practices.

When asked about impacts of changes in forest industry activity, 22 percent of respondents believed that their communities had been affected and the most significant of these changes was an increase in unemployment. Approximately half of the sample also believed that changes in the industry could potentially affect them in the future.

The occupational groups which were dependent upon forests for a range of goods and services all expressed the relative importance of the industry to the local economy of the areas in which they were operating. These groups included tourist operators who rely on forests for tourist activities. Other groups such as traditional recreational users expressed a desire to have greater access to wilderness areas to pursue recreational activities such as 4 wheel driving, hunting, horse riding and fishing.

When asked about new industry development, tourism was raised as the preferred type of industry development across all regional sectors within Tasmania. However, forestry was also referred to by 38 percent of the population.

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Chapter 4 Forestry

4.1.8 Increasing resource quality and quantity

This report focuses on opportunities to increase the quality and quantity of the plantation and native forest resources. A number of agricultural crops have also been proposed as potential substitutes for some applications for which wood is currently preferred and these will be assessed in a subsequent report on future opportunities for the forest industry sector in Tasmania.

Native forests

This section considers various silvicultural regimes that may increase the productivity of native forests. They fall into three main classes:

- early age spacing, at age 5 to 15;
- young regrowth thinning, at age 25 to 35; and
- old regrowth thinning, at age 45 to 60.

Most of the possible silvicultural techniques require significant research and operational trials before a decision can be made about their commercial viability. However, they each represent silvicultural practices that it is believed will result in increased production of preferred products from native forests.

Thinning for instance retains trees of high potential and removes those of less potential. The retained trees grow more quickly in response to the reduced competition for light, soil moisture and nutrients. The increased growth is seen in increased diameter and, therefore, volume. The higher growth rate of these trees means they reach a commercial size at an earlier age. Thinning does not increase the gross productivity of a forest, but ensures that the most valuable tree are encouraged.

Most of these regimes require economic analysis before a decision can be made about their commercial viability. Such an analysis is often required on a case by case basis, because of the great range in critical variables from site to site. Practices such as thinning are not without risk and an n assessment of commercial viability must include an assessment of the risks that might result. The benefits of thinning depend on careful planning and on careful conduct of the thinning operation to minimise these risks.

Background - research up to 1990

Up until 1990, the most detailed and reliable information about growth response to thinning in Tasmania came from the work of Goodwin (1990).

A cautious approach to operational thinning in native forests was considered to be prudent until more information was available on:

- the magnitude and longevity of the growth response; and
- the potential risks to final crop trees as a result of factors such as thinning damage and branch retention.

CSIRO conducted the Young Eucalypt Project during the late 1980s and the resultant report was published in 1991 (Kerruish and Rawlins 1991). Subsequent reviewers considered growth responses used for project were based on a non representative set of plantation growth data, run through an inappropriate growth model. The data generated are now felt to be inapplicable to the Tasmanian situation.

Thinning and sustainable yield estimates

The sustainable yield estimate in the Forests and Forest Industry Strategy assumes that 78 000 cubic metres per year of eucalypt veneer log and sawlog will become available from thinned regrowth during the period 2030 - 2049, . The underlying assumptions are listed below.

It was assumed that commercial thinning was the only viable option. Based on 'regime 2' described on page 44 of Kerruish and Rawlins (1991), the assumed treatment was to thin at age 25 and to clearfell at age 65.

It was assumed that young regrowth on the best 10 per cent of all E1 & E2 sites would be thinned from 1990 onwards, i.e. 300 hectares per year (equivalent to about 20 000 hectares over a 65 year program or 6 000 hectares for a 20 year program). ('E1 & E2' are classes of land that appear to carry the most productive native forests.

It was assumed that the yields (per hectare) would be 260 tonnes at thinning and 520 tonnes at clearfell, i.e. a mean annual increment of 12 tonnes per hectare per year. This is double the current mean annual increment for all E1 & E2 sites and equals the mean annual increment used in the Young Eucalypt project's regime 2 (as adjusted for differences between Victorian and Tasmanian site indices). Other regimes modeled for the Young Eucalypt Project had higher mean annual increments.

It was assumed that the clearfell yields would consist of sawlog and pulpwood in the ratio 1:1. This compares with 3.8:1 used in the equivalent regime modelled for the Young Eucalypt Project.

It was assumed that thinning would be divided equally between the Derwent and Huon districts.

Summary of knowledge - research from 1990 to 1995

A range of eucalypt trials has been established to monitor growth response to a range of thinning intensities. This has added both breadth and depth to the available data.

A biologically based growth model has been developed using Tasmanian data. The model has been used to predict yields from thinned and unthinned stands, including the increase in sawlog volume or the reduction in rotation length which can be anticipated as a result of thinning.

The model predicts that a stand of *Eucalyptus regnans* thinned at age 25 years will produce an extra 18 per cent of sawlog with an estimated 15 year reduction in rotation length. This compares to:

- a trial in which a stand of *Eucalyptus regnans* thinned at age 25 years has recorded an extra 25 per cent of sawlog at age 50; and
- a trial in which a stand of *Eucalyptus delegatensis* thinned at age 50 years has recorded an extra 12 per cent of sawlog at age 75.

Commercial thinning trials

Ground-based harvesting systems

In the Forests and Forest Industry Strategy it was assumed that 300 hectares per year of suitable sites would be thinned using ground-based equipment. Several combinations of ground-based equipment were subsequently tested in operational trials during the early 1990s.

Single machine operations were effective but had low production rates and were restricted to short snigs. These operations did not break even during the life of the trials.

Multiple machine operations did not reach economically viable production rates Pulpwood not sufficient to cover the costs of the lower daily production and the required increase in skill levels.

In summary, the trials showed:

- variable stand damage, depending on operating conditions;
- significant ground disturbance and root damage to retained trees;
- machines were limited to slopes of less than 25 per cent;
- access was severely limited by previous logging debris;
- irregular stocking in retained stems (due to limited access, as above); and
- operations had to be limited to dry weather .

The lack of success of ground based-trials led to a reassessment of the operational trials and a shift in emphasis to cable systems.

Cable harvesting systems

Ongoing cable thinning operations have been effective in thinning regenerated stands on public forest. About 40 000 tonnes of thinned pulpwood (and some small sawlogs) have been produced from about 250 hectares of young regrowth forest over the past 30 months. Monitoring has shown low crop tree damage (less than 10 per cent) and low soil disturbance (less than one per cent) . In summary the system has proven its capability in terms of:

- terrain;
- weather, although production is sensitive to wind and snow;
- uphill and downhill yarding, although uphill yarding is the most productive regime;
- ground debris; and
- ability to meet preset silvicultural prescriptions and objectives (e.g. stems can be retained at preferred, regular spacings).

Maximum feasible yarding distance has proven to be between 200 and 270 metres. Some road networks limit access (e.g. those built for 1960s ground-based logging with 800 metre snig distances).

Downhill yarding has been shown to be 30 per cent less productive than uphill yarding, because of the need to rig extra lines. Some road networks necessitate downhill yarding.

While cable harvesting is only marginally viable on present prices, its success as a low-impact precision harvesting system is unequalled.

In addition, the system can be used to log steep terrain and also flat terrain unsuitable for ground based equipment, such as blackwood swamps.

Resource estimates for cable thinning

The minimum assessment criteria for commercial cable thinning (based on examination of young regrowth types across the range of density classes) have been found to be:

- forest type E1 or E2 site potential;
- site index greater than 34 (site index is a classification of land based on the predicted mean height in metres of the tallest trees at age 50);
- more than 400 stems per hectare, of which at least 250 stems per hectare (60 per cent) have sawlog potential;
- mean merchantable volume greater than 0.2 cubic metres per tree; and
- estimated volume of thinnings greater than 70 cubic metres per hectare.

Minimum potential sawlog length is 3 metres. All trees down to 10 centimetres diameter at breast height are assessed, but only eucalypts measuring greater than 17 centimetres are counted towards the thinnable pulpwood volume, on the basis of species preference and piece size. Trees measuring less than 10 centimetres are not assessed. The minimum thinned eucalypt volume (70 cubic metres per hectare) contrasts markedly with the average that was assumed in the Forests and Forest Industry Strategy (260 cubic metres per hectare). The average thinning yield for the current cable operation is 130 cubic metres per hectare.

Assessments have focused on a 15 year slice of regenerated forest established throughout the 1960s and early 1970s, and was done on a forest stand basis. About 35 coupes, totalling 3500 hectares, were assessed statewide using more than 2300 plots. This stage of the assessment has been biased towards the areas thought to be most likely to meet the criteria for thinning:

- in the Derwent District - ANM Concession supply zone, 60 per cent of the 1960s area and 30 per cent of the 1970-74 area has been assessed;
- in the Huon District, 50 per cent of the 1960s area and 14 per cent of the 1970-74 area has been assessed; and
- area and volume statements for ANM and Huon have been verified independently.

These assessments indicate 1430 hectares are suitable for commercial thinning and are estimated to contain 150 000 tonnes of pulpwood thinnings:

- 158 hectares in Circular Head, possibly too remote to justify moving the equipment;
- 40 hectares in Bass, 45-year -old regeneration forest;
- 90 hectares in Mersey, 45 -year-old regeneration;

- 300 hectares in Huon, although minimum viable thinning volumes are only achieved if wattle is included with eucalypt;
- 84 hectares in Derwent (other than ANM), plantation; and

  758 hectares in Derwent (ANM), of which 130 hectares has already been thinned.

Of the 3500-hectare area that has been assessed, slightly more than 50 per cent has been discounted. The discounted areas:

- have insufficient volume (or average piece size) for commercial thinning; or
- are currently adequately stocked (i.e. don't require thinning); or
- are understocked.

No allowance has yet been made for road networks that limit access (see 'Cable harvesting systems' above) or for high numbers of dangerous standing dead trees ('stags'). Each of these is a particular problem in the Huon District and may result in an eventual net area suitable for thinning of 1000 hectares.

It is estimated that there are no more than 2000 hectares of young regrowth available on public forest statewide suitable for commercial thinning using the existing cable machine system. Confirmation of this estimate requires further assessments. It assumes that additional areas of 1975-79 regenerated forest will be found to be suitable. The stock is, as yet, too young to assess. Relatively little forest regenerated in the 1980s and 1990s is expected to be suitable, because of reduced sowing rates and a reduction in the proportion of harvested areas with E1 or E2 site potential.

A reasonable expectation is that each 1000 hectares of commercially thinned young regrowth will produce about 1800 cubic metres per year of sawlog at age 65 (instead of about 1500 cubic metres per year at age 85). On this basis, each 1000 hectares of commercially thinned young regrowth will increase the sawlog yield by an estimated 300 cubic metres per year in the long term and will contribute an estimated 1800 cubic metres per year during the period 2030-2049.

Cable thinning is significantly more expensive than ground-based harvesting operations. The average cost of logs 'loaded on truck' in the operational trials to date has been 30 per cent greater than in normal harvesting operations.

Early age spacing

At the time the Forests and Forest Industry Strategy was formulated, it was assumed that non-commercial thinning, or early age spacing, was not viable. Trials in 1991 and 1992 (totalling 42 hectares), using brush cutters and lightweight chainsaws, showed costs of up to $2400 per hectare. In addition there was:

- an increased risk to operators, because of confined working conditions;
- an additional fire risk, with huge quantities of slash and no possibility of understorey burning;
- no commercial interest for the thinning products;
- persistent coppice from cut stumps; and

- potential to degrade the retained trees during felling, , although less than 10 per cent of crop trees recorded obvious damage at the time of thinning.

Early age spacing by injecting unwanted trees with Glyphosate 360 was assessed in a 20 -hectare trial in early 1995. The system allows a relatively cost effective method of non -commercial thinning at an early age in overstocked stands (i.e. more than 3 000 stems per hectare). A subsequent commercial thinning remains possible in suitable stands. Yield projections estimate substantially increased sawlog output. In summary this system:

- is relatively low cost ($400 per hectare, based on the trials);
- lends itself to contractor workforce, easily integrated with other such forest works, e.g. planting, pruning and regeneration surveys;
- results can be monitored easily;
- means stands are relatively accessible for treatment; and
- can be integrated with commercial thinning on coupes where areas of small trees cannot be thinned for a commercial return.

An immediately available resource of some 600 hectares is estimated. Other areas may be suitable, up to a maximum of 4000 hectares. Most of the suitable area is expected to come from 1970s regrowth as sowing rates were reduced from the early 1980s. On this basis, 1980s and 1990s regrowth is not considered likely to contain many suitable areas. About 90 hectares has already been treated.

It is expected that about half the available area will be suitable for commercial thinning following the early age spacing.

For those areas that are suitable for commercial thinning following the early age spacing, a reasonable expectation is that each 1000 hectares of regrowth that received early age spacing will produce about 2800 cubic metres per year of sawlog at age 65 (instead of about 1500 cubic metres per year at age 85). On this basis, each 1000 hectares of early age spaced regrowth will increase the sawlog yield by an estimated 1300 cubic metres per year in the long term and will contribute an estimated 2800 cubic metres per year during the period 2030 - 2049.

Costs of early age spacing vary, depending on the condition of the forest and on topography. Based on the above estimates of growth response, the maximum cost for a commercially viable return from early age spacing is $400 per hectare.

Further opportunities

The two regimes described in the previous sections represent those for which operational trials have indicated a reasonable expectation of commercial viability. Other regimes are under consideration, but have yet to be properly assessed in operational trials. Further research is required , including economic analyses.

An overall requirement is a comprehensive inventory of the regenerated forest. The importance of such an inventory is increased by the need for robust information when planning the areas suited to and available for each or all of the following regimes.

Thinning older regrowth

Some additional resource is potentially available in older regrowth (e.g. 1934 regrowth). The available public forest has been estimated at between 5000 and 6000 hectares, most of which is in the Huon and Derwent districts. The most obvious examples are in Plenty (about 600 hectares), Taranna (about 300 hectares) and Ellendale (about 150 hectares). Access to Taranna and Ellendale for thinning is critical to maintain year-round operation of the cable machine, because of problems in winter with wind and snow at higher elevations. Thinning in these older forests can not be expected to result in the same growth response (and future increase in sawlog productivity) as thinning in younger forests, but will attract higher average prices to Forestry Tasmania. This is because of the proportion of electricity poles, small sawlogs and veneer logs in the thinned volume.

Access to suitable stands is limited by road intensity, ground conditions and weather and by the often scattered distribution. The minimum area of a suitable stand is five hectares, based on the cost of transferring and setting up the operations. More care is needed to prevent damage to retained stems than in younger regrowth, due to the greater length and weight of the thinned stems. One aspect of the greater care required is the need to cut felled stems into shorter lengths in the bush, before hauling them out to the landing. This imposes an extra cost.

Stag felling in younger regrowth

Dead stags are a significant constraint when planning normal thinning, in particular in the 30-year -old regrowth that resulted from the 1966 and 1967 wildfires in the Huon District. Removal of these stags will significantly

increase the area available for normal thinning, but is an expensive and dangerous process.

A 42-hectare trial in 1996 found an average 76 cubic metres of stags per hectare . The estimated average size of stags felled in the trial was about 30 cubic metres. Individual size was variable, ranging up to 120 cubic metres. Labour costs in the trial were about $1 per cubic metre, with total costs estimated to be $3 per cubic metre (or $230 per hectare). The trial highlighted significant concerns about safety . If it is possible to conduct such an operation within acceptable safety risks, then the necessary measures can be expected to result in higher costs than were concluded in the trial.

Modified prescriptions for normal thinning in younger regrowth

The current prescriptions retain 80 per cent of trees with sawlog potential. A lower prescription may be acceptable, with multiple benefits.

The current prescriptions are restricted to higher site quality (i.e. E1, E2 and E+3). A lower prescription may be acceptable, including thinning of *E. sieberii*.

Modified equipment for normal thinning in younger regrowth

An operations analysis by CSIRO of the current thinning operation has led to some suggestions for improved machinery configurations and operating practice. In addition, areas of younger regrowth that are outside the operating limits of the current thinning operation may be suited to a different configuration.

Integrated stand management

Integrated planning at the time of harvest for the first crop can potentially reduce management and operational costs for subsequent silvicultural and harvesting operations. A reduction in these costs will increase the areas that can be thinned commercially. This approach has not yet been developed to an operational level. It is proposed to involve the following:

- planning and constructing road access and landings to facilitate thinning and final crop harvesting as well as to facilitate the initial harvest of the existing native forest;
- planning slash treatment (e.g. windrows) to facilitate orderly access for thinning and final crop harvesting; and
- planning the intensity of sowing (or planting) to ensure sufficient stocking for a viable thinning operation and for good selection of final crop trees.

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Forest resource

4.1.1 General description

Tasmania supports an extensive and varied forest estate. Native forests and plantations cover about 3 666 000 hectares, or 54 per cent of the total land area. A broad classification of the forests, commonly used when assessing forest resources, is shown in Table 4.1. This classification describes the general species group, age and structure of the forest. It does not describe the 'floristic' composition, quality or likely productivity of the forest.

Table 4.1: Forest types in Tasmania

Mature eucalypt forest
Native forests in which the largest trees are predominantly eucalypts and are mature or overmature (nominally 110 years of age or older).

Regrowth eucalypt forest
Native forests in which the largest trees are predominantly eucalypts and in which there is a significant component of immature eucalypt trees (nominally up to 110 years of age), usually regenerated after wildfire or other disturbances, including logging. These forests may contain scattered individuals or stands of ecologically mature trees.

Silvicultural regeneration
A type of regrowth eucalypt forest which has been regenerated after logging using deliberate site preparation and seeding techniques. The year of sowing is documented and the age of the trees may be determined.

Rainforest
Native forest which has no significant eucalypt element present and in which myrtle is either the most significant element or is present among other significant non-eucalypt elements.

Other native forest
Acacia and other native forests with no significant eucalypt or rainforest elements.

Plantation (tree farms)
Forests of either native or exotic species, created by the regular placement of seedlings or seed. In Tasmania plantations are mostly eucalypt (hardwood) or radiata pine (softwood). In nearly all commercial cases planting of seedlings is the preferred establishment method. The term 'tree farm', rather than plantation, is being used to describe this activity by some sectors of the industry.

Non-Forest
Areas of rock, water, grass, scrub and non-forest woody species.
Forest
All the living and non-living components of an area dominated by trees usually having single stem, a potential height exceeding two metres and crown cover density greater than 20 per cent (National Forest Inventory). (However, in this report, some data includes areas that have crown cover densities as low as five per cent).

Forest productivity is generally assessed using 'stereoscopic interpretation' of aerial photographs to classify contiguous areas of forest, based on height and density. This is known as the PI system (from 'photo interpreted'). By relating height to age (which is assessed from supplementary sample plots) it is possible to rank site productivity. For this report, productivity has been ranked into three classes (high, medium and low). Table 4.2 shows the occurrence of these productivity classes in Tasmania, by land tenure, using the forest types defined in Table 4.1. The data in this section is the result of recent analyses.

Table 4.2: Area[(1)] of forest types by tenure and productivity class

Forest type	National parks and reserves	Land managed by Forestry Tasmania	Other public land	Private land	Total
Mature eucalypt	245	380	113	423	1,162
Eucalypt predominantly mature	35	176	18	103	332
Eucalypt pre-dominantly regrowth	37	128	16	172	353
Regrowth eucalypt	59	173	25	199	457
Regeneration eucalypt	1	185	5	2	194
Rainforest	179	194	148	26	548
Other native forest	89	127	41	221	478
Plantation	1	67	<0.5	75	143
Non forest	977	171	511	1469	3,127
Not classified	4	<0.5	2	<0.5	7
Total	**1,627**	**1,601**	**879**	**2,690**	**6,801**

(Source Forestry Tasmania, November 1996)

[(1)] '000s hectares. Does not include Macquarie Island

Product volumes (e.g. sawlog and pulplog) can be estimated for each combination of forest type and productivity class. An explanation of the system for preparing such estimates is presented in the section titled 'Yields' (section 4.1.5). The term 'standing volume' refers to an estimate of the current volume. Naturally, most of the standing volume will be in mature forest classes with large trees. The assumptions required to calculate standing volume are minimal.

On the other hand, estimates of yield require knowledge of growth rates and assume a specific cutting strategy. (See Tables 4.3 and 4.4)

Table 4.3: Current veneer and sawlog volume[(1)]

Forest Type	National parks & reserves	Land managed by Forestry Tasmania	Other public land	Private land	Total
Mature eucalypt	6 615	12 7040	1 160	4 273	24 752
Eucalypt predominantly mature	1 135	4 980	260	2 309	8 684
Eucalypt predominantly regrowth	375	2 987	144	2 764	6 270
Regrowth eucalypt	582	5 745	360	4 415	11 102
Eucalypt regeneration	2	201	1	0	204
Rainforest	832	883	724	328	2 767
Other native forest	679	1 681	385	0	2 745
Plantation	0	0	0	0	0
Non-forest	0	0	0	0	0
Total	**10 220**	**29 181**	**3 034**	**14 089**	**56 524**

(Source Forestry Tasmania, November 1996)

(1) '000s cubic metres

Table 4.4: Current pulpwood volume(1)

Forest type	National parks & reserves	Land managed by Forestry Tasmania	Other public land	Private land	Total
Mature eucalypt	46 260	79 566	15 162	26 257	167 246
Eucalypt predominantly mature	6 751	32 386	2 504	11 494	53 135
Eucalypt predominantly regrowth	3 848	22 695	1 569	17 262	45 375
Regrowth eucalypt	7 624	39 046	3 725	27 154	77 549
Eucalypt regeneration	73	7 048	94	0	7 215
Rainforest	40 892	42 096	35 629	3 979	122 597
Other native forest	9 565	17 592	4 51	3 558	35 235
Plantation	0	0	0	0	0

Non-forest	0	0	0	0	0
Total	**115 013**	**240 429**	**63 202**	**89 706**	**508 351**

(Source Forestry Tasmania, November 1996)

(1) '000s cubic metres

Maps S&E 4.1 and S&E 4.5, which are provided with this report, illustrate the distribution of forest types and estimated current ('standing') volume for sawlogs.

These maps are derived from complex sets of data that have been grouped into broad categories to simplify presentation. The categories represent average yields of timber per hectare for forests of similar tree age, crown cover density, tree size distribution and site productivity..

4.1.2 Availability

It is estimated that just over 30 per cent of Tasmania's total forested area is available for wood production. This includes land on all tenures except that shown as 'National parks and reserves' in Table 4.2.

Not all the potentially available land is harvestable. The land actually available for wood production is determined by environmental, operational and economic constraints. Apart from the obvious constraint related to land tenure (e.g. national parks and reserves) these limiting factors may include inaccessibility of the forest (e.g. too steep), costs of extraction, exclusion under the Forest Practices Code (e.g. stream reserves) or the private owner's preference not to harvest or sell.

Public forest area

Native forests

Forestry Tasmania uses a system called 'couping up' to provisionally define areas available for harvesting (termed 'provisional coupes'). This simultaneously estimates the net area of land available for production. Provisional coupe boundaries are mapped on Forestry Tasmania's geographic information system.

Reasons for areas to be excluded from harvesting (i.e. excluded from provisional coupes) include:

- stream reserves, as defined in the Forest Practices Code (Forestry Commission 1993);
- terrain, e.g. areas that are too steep to be logged with cable harvesting equipment, or too rocky;
- proposed future reserves;
- protected forest;
- inaccessible forest;
- geomorphic hazards, e.g. susceptibility to erosion, landslide or flood;
- high visual sensitivity;
- wildlife corridors;
- recreation; and
- cultural heritage.

Table 4.5 shows the gross area of public native forest.

Table 4.5: Public forest area(1)

Forest type	Deferred forest 2(	Multiple use forest 2	Not registered	Total
Mature eucalypt	33	318	29	380
Eucalypt predominantly mature	10	149	17	176
Eucalypt predominantly regrowth	6	111	11	128
Regrowth eucalypt	7	154	12	173
Regeneration eucalypt	<0.5	185	<0.5	185
Rainforest	18	154	23	194
Other native forest	6	112	9	127
Plantation	<0.5	66	1	67
Non forest	13	145	12	171
Total	**93**	**1,394**	**114**	**1,601**

(Source Forestry Tasmania, November 1996)

(1) '000s hectares.

(2) As classified under the Forestry Act 1920 (Tas.) Not registered means the land has not been classified.

Both multiple use and deferred forests contribute to the estimate of sustainable yield that is the basis of current legislated supply commitments for veneer logs and sawlogs from public forest.

Map S&E 4.3, which accompanies this report, uses three groups to illustrate the relative importance of public forests for commercial wood production. These three groups - 'important', 'less important' and 'not available'- are also used in Table 4.6 and subsequent tables.

Table 4.6: Importance of State forest areas, by forest type(1)

	Important2	Less important2	Not available	Total
Mature eucalypt forest	169	120	71	380
Eucalypt predominantly	102	40	33	176

mature				
Eucalypt predominantly regrowth	72	32	25	128
Regrowth eucalypt	104	39	30	173
Regeneration eucalypt	174	6	5	185
Rainforest	48	104	42	194
Other native forest	44	57	27	127
Plantation	65	2	<0.5	67
Non forest	13	115	43	171
Total	**811**	**515**	**276**	**1,601**

(Source Forestry Tasmania, November 1996)

(1) '000s hectares.

(2) See also Map S&E 4.3 that accompanies this report. Importance is defined as potential contribution to sustainable yields of veneer, sawlogs and pulpwood. 'Less important' areas for commercial wood production include stream reserves, steep terrain, non-forest and inaccessible forest.

Table 4.6 can also be expressed in terms of gross standing volume (based on the total area), as shown in tables 4.7 and 4.8

Table 4.7: Standing volume (veneer logs and sawlogs) in public forests(1)

Forest type	Deferred(2)	Multiple use(2)	Not registered(2)	Total
Mature eucalypt forest	1 738	10 250	716	12 704
Eucalypt predominantly mature	467	4 182	332	4 981
Eucalypt predominantly regrowth	129	2 650	208	2 987
Regrowth eucalypt	163	5 240	342	5 745
Eucalypt regeneration	1	199	0	200
Rainforest	84	696	103	883
Other native forest	92	1 479	111	1 682
Plantation	0	0	0	0
Non-forest	0	0	0	0
Total	**2 674**	**24 696**	**1 812**	**29 182**

(Source Forestry Tasmania, November 1996)

(1) **In '000s cubic metres**

(2) As classified under the Forestry Act 1920 (Tas.) Not registered means the land has not been classified.

Table 4.8: Standing volume (pulpwood) in public forests(1)

Forest type	Deferred(2)	Multiple use(2)	Not registered(2)	Total
Mature eucalypt forest	7 368	67 113	5 085	79 566
Eucalypt predominantly mature	2 048	27 653	2 685	32 386
Eucalypt predominantly regrowth	961	20 027	1 708	22 696
Regrowth eucalypt	1 282	35 387	2 377	39 046
Eucalypt regeneration	20	7 016	12	7 048
Rainforest	3 368	33 729	5 000	42 097
Other native forest	761	15 544	1 288	17 593
Plantation	0	0	0	0
Non forest	0	0	0	0
Total	**15 808**	**206 469**	**18 155**	**240 432**

(Source Forestry Tasmania, November 1996)

(1) **In '000s cubic metres**

(2) As classified under the Forestry Act 1920 (Tas.) Not registered means the land has not been classified.

The information in Table 4.6 can be used as the basis for an estimate of the current veneer log and sawlog resource on public forest, using the same 'importance' groupings. This provides a different illustration of the resource than the estimates of gross volume in Table 4.7. See Table 4.9.

Table 4.9: Standing volume (veneer logs and sawlogs) by importance of areas(1)

Forest type	Important(2)	Less important(2)	Not available(2)	Total
Mature eucalypt forest	7,879	2,710	2,115	12,704
Eucalypt predominantly mature	3,300	863	817	4,980
Eucalypt predominantly	1,965	530	492	2,987

regrowth				
Regrowth eucalypt	3,995	948	802	5,745
Eucalypt regeneration	182	8	11	201
Rainforest	210	484	189	883
Other native forest	665	666	350	1,681
Plantation	0	0	0	0
Non-forest	0	0	0	0
Total	**18,196**	**6,209**	**4,776**	**29,181**

(Source Forestry Tasmania, November 1996)

(1) In '000s of cubic metres

(2) See also Map S&E 4.3 that accompanies this report.

Public plantations Public plantations are mapped at a much higher resolution than native forests. The planted area is readily estimated and it is assumed that all of it will be available for harvest. See Table 4.10.

Table 4.10: Public softwood plantations, including joint ventures, by 10-year age classes(1)

Age class	Area	Age class	Area
Not classified	757	1970-74	8,817
pre 1944	299	1975-79	10,604
1945-49	46	1980-84	8,124
1950-54	46	1985-89	6,663
1955-59	648	1990-94	5,773
1960-64	1,325	1995-99	1,897
1965-69	7,726	**Total**	**52,725**

(1) In hectares (Source Forestry Tasmania, November 1996)

Table 4.11: Public hardwood plantation,including joint ventures, by five-year age classes (1)

Age class	Area
Not classified	151
Pre-1984	2 488
1985-89	2 708

1990-94	7 718
1995-99	1 242
Total	**14 306**

[1] In hectares (Source Forestry Tasmania November 1996)

Private forest area

Native forests

The private forest resource varies from small patches of native forest or plantings to large holdings. Mapping it is no more difficult than mapping public forest. Estimating its availability for wood production, however, is more difficult because the diversity of ownership results in a greater range of management intentions.

Despite the prominence of three private forest owners (i.e. North Forest Products, Boral and Australian Newsprint Mills), the majority of private forest is held by small owners and small companies.

Generally, it is not practical to estimate wood availability from private forests by the couping up system. Instead, net harvestable area is done on a sampling basis. This involves a method of 'discounting' for non-harvestable areas. The major difference between the two methods is that couping up is based on the expected boundaries of harvesting coupes, whereas systematic sampling is based on a regular grid of sample points, e.g. one sample point per 100 hectares.

The discounts represent the effects of different factors that reduce area or yield. Discounts fall into two groups:

- Environmental factors- attributes of the landscape that restrict harvesting. This group includes steep slopes and stream reserves. The statewide weighted average used for the most recent review was 13.4 per cent;
- Owner intent - an estimate of the proportion of the private estate that owners wish to retain. The statewide weighted average used for the most recent review was 40 per cent. It is important to note that this discount only applies to private forest that is neither in industrial ownership nor in a private timber reserve. (Private timber reserves are areas of private land gazetted under the *Forest Practices Act* with the owner's consent, to be managed for forestry purposes.)

The process for determining and applying overall discount levels has been reviewed recently by the Australian National University (Turner 1996) as part of an assessment of inventory methods (see Appendix 4.3 for the executive summary).

The discounting method can only be used to determine the availability of timber on private land at an aggregated statewide level. See Table 4.12**.**

Table 4.12: Current available standing volume of private native forest [1]

Product	No discount	After environmental	After environmental and owners discount

	discount		
Sawlog	14 089	12 201	7 321
Pulpwood	89 706	77 685	46 611

[(1)] In '000s of cubic metres (Source Private Forests Tasmania, November 1996)

Private plantations

Like public plantations, private plantations are assumed to be fully available for wood production, although the specific market intentions of each owner are not known. Table 4.13 shows current private plantation area.

Table 4.13: Area of private plantations[(1)]

	Eucalypt	Softwood	Total
Area	59 271	15 772	75 043

(Source Private Forests Tasmania, November 1996)

[(1)] In hectares

4.1.3 Productivity, products and uses

Productivity

Land suitable for forests can also be suitable for agriculture. Large areas of previously forested land are now used for intensive cropping and grazing enterprises, that in turn support substantial industries.

Forest productivity is determined by a range of environmental factors. The most significant of these are rainfall, temperature, soil condition, geology, slope, aspect and drainage. Productivity generally increases with rainfall.

A common measurement of forest productivity, in terms of wood production, is mean annual increment (MAI), which refers to the quantity of wood produced per hectare per year over the life of the forest, measured in cubic metres. MAI can be expressed in terms of total volume or product volume (e.g. sawlog MAI or pulpwood MAI or total MAI).

MAI varies considerably within Tasmania. Plantations in particular, because of site preparation and genetic selection, tend to display a higher MAI than native forests on similar sites. The average MAI for good hardwood plantations in Tasmania is about 20 cubic metres per hectare per year. The average for high quality native forests is about five cubic metres per hectare per year. The most productive native forests in Tasmania, represented by relatively small areas, have MAIs below that for average plantations (MAI in excess of 15 compared to MAI 20).

MAI is one factor used for investment decisions in intensive forestry. The 'threshold MAI' for commercial viability varies with market conditions. Higher prices and lower costs can decrease the threshold, increasing the area of sites suitable for intensive forestry. Conversely, lower prices or higher costs tend to increase the threshold, limiting the area of suitable sites.

Developments in plantation forestry, such as careful selection of species and improved site preparation, have made less productive sites viable for forestry, in particular, softwood plantation production. Currently, the threshold for sites with plantation potential is an estimated MAI of 15.

Productivity helps determine rotation length (the time from establishment of a forest through to the final harvest), especially for some forestry products. For a clearfall regime, rotation length is the age at which the forest is clearfelled. For a partial felling regime, the rotation length equates to the age of the oldest trees harvested.

Plantations grown for sawlog and veneer log production are generally managed on a 30 to 40 year rotation. Rotations for hardwood are likely to be longer. The size of pruned or unpruned saw and veneer logs affect their market value significantly. It is difficult to achieve the current size requirements at less than 30 years for softwoods and longer for eucalypt plantations.

Shorter rotation lengths (i.e. 15-20 years), are more common for pulpwood plantations. Log size is not as critical, although logs that are too small can lead to unacceptably high harvesting costs. Requirements for wood fibre quality can also influence the choice of rotation length in pulpwood plantations.

Productivity of public forests

Public forests are generally on sites of moderate quality because better land has generally been converted to farmland over 200 years of settlement.

Where public forests are on highly productive areas, they are often isolated or the terrain is more difficult. The relatively high productivity of some public forests is therefore often offset by greater costs for management, harvesting and transport.

Productivity of private forests

The bulk of private native forest is on sites of moderate or poor quality because very little of the best private land is now forested.

Plantation expansion on private land has been restrained by the availability of suitable land and its value for other uses. Less than half (about 40 per cent) of private plantations are located on land classified most suitable according to environmental parameters. A substantial area (over 10 per cent) is on land considered unsuitable for commercially viable plantations. Despite their low productivity, these plantations provide visual buffers and shelter for livestock and crops or fulfil other landcare objectives.

Products and uses

Trees may be processed into a number of products of different value in the marketplace. Veneer logs, for example, generally have a higher value than sawlogs, both have a higher value than pulpwood and all three are worth more than firewood.

Veneer logs usually come from the lower sections of the largest and highest-quality trees. In Tasmania, veneer grade timbers are mostly used in ways that make use of their appearance, such as panelling and furniture. It is rarely used for plywood, a common use of veneer timber elsewhere.

Sawlogs also usually come from the lower sections of the tree, but are darker and less evenly grained or have some other minor defect that renders them unsuitable for veneer. Sawlogs are milled for a wide range of uses, including structural timber, mouldings for internal finishing, decorative panelling and furniture.

Pulpwood is wood with major defects or too small to be milled economically. A significant quantity of pulpwood is used by pulp mills in Tasmania. However, a large proportion of the current harvest is exported for pulp and paper manufacture in Japan and Taiwan.

The quantities of different wood products yielded can vary markedly between forests due to variations both in the composition of the forest and in market requirements.

Product classification

Logs are graded according to the highest end use for which they qualify. For example, eucalypt logs from public forest are graded:

- VQ1 veneer logs (i.e. premium veneer logs from mature forests);
- VQ2 veneer logs (i.e. second grade veneer logs from mature forests);
- VR veneer logs (i.e. veneer logs from regrowth forests);
- Category 1 sawlogs (i.e. premium sawlogs from mature forests);
- Category 3 sawlogs (i.e. premium sawlogs from regrowth forests);
- Category 2 sawlogs (i.e. second grade sawlogs);
- Category 8 sawlogs (i.e. third grade sawlogs); and
- Pulpwood (i.e. logs that do not meet specifications for any of the previously listed products).

Specifications for the first six categories are at Appendix 4.1. The legislated minimum annual sawlog cut from public forest (i.e. 300 000 cubic metres) consists of logs in the first five categories. Other categories (i.e. categories 4, 5 and 6) relate to radiata pine products and special species timbers. There is no Category 7.

Products from public forests

The Forests and Forest Industry Strategy (Forests and Forest Industry Council 1990), together with subsequent legislation, clearly defines the framework within which Forestry Tasmania manages public forests to produce products for the forest industry.

The requirement to meet legislated sawlog targets drives many of the underlying silvicultural and management activities on public forests.

For example, Forestry Tasmania generally manages native forest on a rotation length of 80 to 85 years. Some of the less productive sites are managed on a longer rotation length and some of the more productive sites are managed on a shorter rotation length.

These rotation lengths are estimates of the age at which sawlogs of sufficient size and quality will be achieved. The rate at which trees grow decreases as they mature. This dictates a trade-off between the minimum size specified for each product, the maximum value per cubic metre for some products and the reduced growth and increased internal decay associated with ageing. Rotation length may be varied for each coupe, depending on productivity and market conditions.

Products from private forests

Private forest owners are under no legal obligation to provide timber, so the use of private forest has largely been determined by market demand and individual preference. Consequently, much of the original private forest has either been converted to other uses or cut over regularly to meet local demand for sawn timber.

Currently, the standing volume per hectare of private native forest is generally lower than that of public native forest, and is skewed more towards pulpwood. Nevertheless, there is still a high demand for sawlog from private forests.

Although businesses obtain logs from both public and private forests, product size and quality specifications from private forests are less well defined. As a result it cannot be assumed that the resources are directly comparable from the quality perspective.

Many private eucalypt plantations are focused towards producing pulpwood on short rotations. There are some private owners who have a strategy of longer rotations resulting in other products.

Log quality

From the preceding discussion it should be apparent that the production of high quality logs is an important consideration in planning forest operations and sales.

Even in the best quality forest, the ratio of veneer to sawlog to pulpwood is seldom better than 1:10:10 (i.e. for one cubic metre of veneer logs produced, 10 cubic metres each of sawlog and pulpwood are also produced). For poorer quality forests, this ratio may be 1:100:2000. The low proportion of veneer logs and sawlogs in poor quality forests can be a consequence of inappropriate management in the past or of adverse site and environmental factors.

Given the relative scarcity of veneer logs, even in the best forest types, it is apparent that continuing veneer log production is highly dependent on certain types of forest.

In addition, veneer and sawlog proportions tend to be lower, relative to pulpwood, in currently mature forests than in regrowth forests. This is because significant areas of mature forests were 'picked over' by sawmillers during the 100 years preceding the late 1960s, and the best quality trees were taken. In the absence of pulpwood markets, it was often commercially impossible to implement silvicultural options that would have maintained the quality of the forests. As a result, poor quality trees often remained after logging and have continued to hinder the development of new sawlog crops.

Log quality in dry forests that have been degraded by this form of partial logging can be improved by harvesting the previously retained pulpwood trees. This is only viable if there are markets for the pulpwood. Trees with a high potential for producing veneer logs and sawlogs continue to be retained as growing stock.

Plantation silviculture allows the manipulation of stands (e.g. by fertilising, thinning and pruning). This can greatly increase the proportion of higher quality products (e.g. veneer and sawlogs) in the final crop. Thinning operations generally produce a high proportion of pulpwood because the trees that are removed (the 'thinnings') are generally too small for milling. Thinning is also an option in native forests, to encourage growth on the highest quality trees.

However, plantation establishment and management is substantially more expensive than native forest management. For this reason the commercial returns on plantation investment are critically dependent on the productivity of the site, the timing of operations and the availability of markets.

There are always some trees left at the end of harvesting. These trees, called residual roundwood, are too small or too twisted to be retrieved and then secured on a truck, or are full of rot, or have charcoal on them and therefore cannot be used for paper production.

4.1.4 Forest management and silviculture

The potential quantity and quality of products from a site can be manipulated by silvicultural management. In native forest this includes

- burning residues to prepare a seed bed for regeneration and to reduce competition; and
- thinning, (i.e. removing less desirable trees), which accelerates and improves growth by concentrating the resources of the site on trees of desired quality and vigour.

Plantations are usually managed more intensively than native forest, particularly if the aim is to produce high quality veneer logs or sawlogs. Activities such as thinning, pruning, fertilising and scrub control are common.

The commercial returns from silvicultural activity are largely dictated by site productivity. As a general rule expenditure on silvicultural treatments will give a better commercial return on the most productive sites. This conclusion is somewhat dependent on the degree of competition for a given piece of land by alternative uses.

Native forest silviculture

In broad terms, silviculture of native forests in Tasmania can be split into two groups. The first is practised in wet forests, which are generally managed by clearfalling. The second is applied in dry forests, which are generally managed by partial cutting.

Clearfalling describes a harvesting strategy based on complete removal of the mature standing forest, followed by its regeneration to native forest or establishment to plantation. This regime is appropriate for wetter forests, where a high level of disturbance is essential to promote the satisfactory establishment of a new forest.

Clearfalling regimes may include thinning of the new forest to remove suppressed trees and promote growth on dominant stems.

Partial cutting describes silviculture that is based on the retention and husbanding of a proportion of the existing trees. Partial cutting regimes cover a broad range of variations and are generally more suited to the drier, colder or less productive forests, in which a high level of disturbance is not required to promote satisfactory regeneration.

The detail of these silvicultural practices are outlined in various Forestry Tasmania manuals and technical bulletins that prescribe silvicultural practices. Given common species and underlying economic and environmental factors, the silvicultural practices employed on private native forest are generally fairly similar to those for public forest.

Public plantation silviculture

The long experience with plantation silviculture on public forest, particularly for softwood plantations, is reflected in the *Plantation Handbook* (Forestry Commission, Tasmania 1990). Although silviculture is a practice that is constantly evolving in response to new developments in research, this publication provides an excellent reference point for current knowledge of plantation silviculture.

For softwood plantations, current management revolves around three principal regimes, 'clearwood', 'knot control' and 'unthinned'.

A clearwood regime results in the production of clear (knot free) logs for high quality veneer or sawn timber. This usually represents about 30 per cent of the total harvest volume. Clearwood stands are established on the most productive sites.

A knot control regime produces unpruned sawlogs with small to moderate sized knots. Knot control is generally used for stands on sites that are not suitable for clearwood but can be thinned commercially. The regime features a single commercial thinning, carefully timed to reduce knot size and to avoid windthrow.

Unthinned stands are those that cannot be thinned because of slope or other site factors.

The management emphasis for public eucalypt plantations is to produce veneer logs and sawlogs. Research on the topic has occurred over the last five years and is summarised in the final project report to the Forests and Forest Industry Council, titled 'Thinning and Pruning Eucalypt Plantations for Sawlog Production in Tasmania' (Gerrand et al. 1995).

Private plantation silviculture

Management of private softwood plantations, particularly the larger holdings, has a similar focus to public plantations, that is, there is an emphasis on pruned logs (veneer logs and sawlogs) and on rotation lengths of up to 30 years.

The major emphasis for private eucalypt plantations is the production of pulpwood over short rotation lengths (15-20 years). After the establishment phase silvicultural management of these plantations is reduced (relative to those grown for veneer log and sawlog production).

Some private plantation owners and investors, however, are producing veneer logs and sawlogs. Currently, it is estimated that these owners account for about 15 per cent of non-industrial eucalypt plantations. Their silvicultural procedures are likely to follow those for similar quality logs from public forests.

Management regulations

Although there is a range of management activities across the State, depending on ownership and site factors, all must comply with the requirements of the *Forest Practices Act 1985 (Tas)*.

The Act was passed in 1985 '*to ensure forest operations are conducted in an environmentally acceptable manner on crown and private forest lands'* (Forest Practices Code, 1993).

The practical implementation of the Act is through the Forest Practices Board, the designated forest practices officers and the Forest Practices Code (the code).

The code is a statement of actions and guidelines that provides a set of standards for environmentally sound forest operations. A major mechanism for defining acceptable operations is the requirement under the Act to prepare a timber harvesting for each harvesting operation. The plan must be approved by a forest practices officer before the harvesting operation can commence. The officer checks the plan to ensure compliance with the code and, when necessary, seeks the advice of relevant specialists. Conduct of the harvesting operation is monitored to ensure compliance with the plan and the code.

4.1.5 Yields

Inventory and planning processes for Tasmania's public forests have been a major ongoing activity since the late 1940s.

Two types of yield data are generally produced:

- current or standing volume, being a calculation of the existing timber volumes, with little or no growth assumed; and
- projected yield, being an estimate of wood availability over a substantial period and requiring an estimate of growth on the standing forest.

Yield projection may also be used to estimate wood availability in future regenerated forests.

Public forests - principles of yield calculation

The yield from a forest can be defined in a number of ways. As an example, Section 8(1)d of the *Forestry Act* states that:

The corporation has the following functions -

- to use multiple use forest land for wood production and, in a manner that is consistent with sustainable forest management and forest produce production policy, for other purposes including -
- the conservation of flora and fauna; and
- the conservation of landforms; and
- the conservation of cultural heritage; and
- the care of the environment including scenery; and
- recreation

The requirement to undertake wood production is further qualified under Section 22AA of the Act which states:

(1) Each year, from multiple use forest land, the corporation must make available for the veneer and sawmilling industries a minimum aggregate quantity of eucalypt veneer logs and eucalypt sawlog, that meet the prescribed specifications.

(2) In subsection (1), 'minimum aggregate quantity' means -

(a) 300 000 cubic metres; or
(b) if another quantity is prescribed - the prescribed quantity.

The quantity is set on the basis of the estimated 'sustainable yield' that was calculated as part of the Forests and Forest Industry Strategy in 1990. The estimate was based on the concept of a permanent, non-declining level of production for veneer logs and sawlogs. It used certain assumptions about the existing forest, growth rates and markets.

Sustainable yield represents a long-term estimate of the productive capacity of the forest. Annual harvest may vary around the estimate due to fluctuations in markets, seasonal conditions and other factors. However, the long-term average harvest is expected to meet sustainable yield figures. A practical derivative of the estimate of sustainable yield is the allowable cut, which is the maximum quantity that can be offered for sale each year (Davis and Johnson, 1987).

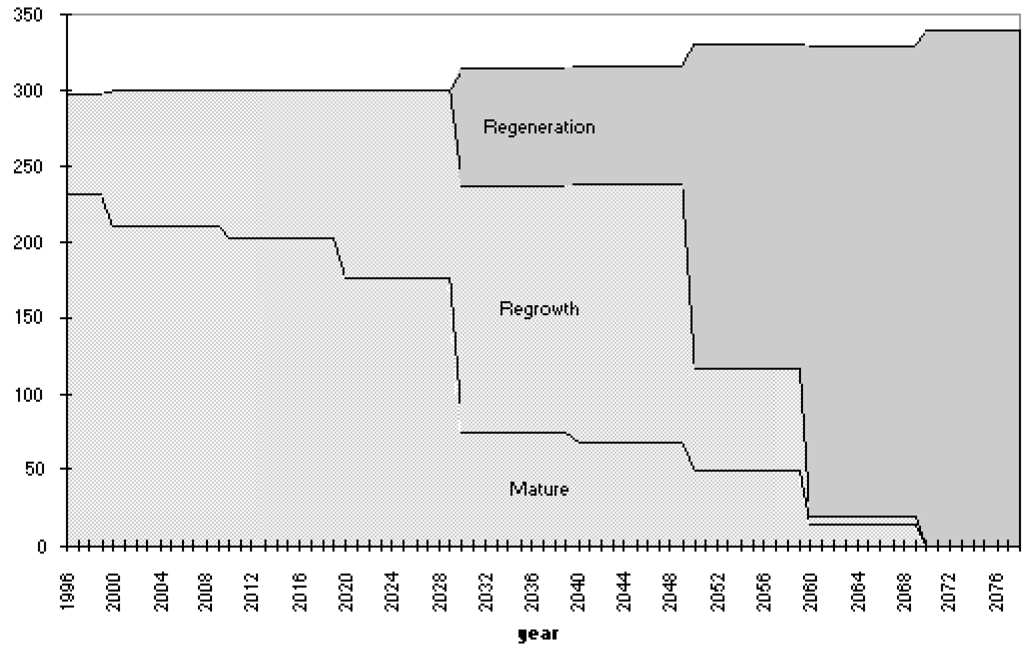
Sustainable yield is conceptually linked to the notion that the forest to which it relates is permanently available. This concept applies reasonably well to public forest. However, it is less applicable to private forest.

In the latter situation, the concept of continuing yield is used. Continuing yield uses an estimate of the level at which supply of a product can be maintained for an extended time (but not permanently).

The 1990 estimate of the sustainable yield of eucalypt veneer logs and sawlogs from public forests is displayed graphically in Figure 4.1. The estimate is currently under review as part of the comprehensive regional assessment.

Figure 4.1

Estimated sustainable sawlog yield from public native forests[(1)]



Source Forest and Forest Industry Strategy 1990

(1) By broad forest type

Pulpwood is managed as an 'arising' from the production of sawlogs and veneer logs. It is, therefore, not the primary focus of modelling that aims to estimate sustainable yields. As discussed in Section 4.1.3, the annual production of pulpwood can vary significantly, depending on the quality of the forest being logged for veneer logs and sawlogs and on market conditions.

In the long term, pulpwood availability could move up or down, or remain stable, depending on the strategy used to meet the production targets for veneer logs and sawlogs.

Strategies for the production of timber are put into operation through the three-year wood production plan. The production plan is a public document which details wood availability for the following three years. It is updated annually.

In the plan, wood availability for each product is specified for each individual harvesting unit (i.e. 'coupe'). The plan also details roading requirements, harvest method and special considerations relating to forest practices. Where products are subject to export licences, the plan is subject to review by the relevant Commonwealth government departments.

Public forests - yield calculation methods

Yield calculation is a complex process that involves several stages. In summary, yield is derived using net harvestable area, age, and predicted volume at that age. This naturally involves a strategy that determines the age at which it is expected each area of forest will be harvested. Forestry Tasmania uses the following inputs for the calculation.

Area

Photo interpretation of the forest, as discussed at the beginning of the chapter, is used to describe a number of attributes for each patch of forest that is greater than two hectares in area. Computerised mapping makes it possible to measure each forest type accurately.

An area database, which can be created on a computerised geographic information system, is a major input for yield calculation. Maps of photo interpreted forest stands and of provisional coupes are overlaid with other 'layers' of digital information. These other 'layers' include tenure, slopes and supply zones. The composite provides a necessarily complex database describing the forest and its attributes.

Age structure

The basic structure is described in Table 4.1.

Height

Height classes are estimated from aerial photographs. There are a number of height classes covering the mature, regrowth and regeneration forest (e.g. 0-15m, 15-22m, 22-34m, 34-41m, 41-55m, and 55m or more).

Density

Forest density is mapped by using the proportion of the area covered by tree crowns in each age class. There are a number of density classes that vary according to whether the forest is mature, regrowth or regeneration.

Plots

A series of temporary and permanent plots has been established across the State over a long period. The plots are located within separate regions (stratified) at the rate of one plot for every 250 hectares of forest. Trees within the plots are measured to estimate the quantity of different products. Those in the temporary plots are usually measured once. Those in the permanent plots are measured every 10 years, using a set of standards developed jointly by Forestry Tasmania and industry. Volume calculations are made using the height and diameter measurements. Volumes can vary significantly, ranging from 1000 cubic metres per hectare in some areas of wet forest to as little as 50 cubic metres per hectare in the dry forests of the east coast.

Growth

Forestry Tasmania has a growth model for both even and uneven aged stands. The model has been developed using data collected over several decades from Forestry Tasmania's permanent plots.

Data from each inventory plot are 'grown on' individually, using the growth model. The estimated future volumes for all plots in similar forest classes are then combined in the same way as for standing volumes estimates, to produce estimates of future volumes for each forest class. Average growth rates range from five to nine cubic metres per hectare per year on good sites in wet forests, to less than one cubic metre per hectare per year in dry forests.

Calibration

Estimated volumes often differ from the harvested volumes because of a number of factors that include, in particular, internal defects in the log that cannot be seen until the tree is felled. Variations in market demand also lead to differences between estimated and actual volumes. The effect of these differences is incorporated in subsequent resource estimates by comparing known production from past harvesting with estimated volumes for the same areas.

Management systems

Area and inventory data are combined in a system called the 'Forest Inventory Projection System'. The system produces data that are used as inputs into Forestry Tasmania's 'Woodshed' modelling package.

Woodshed uses a linear programming module to model the area and inventory data. Woodshed can be set to analyse different strategies for managing and harvesting the forests. Objectives can be set that apply to a range of variables, including area, age and product volume. This enables a wide range of management strategies to be assessed relatively quickly. Many types of constraints can also be set.

Woodshed can model the effect of coupe dispersal on yield and, for chosen strategies, can provide outputs that consist of lists of coupes suitable for inclusion in tactical or operational plans. The latter enhancement is possible because the data used are based on provisional coupes. Coupe dispersal is the requirement, under the Forest Practices Code, for harvesting areas to be separated from one another by other areas of forest that will not be harvested for, say, fifteen years.

Public plantations - yield calculation methods

The systems used to calculate yield from plantation are similar in concept to those used for native forests.

Relevant attributes that characterise each plantation area are recorded in Forestry Tasmania's 'Plantation Area System'. These include the treatment history (e.g. thinning and pruning). Measurement data are collected through another system, the 'Plantation Inventory System'.

The data from the two systems are combined and processed through a third system, the 'Plantation Integrated Management System', which is used to compile three-year plans and Woodshed analyses of strategic and tactical options. The system currently only contains softwood growth models but will be modified to accept eucalypt data and models when these become available.

Private forests - principles of yield calculation

Estimating the potential long-term private forest resource is necessarily different from the same exercise with public forests. The diversity of ownership, the reduced ability to predict the management intentions of individual owners and differences in the characteristics of the private forest, together with the range of alternative uses for private land, require a different approach to yield calculation.

The Private Forestry Council's 1989 report, 'Review of the Private Forest Resource as at 1988', presented a series of long-term pulpwood strategies. These were based on stable or increasing total volume, but with the source changing over time from native forests to plantations. These strategies were based on the assumption that a significant proportion of the existing native forest could be converted to plantations and that some would be converted for other agricultural uses.

This concept was carried into the Forests and Forest Industry Strategy (Forests and Forest Industry Council 1990, refer to Principle 3, on page 55). The current strategic review of the private forest resource is to be based on modified versions of this strategy, together with a revision of the private forest inventory.

It is assumed that a significant number of owners will not harvest their native forests, or will not convert them to plantations or other uses. Appropriate discounts to take account of this can be applied when modelling alternative strategies for private forests.

A regular (i.e. five-yearly) review of a strategy for private forests is an important part of the process. This is because a review allows for changes in market conditions, product prices and landowner intent to be factored into predictions about wood availability.

Private forests - yield calculation methods

The calculation of yield for the private forest resource is based on similar principles and processes to those for public forests. However, the level of detail that can be presented is significantly different in certain areas because of the commercial sensitivity of such information when it applies to individual landowners with relatively small holdings.

Area

The process for recording area data for private native forests is generally the same as for public forests. It uses the same forest class system.

However, there is a greater diversity in the source of information than for public forests. As an example, the large individual companies maintain their own records for their portion of the resource. Dr Brian Turner has conducted an 'audit' of the systems used for private forests and for public forests (see Section 4.1.6 later).

Volume

The diverse ownership of private forests has precluded the development of the large, continuous strategic inventories that underpin the management of public forests. Partly for this reason, Private Forests Tasmania was established in 1994 as a small government authority to provide, among other things, a regular update of the private forest resource for private forest owners.

However, the high level of forestry activity in private forests means that there is considerable knowledge of the volume of output of different forest classes on private land. This knowledge is principally available for private forest in industrial ownership, but can be extrapolated to similar forest classes on other private forest.

Due to the differences in the harvesting and fire histories between private and public land (in particular, that private forests have generally been more heavily cut over and / or more frequently burnt), data from public forests are not broadly transferable to private lands.

Management systems

The recent Private Forest Resource Review was undertaken by Forestry Tasmania under contract to Private Forests Tasmania. The industrial private forests owners maintain management systems with mapping and modelling capabilities similar to those used by Forestry Tasmania. For the review, Forestry Tasmania received 'pre modelled' data as an input from

the industrial owners, but the bulk of the area was modelled using Forestry Tasmania's standard systems (e.g. Woodshed).

4.1.6 Research and development

A number of agencies are involved in research and development for forest resources in Tasmania. Current research is focused on:

- establishment and subsequent silvicultural techniques for plantations;
- nursery techniques for plantations;
- genetic improvement for plantations;
- silvicultural techniques for extensively managed native forests;
- sustainability indicators for extensively managed native forests;
- silvicultural techniques (e.g. thinning) for intensively managed native forest;
- inventory techniques and yield modelling;
- protection against insect, vertebrate and fungal pests.

In particular, reviews have recently been concluded into the inventory techniques and yield modelling that are to be applied in the current reviews of native forest resource estimates for public and private forest. The reviews were conducted by Australian National University (Turner et al, 1996, Turner 1996). An extract of each review report is attached, consisting of the relevant executive summaries (see Appendix 4.2 and Appendix 4.3).

In addition, the research programs conducted by the Cooperative Research Centre into Temperate Hardwood Forestry, the Tasmanian Forest Research Council and Forestry Tasmania are reviewed regularly. Research results are published in various forms for use by relevant practitioners.

4.1.9 Plantations

Tasmania's plantation estate has expanded by more than 5000 hectares per year during the 1990s. This section of the report outlines the considerable potential for further expansion on both private and public land. It documents contemporary research, the main objectives of which are:

- to investigate the nature and extent of land capable of growing plantations on both public and private lands;
- to improve productivity and to reduce production costs;
- to control the risk of damage or loss from insect and vertebrate pests; and
- to assess the likely social and economic effects of strategic options for the nature and extent of plantations.

A considerable amount of work has already gone into the first three of these objectives and is documented below.

Plantation capability is based on physical and climatic criteria. Key issues include potential growth rates, and soil and site limitations.

Research into productivity has focused on tree breeding, wood quality assessment and vegetative propagation. Research into cost reduction has focused on maximising early survival of seedlings and on growth (including fertiliser and weed control regimes). Research on risk management has focused on specific leaf-eating insects and on vertebrate browsing control.

The last research objective (i.e. likely social and economic effects) will be an important focus during the assessment of options that is to precede the regional forest agreement. Key issues include financial evaluation, market opportunities and possible conflict with other land management objectives (e.g. agriculture or conservation).

Table 4.22: Outline of the main stages of work for the project on potential plantation areas

Phase	Stage	Outline of work
Data collection	1	Data collection - develop spatial (GIS) databases of relevant climatic and physical information for assessing plantation capability and suitability e.g. calculate high resolution slope database
Site selection (capability)	2	Simple rules based approach, using climatic data and simplified geology information
	2a	Where Mature Height Potential information exists - (most private and public forested land) use this to assist rule based system
	2b	Where Mature Height Potential information DOES NOT exist, use a simple climatic rules based approach
	3a	Prepare a physiologically based growth model for *E.*

		globulus and test it on a sample 1 : 25 000 mapsheet
	3b	Run physiologically based growth model for whole of Tasmania
	4	Validation and quantifying productivity
	4a	Compare actual plot data points against empirical projection models
	4b	Compare regions where soils are mapped for plantation suitability
Social & economic evaluation (site suitability)	5	Risk analysis
	6	Financial analysis
	7	Evaluation of regimes

Outlines the methods used to determine areas suitable for plantations. The project can be considered as having three main phases comprising seven stages. At the time of preparation of this report, Stage 1 (data collection) has been completed and work is progressing on stages 2 and 3. Stages 4 through to 7 will be done during the integration phase of the agreement process. A report on stages 2, 3 and 4 will be prepared at the completion of the integration phase.

(The human face of the forest industry)

Species

Tasmania has a temperate climate and soils suited to a number of commercial timber species. Neilsen (1990) presents 13 species and sets out their characteristics considering growth rate, wood quality and suitability to the site.

The major eucalypt species considered suitable for pulp and high quality timber production from plantations in Tasmania are *Eucalyptus nitens* and *E. globulus* (Tibbits 1986; Gerrand et al. 1995).

Pinus radiata is also extensively planted and forms the basis for important industries based on either solid wood or fibre.

Niche market species include blackwood *(Acacia melanoxylon)* and black walnut *(Juglans nigra).* These have not been extensively planted and are not covered in detail in this report.

The following subset of the best performing species was chosen for this study, to cover the majority of potential plantation areas.

Pinus radiata is the most widely planted softwood species in Tasmania. Its characteristics include:

- fast growth;
- suited to wide range of products sawlogs, pulp and veneer;
- flexible silviculture; and
- very few major problems (Sirex wasp and diseases are relatively minor).

E. nitens is the most promising eucalypt species for hardwood plantations in Tasmania. Its characteristics include:

- good growth rates on a wide variety of sites;
- reasonable frost tolerance;
- good wood quality for pulp, sawn timber and veneer;
- generally good form and stem straightness even at an early age;
- less susceptible to insect attack;
- persistent branches causing knots in wood are a problem for high quality solid timber; and
- The risk of decay needs further research.

E. globulus also has good potential:

- good growth on non-frosty sites (nominally less than 400m);
- high pulp yield
- excellent fibre properties for paper making;
- less susceptible to insect attack; and
- Dense wood, resulting in difficult seasoning and moderate solid wood quality.

E. regnans has high timber quality (Haslett 1988). However, it has been found to be inferior to the above species when grown in plantations in Tasmania because it displays:

- poor growth;
- Extremely poor form. *E. regnans* has a far higher proportion of multiple stemmed trees than *E. nitens;* and
- Susceptibility to regular severe insect attack (Elliott et al. 1990).

The last of these characteristics of *E. regnans* may be able to be controlled, but it requires regular monitoring and the use of broad spectrum insecticides at considerable cost.

Acacia melanoxylon (Blackwood) has the following characteristics:

- very high quality appearance products for sawlogs and veneer;
- good pulping properties;
- slow to moderate growth;
- wide genetic variation - poorly known; and
- Susceptibility to browsing.

Potential growth rates

Growth rates for *P. radiata* plantations are reasonably well known, having been built up over many years and covering the significant areas that have been planted. Productivity varies across regimes and sites, with a range from 5 to 40 cubic metres per hectare per year. However, the average in Tasmania is about 16 cubic metres per hectare per year. The average is reduced by a significant area of sites with relatively low productivity. Future commercial plantations can be expected to have growth rates of at least 20 cubic metres per hectare per year.

There is very little long term information on the growth of eucalypt plantations over a full rotation length, because most eucalypt plantations in Tasmania are less than 20 years old. It is particularly true of the longer rotations needed for sawlog plantations. Goodwin and Candy (1986) present growth data based on stem analysis of a 42 year old stand of *E. globulus* in northern Tasmania, with a peak mean annual increment of just over 30 cubic metres per hectare per year at age 20 years. Beadle and Inions (1990) note the spectacular growth rates of eucalypts grown in tropical areas outside Australia, in a review of the productivity of eucalypt plantations. They conclude that growth rates within Australia are still quite favorable when compared to other temperate regions. They present Australian results, demonstrating that growth rates of up to 30 cubic metres per hectare per year are achievable for short rotation lengths.

Very few results are presented in the literature for long rotation sawlog regimes. Haslett (1988) reports that eucalypt plantations in New Zealand will produce 340 cubic metres of sawlogs per hectare at age 40. This equates to a mean annual sawlog increment of 8.5 cubic metres per hectare per year. Results presented in Gerrand et al. (1993) are more conservative, with mean annual sawlog increments ranging from three to seven cubic metres per hectare per year, depending on site quality.

Fifteen cubic metres per hectare per year has been nominated as a lower limit for commercially viable plantations in Tasmania (Neilsen 1992; Gerrand et al. 1993). There has been considerable attention to site selection criteria in Tasmania (Laffan 1991; Laffan 1993) and, if current site selection criteria and establishment guidelines are followed, then the majority of future plantations will have a productivity of at least 15 cubic metres per hectare per year (Gerrand et al. 1993).

A considerable amount of work has also been done within industry to characterise productivity in terms of basic density and fibre yield. These attributes are particularly important in assessing the commercial viability of plantations grown for pulpwood.

Definitions

Land

The term 'land' is used in the general sense. It includes not only the soil, but the other physical attributes of the site such as the topography, climate and the existing vegetation.

Land capability

Land capability is the assessment of land for a range of broadly defined uses such as cropping, grazing or forestry. Land capability assessment aims to classify land according to its biophysical limitations. It is used to develop recommended land uses compatible with the long term sustainable use of the land (i.e. within its biophysical limitations) (Noble 1992a).

Land capability assessment does not include consideration of the social or economic evaluations of the various uses (these are considered in land suitability, defined below). Two pieces of land may have the same capability class, for instance cropping, but may have a different suitability for potatoes than for poppies.

In this study, the initial work has concentrated on developing general capability for plantations of the three major species considered for commercial plantations in Tasmania (i.e. *Eucalyptus globulus*, *E. nitens* and *Pinus radiata*). Further work will consider productivity estimates based on a growth model specifically for *E. globulus*.

The Tasmanian Department of Primary Industry and Fisheries has mapped land capability for private land in several mapsheets in northern Tasmania (Noble 1992a; Noble 1992b; Noble 1993). A classification system has been developed specifically for Tasmania, comprising seven land capability classes. It is based on the capability of the land to support a range of agricultural uses on a long term sustainable basis.

The system has seven classes, ranked according to increasing limitations or hazards on use and to decreasing versatility. Class 1 land has negligible limitations and is suited to cropping and a wide range of other uses. Class 7 land is unsuited to cropping or pastoral uses and has extremely limited land use options.

Land suitability

Land can be classified by dividing it up into reasonably homogeneous areas with respect to its suitability for a particular purpose. Land suitability is defined by the Food and Agriculture Organization (1976) as the fitness of a given type of land for a specified use. The concept of land suitability is only meaningful if the use is specified (Food and Agriculture Organization 1983).

Land suitability includes evaluation of the social and economic factors relating to the specified land use. As indicated in the definition of land capability, two areas of land may have the same capability class but be in different suitability classes due to economic factors such as distance to market.

Availability

Land may not always be available for a particular use. Consideration needs to be given to the potential conflict with other land uses and to the political implications of various options.

The National Forest Policy (Commonwealth of Australia 1992) encourages the expansion of the plantation base by industrial growers and, where appropriate, by public forest agencies. Australian States have varying policies on the clearing of native forests for plantations. This reflects, in part, the great differences in the past history of land clearance between the States. With respect to Tasmania, the policy supports the conversion of native forest to plantation, on either public or private land, where this does not compromise regional conservation objectives or catchment management objectives. This aspect will be considered as part of the evaluation of options stage of the regional forest agreement process.

Turvey et al. (1990) discussed the conflicting information on the availability of land for plantations nationwide. They highlighted the dearth of information for effective planning for expansion of the plantation estate, particularly for eucalypt plantations. Estimates for Tasmania have varied from more than 100 000 hectares to less than 20 000 hectares.

The National Plantations Advisory Committee (1991) considered that there were substantial areas of land available for plantation expansion nationally. The terms of reference for that study concentrated on eucalypt plantations and were limited to consideration of cleared agricultural land, including land containing minimal areas of impoverished forest (Booth and Jovanovic 1991).

The study by the National Plantations Advisory Committee included work on the interaction between agricultural land use and capability for plantation development. A three class rating of the intensity of land use for agriculture was developed by combining cropping and grazing indices. This was then presented in a matrix, with plantation capability ratings from low to high, to illustrate the potential conflict with agricultural land uses.

For Tasmania, the study concluded that, although fairly large areas of land had medium or high plantation capability, a very large proportion of this is in areas of high agricultural intensity. Of the 35 000 hectares identified as being within 160 kilometres of Burnie and as having a high plantation capability, 66 per cent was also considered to have high agricultural capability.

Simple rules based approach

Relative ranking of sites

Estimates of absolute growth rates are very difficult to obtain for all sites that might be of interest. However, site selection can be done by developing a method for relative ranking of sites based on simple rules. These 'notional relationships' have been used by Hackett (1985; 1988), culminating in the computer software system 'Plantgro' (Hackett 1991). The system can be used for coarse prediction of plant growth.

These methods produce rankings of sites, based on simple relationships between plant growth and a range of environmental variables. These are then combined into an assessment for a given site, based on the most

limiting value for that site. This enables relative comparisons of sites, so that the best sites can be selected first.

Productivity estimates

Laffan (1993) has developed a framework for assessing land for plantations in Tasmania. It uses a method similar to the Plantgro system, where eight land qualities are assessed in relation to how they affect site productivity (e.g. temperature, moisture and nutrient availability). The most limiting value is used to determine an overall productivity estimate for each site. Laffan's system also provides estimates of quantitative productivity in four classes and of the risk of land degradation.

Osler et al. (1996) reviewed Laffan's system and concluded it was a conservative predictor of site productivity. In particular, Osler found that, when the system predicted a site had lower productivity, there was a significant probability that its actual productivity was higher than that predicted by the model.

For the purposes of this study, the four productivity classes used by Laffan are assumed to apply for the simple rules based method. This is because the ranges used are largely the same (see Table 4.23 and Table 4.24).

Climatic suitability

Species selection has long been guided by matching climatic conditions of the proposed sites with those of the natural range of a species. Booth and Saunders (1980) outlined a method using climatic data to assist species selection. This has been refined in subsequent work (Booth 1985; Booth et al 1988; Booth et al 1989).

Table 4.23: Climatic ranges for major plantation species used in Tasmania

Climatic variable	*E. globulus*	*E. nitens*	*P. radiata*	*Acacia melanoxylon*	*General climatic envelope (excl. A. melanoxylon)*
Mean annual rainfall (mm)	600 - 1500	750 - 1500 [a] 750 - 1780 [d]	650 - 1600	480 - 2950	800 - 1600
Rainfall regime	winter / uniform	winter / uniform / summer	winter / uniform		N/A
Dry season length	0 - 5	0 - 4	0 - 4		0 - 5
Mean max. temperature hottest month (°C)	19 - 30	20 - 28 [a] 20 - 26 [d]	20 - 30	19 - 34	19 - 30
Mean min. temperature coldest month (°C)	2 - 12	-3 - 5 [a] -3 - 3 [d]	-2 - 12	-3 - 16	-3 - 12
Mean annual temperature (°C)	9 - 18	8 - 14 [d]	11 - 18	9 - 25	7 - 18

Notes:
[a] Most data derived from Booth and Jovanovic (1991) except for E. nitens where noted below.
[b] The extremely wide latitudinal range and genetic variation of A. melanoxylon does not indicate that those provenances grown in southern Australia and especially Tasmania for timber production can tolerate these conditions.
[c] Due to (a) above the generalised bioclimatic domains used for plantation capability in this study excluded A. melanoxylon and concentrated on covering the climatic range for E. nitens, E. globulus, and Pinus radiata.
[d] Lower (5%) and upper (95%) confidence intervals from Lindenmayer et al (1996).

Nix et al. (1992) undertook what is probably the most detailed technical study yet into the capability for hardwood plantations in Tasmania. They derived a range of bioclimatic domains for the major hardwood species, based on a variety of data sources. They derived statistical probabilities for the occurrence of each species, based on 22 climatic variables. The current study uses the same underlying data. The core climatic variables and ranges are very similar, although the rules based approach is simpler and the physiological models are quite different. Lindenmayer et al. (1996) have recently produced another set of bioclimatic domains for *E. nitens* that differs slightly from those used by Nix et al. (1992), notably in rainfall. These have been presented in this report for the purposes of comparison. They were not used in the rules based approach, to reduce inconsistencies from mixing data sources.

Temperature to elevation conversion

The *Forestry Tasmania Plantation Handbook* (Neilsen 1990) gives guidelines for plantation suitability using altitude rather than temperature, based on field experience in Tasmania. Altitude is used as a surrogate for temperature, because there is a strong correlation between them and because it is easily available from topographic maps.

Comparison between mean annual temperature and elevation data collated in this study for Tasmania demonstrated a high correlation of 95 per cent. The derived relationship *mean annual temperature = -1.0 * (elevation - 1929.65) / 143.117,* can be used to convert rules based on elevation into those based on temperature (see Table 4.24).

Table 4.24: Conversion between rules based on elevation to temperature

Elevation (m)	Mean annual temperature (^{o}C)	Use and source
300	11.4	Laffan (1993) for upper limit for E. globulus
400	10.7	Osler et al. (1996) revised E.globulus upper limit
500	10.0	Neilsen (1990) preferred upper limit for plantations of Pinus radiata.
700	8.6	Neilsen (1990) suggested maximum limit for P. radiata plantations
800	7.9	Neilsen (1990) suggested maximum limit for eucalypt plantations.

There is general agreement between the climatic envelopes given in Table 4.23 and the rules based on altitude in Table 4.24. In particular, the revised *E. globulus* upper limit advocated by Osler et al. (1996) is more in line with the temperature range for the species in Table 4.23 and is being considered for inclusion in the Laffan system.

Where mature height potential information exists

If information on the existing or past forest is available, then it can be used to assess the potential for plantations. The first example is information about species, that is floristic indicators. The second is the mature height or density of the forest.

Floristic indicators have been used successfully for assessing plantation potential in South Australia (Lewis et al. 1976) and in Western Australia (Inions et al.

1990). In Tasmania, major overstorey species has also been used as a useful site indicator. As an example, the proportion of *E. obliqua,* compared to the peppermint and gum species was found to be a useful guide to site quality on some poorer sites in northeast Tasmania (Neilsen 1990). The complexity of species distributions and the relative lack of knowledge about which floristic communities are indicators of plantation potential means that this approach is limited to areas in which the required information and knowledge is available.

Forestry Tasmania uses aerial photographs to map forest types for forest management and timber volume assessment. The photo interpreted types contain detailed information about forest structure, that is , height and density class. The potential height of the mature forest is one attribute that is available statewide and that can be used to assist in determining plantation potential. A key assumption in this regard is that tall mature forest indicates better plantation potential.

Photo interpreted types can be used where rainfall and temperature information does not provide enough local detail. Generalised rainfall and temperature information often lacks the precision required to identify areas that are capable of supporting high quality native forests or plantations. Photo interpreted types can also be used to exclude areas of very low height or very low density and to separate areas of higher quality into productivity groupings.

For the purposes of this study the generalised climatic envelope for plantations, shown in Table 4.23, was used to broadly define the boundaries for areas with a high capability for plantations. Further restrictions and limitations within these areas were based on other factors (e.g. geology, mature height potential and slope). These are listed in tables 4.26 to 4.29 (see subsection 'Other tables and maps').

Where no mature height potential information exists

If there is no information on the mature height potential (e.g. on cleared land), then other methods are used to assess plantation capability. The simplest of these is to use the 'rules based' approach on climatic data, without mature height potential. This gives a broad (and probably optimistic) estimate of land capable of growing plantations. A second approach is to use a growth model, as outlined in the next subsection 'Physiologically based growth model for *E. globulus*'. The rules based approach involves an overlay of climatic variables, as developed by the Centre for Resource and Environmental Studies at the Australian National University (Nix et al. 1992). Areas were selected using the climatic ranges given in Table 4.23, combined with the slope, and capability ratings for geology types. (Refer to tables 4.25 to 4.29). The same method was applied to both public and private land.

The method for assessing capability classes when variables are combined is based on the 'most limiting value' method, similar to that used by Laffan (1993). The most limiting variable is deemed to be the value for any combination of overlays. For example, if the temperature characteristics of a site correspond to capability class 1, but the rainfall characteristics only correspond to class 3, then the resulting classification is class 3.

Risk analysis

The capability maps produced as outputs from this process are not absolute. They should be regarded as estimates, based on the models and rules used to generate them. As such, it may be appropriate to conduct sensitivity analyses to determine the 'risk' associated with each zone.

A form of risk analysis can be done by including the variability of climate (e.g. reliability of rainfall) into the capability assessment. A second method is to conduct sensitivity analyses, by varying the assumptions. For example, it is possible to use three levels of soil water and to run the physiological model as a 'sensitivity' analysis. This will give an indication as to the robustness of the areas of land selected from the original model. If, when soil water is reduced by 30 per cent, an area classed as capable for plantations becomes classed as not capable, and if soil water is thought to vary significantly, then the risk of planting those areas that changed from 'capable' to 'not capable' is relatively high.

Financial evaluation

Key issues for site selection should include consideration of potential growth rates, soil and site limitations, financial evaluation and market opportunities. Only sites of high quality in all of these criteria should be planted for sawlog production.

Some work has been done to evaluate the financial viability of various eucalypt plantation regimes and has been reported in detail elsewhere (Gerrand et al. 1993). The main conclusions from that study are still valid:

- for most realistic commercial discount rates, the maximum financial return was gained on high quality sites where the plantation was situated close to the processing plant and managed for pulpwood on a short rotation length;
- longer rotation lengths, for example, for sawlogs, were less attractive (only one variation offered a positive return, based on a commercial thinning regime on very high quality sites);
- a 'clearwood' sawlog regime (i.e. based on early age spacing) did not produce a positive return;
- financial viability is greatly reduced by low growth and by high establishment or transport costs;
- the net present value was very sensitive to site quality (productivity) and to distance to market;
- sites with productivities of less than 15 cubic metres per hectare per year are unlikely to show a positive return at current establishment costs, even when close to a mill site;
- break even establishment costs for plantations were determined, using certain assumptions, and were presented in map form to assist managers to select financially viable sites; and
- distance to mill can be used to determine efficient plantation locations.

Stephens et al. (1993) have evaluated the competitiveness of selected Australian plantations. They concluded that, for northern Tasmania, hardwood plantations managed for pulpwood may be internationally competitive. These factors will be assessed further in conjunction with other work being carried out during the assessment of options stage of the regional forest agreement process (Hansard et al., in prep.).

Other tables and maps

Inputs

The following four tables present the classification of plantation capability, based on physical and climatic variables used for the simple rules based method.

Table 4.25: Classification of the water status of sites based on indirect indicators

Water indicator	Range	Capability class	Notes
Mean annual rainfall	<800 mm	4	Not considered suitable for plantation in Tasmania
	800 - 1,000	3	Suitable for *E. globulus, P. radiata*
	1,000 - 1,600	1	Suitable for *E. globulus, E. nitens, P. radiata*
	>1,600 mm	2	Suitable for *E. globulus, E. nitens, P. radiata*
Rainfall regime			Not applicable
Dry season length	0 - 4	1	Suitable for *E. globulus, E. nitens, P. radiata*
	>5	2	Suitable for *E. globulus*

Table 4.26: Classification of the temperature status of sites, based on indirect indicators

Temperature variable	Range (°C)	Capability class	Notes
Mean annual temperature	11 - 14	1	Suitable for *E. globulus, E. nitens, P. radiata* Equivalent to 0 - 400 m in Tasmania
	9 - 11	2	Suitable for *E. nitens, P. radiata* generally unsuitable for *E. globulus,* depending on frost frequency and cold air drainage Equivalent to 400 - 650 m in Tasmania
	8 - 9	3	Suitable for *E. nitens,* marginal for *P. radiata* Equivalent to 650 - 800 m in Tasmania
	< 8	4	Unsuitable for commercial plantations Equivalent to > 800 m in Tasmania

Geology types were classified into three groups according to their estimated capability for plantations, using Mineral Resources Tasmania's 1 : 250 000 series of mapsheets. This was a variant of the nutrient availability technique used by Nix et al. (1992), who used the 1 : 500 000 geology maps in a similar way.

Table 4.27: Classification of capability class based on simplified geology type

Geology types from 1 : 250 000 maps	Geology class	Capability class	Notes
Cb, Cba, Cbt, Cc, Ccb, Cd, Cdl, Cds, Cdsp, Cdsv, Cdv, Cdva, Cdvt, Cm, Cw, Cwb, Cwmb, Dc, Dd, Dg, Dga, Dgaa, Dgaf, Dgd, Dgn, Dgr, Dp, Jb, Jd, Ka, Ks, Lac, Ld, Ldv, Lj, Ljd, Ljp, Lob, Lr, Lrp, Lsb, Lsv, Lvb, Lw, Lwc, Lwd, OD, ODm, Odq, Ol, P, Plc, Pt, Pu, Puc, Q, Qh, Qp, Qpg, Qpl, Qps, Qpt, Qt, Rb, TQ, Tb, Tm, Ts	1	1	These geology types are generally suitable for plantation establishment. Class 1 only if rainfall and other factors are Class 1, otherwise the most limiting value determines capability.
Ca, Caq, Cas, Cbtg, Ccc, Cs, Csd, Csp, Csx, Ct, Dl, Lod, Lsd, Lss, Lwt, ODw, PR, Pl, R, Rq, Rv, Rvc, Rvv	2	2, 3, or 4	Marginal, or geologies exhibiting a wide range of productivities - depending on rainfall or temperature regime. Class 2 where rainfall and temperature are Class 2 otherwise the most limiting value determines capability.
CO, COb, COd, COn, COu, COuf, COum, Cal, Cg, Cgr, Cqf, Cwc, Lap, Lat, Lds, Lg, Ljs, Lma, Lo, Loq, Lrs, Ls, Lsc, Lt, Ltc, Ltd, Ltg, Ltp, Ltpg, Lts, Ltsg, SD, SDa, SDb, SDc, SDf, SDl, Tc	3	4	Unsuitable for plantation establishment, due to either poor growth or operations hazards.

Table 4.28: Classification of the slope codes

Slope code	Range (%)	Notes
1	<30%	Trafficability acceptable for plantation establishment and sustainable management
2	30-50%	Marginal - slope conditions may require special management for plantations
3	>50%	Unsuitable for plantation establishment

Table 4.29: Classification of mature height potential from photo interpreted forest type maps into plantation capability classes

Simplified Mature Height Potential Class	Mature Eucalypt Height	Capability class	Notes

1, 2,	>34m	1	Generally capable of growing plantations
+3	34-41m	1 or less	+3 only class 1 where temperature and rainfall are not limiting - where rainfall or temperature are limiting the most limiting value determines capability
-3	27-34m	2 or less	Where rainfall or temperature are limiting the most limiting value determines capability
4,	<27m	3 or less	Marginal for plantations, where rainfall or temperature are limiting the most limiting value determines capability
5	<15m	4	Unsuitable for commercial plantations
8	Unknown	Unknown	Need to use other methods, e.g. use a physiological growth model

Outputs Maps of preliminary outputs from the data gathering phase of this project will be on display in the Public Land Use Commission's designated reference centres. The relevant outputs, each relating to the 'rules based' method of assessing plantation capability, are:

- mean annual rainfall classes;
- mean annual temperature classes; and
- geology classes.

In addition, Map S&E 4.6 can be used to provide an indication of plantation capability, based on mature height potential from photo interpreted forest type maps.

The human face of the forest industry

For 43 years Robert Blacklow has been involved in several facets of the woodcraft industry - cabinet-making, teaching - from secondary to undergraduate levels, boatbuilding, firearms manufacture and even marquetry, the use of veneers to create pictorial works in wood. Now 60 years old, he runs a business under his own name with no other employees.

He works mainly in Tasmanian solid timbers - 'We have the best timbers in the world and we may as well use them,' he says - using between three and five cubic metres a year. The types he uses varies with his workload in a particular year, but he steers clear of eucalypts, which are not popular with his customers. Huon pine, celery-top pine, blackwood, myrtle and sassafras are among his common working media but for special applications he has also used some non-commercial understorey species - musk, tea-tree, wattle, dogwood and tallow wood.

He sources his timber from six or seven suppliers across the State, some of whom will contact him when they receive a log of sufficient quality, as he prefers to purchase timber from a single log to get around colour-matching problems.

One of his major concerns is that the State's cabinet-making industry is not sufficiently served with training infrastructure. Although he acknowledges the reputation of the University of Tasmania's course for furniture designer-makers, he points to the need for training courses with greater emphasis on traditional furniture-making skills. This can be counteracted to some extent by the interchange of skills and information fostered by such interest groups as the Woodcraft Guild and the Wooden Boat Guild.

Another of Robert Blacklow's concern centres on management of the State's forests with the objective of maximise the yield of eucalypt species. This leaves in doubt the future resource of the slower-growing species on which his work relies. 'If I was starting out now I would be very worried,' he said. 'I don't believe in locking up great tracts of forest; I believe in harvesting traditional timbers in a traditional way.' He is confident that correct management techniques will see Tasmania's forests last forever. However, he is concerned that international competition from countries with different forestry practices - simply cut and clear, for example - is depressing the value of special species timber in Tasmania.

He has developed thrifty habits in the use of wood to reflect its value, turning the smallest amounts of waste into saleable items such as pens and letter-openers. 'You don't throw your waste into the fire in the corner to keep the place warm any more,' he says. 'You look at it twice these days, because you can make money from it.'

Apart from spending 75 per cent of his income in the local area, Robert Blacklow maintains that he contributes to community life by adding to society's store of fine craft objects: 'A thing of beauty is a joy forever and can be made in wood by a cabinet maker.'

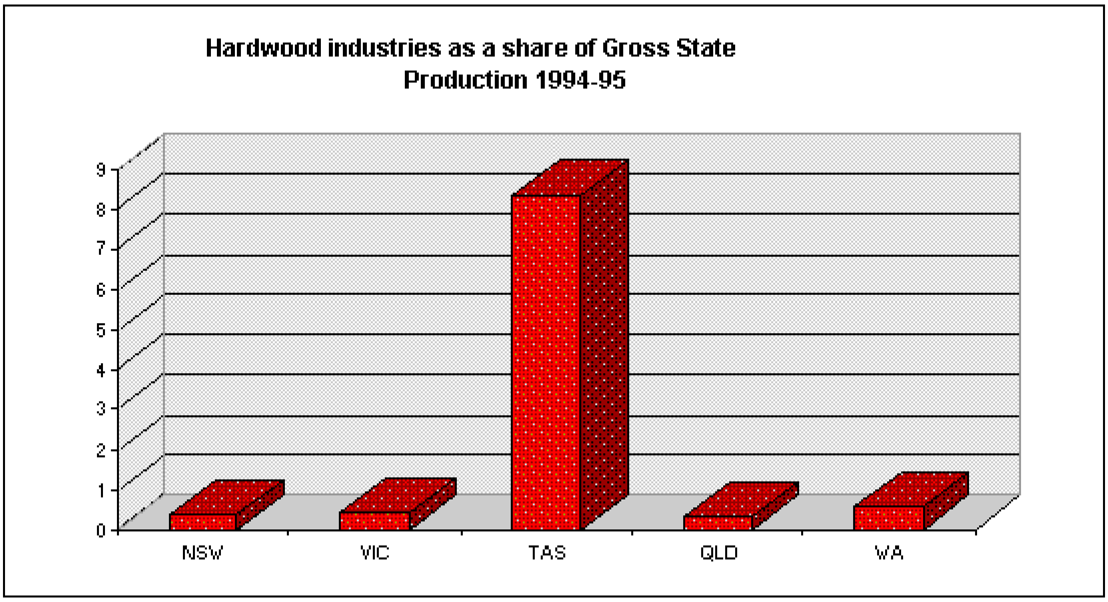
4.2.1 General

Value and significance of Tasmania's wood-based industries

Contribution to the Tasmanian economy

The hardwood-based forest industries make a substantially greater contribution to Tasmania's economic activity than to activity in other Australian states. In 1994/95 hardwood-based industries contributed just over eight per cent of gross state product (GSP). This is illustrated in Figure 4.2. Before processing, the value of hardwood logs harvested in 1994/95 is estimated to be $167 million. With processing, including sawmilling, paper manufacture and production of export woodchips, the gross value of production is estimated at $811 million in 1994/95. A little over half of this value is attributable to newsprint and paper products. When forest-dependent industries such as printing and furniture manufacture are considered, the contribution to gross state product is slightly higher. The contribution of Tasmania's native forest-based and allied industries was estimated at about seventeen per cent of gross state product in 1989 (CREA 1991).

Figure 4.2: Hardwood industries as a share of gross state product 1994/95



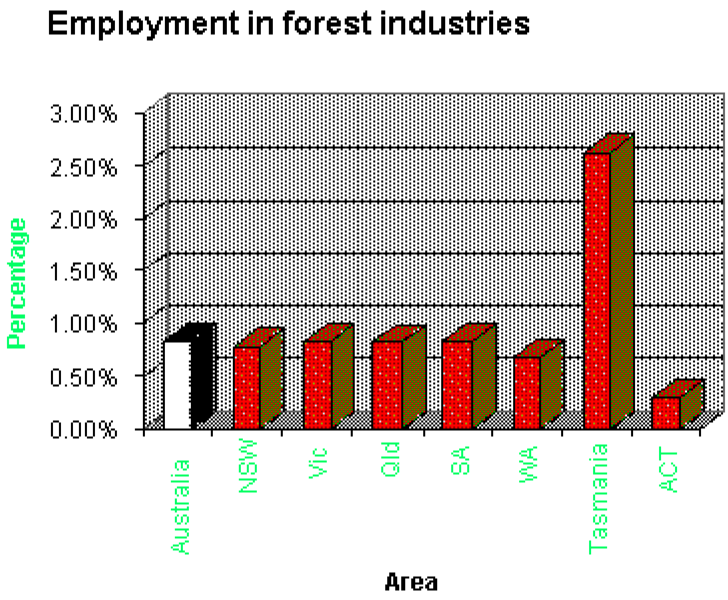
Preliminary estimates subject to revision

ABS 1996, ABARE estimates.

Employment

Figure 4.3 shows that Tasmania has a higher proportion of its workforce employed in the forest industries than for other Australian states. In 1996 the industry directly employed 6558 people. Of these 2484 were in forestry and logging, 2339 were in wood and wood products processing and a further 1735 were in paper and paper products manufacturing. These represent about three per cent of total employment in the State. The proportion is higher when further downstream processing and indirect employment in related sectors such as transport are included.

Figure 4.3: Employment in forest industries by State 1995-96



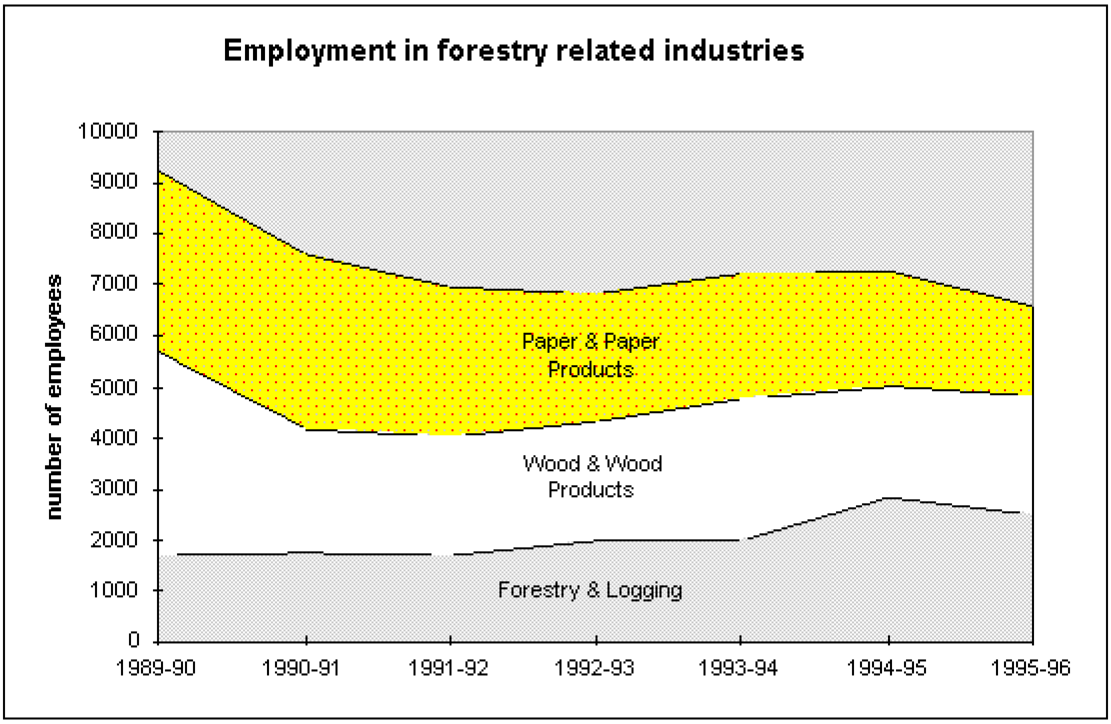
Employment in the forestry and logging sector increased by 46 per cent between 1989/90 and 1995/96. There has been strong growth in employment in forestry and logging and in wood and wood product manufacturing over the period. The growth has been in response to improved conditions in the building and construction sector, following depressed conditions in the 1980s and early 1990s.

Forestry and logging activities employed about fifteen per cent of the State's agricultural sector workforce in 1995/96. In the same year, wood processing industries employed about seventeen per cent of the workforce involved in the manufacturing sector.

Activity in the building and construction sector in Australia is a key determinant of employment in the sawn timber and wood-based panels sectors, particularly in the short term. Sawn timber used in house construction, e.g. framing, flooring and decorative panels, represents an important market for the Tasmanian woodbased industry. Employment in woodbased industries declined in Tasmania through the 1980s and into the early 1990s. This trend is illustrated in Figure 4.4. The trend was, in part, a reflection of the downturn in housing construction activity over that period.

Technological change has also contributed to the decrease in employment over this period. Such change has accompanied the amalgamation of mills and the introduction of larger scale, less labour intensive processes. It should be noted that employment in other sectors, such as agriculture, has declined over this period. This also reflects the development of less labour intensive processes.

Figure 4.4: Employment in forestry related industries



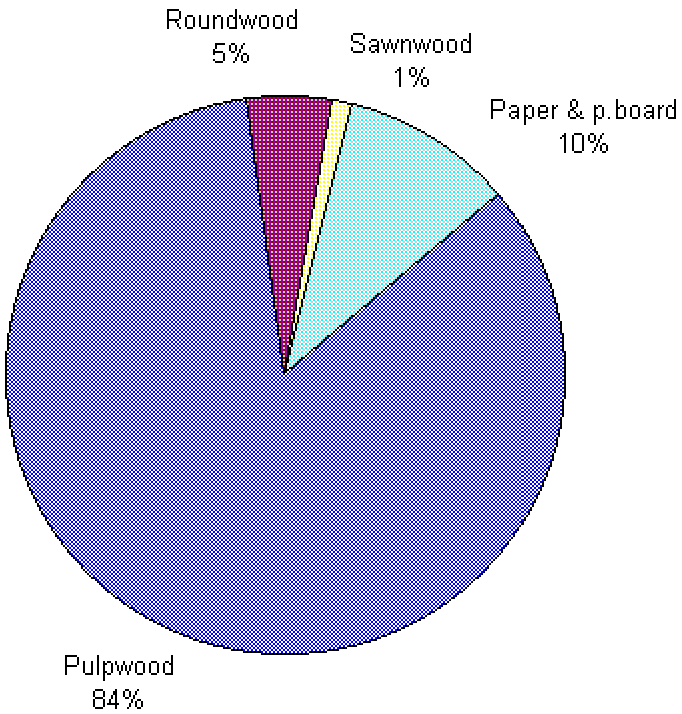
Trade

Tasmania recorded a surplus in forest products trade of $188 million in 1994/95, while Australia recorded a trade deficit of almost $1.9 billion in the same year.

Tasmania exported $268 million of forest products in 1995/96. This is about 27 per cent of Australia's forest product export earnings (Table 4.30).

Figure 4.5: Exports of forest products from Tasmania

Exports of forest products from Tasmania 1995 - 96



Tasmania's exports of printing and writing products, pulpwood and roundwood accounted for more than one third of Australian export earnings for these products in 1995/96. Although printing and writing paper accounted for only ten per cent of Tasmanian export earnings from forest products, it represented more than half of Australian export earnings from printing and writing paper. The majority of Tasmanian export earnings comes from woodchips, produced from pulpwood and sawmill residues (Figure 4.5).

Table 4.30 Exports of forest products from Tasmania 1995-96

	$A million	**Share of Australian exports (%)**
Roundwood	13.8	37
Sawnwood	2.0	5
Paper & panelboard	36.8	11
Printing & writing	26.6	51
Woodchips	224.0	41
Total	**267.8**	**27**

Source: ABS

Imports

Table 4.31 illustrates Tasmania's forest product imports in 1995/96. Tasmania is a small importer of forest products. The $51 million of forest product imports to Tasmania in 1995/96 represented less than two per cent of Australian imports in this sector. Softwood pulp, for use in the production of paper and paper products, accounted for 91 per cent of Tasmania's forest product imports.

Table 4.31: Imports of forest products to Tasmania 1995-96

Description	$A million	Share of Australian exports (%)	
Sawnwood	1.5	0.4	
Paper & paperboard	2.0	0.1	
Pulp	46.6	25.4	
Total	**51.1**	**1.7**	

Source: ABS

Characteristics of Tasmania's forest growing industry

An understanding of the characteristics of the current structure of Tasmania's forestry and wood processing industries requires some knowledge of the factors which have shaped them over the past decades. Until the 1930s the wood based industry in Tasmania was essentially limited to sawmilling and the production of sleepers, shingles and poles. Production facilities were generally dispersed across numerous locations close to the native forests from which the resource was drawn, as well as in towns and cities.

In the late 1930s integrated pulp and paper mills were established at Burnie (north west Tasmania) by Associated Pulp and Paper Mills Ltd and at Boyer (southern Tasmania) by Australian Newsprint Mills Ltd. The Burnie mill produced printing and writing grades and the Boyer mill newsprint.

A number of economic and technological developments in the 1940s and 1950s resulted in a substantial expansion of sawmilling capacity and activity with a trend to consolidation of sawmills in urban centres. The 1950s also saw the establishment of a pulpmill at Geeveston, owned by Australian Paper Manufacturers Ltd and producing unbleached chemical pulp. The product from this mill was shipped to papermills in other States for the manufacture of packaging. Other important developments occurred in the management and regeneration of eucalyptus forests for wood production.

As forest inventory methods became more sophisticated it became clear that in the high post-war levels of sawlog harvest were not sustainable on public forest. A direct consequence of this was a phased reduction over the 1970s and 1980s of the sawlog harvest in public forest by some 50% in total. The 1980s and early 1990s have also seen a further consolidation of sawmilling, as a result of both the reduction in log harvest and of national economic policy changes and of the increasingly more competitive markets.

A major policy initiative influencing the forestry and forest products industry in recent years has been the Tasmanian Forests and Forest Industries Strategy

(FFIS). Adopted by the then Tasmanian Government in 1991 the FFIS covers a wide range of issues which relate to forestry and forest based industry including: employment, nature conservation, crown forest management, resource allocation and pricing, and private forest matters. Policy guidelines which are embodied in the FFIS are in some cases quite specific, for example adoption of a minimum production target of 300,000 m3 a year of high quality sawlog from public forests. On other matters they are more general. A significant body of policy legislation and regulation has been developed in response to the FFIS, relating to nature conservation, public resource log pricing and allocation, and administration of the public forest resource among other issues. Some of these policies are discusses in more detail in the following sections.

Log supply

A detailed discussion of Tasmania's forest estate can be found in Section 4.1.

Tasmania's forests produced just over five million cubic metres of logs in 1994/95. Of these, 68 per cent came from public forests. As shown in Figure 4.6, the volume of sawlog removals from public forest has increased in the five years to 1994/95, while the volume of sawlog removals from private land has remained steady. Pulp log removals from private land have increased since 1990/91, while from public forest the volume of logs removed has remained at about the same level (see Figure 4.7).

Figure 4.6: Sawlog removals

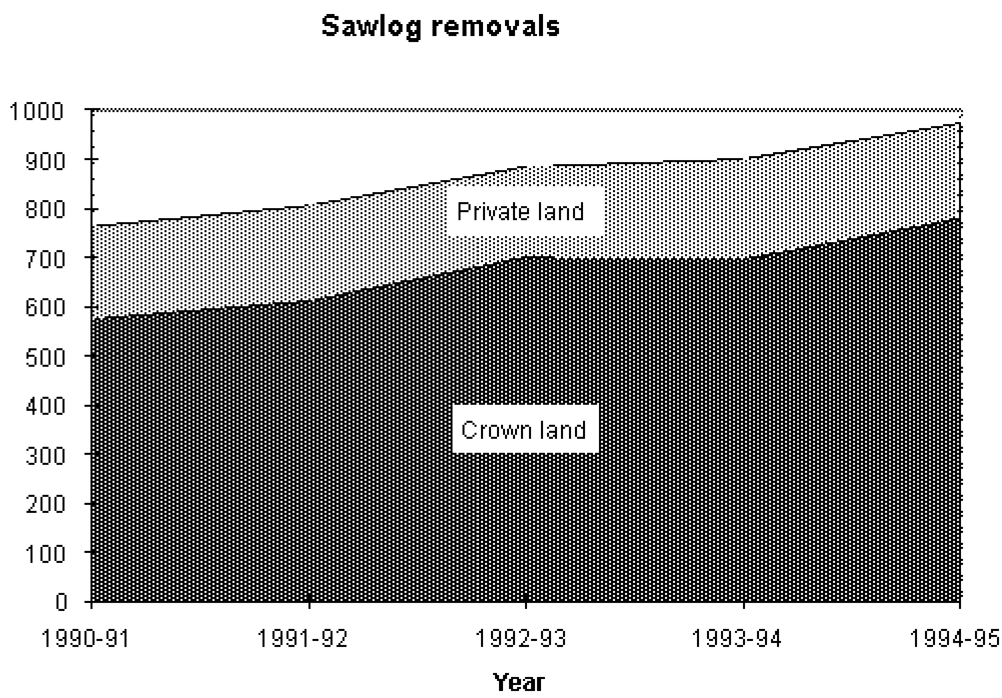
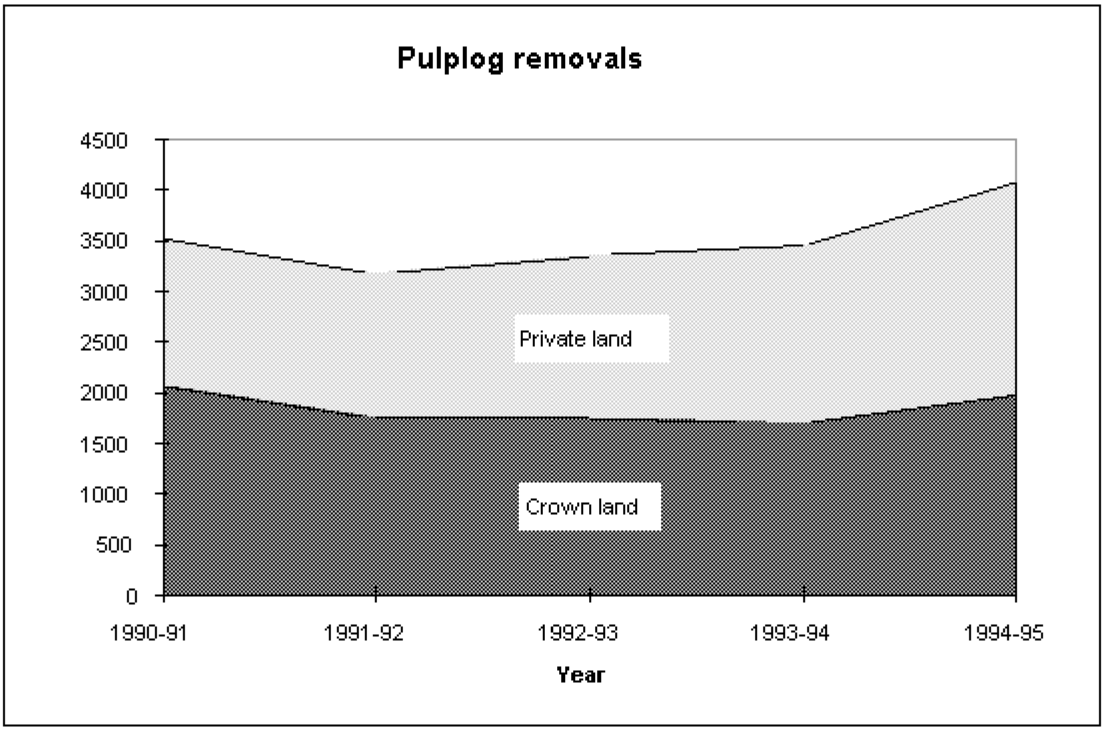


Figure 4.7: Pulplog removals



Management of the forests

Public forests

Forestry Tasmania is a government owned corporation, with responsibility for the management of all State owned multiple use forests. The objectives of Forestry Tasmania are to optimise the economic returns from wood production activities and to optimise the benefits from non-wood forests use (*Forestry Amendment (Forestry Corporation) Act 1995* (Tas.)).

Since 1991, the legislated harvest from public multiple use forests has been set at a minimum of 300 000 cubic metres a year of eucalypt veneer logs and sawlogs. The minimum is based on the sustainable yield of these logs, derived from the land base and management regimes that were agreed to under the Forests and Forest Industries Strategy (Forests and Forest Industry Council 1990, 'the Strategy'). The estimated sustainable yield includes assumptions about some future improvements in productivity. The potential harvest of pulpwood from public forest under the Strategy is about 2.3 million tonnes per year. Further details are presented in Section 4.1.

Private forests

Table 4.32 summarises the ownership of private forests in Tasmania. The majority of Tasmania's private forests are owned by farmers. Other owners of private forests include individuals not associated with farming, partnerships and private companies. There are also a number of large publicly listed companies who own and manage forests (Private Forestry Council of Tasmania 1990).

Table 4.32: Ownership of private forest in Tasmania

	%
Farmers	55

Forest industry and forest managers	22
Business/professional/finance and others	23

Source: Private Forests Tasmania

Private native forests can be managed for a number of purposes including recreation, conservation, lifestyle and wood production. It has been estimated that about 57 per cent of Tasmania's private forests are managed for some form of wood production.

The factors that influence the supply of wood from private forests owned by individuals have not been explored to any great degree in Australia (Private Forestry Council of Tasmania 1990). While an increase in timber prices may encourage private forest owners to increase harvested volumes, Binkley (1981) and Hyberg (1987) have shown that, as income rises, private forest owners may be less likely to harvest trees on family farms. Consequently, it is difficult to predict, without further research, what the behaviour of private forest owners may be given any particular set of market conditions.

Regulations influencing wood production

All forest owners are required to meet the legislative requirements of the *Forest Practices Act 1985* (Tas.). The Act requires the preparation and approval of timber harvesting plans and requires that all harvesting is undertaken in accordance with the approved plan. The purpose of the Act is to provide for the protection of forest use sustainability and environmental values. All the operations undertaken to manage and harvest forests in Tasmania are either directly or indirectly controlled by the operation of the forest practices system.

In addition, a number of other Acts influence the management and harvesting of forests. These include the *Threatened Species Protection Act 1995* (Tas.), the *Aboriginal Relics Act 1975* (Tas.) and the *Historic Cultural Heritage Act 1995* (Tas.). Private forest operations are also subject to the provisions of the *Land Use Planning and Approvals Act 1993* (Tas.) and to local government planning schemes.

Log allocation and pricing arrangements

Logs harvested from public forests are sorted into a number of log classes, based on the requirements of the various processing industries. Adherence to the relevant specifications is carefully monitored by Forestry Tasmania. The categories are summarised and more detail given in Appendix 4.1 and Appendix 4.6.

The categories used on public forest are often also used for logs from private forests. However, it is also common for logs from private forests to be sold as 'run of the bush', i.e. without segregation into quality classes.

Logs from public and private forests are priced according to quality and to prevailing market conditions. Average prices 'at the stump' are summarised in Table 4.34. For logs from public forests, prices are determined by log category. In many cases, these categories are further sorted for various purposes. For example, high quality eucalypt sawlogs obtained from public forests are further separated on the basis of diameter, species group, harvest method and distance to market. Different prices apply to each of these subclasses.

Table 4.34: Average royalty rates for Tasmanian wood products

Year	Eucalypt Cat. 1&3 ($ / m3)	Eucalypt Cat. 2&8 ($ / m3)	Special Species ($ / m3)	Eucalypt Veneer ($ / m3)	Native Forest Pulpwood ($ / tonne)	Other Forest Products ($ / m3)
1990/91	$19.81	$16.77	$33.48	$46.04	$10.68	$4.75
1991/92	$20.27	$11.61	$33.04	$46.13	$10.93	$5.27
1992/93	$21.18	$12.42	$37.77	$36.56	$10.96	$5.37
1993/94	$22.59	$13.52	$39.58	$48.07	$12.21	$4.89
1994/95	$23.00	$15.23	$41.15	$53.29	$11.85	$6.42

Source: Forestry Tasmania

Pricing and log allocation methods applying to public forests have undergone significant reforms in recent years, following the implementation of the Forests and Forest Industry Strategy (Forests and Forest Industry Council 1990, 'the Strategy'). The Strategy provides a clear direction for the development of market-based pricing and allocation methods for logs from public forests and from private forests.

Veneer logs and sawlogs from public forests are sold through negotiated contracts with wood processors. Each customer is required to meet minimum standards for workplace safety, environmental standards and local government planning requirements. Depending on the log class, contracts for between five per cent and 75 per cent of the total quantity are sold by tender. The prices of logs not sold through tender are determined by negotiation and are generally based on a number of factors, including distance to market and prevailing market conditions.

The method for selling pulplogs is being changed from annual licences issued under industry specific State legislation (the 'pulpwood concession' system) to new wood supply agreements. These agreements will typically have a duration of 10 years or more and will contain provisions for annual price adjustments. Arrangements to bring all pulplog sales under wood supply agreements are well underway, and only one pulpwood concession remains (for a domestic paper manufacturer).

Logs from private forests are usually sold to the company conducting the harvest operation, under a negotiated contract. The contract will often include agreement about the regeneration of the harvested forest. The relevant company will sell to other businesses those log classes that it does not process itself. For example, a pulpwood processor harvesting private property will usually sell veneer logs and sawlogs that it harvests to veneer mills and sawmills. These logs are usually sold by tender.

Private forest growers face a number of factors that can limit their accessibility to domestic and export log markets. These include economies of scale of private forests, infrastructure and transportation, technical information, market information and institutional arrangements such as export licences. Many private forest growers have holdings of less than 100 hectares. As a result, their log sales are often 'one-off' and are small in volume. These factors can reduce the price competitiveness of logs from private forests.

In response to these factors, private growers have established tree grower cooperatives. There are three cooperatives in Tasmania, in the northwest, northeast and south. The aims of the cooperatives are

- to gain improved returns to growers, by coordinating the collective sales of private wood;
- to assist in finding new markets; and
- to encourage new industries that will utilise products in a more productive way.

The cooperatives have had a combined sales turnover in excess of $9 million over the three years during which they have operated.

Characteristics of the logging and haulage industry

Logging contractors

It is estimated that between 460 and 500 people are employed harvesting logs from public and private forests. . has been estimated at between 460 and 500. Most harvesters work in native forest logging operations, while about 60 people are employed in softwood logging operations. Approximately 80 per cent work within the district in which they live. The sector is becoming increasingly capital intensive, with the harvesting machinery for a typical operation now being worth in excess of $1 million.

Haulage operators

The majority of log trucks in Tasmania are operated by small firms or owner drivers. Truck operators rely on regular business from logging contractors according to quotas. Most quotas are between 200 and 400 tonnes per week and are only transferable as a complete business unit, along with the truck and licence.

The haulage distances for logs from forest to mills vary greatly. The average haulage distance for pulplogs varies between the six main processing points, ranging from 80 to 120 kilometres. It is more difficult to estimate the average for the numerous sawmills. However, the actual haulage distance for the majority of sawlogs typically ranges from 50 kilometres to 250 kilometres.

Characteristics of Tasmania's wood-processing industries

Tasmania's forest industries manufacture a wide range of wood products for sale in Tasmania, mainland Australia and overseas. These products include:

- laminated beams (structural and decorative);
- prefabricated houses and prefabricated house components;
- joinery;
- furniture and fine craft;
- wall panels;
- flooring;
- parquetry;
- packaging;

- veneers (decorative and structural);
- sawn timber products (green and seasoned);
- panelboards;
- woodchips, suitable for chemical and other forms of pulp production; and
- pulp and paper, including both printing and writing grades and newsprint.

Almost 239 000 cubic metres of veneer and sawntimber were produced by Tasmania's forest industries in 1994/95. In addition, just over 3.5 million cubic metres of paper, paper products and woodchips were produced. The gross value of these products, shown in Table 4.35, is estimated to be $152 million in sawn products, $438 million in paper products and $212 million in woodchip exports. The paper and woodchip values in 1994/95 include chips produced from 500 000 cubic metres of sawmill offcuts (see Figure 4.8).

It should be noted that the gross values for sawn timber are calculated at mill door and do not include further processing, e.g. into furniture, wooden pallets or kitchen doors.

Figure 4.8: Hardwood timber industry in Tasmania

Table 4.35: Ex mill production of wood and fibre products

		Value	**Volume**
Crown	Veneer	$7,746,070	3420
	Sawntimber	$91,652,581	132,872
	Chip	$103,264,317	1,523,363
	Pulp and Paper products	$130,125,524	206,000 kt
Private	Veneer	$1,628,575	697
	Sawntimber	$60,712,433	102,063
	Chip	$108,600,342	1,573,161
	Pulp and Paper products	$307,503,840	243,200 kt
	Total	**$811,233,682**	

Source: ABARE estimates

Note: Paper figures include approximately $97m worth of products derived from softwood and imported fibre input.

4.2.2 Special species timbers sector

This section of the report profiles special species timbers in Tasmania in terms of the contribution to the State's economy. Their contribution to veneer milling and sawmilling alone has been estimated at $15 million per year. There is also the unquantified additional contribution from the sector that processes the veneer and sawn timber and the sector that uses special species timber logs. The latter consists of artists, craftspeople, interior decorators, builders, boat builders, furniture manufacturers, veneer millers and sawmillers.

Special species timbers arealso the basis of one important element of Tasmania's national and international identity. Although many aspects of this contribution are intangible, the following tangible aspects of the contribution of special species timbers to the State's economy are described:

- the current characteristics of each of the major industries that process special species timbers in Tasmania, relative to location, employment, wood inputs (logs or semi-processed timber), wood based outputs and wealth generated;
- the future prospects for special species timbers to be processed in Tasmania; and
- the sensitivity of the current industry and of future processing opportunities to changes in the availability of special species timbers.

Profile of the industry

Blackwood accounts for more than half the harvest of special species timber sawlogs. Other species, ranked in decreasing order of the amount currently harvested and processed each year, are myrtle, celery top pine, sassafras, Huon pine and silver wattle (see Table 4.15).

Veneer milling

Veneer is sold in Tasmanian, mainland and international markets. End uses are furniture, fine craft and decorative wall panels. Total annual supply of special species timber sawlogs from all sources for slicing at these mills is no more than 2000 cubic metres. Three veneer mills slice special species timbers for veneer. One specialises in special species timbers, another processes some as an important part of its product mix and a new mill is able to peel special species timbers for appearance grade plywood, but has only processed very small quantities.

Sawmilling

Seven sawmills specialise in special species timbers. Many eucalypt sawmills and four veneer mills also process some special species timbers. Some special species timbers sawlogs are processed and sold by businesses that essentially deal in craftwood. Some special species timber sawlogs are processed by, or on contract to, vertically integrated businesses that produce finished products such as joinery and fine craft.

About 14 000 cubic metres was harvested from multiple use forests in 1995-96. As mentioned in the previous section, about 2000 cubic metres of this amount was processed for sliced veneer.

The most recent data for private forests (1994-95) show a harvest of about 5700 cubic metres of special species timbers (Des King, Private Forests Tasmania, speaking at the Australian Tree Growers' Conference in Mt Gambier, September 1996).

Britton Brothers Sawmill, Smithton

Uses include furniture, joinery, wall panelling, parquetry, boatbuilding and fine craft. The main markets are mainland Australia.

Further manufacturing

Many companies in Tasmania further manufacture special species timbers to produce products for sale in Tasmania, mainland Australia and overseas. Examples include joinery, furniture and fine craft, wall panels, flooring and parquetry.

Technical support and maintenance

Each sector of the forest industry, including those already listed, gives rise to a large number of support industries that derive at least a significant part of their income, and sometimes all of it, from forest industries. Examples include those businesses that supply machines, power, equipment, fuel, oil, tyres and spare parts.

Forest management

Forestry Tasmania is the largest agency involved in the management of forests for supply of special species timbers. Some other businesses earn at least part of their living in this sector, including harvesting and transport.

Prospects for industry development

The special species timbers sector has significant potential for development. These range from the contemporary revival of traditional uses of many of the timbers (e.g. wooden boat building) to the significant opportunities for new manufacturing facilities to increase the downstream processing of these timbers within Tasmania. The latter applies to products aimed at mainland markets and, increasingly, to products aimed at overseas markets.

In terms of overseas markets, the increasing standard of living and the increasing population in many neighbouring countries (particularly in China, India and several southeast Asian countries) can be expected to translate into a significant demand for high quality furniture. These markets can also be expected to suffer a decrease in the availability of traditional supply from tropical rainforest timbers.

Tasmania is well placed to take advantage of the opportunities that are presented by these developments. In particular:

- the diverse properties of Tasmania's special species timbers cover a range of applications;

- the commitment to sustainable management for special species timbers gives a competitive advantage, compared to other sources of equivalent timbers;
- Tasmania's designers in wood have achieved international recognition;
- there is a pool of trained craftspeople who are skilled in the use of the timbers for a range of applications;
- the existing industry is equipped to produce a range of related products that can be used for further manufacturing, from sliced veneers to sawn timber to craft pieces; and
- new distribution and sales arrangements that have been implemented in accordance with the 1990 Forests and Forest Industry Strategy provide a base for industry to seek new markets and to reinvest.

Clifton Furniture, Launceston

Sensitivity to changes in availability

Businesses that sell products manufactured from special species timbers are particularly dependent on secure access to mixed forests and to rainforests. Their reliance on special timber management units (particularly those encompassing rainforests) will increase in the future. This is because the current cycle of harvesting wet forests for eucalypt veneer logs and sawlogs is undergoing a gradual transition to regrowth forests and regenerated forests, in which special species timbers (other than blackwood, silver wattle and several of the minor species) are unlikely to reach a commercial size.

This sector is dominated by relatively small businesses. For most of these, a reduction in supply of only a few hundred cubic metres per year would probably lead to closure of the business (or, for those businesses that also process eucalypt logs, to that part of the business dealing in special species timbers). This situation is summarised in Table 18.. Note that the supply of special species timbers from private property is relatively insignificant and has a limited future.

Shipwrights Point School of Wooden Boatbuilding, Huon Valley

Table 4.40: Special species and eucalypt entitlements for businesses with an administered supply contract for special species timbers(1)

	Eucalypt	0 m3pa	1 000 - 2 500 m3pa	5 000 - 10 000 m3pa	10 000 - 20 000 m3pa	Total
Special species timbers	**150 m3pa**	-	-	-	1	1
	300 - 500 m3pa	4	1	2	-	7
	1 500 - 4 000 m3pa	1	-	-	-	1
	4 000 - 8 000 m3pa	-	1	-	-	1

	Total	5	2	2	1	10

(1) Number of veneer milling or sawmilling
Note: Administered supply is defined below, in the section titled 'Sales arrangements'.

Many businesses see great potential for markets that represent more value and more stable demand, but have been reluctant to pursue them because of the uncertain supply of special species timbers.

As an example, the blackwood sector has suffered under very depressed market conditions for several years. This is largely due to fashion (light woods currently being preferred over dark woods). A renewed effort in terms of design and promotion can be expected to restore market interest in such a well-presented dark timber as blackwood. However, the great expense of such a marketing effort cannot be justified by the relevant businesses when faced by uncertain supply.

As a second example, the myrtle sector has been very static through the 1990s and at levels significantly lower than those in the preceding decades. This is because the sawmills have not been confident of supply and, therefore, have been unable to develop stable markets for myrtle timber. Establishing the special timber management units and associated selective harvesting over the past two years has restored sawmillers' confidence about supply. The myrtle sector is particularly dependent on secure access to rainforests, because of the markedly better colour of timber from this forest type. It is very difficult to find markets for pale myrtle.

Changes in the quality of supply are also significant. In the case of Huon pine, an ever higher proportion of the available logs are utility logs (and craftwood). These logs are more expensive to process and the timber recovered from them generally attracts a lower price. This has required careful scheduling of supply from stockpiled logs and from the

Teepookana management unit, in order to maintain a reasonable balance of log quality.

In the case of the potential future supply of blackwood (and, perhaps, silver wattle) from plantations, it is not possible to predict whether plantation-grown timber will have similar appearance and properties to timber from native forests. In addition, the greater cost of establishing these plantations (relative to native forests) requires a high price for the logs in order to maintain commercial viability. The slow and very slow growth rates of other special species timbers, together with high establishment costs, prevent their use in commercially viable plantations.

Morrison's sawmill, Strahan

Sales arrangements

Forestry Tasmania is the principal supplier of special species timber logs. Special species timber sawlogs are classified as Category 4 logs or as utility logs. This classification is based on length, diameter and a number of other factors related to quality. Category 4 logs are those veneer logs and sawlogs that meet the Category 4 specification (Appendix 4.5). Utility logs are those other special species timber logs that can be sawn, but that do not meet the Category 4 specification.

The logs are made available by either administered supply or tendered supply.

Prices for special species timber logs

Forestry Tasmania's log prices for special species timbers have been determined by negotiation with those customers that receive logs by administered supply. The negotiated rates are also the base price for tendered supply by contract, with tenderers submitting a premium above (or a discount below) the negotiated rate.

With the exception of Huon and King Billy pine, the log price payable to Forestry Tasmania for most Category 4 logs is about $60 per cubic metre. The log price payable for Huon and King Billy pine is about $105 per cubic metre. For pale coloured and other less marketable logs (e.g. silver wattle), the log price is about $35 per cubic metre. Most rates are due to increase by another $10 per cubic metre from 1 January 1997 and to be reviewed at least annually.

The log prices are flat rate with no adjustment for cartage distance, logging difficulty and forest quality. However, Forestry Tasmania log prices may be reduced by up to 10 per cent in cases where road access is constructed by one of its customers. This is commonly the case in management units, where road costs per cubic metre are significantly higher than in eucalypt forests. This is due largely to the lower recovery of logs per kilometre of road, arising from the use of light selective harvesting.

Craftwood Furniture Supplies, Huon Valley

Britton Brothers Sawmill - Smithton

Britton Brothers sawmill is a third-generation family business. The business, is run by, Glenn, Don and Ross Britton. In the early 1900s, their grandfather and his brother moved from the Mallee in Victoria and set up a sawmill in the bush near Smithton.Twenty-five years ago the sawmill was rebuilt in town. The business turns over about $5 million per year and employs 70 people,

Following the investment of over $1 million in the last 18 months, the mill has state-of-the-art equipment for making mouldings and veneers from a range of specialty timbers. Half the mill's timber is specialty species - blackwood, myrtle, celery-top pine, sassafras and leatherwood - the other half is Tasmanian oak, a eucalypt. The wood is used to make furniture and fittings for shops, offices and houses.

Glenn Britton said that the recent investment was a gamble made with his hand on his heart. 'We can't know the future of the industry because there is a sovereign risk hanging over us.' That risk is the possibility of governments deciding to limit the sawmill's access to timber in native forests.All the mill's timber comes from native forests. Two-thirds comes from State forests managed by Forestry Tasmania, one-third comes from native forests on private land, some owned by Britton Brothers.

In the public forests, Subcontractors fell the trees and truck them to the mill. There they are sawn green, air dried, kiln dried and reconditioned, docked and moulded. Though some of the wood is sold rough, Britton Brothers and their contractors have the capacity to turn a standing tree into the architraves and other fine finishes.

'Times are tough at the moment,' said Glenn Britton. 'The building industry is in the doldrums.' A change of 5 or 10 per cent in demand causes chaos in the price of the products. The mill's competitors are other mills in Tasmania and Victoria (for blackwood), imported woods, extruded boards with veneers of wood or formica (which are used for a lot of office furniture), and lacquered boards.

The Tasmanian specialty timbers are a high-quality niche market, offering the ability to sell at a higher price but requiring extra work. Logs are smaller and knottier, with a lower proportion of millable wood and producing smaller pieces of finished timber than eucalypts or oregon. Handling the small pieces requires more labour. Over the last decade there has been a growing demand for the special timbers but the mill does not have the volume of raw material to satisfy the demand.

Uncertainty over the availability of the resource affects the business's expansion plans. The brothers put off their investment plans for 10 years, until the plant and equipment became old and dilapidated. Following the 1991 Tasmanian forest strategy they decided to buy the new equipment. Now they are concerned about another round of inquiries. 'The future of our business revolves around getting complementary federal resource security in the form of a signed regional forest agreement,' said Glenn Britton. 'We need to be expanding the business if possible, not standing still. That's why we have gone into further value adding. But there is a limit to how far you can go.'The uncertain supply of wood also means that whether the market is strong or weak the mill has to take its quota from the forests. Glenn Britton believes that, with a sufficient area allocated to timber production and the current forest management practices, the timber supply would be sustainable.

In Smithton, the wages paid by Britton Brothers supports staff, subcontractors and their families who spend much of their income at local businesses. The mill also buys goods and services from local engineering and other firms. The royalty payments support the local staff and statewide operations of Forestry Tasmania. Other payments, such as taxes and the electricity bill, support other statewide services.

Clifton Furniture - Launceston

Clifton Furniture is a manufacturer of solid timber domestic furniture. Its range includes everything in the household, including dining suites, wall units, sideboards and bureaux. Begun 54 years ago by Cliff Walters, it continued as a family company until five years ago, when it was purchased by Dale Gillie, who had been employed by the firm as a manager.

Of the firm's raw materials, 99 per cent are sourced from within Tasmania. The business converts $300 000 of material inputs to $1.3 million in sales, meaning an added value of 330 per cent. The main timbers it uses are blackwood, which accounts for 75 per cent of its products, and Tasmanian oak (a label that covers several eucalypt species), 20 per cent. Less popular and usually required only for one-off orders are the reddish myrtle timber, the black-hearted sassafras and the pale golden huon pine.

Dale Gillie recalls that when he bought the business, in the middle of a recession, the furniture business was not a popular place for investors: 'It was like buying tickets on the Titanic for a while.' And the tough times since have taken their toll on the industry - a huge downturn in demand for Tasmania's quality furniture over the past five years has seen the closure of about half the businesses involved, Dale Gillie says.

Clifton has grown during that time, from 14 staff to a steady payroll of 20 employees, and Dale Gillie puts the firm's success down to investment in productivity improvements and an innovation in marketing, which has seen the launch of a new wood product, character blackwood.

Before Clifton developed the idea, two years ago, wood defects such as knots meant that on average 85 per cent of the blackwood log harvested ended up reaping either low or no return, being either pulped or simply burned as waste. Select-grade timber constituted only 15 per cent of the harvest. But the firm's marketing efforts have made a virtue out of the tree's defects, selling them as testimony to the character of the wood. This means another 25 per cent of the blackwood harvest can be used in furniture-making, providing access to a cheaper raw material and hence extending productivity of the forest. Within two years, the company has seen the popularity of character blackwood rise to the point where it generates 30 per cent of sales revenue.

For Clifton Furniture, the innovation extends its reach from targeting purely top-range customers to include the more price-sensitive middle-to-upper range of furniture consumers.

Australia is a net importer of furniture, so apart from the jobs the business sustains for local people, Dale Gillie sees its community benefit extending to import substitution, helping with the balance of payments. But there is another important benefit - an environmental one - reducing the Australian market for products from the notoriously unsustainable forestry operations of developing countries in Asia and the Pacific.

It is also arguable that the character blackwood innovation has been a major boost for the viability and sustainability of Tasmanian forestry and furniture, since the timber yield from harvested blackwood has gone up from a mere 15 per cent to around 40 per cent.

Dale Gillie would like to see the advantage of character blackwood pressed home with a promotional campaign aimed at environmentally aware consumers. By purchasing furniture made from this timber they would be taking a concrete step towards increasing the sustainability of Australian forestry, effectively plucking a useful product from what was formerly considered a waste stream.

He is hoping that the awareness of green issues among consumers will help counteract the price advantages enjoyed by imported products, price advantages that flow from the destructive forestry techniques and low wages in developing countries.

Shipwrights Point School of Wooden Boatbuilding - Huon Valley

Every two years the Shipwrights Point School of Wooden Boatbuilding employs three and a half regular staff and seven casual teachers, trains 10 students, consumes 8 cubic metres of high quality timber and builds seven boats worth about $180 000. The training offered is in high demand - 34 people from Australia, New Zealand, Japan and Canada applied recently for the 10 places in next year's intake. Training inquiries continue daily.

The immediate limit to growth is the finance needed to build another shed; the long-term limit is the amount of wood they can get.

John Young is a former Director of the Graduate Centre for Environmental Studies at the University of Adelaide. Since he built his first boat, a flat-bottomed punt, at the age of 11, he has also been an amateur boat builder. In 1991 he moved to Tasmania to build boats. 'Tasmania has everything you need to specialise in building wooden boats.'

He and his wife, Ruth, started running boatbuilding courses which are now accredited by the Tasmanian Training Authority. After two years of full-time study students get a diploma in wooden boatbuilding.

The students use traditional methods to build three kinds of boat - a punt, a clinker-built sailing dinghy and a carvel-built 9-metre yacht. Clinker is a method of building with planks that overlap. In carvel construction the planks are laid flush and then caulked.

Students craft the boats with hand planes, chisels, spokeshaves, drawknives and adzes, with some assistance from electric planes, saws and thicknessers. The yacht is commissioned, the smaller boats are sold on completion, finding buyers without difficulty. A 3-metre sailing dinghy costs about $5000.

The timber used most in the school is celery-top pine, which is good for many parts of boats including the decking on larger boats. Swamp gum (known as mountain ash on the mainland) is a strong, light timber good for stringers (the longitudinal parts of the hull), gunwales and deck framing. Tasmanian blue gum is used for the backbone of boats, including the keel. Huon pine and King Billy pine are used for clinker dinghies.

'We will probably run out of celery-top pine in 15 years,' said John Young. 'But it needn't happen.' King Billy pine has become very scarce and expensive.

Boatbuilding requires long planks with straight grain and no knots. Because many of the trees felled in a clearfelling operation are young, they are also small, offering few good planks in a tree. 'The celery-top pines often need another 300 to 400 years,' said John Young.

'The existing regime of replacing mixed native forest with eucalypt regrowth destroys the species needed for boatbuilding,' he said. 'We are an example of the commercial value of mixed forest.' He would like to see trees harvested at the rate of natural replenishment in the particular ecosystem, and harvested in a way that does not damage the forest as a whole or change its mix of species. As well as being critical of large-scale forestry, the school is also in opposition to parts of the conservation movement. 'We want to use old growth forests but in ways which maintain their ecosystems in their present shape.'

Tourists love the look and smell of the boat workshop, finding their way to the school from other parts of Australia and other countries. There is potential to build up the site as a tourist attraction, with former students setting up boatbuilding and restoration workshops nearby, or offering sailing classes and boat trips. But to achieve that potential, the availability of wood is crucial.

Morrison's sawmill - Strahan

Like any successful business, Morrison's sawmill in Strahan has had to adapt to survive. Ron, Reg and Roy Morrison built the sawmill on the waterfront in 1940. In those days waterborne logs of huon pine from the Gordon River were cut into long straight planks for boat builders.

Because of the loss of traditional timbergetting areas it is now very difficult to supply the boatbuilding industry. Roy's son, Randall Morrison, the co-owner and manager of the sawmill, has shifted the focus to wood suited to furniture making and other crafts. His source of supply is not trees standing in the forest but logs lying on the forest floor, left behind by earlier logging operations. Other wood has come from river valleys before they have been flooded by hydroelectric dams. The sawmill even uses logs that have been washed up on beaches.

Randall Morrison would like to specialise in huon pine but he cannot get enough wood to do so. His salvage operations are limited to 125 cubic metres of huon pine a year. His mill also cuts other specialty timbers - myrtle, sassafras, celery-top pine, leatherwood and blackwood.

The mill supplies craftsmen in Tasmania and on the mainland and, to a lesser extent, boat builders. Because the wood left behind is in short lengths or of low quality - the early timbergetters did not leave any good logs - Morrison's sawmill has had to find new markets, such as wall panelling, which can make use of short lengths of timber. However, the demand for huon pine is strong. 'We don't have to advertise,' said Morrison.

The mill adds value to the timber it gets. Rather than supplying green wood off the saw, as his forebears did, Randall Morrison dries the wood in a kiln. In the sawmill complex is a joinery shop where a joiner, a knifemaker and a wood turner add value in different ways. They rent space and buy wood from the sawmill.

More business growth has come from tourism. People, 100 000 of them a year, come to the mill to see the huon pine and to buy small offcuts, perhaps for turning at home. They visit the joinery shop to watch the craftspeople at work and to buy their wares.

Morrison's sawmill employs five people. It is a traditional operation - logs are pushed through the saw by hand and pulled out again. Subcontractors harvest the logs from the forest; a subcontractor with a fishing boat brings logs across the harbour.

The sawmill's contribution to the local economy is more than as an employer, even though, in a small town of 500 people, employing five people and using subcontractors makes a significant impact. In fact the mill is part of the tourist economy of Strahan, a major drawcard for people from other parts of Tasmania and the mainland. Operators in accommodation or travel use the sawmill to market their services. The waterfront plan for the town is designed around the sawmill, using it as the standard for other buildings. The sawmill is also a purchaser of the goods and services of local businesses.

Randall Morrison estimates that, salvaging huon pine at the current rate, his operation could be sustained for 70 years. The only way for his business to grow would be to add more value, probably by extending the joinery shop and building more displays for the passing tourists. Any extension of conservation areas would make his business less viable. The areas where his father and grandfather obtained huon pine, such as the Gordon and Franklin Rivers, are now part of the Western Tasmania World Heritage area. 'We're happy as long as there are no more chunks taken out of our supply areas,' he said.

Craftwood Furniture Supplies - Huon Valley

Craftwood Furniture Supplies is a partnership established eight years ago to merchandise and process specialty timbers. Its facility at Nicholls Rivulet near Cygnet in the Huon Valley comprises a sawmill with a kiln and racks for drying timber. As well as selling timber either green or dried, the business also arranges finishing on request.

'We're not a hardwood mill; we cut minor species, we cut understorey species,' a partner in the business, Pavel Ruzicka, explains. The business processes between 150 and 400 cubic metres a year, and pays royalties at rates varying between $25 and $60 per cubic metre. In addition it pays a tender premium to the government of $53 per cubic metre. Floatage, or transport charges, of $40 to 60 a cubic metre is paid to individual logging contractors or logging companies. Apart from the two partners in the business there is one employee.

The business began as a part-time activity for Pavel Ruzicka 13 years ago while he was working for the Mines Department and began utilising logs and other waste timbers left behind in logging coupes. He gained an appreciation for this timber while putting roads and helipads into remote areas of the State.

Nowadays it draws its resource from right across the southern half of Tasmania: extending north as far as the Fingal Highway, down to the south-east as far as Port Arthur and across to the south-west as far as the Arve Valley and over to Tarraleah.

'The extraction process that we're winning our logs out of at the moment is pulp-driven,' Pavel Ruzicka says. 'So the actual handling of the minor species can be quite time-consuming, and at times a problem for the logging contractors. The contractor is sometimes responsible for extracting the pieces tagged by the Craftwood Furniture Supplies team but, by and large, Forestry Tasmania organises recovery and sales.

According to Pavel Ruzicka, the firm sells to a myriad of customers, from joiners, fine furniture makers and boat builders to the makers of musical instruments and knife handles and to sculptors and carvers.

Regarding the value of business to the community, Pavel Ruzicka reasons that it is providing raw materials to small businesses, and so is supporting part of a sector that accounts for more than half the State's economic activity. As part of the tender system through which the business gains access to the craftwood resource, it has to undertake to supply timber for these smaller users.

Pavel Ruzicka sees the future of the industry as under a cloud because the pressure to preserve more areas of old-growth forest from logging is reducing the resource base necessary to allow sufficient time for regrowth forest to mature before harvesting. The species on which his business relies, such as myrtle, sassafras, black-heart tea-tree, celery-top pine and blackwood, all take 250 to 400 years to become really useful. Trying to use them at only 100 to 150 years results in undue waste because bark and sapwood are usually a lot thicker than in the mature tree, and excessive spring in the wood makes it more difficult to saw. This latter problem is particularly evident in blackwood, while myrtle and sassafras need time to gain colour.

For the short-term future of his business, Pavel Ruzicka sees a very good possibility of expanding to take in more processing of the timber he sells, to the point where he can offer a range of finished sizes ex-stock. But it depends on when the partners decide they have built up sufficient capital in their stocks of dried wood.

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Note that a bibliography of relevant publications, in addition to those references used in this report, is available on request from the Public Land Use Commission.

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4.1.7 Special species timbers

Special species timbers is a collective term for non-eucalypt tree species that occur naturally in Tasmania and are used for the production of veneer, sawn timber and other solid wood products.

It should be noted that craftwood (including special species timbers that are not generally suitable for sawing, but which are used for fine craft) is covered in Chapter 6, 'Other forest uses'. There is some significant overlap

between craftwood and sawn timber for many users of special species timbers.

Ten recommendations for special species timbers are included in the Forests and Forest Industry Strategy and have been substantially implemented over the last five years. These relate to the management of the timbers and the forests in which they occur, and to the distribution of the timbers to industry. The recommendations are the basis of current policies for special species timbers and for projections of future yield. The 10 recommendations are at Appendix 4.5.

Special species timbers are particularly dependent on the availability of public forests, including rainforests, for wood production. Blackwood is a potential exception, dependent on the degree to which owners of private land invest in blackwood plantations. Opportunities for the long-term supply of other special species timbers from private land are very limited. Stockpiles of durable species (particularly Huon pine) have been established to supplement supply over the next several decades.

The following aspects of the available resource are described:

- the characteristics of each of the major special species timbers;
- the characteristics of the forest types within which each of the special species occurs;
- the distribution of the forest types within which the special species occur, relative to land tenure, management classification and supply zone;
- the standing volume of special species timbers; and
- historic, current and future yields, relative to land tenure, species and supply zone.

A bibliography is available from the Public Land Use Commission, which details references additional to those referred to in this section and in Section 4.2.2. The bibliography is classified by subject area, listing publications relevant to legislation, policy, rainforest distribution, forest classification, conservation status and ecology. This bibliography lists references that are relevant to the management of Tasmanian forests for the supply of special species timbers. The bibliography emphasises recent information on rainforests and on wet eucalypt forests, because of the relative importance of these forests for the future supply of special species timbers.

The resource – species

Major species

With the exception of Huon pine and King Billy pine, the major species are found naturally in rainforests, wet forests, swamp forests and other native forests. In the long term, and if the current market demand for Tasmania's special species timbers continues, these species (with the exception of blackwood, Huon pine and silver wattle) can only be supplied from rainforests. Blackwood is available from swamp forests, rainforests, wet eucalypt and other native forests, and from plantations. Huon pine is available from rainforests (predominantly through the salvage of dead logs, limbs and stumps), stockpiles, and from the salvage of dead logs, limbs and stumps stranded or buried in rivers and on beaches. Silver wattle will continue to be available from wet eucalypt forests and, possibly, plantations.

Table 4.14: Major special species

Common Name	Scientific name	Forest type[1]	Endemic
blackwood	*Acacia melanoxylon*	R,W,S	-
celery top pine	*Phyllocladus aspleniifolius*	R,W	E
Huon pine	*Lagarostrobos franklinii*	R	E
King Billy pine	*Athrotaxis selaginoides*	R	E
myrtle	*Nothofagus cunninghamii*	R,W	-
sassafras	*Atherosperma moschatum*	R,W	-
silver wattle	*Acacia dealbata*	W	-

(Source Forestry Tasmania, November 1996)

[1] R - Rainforest, W - wet forests, S - swamp forests, O - other forests

Blackwood timber is golden brown to dark brown, sometimes with reddish tints or streaks and sometimes with wavy grain. It has a high sheen and is one of Australia's most decorative timbers. It is used for panelling, sliced veneer, cabinet work and furniture.

Celery top pine timber is light cream to very pale brown, with distinct growth rings. It is hard, strong, durable and stable and is easily worked and bent. It is used for panelling, sliced veneer, cabinet work, joinery and boat building.

Huon pine timber is light cream to yellowish, with obvious fine growth rings. It sometimes features a fine 'birdseye' pattern. The timber is soft, even, light, stable, smooth, oily, easily worked and takes a high polish. It is regarded by many to be the most durable Australian timber and is used for boat building, joinery and furniture.

King Billy pine timber is pink to reddish with distinct closely spaced growth rings. It is stable and very soft, with straight grain and fine texture. It is easily worked and bent and is used for boat building and joinery. It is highly regarded by some for musical instruments.

Myrtle timber is pale pink to red brown, with a straight or slightly interlocked grain and wavy figure. It is hard and is moderately strong and durable. It is a beautiful furniture and cabinet timber and is also used to produce sliced veneers and panelling.

Sassafras timber is pale grey to light brown, with fine texture and straight grain. Mottled black staining produces highly attractive patterns in the timber, prized for joinery, furniture, panelling and specialty work. The timber bends well and takes a high polish.

Silver wattle is light brown to pinkish, with similar physical properties to blackwood. It is used for panelling and flooring. Although not favoured, it has potential for furniture and other feature applications.

Minor species

The minor species are found variously in rainforests, wet forests, swamp forests or dry forests. Some are highly prized for particular properties or features that they exhibit, but most are available in much smaller quantities than the major species. In some cases, long term market demand for these species can only be supplied by harvesting them from rainforests.

Table 4.15: Minor special species

Common name	Scientific name	Forest type[1]	Endemic
black wattle	*Acacia mearnsii*	D	-
blanket bush	*Bedfordia salicina*	W	E
bulloak	*Allocasuarina littoralis*	D	-
cheesewood (also known as wallaby wood or tallowwood)	*Pittosporum bicolor*	R,W	-
dogwood	*Pomaderris apetala*	W	-
goldey wood	*Monotoca glauca*	R,W	E
horizontal	*Anodopetalum biglandulosum*	R,W,S	E
honeysuckle	*Banksia marginata*	D	-
lancewood(also known as satinwood or tallowwood)	*Phebalium squameum*	W	-
leatherwood	*Eucryphia lucida*	R,W	E
manuka	*Leptospermum scoparium*	R,W,S	-
musk	*Olearia argophylla*	R,W	-
native cherry	*Exocarpos cuppressiformis*	D	-
native laurel	*Anopterus glandulosus*	R,W	E
native olive (also known	*Notelaea ligustrina*	R,W	-

as dorrel)			
native pepper	*Tasmania lanceolata*	R,W	-
native plum	*Cenarrhenes nitida*	R,W	E
native willow	*Acacia mucronata*	R,W,S	-
needlewood	*Hakea lissosperma*	W	-
pinkwood	*Beyera viscosa*	W,D	-
prickly box	*Bursaria spinosa*	D	-
scented paperbark	*Melaleuca squarrosa*	R,W,S	-
sheoak	*Allocasuarina verticillata*	D	-
swamp paperbark	*Melaleuca ericifolia*	S	-
woolly tea tree	*Leptospermum lanigerum*	R,W,S	-

(Source Forestry Tasmania, November 1996)

(1) D - dry forests, R - Rainforest, W - wet forests, S - swamp forests, O - other forests

The resource - forest types Detailed information about the distribution of different forest types is presented in Section 4.1.1 of this report. The following is a brief definition of each of the general forest types, classified on the basis of floristic composition. Treatment of eucalypt forest types in this classification is slightly different to that used in Section 4.1.1.

Rainforests

Rainforests are closed forests, generally dominated in Tasmania by species from the genera *Nothofagus*, *Atherosperma*, *Phyllocladus*, *Athrotaxis*, *Lagarostrobos* or *Diselma* (Cheshunt pine). Tasmanian rainforests are cool temperate forests able to regenerate without broad-scale disturbance (e.g. fire). They are found in the higher rainfall areas of the western half of the State and in the northeast highlands, with more restricted distribution in the north, east and southeast.

Forests in which more than five per cent of the canopy cover is represented by eucalypts are classified as eucalypt forests (see below), not as rainforests.

Wet forests

Tasmanian wet forests are dominated by a number of eucalypts or, less commonly, acacias. The dominant species depend on fire for successful regeneration.

Mixed forests are wet forests in with rainforest tree species the understorey.

Wet sclerophyll forests are wet forests in which the understorey consists of broad-leaved shrubs and soft ferns.

Dry forests

Tasmanian dry forests are dominated by eucalypt species or, less commonly, *Allocasuarina* or *Callitris* species. These forests mostly depend on fire for successful regeneration.

Swamp forests

Tasmanian swamp forests are wet forests that are seasonally inundated. They are dominated by one or more of *Acacia melanoxylon*, *Melaleuca ericifolia*, *Melaleuca squarrosa* or *Leptospermum lanigerum*.. Swamp forests are most extensive in the northwest of the State.

Management Tasmania's forests consist of a complex variety of vegetation types that have significant values for conservation and tourism and for the sustainable production of special species timbers.

The conservation needs of Tasmania's rainforests, wet forests, dry forests and swamp forests have been assessed on both a Statewide and regional basis. Relevant investigations commenced in 1974 and, in particular, have been a major emphasis of a diverse range of research projects over the past 15 years. A significant objective of the research has been to ensure that representative areas of each vegetation type are reserved. Information on forest reservation and management in Tasmania is summarised in Table 4.16. More detailed information is presented in Section 4.1.1 of this report.

During the past 15 years the production of special species timbers from rainforests has been restricted to small areas adjoining wet forests scheduled for eucalypt veneer log and eucalypt sawlog production. Supply at accustomed levels during this period has only continued because of salvage from areas required for hydro electricity dams and from easements. A summary of past annual supply quantities from public forest is presented in_Table 4.20.

Community expectations for the management of Tasmania's rainforests have been canvassed and are embodied in the Forests and Forest Industry Strategy. In particular:

- 14.3 per cent of rainforest has been set aside in recommended areas for protection and another 16 per cent is on the Register of Deferred Forest Land. These amounts are additional to the 40 per cent in existing reserves;
- 21.7 per cent of rainforest has been set aside for multiple use management, including the production of special species timbers. Many of these areas are in central western and northwestern Tasmania;
- target supply volumes for special species timbers have been agreed. These target volumes aim to meet the reasonable market demand for products made from special species timbers; and
- the need for a competitive market system that allows for the entry of new efficient firms has been agreed.

The growth and regeneration habits of Tasmania's rainforests have been assessed, to ensure that management for the production of special species timbers is ecologically sustainable, that is, on a regional basis, such management will not permanently modify the species composition of the plant communities, or the species composition and demography of the animal communities that occur in the rainforests.

Appropriate silvicultural and regeneration systems for rainforests, wet eucalypt forests, dry eucalypt forests and swamp forests have been developed on the basis of research. This research will continue.

Management prescriptions

Management for special species timbers is also designed to take account of biodiversity of plants and animals and to protect other important environmental values.

These management prescriptions will be considered in more detail in the companion report into ecologically sustainable forest management.

Long-term sustainable supply of wood to industry

Forestry Tasmania manages suitable State forests to supply special species timbers at annual levels that are sustainable and sufficient to meet the reasonable requirements of businesses using these timbers. This statement recognises that management for special species timbers is:

- a high priority in some areas of State forest, to be achieved by management regimes that optimise the long-term supply of these timbers; and
- a lower priority in other areas of State forest, in which management regimes are designed to optimise other products including the long-term supply of eucalypt veneer logs and eucalypt sawlogs.

Special species timber management units

Special species timbers management units are large patches of forest managed for multiple uses that include, as a major priority, the sustainable production of special species timbers. The units consist primarily of rainforests, wet forests and swamp forests. Other forest types are included where this is necessary to achieve sensible management boundaries. Most units have been selected in large contiguous areas of forest to allow dispersal of harvesting over time to protect biodiversity and, where possible, to conserve smaller remnant patches of rainforest.

Currently, 36 units, totalling 103 700 hectares, have been identified. These are in the northwest, west and south of the State (see the section below titled 'Maps and tables'). Of the total area, 72 300 hectares are in multiple use forests currently available for wood production and 31 400 hectares are in deferred forests currently unavailable for wood production. The units on multiple use forests currently available for wood production provide a harvestable area of 24 600 hectares.

It is proposed that a small additional number of units will be identified in the northeast and south of the State, if suitable areas can be found. In addition, swamp forests in the Circular Head supply zone will be managed as a special species timber management unit.

In order to achieve the supply targets for special species timbers recommended in the forest industry strategy on a sustainable basis, additional areas of rainforest will be needed in the longer term. The required additional area (11 400 hectares) represents the harvestable area within the 31 400 hectares of special species management units on deferred forests that are currently unavailable for wood production.

Supply of special species timbers from the deferred forests is conditional upon the completion of scientific studies to assess the conservation significance of these areas (to be done as part of the comprehensive regional assessment), together with the processes identified in the *Public Lands (Administration and Forests) Act 1991 (Tas)*.

Planning for supply from special species timbers management units is integrated with planning for the supply of these timbers from other sources.

Planning for the supply of special species timbers from the management units aims to disperse harvesting operations so as to achieve the maximum practicable period between harvesting operations in adjacent areas.

Timbers are supplied from management units using a range of silvicultural techniques, mostly based on selective harvesting. A harvest age of at least 70 years is applied in blackwood areas. In the other units, a harvest age of at least 200 years will be applied. Silvicultural treatments are applied following harvesting to achieve adequate regeneration that replaces harvested trees. These treatments are generally those that facilitate natural regeneration.

Other sources of special species timbers

Although most State forests are managed to produce eucalypt veneer logs and sawlogs, all forest operations are integrated so that marketable special species timbers are harvested and segregated.

Other sources are the Hydro Electric Commission stockpile and, potentially, blackwood plantations.

Maps and tables

MapS&E 4.5, which accompanies this report, shows the distribution of forest types containing special species timbers. It shows all patches for which either myrtle or other special species timbers are evident from the stereoscopic interpretation of aerial timber management units.

The map should be viewed in conjunction with Map CRA 1.1 'Land tenure in Tasmania' and Map S&E 4.1 'Forest resource types in Tasmania', as well as with the tables that follow.

Table 4.16: Forest types - by tenure and management classification [(1)]

	Wet forest	Dry forest	Rainforest
World heritage area and State reserves	180 350 (20.4)	245 480 (15.4)	224 420 (39.7)
Other reserves	12 550 (1.4)	27 780 (1.7)	250 (<1)
Recommended areas	26 380 (3.0)	50 550 (3.2)	80 630 (14.3)

for protection			
Deferred forests	58 000 (6.6)	66 160 (4.2)	90 320 (16.0)
Subtotal - areas formally reserved from harvesting	**277 280 (31.4)**	**389 970 (24.5)**	**395 610 (70.0)**
Multiple use forests available for harvesting	404 180 (45.8)	420 140 (26.4)	122 770 (21.7)
Private	133 180 (15.1)	657 640 (41.3)	21 460 (3.8)
Other	22 540 (2.6)	63 760 (4.0)	12 410 (2.2)
Total	**882 600**	**1 593 900**	**565 000**

(Source Forestry Tasmania, November 1996)

(1) In hectares & (percentages)

Table 4.17: Public native forest with significant special species timbers

			Gross area (1)	**Net area** (1)	**Net volume** (2)	**Annual yield** (2)
STMU(3)	DF	Ongoing(5)	31 000	11 000	390 000	2 300
	MUF	Ongoing	72 000	25 000	590 000	5 800
Other(4)	DF	Ongoing	n.a.	2 4008	44 000	340
		Current(6)	n.a.	3 500	20 000	n.a.
	MUF	Ongoing	n.a.	41 000	720 000	7 500
		Current	n.a.	32 000	180 000	n.a.

(Source Forestry Tasmania)

(1) In hectares

(2) In cubic metres

(3) STMU - Special species timbers management units.

(4) Public native forest outside special species timbers management units

(5) Ongoing - Areas expected to produce special species timbers for current and subsequent rotations.

(6) Current - Areas expected to produce special species timbers for the current rotation only.

DF- deferred forest

MUF - multiple use forest

Table 4.18: Public native forest with significant special species timbers , by forest type[1]

			Eucalypt (low density)	Myrtle types	Other forest	Total
STMU[2]	DF	Net area	480	10 000	470	11 000
		Volume	2 600	370 000	9 700	390 000
	MUF	Net area	1 500	17 000	6 400	25 000
		Volume	8 900	380 000	170 000	560 000
Other[3]	DF	Net area	3 500	1 800	640	6 000
		Volume	20 000	34 000	9 700	63 000
	MUF	Net area	32 000	21 000	20 000	73 000
		Volume	180 000	390 000	330 000	890 000
TOTAL		**Net area**	**37 000**	**50 000**	**27 000**	**110 000**
		Volume	**210 000**	**1 200 000**	**520 000**	**1 900 000**

(Source Forestry Tasmania)

[1] net areas in hectares, volumes in cubic metres

[2] STMU - Special species timbers management units.

[3] Public native forest outside special species timbers management units

DF - deferred forest

MUF - multiple use forest

Eucalypt (low density - Forests with a low density of eucalypts and a significant component of special species timbers.

Myrtle types - Forests dominated by myrtle.

Other forest - Forests with very few or no eucalypts or myrtle and a significant component of special species timbers.

Specifications for eucalypt veneer logs and sawlogs

1. Category 1 sawlogs and flitches

(a) Minimum dimensions

(i) length - 3.6m; and

(ii) diameter - 40cm.

(b) Permissible defects

(i) end defect limits - as specified in Table 1 of this Appendix 4.1; and

(ii) limbs and bumps (not including epicormic growth) - one significant limb or bump per 3m of length; and

(iii) spiral grain - not exceeding 0.25m circumferential displacement per 2m of length (one in eight); and

(iv) scars (open or overgrown) - a total length of scar or scars not exceeding 2m per 3.6m of log length, provided that the wood adjoining the scar is sound or has surface rot only and is not badly affected by borers; and

(v) sweep - not exceeding 1/7 of mid diameter underbark in any 2.4m length.

(c) Specification split logs

Log sections 3.6m long or greater split from a log with a small end diameter exceeding 60cm (minimum cross sectional area of flitch 40cm x 30cm) and which yield a minimum sawn flitch 150mm x 150mm free of heart, sap and defect.

(d) Specification sawn flitches

(i) half and quarter logs sawn from a log meeting the minimum dimension and having permissible defects meeting (b)(i), (b)(ii),(b)(iii) and (b)(v) above; or

(ii) sawn flitches with a minimum length of 2.4m and minimum section of 150mm x 150mm and meeting (b)(iii) above.

2. Category 2 sawlogs and flitches

(a) Minimum dimensions

(i) length - 2.4m; and

(ii) diameter - 30cm,

provided the logs do not contain either Category 1 or Category 3 sawlogs.

(b) Permissible defects

(i) end defect limits - as specified in Table 1 of this Appendix 4.1; and

(ii) limbs and bumps (not including epicormic growth) - two significant limbs or bumps per 2.4m of length; and

(iii) spiral grain - not exceeding 0.25m circumferential displacement per 2m of length (one in eight); and

(iv) scars (open or overgrown) - a total length of scar or scars not exceeding 2.4m per 2.4m of log length, provided that the wood adjoining the scar is sound or has surface rot only and is not badly affected by borers; and

(v) sweep - not exceeding 1/7 of mid diameter underbark in any 2.4m length.

(c) Specification split logs

Log sections of or exceeding 2.4m in length split from a log with a small end diameter exceeding 50cm (minimum cross sectional area of flitch 30cm x 30cm) and which yield a minimum sawn flitch 150mm x 150mm free of heart and sap.

3. Category 3 sawlogs and flitches

(a) Minimum dimensions

(i) length - 3.6m; and

(ii) diameter - 30cm underbark.

(b) Permissible defects for log sections not exceeding 40cm underbark
Nil.

(c) Permissible defects for log sections exceeding 40cm underbark

(i) end defect limits - as specified in Table 1 of this Appendix 4.1; and

(ii) limbs and bumps (not including epicormic growth) - one significant limb or bump per 3m of length; and

(iii) spiral grain - not exceeding 0.25m circumferential displacement per 2m of length (one in eight); and

(iv) scars (open or overgrown) - a total length of scar or scars not exceeding 2m per 3.6m of log length, provided that the wood adjoining the scar is sound or has surface rot only and is not badly affected by borers; and

(v) sweep - not exceeding 1/7 of mid diameter underbark in any 2.4m length.

(d) Specification split logs

Log sections 3.6m long or greater split from a log with minimum small end diameter exceeding 60cm (minimum cross sectional area of flitch 40cm x 30cm) and which yield a minimum sawn flitch 150mm x 150mm free of heart, sap and defect.

(e) Specification sawn flitches

(i) half and quarter logs sawn from a log meeting the minimum dimension and has permissible defects meeting (c)(i), (c)(ii), (c)(iii) and (c)(v) above; or

(ii) sawn flitches with a minimum length of 2.4m and minimum section of 150mm x 150mm and meeting (c)(iii) above.

(f) Unacceptable defect

Severe end splitting (flying) is an unacceptable defect.

Table 1 Limit of end defect in logs

	Eucalypt	**Special species timbers**
End diameter (cm u.b.)	**Defect limit in (cm u.b.)**	**Defect limit in (cm u.b.)**
40 to 49.9	10	15
50 to 59.9	15	20
60 to 69.9	20	25
70 to 79.9	25	30
80 to 89.9	30	35
90 to 99.9	35	40
100 to 119.9	40	45
120 to 139.9	50	50
140 to 169.9	60	60
170 to 199.9	75	75
200 to 229.9	90	90
230 and over	120	120

4. VQ1 veneer logs and flitches

Logs	**Flitches**
Species	
E. regnans preferred but other light colour species acceptable	As for logs
Colour	
Pale, at least "oak" colour	As for logs
Diameter	
45cm minimum end diameter underbark	150mm x 150mm (minimum)
Length	
Minimum length of 2.6m	As for logs

4. VQ1 veneer logs and flitches (cont.)

Logs	Flitches
Split sections	
2.6m lengths of 45cm log radius	Not applicable
Condition	
Bark off and end greased	Covered and end greased
Shape	
Flared or fluted butts acceptable	Accurately
Occluded bark not acceptable	dimensioned
Log shape not critical	
Heart	
Can be off-centre	Not acceptable
Radial split	
Acceptable if flitches of 150mm x 150mm can be sawn from the log	Not acceptable
Spiral grain	
1 in 35, or 75mm in a minimum 2.6m length	Not acceptable
Sweeps or bends	
Not acceptable in any veneer billet	Not acceptable
Knots	
One knot per 2.6m length acceptable, the diameter of the knot to be no greater than 20% of the log diameter	Not acceptable
Pin Holes	
Not acceptable	Not acceptable
Gum	

4. VQ1 veneer logs and flitches (cont.)

Logs	Flitches
Acceptable only near heart and sap	Not acceptable
Hob Nail	
Not acceptable	Not acceptable

Shatter	
Not acceptable	Not acceptable

5. VQ2 veneer logs

Any complete log which does not meet the specifications for VQ1 veneer logs set out in Section 4 of this Appendix 4.1, but which contains at least one 250mm x 250mm flitch meeting the specification for VQ1 veneer flitches set out in Section 4 of this Appendix 4.1.

VQ2 veneer logs should be barked and end greased.

6. VR veneer logs

Unless the specifications for VR veneer logs are set out in the Forestry Regulations 1993 (Tas), the Forest Industries Association of Tasmania will be advised by Forestry Tasmania.

VR1 veneer logs should be barked and end greased. VR veneer flitches should be kept covered and end greased.

Review of Forestry Tasmania's sustainable yield methodology

1. Executive summary

This report examines the basis of Forestry Tasmania's calculation of native forest sustainable yields and plantation yields being used in the 1996 Native Forest Resource Review. The approach adopted was to review the existing documents about the resource data and analytical procedures, and consult those responsible for different segments of the work. A limited amount of data analysis was done to illuminate some critical aspects of the complex process of estimating forest yield.

The report considers separately the various components of the system of data collection and processing, viz. area measurement, forest inventory, growth estimation, simulation and optimisation, and finally calculation of sustainable yield.

1.1 Area measurement

Many potential sources of error are present when estimating the net areas available for timber production, i.e. those contributing to the sustainable yield. Perhaps the most important is in mapping the forest types from air photography. We consider that a better way of testing the accuracy of this process is needed. However, the process of forming provisional coupes is significantly better than that formerly used and superior to that used in most other Australian forestry organisations. Although the complexity of the estimation process makes it impossible to quantify the cumulative error, we believe that its effect on the estimation of future yields will be small.

1.2 Forest information

The quality of information about the current resource and its past growth depends on the quality of inventory data collected in the field and on the representativeness of the sample. We expect that measurement errors would be minimised by the formal training of the Forest Assessor, the detailed instruction manuals, the training of the measurement crews, and the formal requirements for the Assessor to check a sample of measurements. Most of the measurement procedures conform to the Draft Code of Practice for Forest Mensuration in Australia.

The designed sampling intensity of 2 permanent or 4 temporary plots / 500 hectares for selected strata (on average) of native forest is at least as good as that for the other States in Australia. Some potential sources of bias in the sampling procedures have been identified. However monitoring of yields through the marketing system and destructive subsampling indicate that any bias is small and can be corrected by calibration. Overall, it is our opinion that the estimates of the forest statistics are relatively unbiased, and the precision achieved is appropriate for the level of management of Australian eucalypt forests.

1.3 Growth estimation

Future growth is estimated from models based on the past growth of frequently-measured sample plots and research plots. Our review of the growth models to be used in estimating future yields from the Tasmanian forests has revealed a range of situations. The models developed for eucalypt plantations are undoubtedly the best possible but are largely derived from external data since the plantations are very young or not yet existing. The models for regrowth forests are based on exhaustive analysis but have not yet been subjected to rigorous validation. We believe that the regrowth models are the best that can be derived but we cannot evaluate their reliability. These are perhaps the most critical growth models of all.

The common assumption that mature forests have zero merchantable volume growth needs exploration and confirmation. The methods for dealing with multiple-aged forests are still under investigation but, given the time and data constraints, current proposals are at least plausible. The methodology proposed for extrapolating the condition of uneven-aged forests is similar to that used in other States but leaves much to be desired. Although these forests contribute a quarter of current yields, they are not likely to continue to do so because of their low productivity, so the lower reliability of forecasts may be tolerable.

In general, we are confident that the growth prediction models as described to us match those of most other State forest services and in some aspects are of world class. However, there is some uncertainty about their reliability because much of the work is still in progress and testing, validation and documentation have not yet been completed.

1.4 Simulation and optimisation

The inventory data and growth models are brought together in a decision support system called FIPS (Forest Inventory and Projection System). The system appears to be relatively "user-friendly" and the results of any inventory inquiry or modelling exercise are easily observed which makes it unlikely that major errors will pass undetected. FIPS also records the various assumptions and weighting that are available to the user when making simulations which allows the process to be audited when appropriate. We consider that FIPS is an appropriate and useful tool for use in the sustained yield calculations.

The output from FIPS can be passed to a linear programming optimisation system, WOODSHED, which can calculate the maximum sustainable yield available from a region subject to resource and other constraints. WOODSHED is a suitable tool for making decisions concerning where and when harvests can be made. The program has been in use for several years, so any errors should have been detected by now. The opportunity to consider every coupe as a land unit in the optimisation process means that a much better degree of site specificity will be possible than in similar processes in other States.

1.5 Sustainable yield calculations

The final sustainable yield calculations will result from careful analysis of many optimisation runs where parameters are slightly varied. Our expectation is that the joint demands for wood production and conservation values will ensure that strong pressures will be placed on the system, necessitating very careful scrutiny of all system components. Sensitivity analysis on the final outcomes will be useful for identifying critical data items and better perceiving where improvements are needed.

1.6 Conclusions

In the course of this consultancy we have examined a variety of evidence concerning the data and processes which will form the basis for the new sustainable yield calculations. It appears to us that due care has been taken in collecting and processing the data, and wherever possible, mechanisms for reducing or tracing errors have been instituted.

It is our best judgement that the reliability associated with the final estimation will be as good as or better than that for forested regions in other States of Australia. It should be substantially better than that of the 1990 estimates. Not only is the database better organised and better systems for simulation and optimisation are in place, but substantial improvements have been made to the growth models and in validating the inventory data against actual removals in harvesting.

Because it is not possible to define exact errors, the reliability of the final results depends on the quality of the people collecting and analysing the data. We gained the impression that they represented a team that was striving for excellence in their work and had a professional vested interest in devising a process for yield estimation that would stand up to intense scrutiny.

Appendix 4.3: An appraisal of Tasmania's wood yields from native forests and plantations (an extract) - Turner 1996

Executive Summary

Aim of the Review

The aim of this appraisal was to conduct an evaluative review of the appropriateness of the datasets, models, systems and methodology used in the calculations of the sustainable yield and/or continuing yield of sawlogs and pulpwood from public and private plantations in Tasmania and from the private native eucalypt forests. This supplements the review done by Turner, Brack and Wood earlier this year of Forestry Tasmania's sustainable yield methodology for the Crown native forest resources.

Crown Native Forests

The data, models and methods used by Forestry Tasmania (FT) in forecasting future yields from the Crown native forests were reviewed in the earlier report. It was clarified that the same process is used to estimate current (and future) pulpwood yields as sawlog yields. The development of growth models is a continuing process in FT. In recent months there has been continued testing of the single-aged regrowth model, further development of the models for multiple-aged stands and investigation of the growth of over-mature trees.

The already acceptable processes for yield forecasting for the Crown native forests are continuing to be evaluated and improvements put into place.

Private Native Forests

A complete Private Forest Resource Inventory (PFRI) was conducted in 1995 by FT for the Forests and Forest Industry Council and its implications have been reported to Private Forests Tasmania (PFT). All private forestlands have now been photo-interpreted using the same methods and standards as used for Crown forests. Discount factors have been derived to estimate nett productive areas. Environmental discount factors were derived from an expert panel and other sources. Another discount factor was the reduction in area available for logging due to owners' intent not to log. This discount was derived from a questionnaire survey conducted by independent consultants for PFT in 1996, a commendable approach.

Planning staff within FT were also employed as consultants by PFT under strict confidentiality provisions to model the private forest data using FT planning models.

No plots were measured on non-industrial forestlands in the recent PFRI. Pulpwood and sawlog yields were ascribed to forest classes in the various regions using data from various sources. Yield tables were derived separately for clearfell and partial cut regimes. A critical unknown is whether non-industrial private owners will significantly shift to less harsh regimes than clearfelling; this is partly accounted for by the assumption in this inventory that the drier eastern forests will be managed under partial cutting.

The exception to the above is the data supplied by North Forest Products (NFP) which maintains its own GIS and uses methods similar to FT for typing and estimating nett areas. NFP provided PFT with their estimates of future pulpwood yields using their linear programming-based optimiser called "Woodstock". These data should be as accurate as FT data but their aggregation for commercial confidentiality makes them difficult to assess.

The optimisation tools, FT's Woodshed and NFP's Woodstock, are both capable of doing the kinds of scenario analysis needed to consider sustained yield and continuing yield strategies in the longterm.

Crown hardwood and pine plantations

Crown pine plantations are included in the FT GIS database. The inventory method is similar to that used in other pine regions of Australia and the intensity of sampling is more than adequate for regional decision-making. A recent Pine Log Quality Inventory has updated information on product outturns. It is expected that hardwood plantations will be assessed similarly

A full suite of growth and yield models have been developed for Pinus radiata plantations by FT biometricians and more recently for E. nitens . The growth models have been developed using modern statistical analysis, and can be considered in the ranks of international best practice. The models have acceptable error properties, even though there is no indication that they have been thoroughly tested against independent data. The pine models have been incorporated into a simulator called the "Plantation Integrated Management System" which can be run using either stand or tree models. The simulator is quite flexible and can output to spreadsheets or to the Woodshed optimiser.

The total inventory and analysis package is a well integrated system for managing information about pine plantations and could be easily extended to hardwood plantations, as the need arises. It certainly is in the forefront of such systems in Australia. Private hardwood plantations Locations of private plantations were collected in the PFRI process or have been obtained from the databases of the large industrial companies.

Non-industrial eucalypt plantations were assigned in the PFRI to one of four productivity classes to allow estimates of current volumes and future production. The data is rudimentary, but improvement could be relatively expensive. The proportion of the resource that will grow on to sawlog size is a rough estimate: the next grower intent survey may be able to elicit better information on this. For current strategic planning purposes these estimation procedures may be considered adequate, but better monitoring processes need to be developed.

NFP, the major eucalypt plantation grower, does a 1% sample at age 7, and then assigns stands to productivity classes as the basis of estimation of future pulpwood volumes. Current native forest is also classified for plantation potential. The evaluation of the industrial eucalypt resource is hampered somewhat by commercial confidentiality considerations; some companies have degraded the resolution of their data and provided only smoothed wood flows. Private pine plantations A productivity ranking based on spatial analysis of the relationship between environmental variables and the productivity of Crown forests in the same region was used to assign volumes and yield tables to non-industrial pine plantations.

The major industrial owners of pine plantations are NFP and ANM. NFP is in the process of liquidating its pine resource and converting to eucalypt plantations. ANM uses an inventory method similar to that of FT. Most industrial growers use FT growth models for their projections. As for the hardwood plantations, industrial softwood owners have supplied aggregated estimated future yields.

Because of the longer history of growing pine in the state, their growth can be predicted with more confidence than for the eucalypt plantations. Uncertainties are created by the difficulty of predicting the rate of conversion of NFP's plantations and the lack of inventory plots on the non-industrial plantations.

Overall evaluation

Tasmania now has a database of its commercial forests and wood production potential that is not likely to be excelled in its completeness by any other forest agreement region. The quality of the data is however highly variable, varying from more than adequate for strategic planning to barely adequate. When all of the data are considered jointly it will be possible to assess whether the most critical elements have adequate precision for regional analysis. Sensitivity analysis may be needed to determine how critical the poorer quality information will be in determining regional estimates of sustainable and continuing yields.

Given the constraints which restrict information collection, in particular for the private forest sector, it is evident that Tasmania has made a concerted effort to produce a data gathering and analysis system which is modern, scientifically valid and robust and should produce wood flow estimates which are adequate for regional planning. Certainly the processes and systems can be considered best practice to at least Australian standards.

Net Standing volumes

Table 1 Net standing volume by major species and management classification, for each supply zone(1)

Supply Zone			MYR	SAS	BLA	SIL	CTP	HKP
Bass District								
Other	DFL	Ongoing	580	78	54	2408	0	0
	MUFL	Current	6 200	6 200	6 200	6 200	6 300	0
		Ongoing	46 000	11 000	18 000	100 000	9 600	0
Circular Head District								
STMU	DFL	Current	110	44	25	0	0	0
		Ongoing	74 000	5 700	2 300	83	1 700	0
	MUFL	Current	2 300	920	650	120	620	0
		Ongoing	99 000	20 000	140 000	1 400	18 000	0
Other	DFL	Current	480	190	110	13	140	0
		Ongoing	7 100	1 300	650	28	2 600	0
	MUFL	Current	16 000	6 900	7 000	1 700	12 000	0
		Ongoing	71 000	24 000	52 000	1 300	58 000	0
Derwent District - ANM								
Other	DFL	Current	5 700	2 600	3 000	470	5 400	0
		Ongoing	5 600	2 000	1 200	130	4 200	0
	MUFL	Current	11 000	5 300	5 600	1 000	11 000	0
		Ongoing	14 000	5 100	4 900	5 800	13 000	0

Derwent District - central highlands								

Appendix Table 1 Net standing volume by major species and management classification, for each supply zone(1) (cont.)

Supply Zone			MYR	SAS	BLA	SIL	CTP	HKP
Other	MUFL	Current	970	870	950	860	1 100	4 000
		Ongoing	1 200	500	1 000	2 800	1 600	0
Derwent District - east coast								
Other	MUFL	Current	80	80	80	80	80	0
		Ongoing	120	60	300	1 200	190	0
Eastern Tiers - north								
Other	DFL	Current	4	4	4	4	4	0
		Ongoing	66	33	99	33	99	0
	MUFL	Current	2 200	2 200	2 200	2 200	2 200	0
		Ongoing	2 100	830	5 000	31 000	2 200	0
Eastern Tiers - south								
Other	DFL	Current	22	22	22	22	22	0
		Ongoing	8	4	50	330	12	0
	MUFL	Current	170	170	170	170	170	0
		Ongoing	110	55	180	260	170	0
Huon District								
STMU	DFL	Current	340	340	340	340	340	0

Appendix Table 1 Net standing volume by major species and management classification, for each supply zone(1) (cont.)

Supply Zone			MYR	SAS	BLA	SIL	CTP	HKP
		Ongoing	5 800	1 800	980	93	3 300	0
	MUFL	Current	470	470	470	450	490	0
		Ongoing	4 200	1 600	940	97	3 600	0
Other	DFL	Current	8	8	8	8	8	0
		Ongoing	240	100	120	27	380	0
	MUFL	Current	5 300	5 300	5 300	5 300	5 300	0
		Ongoing	3 000	1 300	3 200	6 000	4 100	0
Mersey District								
Other	DFL	Current	230	230	240	240	240	0
		Ongoing	84	43	700	4 900	160	0
	MUFL	Current	2 600	2 200	3 000	2 600	2 700	0
		Ongoing	14 000	4 200	10 000	55 000	8 100	0
Murchison District								
STMU	DFL	Current	270	120	110	23	160	0
		Ongoing	240 000	22 0006	14 0001	120	10 000	0
	MUFL	Current	720	320	360	180	370	0
		Ongoing	190 000	29 000	13 000	590	32 000	26 000

Appendix Table 1 Net standing volume by major species and management classification, for each supply zone(1) (cont.)

Supply Zone			MYR	SAS	BLA	SIL	CTP	HKP
Other	DFL	Current	3	3	3	3	6	0

		Ongoing	6 500	990	1 200	6	1 900	0
	MUFL	Current	3 500	1 600	1 800	660	3 100	0
		Ongoing	83 000	12 000	11 000	6 100	12 000	0

(1) (cubic metres, estimated to two significant digits

Notes: STMU Areas and volumes occurring within special species timbers management units.

Other Areas and volumes occurring within forests other than special species timbers management units.

DFL Deferred Forest Land.

MUFL Multiple Use Forest Land.

Ongoing Areas expected to produce special species timbers for current and subsequent rotations.

Current Areas expected to produce special species timbers for the current rotation only.

MYR Myrtle.

SAS Sassafras.

BLA Blackwood.

SIL Silver wattle.

CTP Celery top pine.

HKP Huon pine and King Billy pine.

(Source Forestry Tasmania)

Appendix 4.5: Recommendations of the forests and forest industry strategy pertaining to special species timbers

Of the recommendations made within the Forests and Forest Industry Strategy, the following ten are specific to special species timbers.

1. Marketing of special species timbers will be given the highest priority and cooperative marketing arrangements encouraged.
2. Demand predictions for special species timbers will be fed into Forestry Commission and sawmilling industry wood procurement plans.

3. Selected areas of existing oldgrowth and mixed eucalypt forest will be identified for prelogging trials to seek to optimise recovery of special species timbers. Within each region, special areas will be identified and zoned in management plans for long rotation management to provide for a future level of special species timber supply.
4. Within carefully defined localities selected areas of mixed forest and associated rainforest will be identified for medium term special species timber supply and be subject to environmental assessments to ensure conservation objectives for species, communities and habitats can be met prior to harvesting.
5. Ongoing supplies of special species timbers will be secured for the West Coast sawmilling industry from the Teepookana State Forest which will be managed as a multiple use forest in accordance with proposals in the draft Teepookana Forest Management Plan.
6. The value of special species timbers will be reflected in new more commercial royalties which provide a fair return to the wood grower of these high value forest products.
7. The Blackwood Management Plan will be implemented. The volumes available under the Blackwood Management Plan will be optimised by access to blackwood rich forest and the establishment of additional blackwood plantations. Research findings will be implemented in a cost effective manner. A minimum volume of blackwood supply of 10 000 cubic metres per year from public forests on the Register of Wood Production Forests should be the target supply level.
8. Minimum volumes of silver wattle (3 000 cubic metres per year), Huon pine (500 cubic metres per year), deep red myrtle and sassafras (5 000 cubic metres per year) from public forests on the Register of Wood Production Forests should be the target supply level.
9. The allocation system for special species timbers will ensure a competitive market for special timbers and allow for the entry of new efficient firms.
10. The communications between end users, sawmillers, logging contractors and forest owners will be strengthened by business and marketing plans developed by the Tasmanian Development Authority and the Forestry Commission in cooperation with the special species timbers industry.

Appendix 4.6: Specifications for special species timbers sawlogs

Note that these specifications are regularly reviewed in consultation between Forestry Tasmania and its customers, in order to determine the most practicable and equitable system for the identification and distribution of special species timber sawlogs.

(a) Minimum dimensions

i. length - 3 m; and
ii. diameter - myrtle 40cm, species other than myrtle 25cm.

(b) Permissible defects for species other than myrtle, for log sections not exceeding 30cm diameter underbarkNil.

(c) Permissible defects for log sections exceeding 30cm diameter underbark

i. end defect limit:
   - for species other than myrtle, for log sections exceeding 30cm diameter underbark but not exceeding 40cm diameter underbark the minimal radial width of sound wood free of heart and sap is 10cm; and

- for log sections exceeding 40cm diameter underbark - as specified in Table 1 of this Appendix 4.5, and

ii. limbs and bumps:
   - logs not exceeding 60cm - restricted to one quarter face of log length; and
   - logs exceeding 60cm - restricted to one half face of log length; and
   - in celery top pine - green branches not exceeding 3cm in diameter unlimited, and

iii. spiral grain - not exceeding 0.25m circumferential displacement per 2m of length (one in eight); and

iv. scars (open or overgrown) - a total length of scar or scars not exceeding 2m per 2.4m of log length, provided that the wood adjoining the scar is sound or has surface rot only and is not badly affected by borers; and

v. pin hole borers - no significant evidence of borer attack; and

vi. sweep - not exceeding 1/7 of mid diameter underbark in any 2.4m length.

Metadata used in Forest resource profiles

Photo-interpreted forest type

General

Title: Photo-interpreted forest type (PITYPE9609)

Custodian: Forestry Tasmania

Jurisdiction: Tasmania

Description

Abstract: The dataset is a digital 1:25 000 map series covering Tasmania detailing photo-interpreted forest types derived from varying scales of colour aerial photography. The data is a composite of photographs mainly from the 1970's and 1980's with additional 1996 information for selected areas of interest.

For the purpose of the CRA, PI typing from the Private Forestry Resource Review is included as is all Forestry Tasmania regeneration which would not normally have been added to the base dataset at the time of compilation.

Search Words FORESTS, FORESTS Mapping, FORESTS Natural Mapping, FORESTS Plantation Mapping, VEGETATION Structural

Attribute List:

Photoyear	Year of aerial photography
Pitype	Photo-interpreted forest type
CondensPI	Structured code (derived from PI type) containing Continuous Forest Inventory Substratum, mature eucalypt height potential, mature density, regrowth height class, regrowth density, decade or year of regeneration, regeneration treatment, myrtle predominance, other important species.
Forclass	Standard forest classes derived by grouping condensed PI classes.

Attribute List: (cont.)

Photoscale	Scale of photography (mainly 15 000, 20 000, 42 000)
Mapno	1:25 000 map series number
SourcePItype	Source of the PI type data.
ScalePItype	Scale of the source data

Sourcedate	Date of last update of the source data

Geographic Extent Name: Tasmania

Data Currency

Begin Date: 13 Jan 1974

End Date: Current

Dataset Status

Progress: Complete

Maintenance & Update Frequency: Annual

Format

Stored Data Format: DIGITAL Arc/Info Revision 7.0.4 vector coverage stored in a Librarian layer as 1:25 000 mapsheets.

Available Format: DIGITAL Arc/Info export file.

NON DIGITAL Plotted map output is available from an ARCPLOT menu using a HP750 plotter.

Data Quality

Lineage: The forest type boundaries were captured photogrammetrically at 1:25 000 scale using mainly 1:20 000 scale colour aerial photography. Forest types were then coded by photo-interpreters into Forestry Tasmania's standard classifications indicating type of forest, height, and density.

Data from the 1995 Private Forestry Resource Review replaced older information on the base layer. Coupes affected by 1995/96 harvesting and regeneration and current harvesting operations were added.

Positional Accuracy: The estimated positional accuracy of the mapped polygon boundaries for both Forestry Tasmania and Private Foretsry Resource Review PI typing is within 40 metres. Boundaries of current harvesting operations are based on provisional coupes.

Attribute Accuracy: The forest type classification is based on forest management and inventory considerations rather than scientific communities. The heights are measured from aerial photographs to +-5 metres and placed into classes. Density is also determined from aerial photography and density classes are grouped into broad percentage crown cover classes.

Attribute accuracy is checked visually at the time of data entry.

Codes within each forest type are validated by using the PI type Decoder Library Program (PIDL).

The base data is frequently used by clients in the field who report errors.

Logical Consistency: Verification of table, column and item identities and definitions along with associated map tolerances of the base dataset using the Arc/Info AML program TRANSFER.

Edge matching was examined by joining digital maps together to maintain coherence in codes and lines from one mapsheet to another.

Completeness: Forest type classification is complete for each 1:25 000 mapsheet covering the mainland of Tasmania and most offshore islands.

Private Timber Reserves

General

Title: Private Timber Reserves of Tasmania (PTRs)

Custodian: Forestry Tasmania

Jurisdiction: Tasmania

Abstract: The dataset is a digital 1:25 000 map series covering Tasmania detailing private timber reserves that have been declared or are about to be declared. Private timber reserves are areas of land that may be declared under the *Forest Practices Act 1985* (PART II sections 5 and 11) to be used only for ;

i) establishing forests, or growing or harvesting timber in accordance with the Forest Practices Code, and

ii) such other activities which the Forest Practices Board considers to be compatible with establishing forests, or growing or harvesting timber.

Search Words: BOUNDARIES, BOUNDARIES Management, FORESTS, FORESTS Natural, FORESTS Mapping, FORESTS Management, FORESTS Production, FORESTS Reserve, FORESTS Resources, LAND Use

Attribute List:

PTRCODE	Private timber reserve reference code.
MAPNO	1:25 000 map series number
TRDATE	Date of most recent update.

Geographic Extent Name: Tasmania

Data Currency

Begin Date: 01/01/1986

End Date: Current

Dataset Status

Progress: Complete

Maintenance & Update Frequency: As required

Format

Stored Data Format: DIGITAL Arc/Info Revision 7.0.4 vector coverage stored in a Librarian layer as 1:25 000 mapsheets.

NON DIGITAL Plotted map output is available from an ARCPLOT menu using a HP750 plotter

Data Quality

Lineage: Source data for private timber reserves was collected from information held by Private Forests Tasmania as part of the preparation of the Private Forests Resource Inventory Report, 1995. This was digitised onto the Department of Environment and Land Management (DELM) 1:25 000 scale lands base map.

Scale: 1:25 000

Positional Accuracy: The estimated positional accuracy of the mapped polygon boundaries is within 25 metres.

Attribute Accuracy: Attribute accuracy was visually checked at time of data entry.

Logical Consistency: Logical consistency tests not yet performed on this dataset.

Completeness: The coverage is complete for all private forest areas for each 1:25 000 mapsheet covering mainland Tasmania and the major offshore islands.

Climate grids of Tasmania

Dataset

Title: High Resolution Climate Grids of Tasmania

Custodian: Bureau of Resource Sciences

Jurisdiction: Tasmania

Description

Abstract: The rainfall and temperature grids were calculated using the ANUCLIM/BIOCLIM program and the 200 metre derived by the Centre for

Resource and Environmental Studies (CRES), Australian National University (ANU) for the Bureau of Rural Resources (BRS, 1992).

Search Words: CLIMATE AND WEATHER Models, CLIMATE AND WEATHER Rainfall, CLIMATE AND WEATHER Temperature

Attribute List:

Annual Mean Temp	Mean of twelve monthly mean temperatures (deg. C)
Annual Mean Precip	Mean total annual precipitation (millimetres)

Geographic Extent Name: Tasmania

Data Currency

Begin Date: 1991End Date: 1992

Dataset Status

Progress: Complete

Maintenance & Update Frequency: Irregular

Format

Stored Data Format: DIGITAL ARC/INFO GRID

Available Formats: DIGITAL ARC/INFO GRID

Data Quality

Lineage: BIOCLIM was used to interogate the 200 metre resolution DEM for Tasmania. The resultant ASCII grids were imported into ARC/INFO GRID. Methods are explained in the following reference:

Nix, H.A, Stein, J.A, Stein, J.L. (1992) Developing an Environmental GIS for Tasmania. An Application for Assessing the Potential for Hardwood Plantation Forestry, BRR working paper No WP/1/92.

Cell Size: 200 metres

Positional Accuracy: The positional accuracy is within 200 metres.

Attribute Accuracy: Predictive errors for temperature values are estimated as within 0.5 degree Celsius. Predictive errors for rainfall values are estimated as +-10%.

Logical Consistency: The climate surfaces used are internally consistent. The climate grids generated are visually verified.

Completeness: The DEM is completely attributed for Tasmania including Bass Strait islands.

Geological Productivity

General

Title: Geological Productivity

Custodian: Forestry Tasmania

Jurisdiction: Tasmania

Description

Abstract: The dataset is a digital 200m x 200m grid coverage of Tasmania dividing land into three broad potential productivity classes for plantation forest growth according to soil and substrate, and influenced by rainfall, temperature regime, physical barriers (operational hazards).

Search Words: BOUNDARIES, BOUNDARIES Biophysical, FORESTS Distribution, FORESTS Management, FORESTS Planning, GEOSCIENCES Geology

Attribute List:

Geology Class	1. Those geology types generally suitable for plantation establishment if rainfall and other factors are not limiting. 2. Geology type which are marginal or exhibit a wide range of productivity depending on rainfall and temperature regime. 3. Unsuitable for plantations establishment due to either poor growth or operational hazards.

Geographic Extent Name: Tasmania

Data Currency

Begin Date: Unknown

End Date: Current

Dataset Status

Progress: Complete

Maintenance & Update Frequency: Not Planned

Format

Stored Data Format: DIGITAL Arc/Info Revision 7.0.4 grid stored in a Librarian layer as a single tile.

Available Formats: DIGITAL Arc/Info export file.

NON DIGITAL Plotted map output is available from an ARCPLOT menu using a HP750 plotter

Data Quality

Lineage: Geology types from the Mines Department 1:250 000 geology series were coded according to expert opinion of their productivity for plantation establishment and growth. The polygon coverage was then converted to grid at 200 m.

Scale: 200m x 200m grid

Positional Accuracy: The estimated positional accuracy of the mapped polygon boundaries of the source data is within 1 kilometre.

Attribute Accuracy: Not relevant

Logical Consistency: The gridded classification is internally consistent.

Completeness: The environmental domain classification is complete for the mainland of Tasmania as well as most offshore islands.

Tasmanian Slope Classes

General

Title: Tasmanian Slope Classes

Custodian: Forestry Tasmania

Jurisdiction: Tasmania

Description

Abstract: The dataset was derived from a composite of 2 digital elevation models (DEMs) for Tasmania. The first is a seamless 25 metre resolution DEM covering 324 map sheets developed for this project. The reamaining 129 sheets in the south west of tasmania have come from a 200 metre resolution DEM (BRS, 1992) that has been oversampled to 25 metres and merged with the finer scale DEM.

Four slope classes have been derived from each DEM which relate to Codes of Practice thesholds.

Search Words Digital Elevation Model, DEM, Terrain, Slope

Attribute List:

SLOPE	Slope calculated as percentrise using Arc/Info
SLOPE_CLASS	SLOPE reclassified into 4 classes: <30%; 30-49%; 50-69% and >=70%

Geographic Extent Name: Tasmania

Data Currency

Begin Date: November, 1996

End Date: Current

Dataset Status

Progress: Complete

Maintenance & Update Frequency: 200 metre resolution component to be updated as contour information becomes avavailable.

Format

Stored Data Format: DIGITAL Arc/Info Revision 7.0.4 GRID

Available Format: DIGITAL Arc/Info GRID

NON DIGITAL Plotted map output is available from an ARCPLOT menu using a HP750 plotter.

Data Quality

Lineage: High resolution DEM of 325 map sheets was derived from 1:25,000 scale contour information. A TIN model was generated using ARC/INFO with a proximal tolerance and weed distance of 12.5 metres. The continuous surface (GRID) was derived using the quintic interpolation algorithmn provided by ARC/INFO. Slope was calculated using ARC/INFO GRID's slope function.

The 200 metre resolution DEM was sourced from the 1992 study undertaken by the Centre for Resource and Environmental Studies for the Bureau of Rural Resources (now BRS). The full reference for this report is:

Nix, H.A, Stein, J.A, Stein, J.L. (1992) Developing an Environmental GIS for Tasmania. An Application for Assessing the Potential for Hardwood Plantation Forestry, BRR working paper No WP/1/92.

Scale: 25 metres and 200 metres

Positional Accuracy: 25 metre DEM: +- 12 metres in the x and y

200 metre DEM: +- 100 metres in the x and y.

Attribute Accuracy: 25 metre DEM: +- 10 metres in elevation

200 metre DEM: unkown.

Logical Consistency: 25 metre DEM: Edgematching of contours was checked prior to the generation of the DEM. A 1:25,000 scale coastline was used to clip the DEM.

200 metre DEM: unknown.

Completeness: Complete at 25 metre resolution for 324 map sheets and 200 metre resolution for the remainder of Tasmania (129 map sheets).

Chapter 5 Minerals

Table of Contents

Summary

The minerals industries, comprising mineral exploration, mining and mineral processing are of vital importance to the economy of Tasmania and employed 4423 people in 1993-94. The gross value of the output of the minerals industries in 1994-95 was in excess of $1 billion and the industries are the source of Tasmania's exports, accounting for 43 per cent of the total in that year.

Tasmania is endowed with a variety of metallic mineral deposits, many of which are recognised as being of world class, using the definition of the United States Geological Survey (USGS; economic deposits containing the top 10 per cent by mass of a given metal). The Rosebery and Hellyer mines are each world class deposits for three metals: zinc, lead and silver and in addition both have significant copper and gold credits. Mount Lyell is a world class copper deposit, Renison and Mount Bischoff are world class tin deposits and there are world class tungsten deposits on King Island. In addition there is a major iron resource at Savage River. There are high grade gold deposits at the Henty and Tasmania mines, and rutile and zircon production is to resume shortly on King Island.

The state also has significant deposits of coal, limestone, dolomite, magnesite, silica, clay, ochre and construction materials, some of which are currently in production.

The known mineral resources of Tasmania are detailed in Section 5.1.

Because mining involves depletion of non-renewable resources, mineral exploration is necessary to sustain the industry. A significant proportion of exploration effort in the State is directed to the discovery of additional reserves adjacent to existing mines. This has been very successful in recent years, with significant new discoveries at the Mount Lyell, Renison and Rosebery mines. However, in many cases mining exhausts resources. For example, in recent years the Que River mine has been mined out, and the known resources at the Hellyer mine are only sufficient to sustain the operation for about another five years.

Mineral exploration is a scientific activity which uses advanced technology to locate new deposits. An exploration program is based on available geological, geophysical and geochemical data and on judgements about where targeted types of mineral deposit are likely to occur. Exploration is an inherently high risk activity and it has been estimated that only one in 1000 programs results in the discovery of an economic deposit, and requires an average investment of $51 million (real 1990 dollars, about $61 million in present day terms).

Similarly, the determination of potential (undiscovered) mineral resources is inherently difficult and imprecise. Unlike estimates of timber resources, there is no direct method for estimating undiscovered deposits from satellite images or aerial photographs. For this report the

qualitative methodology developed by the USGS in which geological units, or tracts, were identified in which the potential for specific types of mineralisation is ranked as high, medium, low or unknown. The Bureau of Resource Sciences (BRS) and Mineral Resources Tasmania (MRT) assessed the ranking for each type of mineralisation using a general descriptive model in which the geological

features of the 45 model deposits were compared with those of the tract in question.

In addition to the ranking of the potential for the tract, the degree of certainty of the assessment was estimated according to the reliability of the geoscientific data base for the tract. MRT has developed a method of reliability assessment and has produced a map showing this reliability for deposits of metallic minerals. Both the geoscientific data bases and the models on which the assessments are based are subject to change with the acquisition of new knowledge, and sometimes revolutionary change. Hence there is a need for periodic reassessment.

Using the method outlined above, the mineral resource potential was assessed using 45 mineral deposit models, some of which were developed for the Tasmanian assessment, in subregions (elements) defined by geological criteria. These elements are Rocky Cape, Dundas, Sheffield, Tyennan, Adamsfield-Jubilee, Northeast Tasmania and the Tasmania Basin (Figure 5.1). This scheme was chosen as the basis for the assessment of mineral resources but modified in that two of the subdivisions, Dundas and Sheffield, are considered together and King Island and the Furneaux Group are not included as they lie outside the Tasmanian comprehensive regional assessment region.

Areas of significant potential for metallic minerals have been identified in western, northwestern, southwestern, northeastern and parts of central Tasmania.

There is high to moderate-high potential for a range of deposit classes including:

- base and precious metal deposits 'hosted' by volcanic rocks, similar to Rosebery, Hellyer, Mount Lyell and Henty;
- tin, tungsten, magnetite, base and precious metal mineralisation associated with granites, similar to the orebodies of Renison, Mount Bischoff, King Island, Kara, Magnet, Anchor and Aberfoyle;
- carbonate hosted base metal and silver deposits of Irish style, of which Oceana is a probable Tasmanian example;
- slate belt gold deposits such as the Tasmania mine at Beaconsfield and the New Golden Gate mine at Mathinna;
- iron deposits of the Savage River type;
- ironstone hosted gold in northwest Tasmania;
- porphyry copper-gold deposits in the Mount Read Volcanics, particularly in southwest Tasmania;
- nickel, copper and platinoid mineralisation associated with ultramafic rocks and gabbros;
- carbonate hosted gold deposits of the Carlin type;
- copper and other base metal deposits associated with basalts;
- sediment-hosted base metal deposits; and
- alluvial and beach deposits containing various combinations of gold, tin, chromite, platinum group metals (PGM), rutile and zircon.

In addition, recently discovered gold deposits in the Weld River area of southern Tasmania are promising, but there is insufficient information at this stage to accurately define tracts of high potential.

Because the main geological units favourable for metallic resources are obscured by younger strata several hundreds of metres thick in most of eastern and central Tasmania (Tasmania Basin Element), any assessment of the metallic mineral potential in this area is of low certainty, but available geophysical evidence, locally confirmed by drilling, indicates that mineralised rocks may exist at depth.

There is high potential for various industrial and fuel mineral resources including:

- magnesite in northwest Tasmania;
- silica flour in northwest Tasmania and near Maydena;
- ochre in northwest Tasmania and near Beaconsfield;
- kaolin in northeast Tasmania;
- coal in central and eastern Tasmania;
- dolomite and limestone over large areas of the State; and
- construction materials, lump silica and dimension stone are widespread.

The tracts of mineral potential for various types of mineral deposits (maps 5.6 to 5.40 that accompany this report) have been combined and summarised in two different ways in maps 5.3 and 5.4. The tracts for construction, dimension stone and hard-rock silica were not included in these summaries.

Map 5.3 is a composite of mineral potential tracts over Tasmania and shows the highest level of mineral potential assessed (in September 1996) for any particular area in the region. In this approach, tracts of lower mineral potential are obscured by the tract having the highest level of mineral potential in any particular area. Areas of high mineral potential in the Dundas-Sheffield Element partly reflect the potential for more base metals and gold in volcanic massive sulphides and various types of granitoid-related tin and tungsten deposits already known to occur in the element. Also represented are tracts of high potential for other types of less dominant deposits known to occur in the element, such as Irish-style carbonate-hosted base metal deposits, silver-bearing metallic veins, gold-bearing base metal-tin veins, and carbonate-hosted gold-silver deposits which extend northwest into the Rocky Cape and southeast into the Tyennan and the Adamsfield-Jubilee Elements. In the Rocky Cape Element the tracts of high potential are dominated by tracts related to known deposits of magnesite, magnetite, dolomite and silica flour, as well as tracts assessed on the basis of geology favourable for base metals associated with basaltic volcanic rocks, silver-bearing polymetallic veins, and tungsten and molybdenum. The tracts of high potential in the Northeast Tasmania Element are for slate-belt gold, tin and tungsten-molybdenum veins, tin greisens, and for coal deposits.

Map 5.4 is a composite of mineral potential tracts for different types of mineral deposits that do not have equal economic values. For example, a tract with moderate potential for base metals and gold in volcanic massive sulphides may be considered to have a higher economic value than a tract with high potential for silica. In order to mitigate such anomalies, tracts for construction materials, dimension stone and hard-rock silica have been excluded from maps 5.3 and 5.4.

The mineral potential tracts maps 5.6 to 5.40 are superimposed on map 5.4 to highlight areas with overlapping tracts. This presentation takes account of the diversity of mineral resource potential as well as the level of potential. This was done by allocating standard scores according to a subjective ranking of levels of mineral potential as follows: high potential (18), moderate/high (12), moderate (6), low/moderate (2), low (1), unknown potential (no score). Scores of overlapping tracts were then added to derive a 'cumulative mineral potential' score. Areas with high cumulative scores indicate potential for more than one type of deposit (e.g. moderate potential for epithermal gold (6) + high for base metals in volcanic massive sulphides (18) + high for replacement tin deposits (18) = 42).

It should be understood that the areas with overlapping tracts highlighted on map 5.4 emphasise the diversity of mineral potential, but these areas are not necessarily more prospective than a single tract of high potential, for example, for base metals in volcanic massive sulphides. The relative economic significance of the tracts for different types of mineral deposits, as perceived by

mining companies, would be dictated by perceptions of prospectivity, future market conditions, land access and other factors. Maps 5.3 and 5.4 cannot therefore be used as an indication of the relative economic potential for minerals of different areas of Tasmania.

The cumulative potential scores highlight the diversity of potential resources in the northwestern portion of the Dundas-Sheffield Element and the Northeast Tasmania Element. They also give added emphasis to the southern portions of the Tyennan and Adamsfield-Jubilee Elements for alluvial placer tin deposits, replacement-type tin deposits, tin and tungsten-molybdenum vein deposits, silver-bearing polymetallic veins, sedimentary copper, sedimentary exhalative lead-zinc deposits, and various types of skarn deposits. Although the potential for many of these deposit types is moderate or moderate to high, the cumulative score for all of these tracts is high.

Repetitive access to large areas of land is needed for mineral exploration because:

- the location of future mineral deposits cannot be predicted with any precision,
- the minerals needed by society change with time,
- there are advances in geological and metallurgical knowledge, and
- there is progressively better awareness and understanding of the factors controlling the location of mineral deposits.

The potential economic benefits of mineral discovery are large. It was estimated that a 20 million tonne massive sulphide deposit with characteristics similar to Rosebery would have a net present value of $535 million, while a 15 million tonne Irish-style zinc-lead-silver deposit would have a net present value of $86 million. Note that the net present value is a measure of the expected profitability of an investment expressed in present day dollars and does not take into account community benefits such as employment and purchase of goods and services.

Some 76 per cent of Tasmania is available for mineral exploration and mining development; the remaining 24 per cent is in reserves where mining is not permitted. Most of the State's major mines are located in forested land and much of the area with high potential for future discoveries is also in forest. Consequently, any decision which might restrict future access to land for mineral exploration and mining is of concern to the minerals industry and could affect Tasmania's economy. The environmental costs of exploration are generally low so that land access arrangements that further preclude the activity are unlikely to be optimal.

There is strong evidence that uncertainty in relation to future land access is a major inhibitor of investment in mineral exploration. Expenditure on Tasmanian exploration and retention licenses decreased from $10.45 million in 1989 to $5.11 million in 1991 following the Commission of Inquiry in the Lemonthyne and Southern Forests (Helsham Commission) and subsequent to the declaration of the World Heritage Area and national park system. Expenditure remained depressed until 1995, when there was a sharp increase to $10.15 million. Over a similar period, ABS figures show that Tasmania's share of Australian exploration expenditure dropped from 1.94 per cent in 1989-90 to 1.65 per cent in the following year. The proportion then further declined and remained at between 1.2 and 1.3 per cent for the next three financial years until 1994-95 when it increased to 1.65 per cent and further increased to 1.94 per cent in 1995-96. This indicates that the decline from 1991 to late 1994 was not merely due to external factors. This recovery was in part due to the introduction of the *Mining (Strategic Prospectivity Zones) Act 1993,* and partly due to the acquisition and promotion of new geoscientific data, particularly for the gold province of northeast Tasmania. However, the recovery has not been experienced in areas subject to continued debate about land access, for example the Adamsfield area and parts of northwest Tasmania.

Expenditure on exploration and retention licences in the period 1989 to 1995 was $51 million, approximately the average amount required to discover a new deposit. This underscores the need to maintain or increase exploration investment to sustain the mining industry in the longer term.

Modern exploration emphasises remote sensing, such as the acquisition and interpretation of detailed aeromagnetic surveys to select areas for further investigations. This follow up work may consist of very low impact ground activities such as geological mapping, stream sediment and rock sampling for assay and ground geophysical surveys. It is only after these phases of a program have been conducted that small areas are defined for more intrusive activities such as trenching and drilling. Even these activities can now be conducted with generally low impact, for example by using helicopters for access and by using portable rigs. Rehabilitation of drill pads, access tracks and trenches is required practice in Tasmania.

The environmental performance of exploration in Tasmania is subjected to close monitoring. Under the *Mineral Resources Development Act 1995.* a bond must be provided to ensure compliance with the conditions of the licence. During the currency of the licence, all activity is monitored and must be conducted to standards consistent with the Mineral Exploration Code of Practice. Ground disturbing activities must be approved in advance by MRT.

In environmentally sensitive areas, the programs are assessed by the Mineral Exploration Working Group (MEWG). Matters considered include possible impacts on historical, archaeological, botanical, zoological or ecological values. The MEWG may require studies on some of these aspects to be carried out to assess probable impacts and may subsequently require modifications to programs.

In addition to these external standards, most exploration companies work to strict internal standards and manage programs in accordance with best practice principles.

Mining is concentrated in small areas and involves a wide range of techniques ranging from large open cut operations affecting tens of hectares, to small underground mines. Many of the larger Tasmanian mines are underground operations with workings at depths of up to one kilometre.

Mining can be an environmentally intrusive activity, with the main proximal effects being visual impacts, dust and noise and the main distal impacts resulting from waterborne wastes, such as tailings, siltation and acid mine drainage, and airborne waste such as smelter fumes and dust.

These impacts were often uncontrolled in the past. The effects on the King River and Macquarie Harbour in western Tasmania are well known examples.

Contemporary mine management largely avoids such impacts through life of mine environmental management programs, generally conducted by in house professionals in the field. Such management includes better waste containment practices, such as the current tailings containment at the Mount Lyell mine, progressive rehabilitation of areas during the mine life and using waste rock to fill underground voids created by mining. Metal pollution is also minimised by more efficient processing leading to better recoveries.

Tasmania has recently introduced a package of new environmental protection and planning approval legislation founded on principles of ecologically sustainable development. New mining and mineral processing operations require the approval of Mineral Resources Tasmania, Department of Environment and Land Management and the local government authority. A mining operation must be in accord with the provisions of a Development Proposal and Environmental Management Plan, which must adequately address issues and standards defined by DELM on a project and site-specific basis. These plans are subject to public scrutiny and appeal.

Under the Mineral Resources Development Act 1995, part of the royalty paid on minerals recovered in Tasmania is paid into a Rehabilitation of Abandoned Lands Trust Fund, which is used on projects to mitigate the environmental damage caused by historical operations.

5.1.1 Introduction

Known mineral resources and potential (undiscovered) mineral resources of Tasmania have been assessed as part of the comprehensive regional assessment of Tasmania. This is the region referred to in this report as 'Tasmania', or 'the region'.

The mineral resources were assessed on a regional scale of 1:250 000 for Tasmania by the professional staff of Mineral Resources of Tasmania and the Bureau of Resource Sciences (BRS).

A brief description of the geological setting of Tasmania is provided in Section 5.1.4. The broad scale assessment was conducted according to geological areas which make up the Tasmanian Comprehensive Regional Assessment region (figure 1). The geological areas are as follows:

- Rocky Cape element;
- Dundas and Sheffield elements;
- Tyennan element;
- Adamsfield/Jubilee element;
- Northeast Tasmania element; and
- Tasmania Basin.

The geology, exploration, identified (known) mineral resources and potential (undiscovered) mineral resources are described for each of the geological provinces. The language used in these more detailed descriptions is more technical, but a glossary is provided in Section 5.1.2.

Figure 5.1 **Major geological elements of Tasmania**

Mineral Resources Tasmania also provided more detailed assessments of selected areas of Tasmania as follows:

- Northwest Forest area;
- Southwest Conservation Area south of Macquarie Harbour;
- Granite Tor-Vale of Belvoir area;
- South West Conservation Area near Mt Darwin and Lake Burbury;
- Huon-Picton area;
- Tyndall Range area; and
- Great Western Tiers.

These detailed assessments as shown in figure 5.2 are available as a separate document on request from Public Land Use Commission.

The identified resources have been compiled in this report from resource data published by mining and exploration companies, most of which are reported according to the Australasian Code for Reporting of Identified Mineral Resources and Ore Reserves (1992).

The mineral potential of the study areas has been assessed by determining the types of mineral deposits likely to be found within the geological framework known or believed to exist there. The general methodology used was developed by the United States Geological Survey (UGUS), and has been used successfully for mineral resource assessments of forest areas in North America and elsewhere. This approach identifies geological units (tracts) which could contain particular styles of mineralisation. The method ranks the potential for occurrence of specific types of mineralisation in specific geological units in terms of high, moderate, low or unknown, based on the professional judgments of the geoscientists involved. To reflect the differing amounts of information available, the mineral potential has also been categorised according to levels of certainty. The qualitative methodology for the assessment of potential mineral resources is described at Appendix A.

Assessments similar to the procedure used in this are commonly used by companies to choose the selection of areas for exploration. It is important to note, however, that the assessment of potential resources is subject to the quantity and quality of data available to the assessors. As geological knowledge of an area is never complete, 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 re-assessed periodically to take account of new data and advances in geological understanding, including new mineral discoveries. Advances in mineral exploration and mining technologies, and changes in mineral markets are other factors which may change the mineral resource potential of an area. An assessment has been made of the reliability of the geoscientific data base and this is discussed in Section 5.1.3.

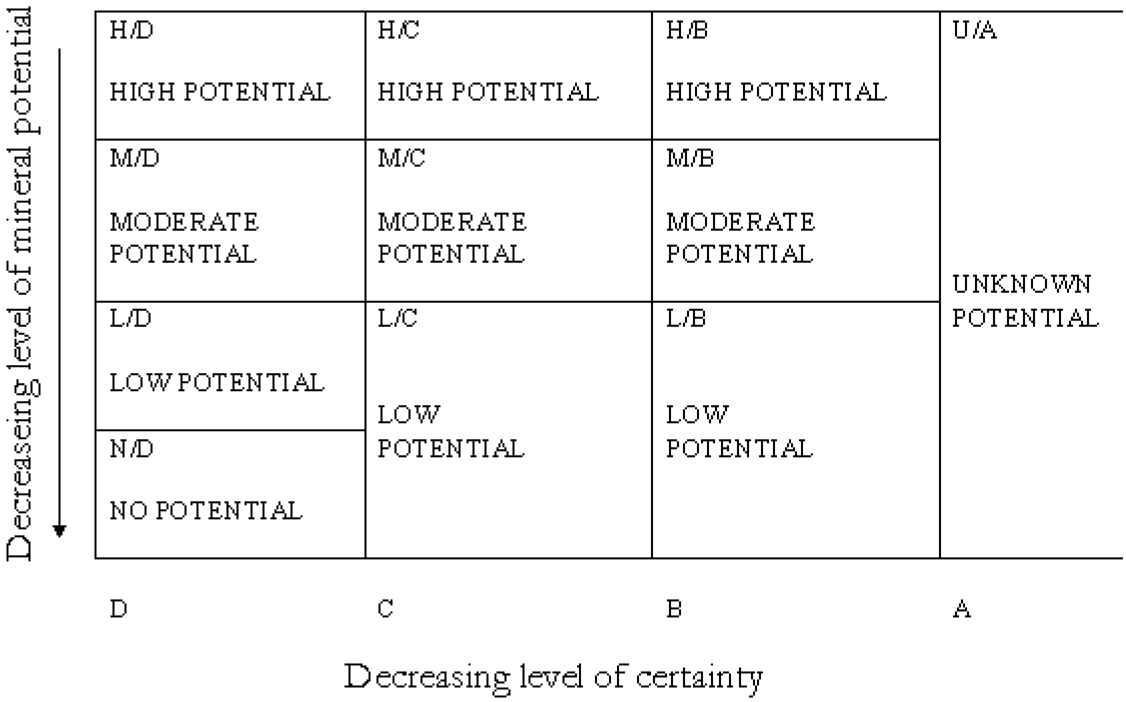
Because of incomplete geological knowledge, the discovery rate in Australia is roughly of the order of one mine for one thousand exploration programs. Thus areas are explored, often repeatedly, before a mineral deposit is found. Increased geological knowledge and other factors can result in discoveries of world-class deposits both in highly prospective areas (e.g. Kanowna Belle in Yilgarn, WA; Century in the Mount Isa Inlier, Queensland) or in areas not previously known to be of very high potential (e.g. Olympic Dam on Stuart Shelf, SA). Thus 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 discovery of mineral deposits, as opposed to the regional assessment of mineral potential, requires geoscientific investigations at a much greater level of detail, and would typically include ground surveys and drilling.

Maps contained in this report

This report contains a number of maps which are standard products from either Mineral Resources Tasmania or the Bureau of Resource Sciences. For the purposes of presentation, copies have been printed for this report but may have suffered degradation of either colour range or resolution. These maps are all crown copyright and original or additional copies should be purchased directly from the relevant organisation. Each of the four 1: 250 000 digital maps of Tasmania is available for inspection at the State Public Libraries at Hobart, Launceston and Burnie and at the offices of the Public Land Use Commission in Hobart and Mineral Resources Tasmania at Rosny Park. Printed copies of the maps may be purchased at a cost of $25 per sheet ($35 laminated) from: Minerals Resources Tasmania, PO Box 56, ROSNY PARK, TAS 7018.

Figure 5.3: Areas of Detailed Mineral Resource Potential Assessment



Sources and reliability of data

The main sources of information used in this assessment of the mineral resource potential are geological mapping, aeromagnetic data, gravity data and the record of past exploration. The quality of the assessment is heavily dependent upon the reliability of the basic information being used to make the assessment. To quantify this, the quality of the existing geological mapping, aeromagnetic data and gravity data have been combined numerically to produce a map (Data reliability map of Tasmania, submitted to PLUC reference centers) of the State which gives a measure of the reliability of the information used for assessing the mineral potential.

The maps used have been the 1:250 000 scale GIS-based geological maps of the State produced by Mineral Resources Tasmania. These maps are based on the best available information from all sources which has been generalised in such a way as to provide a level of detail suitable for display at the 1:250 000 scale. The main source of information has been the systematic geological mapping done by the Department of Mines, as Mineral Resources Tasmania was then called, since the late 1950s. Early mapping was published at 1:63,360 scale, with a scale of 1:50 000 being adopted in the early 1970s with the change to the metric system. Some of the areas with greatest interest to mineral explorers have recently been mapped in greater detail, with the maps being published at 1:25 000 scale. Other geological mapping used came from university theses and open file exploration company reports. Some areas of the State have very poor geological information as they have only been mapped at reconnaissance level. A source reliability map, printed in a small box on each map, is available for each of the 1:250 000 scale GIS geological maps produced by Mineral Resources Tasmania. The different categories of source map have been listed in order of probable reliability and this information is shown on the reliability map. These source reliability maps have been used to give information on the quality of available geological map information.

The quality of aeromagnetic data available for different parts of the State is also variable. Some areas are covered by aeromagnetic data collected at wider line spacing and greater height than for other areas, and these data provide poorer information. There is also a variation in the quality of the gravity data, with some areas having a greater density of gravity stations and thus providing more detailed information than others. Maps showing the different qualities of both aeromagnetic and gravity data were created to give a spatial measure of the type of data coverage available. The aeromagnetic and gravity data were acquired by State and Federal Governments and by exploration companies, and are archived by Mineral Resources Tasmania and the Australian Geological Survey Organisation.

When producing the reliability map, geological mapping was considered to be more important in assessing mineral potential than the aeromagnetic data, which were in turn considered more important than the gravity data. The three types of data were thus weighted according to their perceived importance. It was also recognised that the ideal data coverage had not yet been achieved in any of the three data sets. The numerical values assigned to the reliability of the three types of information have been combined to produce the mineral potential source reliability map.

The record of past exploration activities, consisting of reports provided by the mineral exploration industry, is archived by Mineral Resources Tasmania. The quality of the data is highly variable and the amount of work undertaken in various parts of the State is also uneven. It was not possible to devise an objective method of displaying how the reliability of this source of information varied across the State.

Details of scoring method used to produce the reliability map

Areas were scored on the basis of the quality of three types of information; geological mapping, aeromagnetic data and gravity data. Perfect information was considered unattainable, so despite assigning maximum scores of 5, 3 and 2 for the geological mapping, aeromagnetic and gravity data respectively, the actual scores given were all less than this. This meant that the actual maximum possible score was 8. The scoring of the quality of the geological mapping was based on the reliability information provided with the 1:250 000 scale GIS geological maps of Tasmania. This basis was used because the necessary information was already in GIS form and could be used quickly. The seven categories of reliability used for the GIS geological maps were assigned scores as listed below. Areas covered with Parmeener Supergroup and younger rocks were assigned a score of 0.25, because although the basement rocks are not exposed in those areas, some conclusions about the older rocks can still be made based on the fault patterns, inference from neighbouring areas, and other surface geological information. The Stratotectonic Elements Map of Tasmania was used for the boundaries of the cover rocks as this map gives a clearer picture of the major geological features than the ordinary geological map on which it is based.

SCORE	SOURCE OF DATA
4	Published systematic Geological Survey mapping (1:25 000 scale)
3.5	Published systematic Geological Survey mapping (1:50 000 scale)
3.5	Unpublished compilation Geological Survey mapping (1:10 000-1:50 000 scale)
3	Published systematic Geological Survey mapping (1:63,360 scale) after 1965
2.5	Published systematic Geological Survey mapping (1:63,360 scale) before 1965
3	Mapping (1:63,360 or more detailed scale) from various non-government sources
2	Reconnaissance scale mapping, and/or interpretation based on air photo and/or geophysical data, from various sources
0.25	Geological mapping of areas of Parmeener Supergroup and Tertiary cover sequences

The aeromagnetic and gravity data were scored as indicated below.

SCORE	SOURCE OF DATA
2.5	Aeromagnetic coverage at less than 201 m line spacing.
1.0	Aeromagnetic coverage at 201-500 m line spacing.
0.3	Aeromagnetic coverage at greater than 500 m line spacing.
1.5	Gravity survey with stations at greater than one per square kilometer.

0.1 Gravity survey with stations at less than one per square kilometer.

5.1.3 Geological setting of Tasmania

The oldest exposed sedimentary rocks in Tasmania are inferred to be of Middle Proterozoic (Mesoproterozoic) age (about 1100-1150 million years old, based on modelling of data acquired by the rubidium-strontium technique). These rocks were deposited in a marine continental shelf environment, partly in the intertidal zone, and consist mainly of pure quartz sandstone and mudstone.

The rocks have undergone varying degrees of metamorphism. The main region of metamorphic rocks forms a central belt in western Tasmania (Map 5.1 (see also Legend 5.1), where several phases of deformation and metamorphism occurred around 500 million years ago, when rocks buried to depths of as much as 50 kilometers were emplaced at shallow crustal levels by movement on predominantly shallowly-dipping faults. Metamorphosed sedimentary sequences on King Island, also of inferred Middle Proterozoic depositional age, underwent metamorphism, several phases of deformation, and were intruded by granites around 760 million years ago (map 5.1; also refer to the time-space diagram submitted to the PLUC reference centers), an event which apparently had only a minor effect on the Tasmanian mainland. Similar, but weakly metamorphosed and only mildly deformed, sedimentary sequences, of similar inferred depositional age and also deposited in a shelf environment, occur in northwest and central southern Tasmania (map 5.1).

Widespread marine deposition took place in western Tasmania and on King Island at the end of the Proterozoic Era. Sequences of this age can be subdivided into three main assemblages. The first is an association of poorly sorted sandstone and mudstone deposited in a deep marine environment, below storm wave base, by turbidity currents. These units, the Oonah and Burnie Formations, also contain minor carbonate rocks and basalt. The second assemblage is an association of sandstone, mudstone and carbonate deposits in a shallow marine shelf environment (Success Creek Group and correlates), which is overlain by a marine rift-related assemblage consisting of basalt and basalt-derived sandstone and mudstone (Crimson Creek Formation and correlates).

It is now believed that in the late Early to early Middle Cambrian, shortly before 500 million years ago, a major collision between the 'western Tasmanian' continent and an island arc occurred somewhere east of Tasmania. This resulted in the emplacement, throughout Tasmania, of a number of allochthonous (i.e. derived from outside palaeo-Tasmania from the arc and its environs) rock units which are now in fault contact with the older continental shelf and marine rift sequences (map 5.1). The allochthonous rocks include ultramafic-mafic complexes (which host platinum group minerals, chromite and nickel), and associated basaltic volcanic rocks of a type now forming adjacent to western Pacific oceanic

island arcs, marine sandstone-mudstone sedimentary sequences, and oceanic basalts. The major 500 million year old period of polyphase deformation and metamorphism in western Tasmania may represent the culmination of the after-effects of the major collision event. The highest grades of metamorphism occurred in the main central belt of Middle Proterozoic rocks in western Tasmania and in the Arthur Lineament, a narrow belt of rocks of Late Proterozoic and possibly also Middle Proterozoic age in northwestern Tasmania (map 5.1, Figure. 5.1). The Arthur Lineament hosts Proterozoic iron ore deposits, including the major Savage River magnetite orebody, as well as gold, silica, magnesite, ochre and copper deposits.

In the Middle and Late Cambrian, post-collisional sequences were deposited in an arcuate belt, 30 to 50 kilometers wide, between the main areas of Proterozoic rocks in western Tasmania (map 5.1). These rocks include one of the most economically important units, the Mount Read Volcanics, a narrow belt of volcanic rocks including rhyolite, and esite and subordinate basalt and derived volcano sedimentary rocks erupted and deposited along the eastern margin of the main belt. The Mount Read Volcanics are host to several world-class base-metal and precious-metal deposits, including Mount Lyell, Rosebery and Hellyer, and numerous smaller deposits, many of which show characteristics of volcanic-hosted massive sulphide (VHMS) deposits formed by sea-floor hot spring activity. Sedimentary rocks, including conglomerate, mudstone and sandstone, were deposited at the same time to the west and northwest of the main volcanic belt in a deep marine environment. In the eastern part of the main belt, and in the Adamsfield area in central southern Tasmania, the volcanic and volcano sedimentary rocks were succeeded in the Late Cambrian by thick wedge-shaped, fault-controlled quartzose sedimentary units of conglomerate and sandstone, resulting from repeated uplift of Proterozoic source areas. This may represent a waning phase of the earlier major collision event. The sedimentary rocks west of the Mount Read Volcanic belt also show a change in their source in the Late Cambrian from a volcanic to a quartz-rich terrain.

The immediate post-collisional sequences throughout much of western Tasmania were succeeded by a long period of deposition of sandstone, mudstone and carbonates in a marine stable continental shelf environment which lasted from Early Ordovician to Early Devonian (i.e from about 480 to 395 million years ago, see time-space diagram). During this time there appears to have been a fundamental distinction between western Tasmania and northeastern Tasmania. In the latter region, Ordovician to Early Devonian rocks of the Mathinna Group, consisting of clayey sandstone and mudstone, were deposited in a deep marine environment from turbidity currents (map 5.1). The Ordovician carbonate sequences in western Tasmania have recently been recognised as hosting stratiform and disseminated zinc-lead mineralisation which may be similar to important zinc-lead orebodies known in Eire (termed Irish-style lead-zinc or Irish-style base metal deposits in this report).

Sedimentation in the early Middle Devonian was terminated by a major polyphase deformation event which affected most of Tasmania and involved folding and associated faulting at all scales on a number of trends. The early Middle Devonian deformation in northeastern Tasmania was preceded by a separate period of deformation in the Early Devonian (see time-space diagram).

The early Middle Devonian deformation in western Tasmania was succeeded by a major period of granite intrusion which lasted until the Early Carboniferous. In northeastern Tasmania the intrusion of granodiorite and granite commenced with a major period of activity between the Early Devonian and early Middle Devonian periods of deformation. Overall there is a regional younging of the granitoid intrusive rocks from east to west across Tasmania, with emplacement mainly in the period 400 to 370 million years ago in eastern Tasmania compared with 380 to 330 million years ago in western Tasmania. The granitoid intrusive rocks are associated with widespread significant mineralisation throughout western Tasmania and King Island, including cassiterite-massive sulphide replacement deposits (e.g. the world-class Renison tin deposit), tin-tungsten skarn and vein deposits (including the world-class King Island tungsten deposits), and silver-lead-zinc vein deposits. The most significant mineralisation in northeastern Tasmania was in the form of slate-belt gold vein deposits, with which the major Tasmania mine at Beaconsfield is grouped, but greisen-disseminated tin deposits also occur. One such deposit is currently being mined at the Anchor mine, near St Helens.

The mainly flat-lying cover rocks of the Tasmania Basin (of Late Carboniferous to Triassic age; 310 to 210 million years ago) and younger sequences overlap the folded rock sequences of Tasmania and the Devonian granitic rocks (map 5.1). The Tasmania Basin includes glacial, glaciomarine and marine sandstone, mudstone, conglomerate and limestone, and non-marine sandstone-mudstone sequences with coal measures. These rocks were intruded by Jurassic (about 175 million year old) dolerite sills and feeder dykes, some of which occupied faults formed at this time.

The separation of the Australian and Antarctic continents commenced about 95 million years ago. The intrusion of syenite in the Cygnet area at about 100 million years ago and of dykes of lamprophyre in a number of places, may have heralded this major event.

Bass Strait is supposed to represent a failed rift initiated at about this time. Cretaceous to Tertiary-age terrestrial sedimentary rocks and marine limestone were deposited on the Tasmanian mainland with intermittent, mostly terrestrial basaltic volcanic activity and significant block faulting.

During the Pleistocene there were a number of glacial advances and retreats which were important in the sculpting of Tasmania's landscape and the deposition of sediments from the glaciers and meltwater streams. During the various sea level fluctuations, which continue to the present, there have been periods of erosion and deposition of river alluvium, coastal dune sand and lake sediments. Tasmania remains mildly tectonically active, as demonstrated by occasional earthquake activity documented since European settlement and by recent fault scarps, for example in the area around the former Lake Edgar in southwestern Tasmania.

Ideas about the stratotectonic history of Tasmania are in a state of evolution, and has accelerated in recent years, due mainly to three factors:

Better geophysical modelling made possible by the availability of high-quality statewide gravity and aeromagnetic datasets;

Modelling of the middle to upper crust using modern structural concepts (particularly thin-skinned tectonics);

Precise age control provided by modern techniques, which enables the dating of small areas of individual mineral grains (particularly Pb-Pb dating of zircon using the SHRIMP ion microprobe housed at the Australian National University, Canberra).

Interpretations of the geological and tectonic evolution of Tasmania based on these new controls have tended to emphasise the importance of horizontal tectonics (shallowly-dipping thrust faults; collision events) rather than the traditional approach which was dominated by concepts of vertical tectonics (the dominant role of steeply-dipping faults and upright folds). Earlier interpretations envisaged the existence of Cambrian troughs, bounded by sub-vertical faults, between highlands or 'geanticlines' of older basement rocks whose boundaries remained more or less fixed over significant periods of geological time. These concepts now appear to be misleading or at least only applicable to certain specific time intervals.

Consequently, a recent geological synthesis (Seymour and Calver, 1995) divided Tasmania into eight 'elements' (a deliberately non-genetic term) with variably differing geological histories (Figure. 5.1; refer also to the time-space diagram). The element boundaries have tectonic significance, but are intended primarily to serve as convenient geographical subdivisions for discussion of the geology. This scheme is followed in this report, but because of similarities in geology, the Dundas and Sheffield Elements are considered together in some of the discussion.

Broadscale assessment of mineral resources by structural regions (elements) of Tasmania

Rocky Cape Element

Geology

The entire northwest tip of Tasmania is underlain by Proterozoic sedimentary rocks, which comprise a basal sequence of intertidal to shallow-shelf orthoquartzite and mudstone with minor dolomite, the Rocky Cape Group, disconformably overlain by conglomerate, dolomite, basalt and associated rocks of the Smithton Synclinorium. The NNE-trending Arthur Lineament separates these rocks from the an eastern association, the Burnie Formation, which comprises turbiditic sandstone (quartzwacke), mudstone and rare spilitic basalt. To the south in the Zeehan area, the Oonah Formation, a correlate of the Burnie Formation, also contains carbonates and basalts. Swarms of dolerite dykes intrude the sedimentary rocks.

Mesoproterozoic: Rocky Cape Group

The oldest exposed sequence in the Rocky Cape Element is the Rocky Cape Group and correlates, with a suggested depositional/provenance age (Turner et al., 1992) in the vicinity of 1100 Ma, the age determined for metapelite in the Tyennan Element (Raheim and Compston, 1977). The type section of the group is on the north coast (Gee, 1968; Gee in Turner, 1989a), where an exposed sequence of 5700 m consists predominantly of quartzarenite, sandstone and siltstone.

Burnie and Oonah Formations

A northeasterly-trending metamorphic belt, known as the Arthur Lineament (Gee, 1967), separates the Rocky Cape Group (to the west) from the Burnie and Oonah Formations (to the east). The Burnie Formation consists dominantly of sandy, turbidite-facies quartzose wacke and slaty mudstone with minor altered mafic pillow lava, whereas the Oonah Formation contains additional lithologies including relatively clean quartz sandstone, dolomite, chert and conglomerate (Turner, 1989a).

Turner et al. (1992, 1994) suggest that the Oonah and Burnie Formations are laterally equivalent to basal shallow-water siliciclastic rocks in the Togari Group of the Smithton Synclinorium, and to basal proximal turbidite fan deposits in the Ahrberg Group (see below), both sequences resting unconformably on the Rocky Cape Group.

Smithton Synclinorium In the northwestern part of the Rocky Cape Element, the Rocky Cape Group is unconformably overlain by a sequence of clastic sedimentary rocks, mafic volcanic rocks, dolomite and chert, which forms the Smithton Synclinorium. Current interpretations, based on correlations of rocks in the Ahrberg Group with units in the Smithton Synclinorium (Spry, 1964; Turner, 1990a; Turner et al., 1992, 1994), imply that the major regional deformation and metamorphism in the Rocky Cape Element is relatively young and post-dates deposition of most of the units in the Smithton Synclinorium. This conclusion is supported by geochronological studies in the Arthur Lineament, which date the peak regional metamorphism at around 500 Ma (Turner et al., 1992, 1994; Turner, 1993a).

The unconformity at the base of the lowermost sequence in the Smithton Synclinorium (the Togari Group, see below) represents at least a period of gentle regional folding prior to Togari Group deposition and may correlate with the 760 Ma folding on King Island (Turner et al., 1994; Berry, 1994).

The Togari Group is separated by a considerable hiatus and a slight disconformity from the fossiliferous uppermost unit, the late Middle to early Late Cambrian Scopus Formation. The Kanunnah Subgroup of the Togari Group is correlated with the Crimson Creek Formation of the Dundas Element (Brown, 1989a).

The uppermost unit in the Smithton Synclinorium, the Scopus Formation, consists of interbedded mudstone, siltstone and lithic wacke, and contains fossils indicating biostratigraphic ages between Boomerangian and Idamean (Jago and Buckley, 1971; Jago, 1976; Baillie, 1981), straddling the Middle to Late Cambrian boundary. The Scopus Formation is correlated with the Dundas Group of central western Tasmania.

Ahrberg Group

Near Corinna, on the western flank of the southern part of the Arthur Lineament, the Ahrberg Group comprises an east-facing succession of quartzose sandstone and conglomerate, followed by mudstone, dolomite and tholeiitic metavolcanic rocks, resting unconformably on basement equivalent to the Rocky Cape Group (Spry, 1964; Turner, 1990a; Turner et al., 1991).

High-purity silica 'silica flour' deposits in the Corinna area form an irregular layer between dolomitic rocks of the Ahrberg Group and unconsolidated Tertiary fluvial gravel (Turner, 1990a). A residual origin after silicified dolomite is indicated, and the deposits represent a significant industrial mineral resource.

Arthur Lineament The rocks comprising the Arthur Lineament are known as the Arthur Metamorphic Complex (Turner, 1989a), and consist in part of metamorphic equivalents of the Rocky Cape Group and the Oonah Formation.

In the northern part of the Arthur Lineament, the western section of the metamorphic complex comprises a narrow belt of phyllite and schistose quartzite which is transitional into the relatively unmetamorphosed Rocky Cape Group

The main lithological association in the southern part of the metamorphic complex (Timbs Group of Turner et al., 1991) appears to be extensively developed throughout the Arthur Lineament. In the vicinity of the Savage River mine, the eastern part of the Timbs Group forms a distinct unit, the Bowry Formation (Turner, 1990a; Turner et al., 1991), which consists of pelitic schist with amphibolite and associated pyrite-magnetite lenses, magnesite and dolomite. Similar rocks occur in a similar position in the Arthur River area in the north (Everard et al., 1996).

The Savage River mine worked an orebody consisting of magnetite-silicate-sulphide rocks in an association of metamorphosed mafic rock, serpentinite and carbonate, near the eastern boundary of the Bowry Formation (Turner, 1990a). The ore minerals are magnetite and pyrite with minor chalcopyrite and trace sphalerite, ilmenite and rutile (Coleman, 1975). The mineralisation is currently thought to be of marine, volcanogenic origin, but previous theories included magmatic segregation, late magmatic al fluid and hydorthermal replacement (Weatherstone, 1989). It is also possible that the deposit is a metasomatic replacement of carbonate, perhaps related to Proterozoic granites which crop out to the west of the orebody (Botterill et. al., in press). Other smaller lenses of similar mineralisation indicate stratiform control over a strike length in excess of 70 km (Turner 1990a). Minor gold occurs in quartz and carbonate veins at a number of places in, and to the east of, the Bowry formation.

Magnesite deposits of considerable size occur within the Bowry Formation, in both the Savage River area in the southern part of the Arthur Lineament, and in the Arthur River area in the north (Turner, 1990a). The magnesite most commonly occurs as a fine-grained, equigranular marble, and Frost (1982) favoured an origin by metasomatism of original dolomite by solutions containing MgCl2, rather than a sedimentary origin.

Wurawina Supergroup

Correlates of the Owen, Gordon and Eldon Groups are exposed in the east-trending Duck Creek Syncline, which intersects the west coast at the southern end of the Arthur Lineament (Blissett, 1962; Brown et al., 1994).

The basal conglomerate unit rests unconformably on metamorphosed equivalents of the Oonah Formation, and is considered to be a correlate of the Mt Zeehan Conglomerate (Blissett, 1962). The conglomerate is thin or absent in places, and is succeeded by cross-bedded quartzite considered equivalent to the sandstone sequence overlying the Mt Zeehan Conglomerate in its type area.

The Gordon Group correlate is represented by approximately 90 m of calcareous siltstone, shale and micrite (Blissett, 1962). Conodonts from the base of the section suggest an age equivalent to faunal assemblage OT12 (Banks and Baillie, 1989), which may imply the presence of a hiatus or condensed section between the Gordon Group section and the underlying siliciclastic rocks.

The Eldon Group section in the Duck Creek Syncline includes equivalents of the lower five formations of the group in its type area at Zeehan in the Dundas Element (Blissett, 1962).

Devonian deformation

The full extent of the regional Middle Devonian deformation in the Rocky Cape Element is not well established. Turner (1992) showed that Devonian structures in the southern Arthur Lineament and adjacent Oonah Formation are steep crenulation cleavages of WNW to westerly trend, and are statistically parallel to Devonian slaty cleavage in the Wurawina Supergroup of the Duck Creek Syncline adjacent to the west coast at the southern end of the Arthur Lineament. Several late phases of open upright folding and associated crenulation cleavage development recognised in the Oonah Formation between the Heemskirk Granite and the middle Pieman River (Brown et al., 1994), and similar structures in the northern part of the Arthur Lineament (Everard et al., 1996), are almost certainly also Devonian in age.

Devonian-Carboniferous granitoids

The two major post-tectonic granitoid bodies intruding the Rocky Cape Element are the Early Carboniferous Pieman Granite and the closely associated Interview Granite. The Pieman and Interview granites crop out on the west coast where they intrude Rocky Cape Group rocks, and are petrologically similar to the white phase of the Heemskirk Granite, which occurs a short distance to the south in the Dundas Element. The granites show an isotopic age range of ca. 338.5 to 356.5 Ma (McClenaghan, 1989).

Granitoid-related mineralisation

Sn-W veins occur on the eastern margin of the Interview Granite and are clearly related to the granite. Rocky Cape Group correlates near Balfour host fracture related, chalcopyrite-bearing quartz and sulphide lodes with a NNW trend, and tin-bearing quartz veins (Yaxley, 1981). These latter are also probably Devonian, granite-related deposits (Turner, 1990a), although distant from known granitoids.

Exploration

In that part of the Rocky Cape Element northwest of the Arthur Lineament, the main commodities that have been explored for are tin, tungsten and copper in the Balfour area and on the eastern margins of the Interview Granite; mineral sands in the western coastal dunes; chromite in Tertiary placer deposits in the Salmon River area; silica from quartzite of the Rocky Cape Group; and dolomite from the Late Proterozoic rocks of the Smithton Basin.

Several thousand tonnes of copper and tin ore were mined from numerous small mines in the Balfour mineral field between 1900 and 1920. The Broken Hill Proprietary Co. Ltd (BHP) investigated one of the major tin/tungsten prospects at Specimen Hill in the mid 1960s. This was followed, during the early 1970s and early 1980s, by two larger exploration programs conducted, by ACI Operations Pty Ltd (ACI) for copper, and by CRA Exploration Pty Ltd (CRA) for tin. The ACI program established extensive copper mineralisation of carbonate replacement style, grading around 0.5per cent. Reserves were not quantified but several drill intersections of around 20 m of this mineralisation were achieved (TCR 73-947).

The CRA tin program established that a stock work system of tin and tungsten-bearing quartz veins crop out in a zone parallel to, and westward of, the copper mineralisation. The company concluded that vein grade was on average >1% Sn but that vein frequency was erratic and too low to support the large-scale open cut operation being sought. One report suggested a sheeted vein system of WO3 veins in the Specimen Hill area had potential as a large tonnage low grade deposit (TCR 82-1740). CRA drilling on this prospect showed that at depth, below the tin/tungsten mineralisation, a complex association of sulphide-hosted tin, copper, tungsten, zinc and silver mineralisation existed.

A gravity survey commissioned by Soloriens Mining Pty Ltd during the 1980s suggested that a ridge of negative anomalies, extending from Mt Balfour to Mt Norfolk, was due to a spine of subsurface granite which may be an extension of the Devonian Pieman and Interview granites to the southwest (TCR 89-3057). Known mineralisation in the Balfour region occurs in the area peripheral to this suggested granite body.

The rocks at the eastern margins and in the body of the Interview Granite have been explored for tin and tungsten veins, with Abignano Ltd identifying a vein deposit containing a possible 1.6 million tonnes at 1.4 per cent WO3 (TCR 83-2074). A Department of Mines estimate of one of the prospect areas was considerably more cautious (416 t of vein deposit @ 2.9per cent WO_3) (Collins in Bacon, 1992a). The rocks close to the granite have been suggested as being prospective for replacement skarn Sn-Cu mineralisation (TCR 88-2892).

Geopeko Ltd also had an interest in the area in the late 1980s, working in joint venture with other companies, and considered that the Rocky Cape Group rocks were prospective for stratiform Pb, Zn and Ag deposits of the Mt Isa/ McArthur River type and for stratiform Cu-Zn (Au) deposits of the Besshi type (TCR 91-3220, TCR 91-3213). Gold-only mineralisation was also considered possible, as shear-related gold and volcanogenic gold deposits associated with basic volcanic rocks. Other exploration plays that were considered were Irish-style carbonate-hosted Pb-Zn in the Smithton Basin and carbonate-replacement tin in the Balfour area.

CRA is currently conducting an active base metal exploration project around Balfour, where fracture-related, chalcopyrite-bearing, quartz and sulphide lodes and tin-bearing quartz veins are being evaluated.

A number of companies have explored for mineral sands in the dunes of the west coast. The main heavy minerals were rutile, zircon, cassiterite and, in some areas, chromite. A possible resource of 200 000 tonnes was identified at Marrawah by National Mineral Sands Pty Ltd (TCR 90-3133). Chromite was identified in Tertiary placer deposits by C. H. Whitehead in the Salmon River area (TCR 89-2985). The source of the chromite is not known.

Dolomite occurs extensively throughout the Smithton area. In 1971 two holes were drilled by the Marble Cliff Quarries Company near Irishtown and another near Edith Creek. In 1945 BHP drilled around the town of Smithtown. Small-scale workings have produced dolomite for agricultural use near Roger River (Bacon and Jennings, 1987).

Mineral Holdings Australia Pty Ltd explored for dolomite and magnesite (TCR 88-2843) in the Smithton area, and for silica sand and silica from quartzite in the Dip Range area (TCR 89-3047).

Exploration has largely been concentrated in the southern part of the Arthur Lineament because of difficulty of access. The central part of the lineament is poorly known geologically, while the northern part is overlain by younger flat-lying rocks of the Tasmania Basin Element. Aeromagnetic data confirms the continuation of the lineament under these rocks and for some distance into Bass Strait.

CRA conducted exploration in the Keith River area, in the central part of the lineament, in the 1980s and considered that a number of mineralisation styles were possible, such as carbonate-basic volcanic associated W(Sn) (Mittersil style) and low-pyrite, zinc-lead deposits of Selwyn Basin type.

Early work on the southern part of the lineament included that by the Electrolytic Zinc Company of Australasia Ltd, who explored for base metals and gold (TCR 88-2882) in the middle 1980s. This was followed by Outokumpu Exploration Australia Pty Ltd, who explored approximately the same area (TCR 94-3566). Exploration targets were Besshi-type stratiform Cu-Zn massive sulphide, Starra-style Cu-Au deposits associated with magnetite ironstones in the Bowry Formation, metasomatic tin-tungsten deposits and carbonate-associated Cu deposits. The Bowry Formation rocks are currently being explored for gold associated with the iron-rich units by Goldstream Mining NL.

Alluvial gold has been recovered from Tertiary sediments over a wide area around the Corinna-Savage River district from 1879 to at least 1941. Payable gold was first discovered in 1879 at Middleton Creek, marking the beginning of gold mining on the west coast. The Corinna goldfield eventually stretched east from the Donaldson River to the Meredith Range, and ran north from the Pieman River, including Browns Plains. It also included Nancy and Lucy Creeks and the Paradise River to the southeast of Corinna. Official records are incomplete but it is estimated that at least 900 kg of gold was produced from the field.

The Golden Ridge area was one of the most productive in the district, with an estimated 800 kg of gold being produced in the 20 years following discovery in 1883. Most of the gold came from creeks, with the remainder being found on the surface of the ridge and in quartz veins exploited by shallow workings, as well as from an open cut in schist at Coxs Face.

Specimen Reef, to the north of the present Savage River mine, was discovered in 1882, the first gold reef located on the west coast. There is no record of substantial production from the mine, although 600 m of tunnels were driven and the mine had three levels.

The alluvial sediments were deep leads in high-level Tertiary gravel, partly reworked into more recent alluvial sediments. The source of the gold was mineralised Precambrian Bowry Formation. Auriferous reefs, such as those in the Golden Ridge and Specimen Reef fields, contributed gold to the alluvial sediments.

Identified resources

Few identified resources occur in the Rocky Cape Element to the northwest of the Arthur Lineament. Dolomite is quarried for agricultural and metallurgical purposes from a quarry near Smithton, with a pre-mining resource of 9.3 million tonnes of 93per cent dolomite.

Resources of heavy mineral sands occur on the west coast but these have not been fully documented.

A number of resources occur in the Arthur Lineament. The Savage River iron deposit, with a pre-mining resource of 137.5 million tonnes of 46.4per cent Fe_2O_3, was until recently an operating mine. Australian Bulk Minerals has determined a preliminary open pittable resource of 160 million tonnes of ore remaining (J. Thorsen, personal communication, 23 October 1996). Substantial tonnages of similar magnetite mineralisation occur within a retention licence to the south in the Bowry Formation at Long Plains South and Rocky River. The Corinna silica mine, based on a residual silica flour deposit on silicified dolomite, is currently operating. The Bowry Formation also hosts very large deposits of magnesite, both in the north of the lineament at the Arthur and Lyons rivers and to the south at Savage River and Main Creek. The Arthur River and Lyons River deposits have been estimated to each contain 30 million tonnes of magnesite containing over 40per cent magnesium oxide. The deposits are held under retention licence by Mineral Holdings Australia Pty Ltd. The Main Creek deposit is given as 40 million tonnes of over 40per cent magnesium oxide and is held by Savage Resources Ltd under a retention licence. Ochre, derived from the weathering of underlying magnesite at Main Creek, forms extensive deposits of red, yellow and brown iron oxides. There are reserves of 0.35 million tonnes, and plans are underway by Savage Resources Ltd to establish a mine and treatment plant.

A substantial resource of clay was identified at Browns Plains by Savage Resources Ltd. The deposit was examined as a potential source of pigment extenders and pottery clay (TCR 89-2964, TCR 90-3132).

A number of areas have been investigated as a source of silica. The Australia and New Zealand Exploration Company estimated a resource of 150 million tonnes of silica near Marrawah in 1974 (TCR 74-993). The quality of the chips or samples taken was not good enough for ferrosilicon production but in 1981 the area was re-examined and considered to hold some potential (Summons in Bacon and Pemberton, 1995).

Silica resources were also sought on Hunter Island, with the Tasmanian Electro Metallurgical Company Pty Ltd investigating that area. Small reserves of quartzite were defined at Nelson Bay River (75 000 t) in 1973.

A number of exploration programs in the 1970s were aimed at finding metallurgical grade silica within the Precambrian quartzite sequences. Areas around Forth, Leven, Dip Range and Takone have all been explored (see Bacon and Pemberton (1995) for details).

Large deposits of Tertiary gravel occur in the valleys of the Flowerdale, Inglis and Cam Rivers. The largest deposit in the lower reaches of the Inglis River was used to provide railway ballast, with resources for this deposit being estimated in 1981 at 3.6 million m3 of sand and gravel (Threader, 1981). This deposit is quarried to produce material for use in concrete manufacture, road aggregate, hotmix sealants and concrete blocks (Bacon and Pemberton, 1995).

Slate from the Arthur River region was described by Henry Hellyer in 1927 and some minor scale extraction has occurred. The slate deposit is a varved sediment, part of the Wynyard Tillite (Gulline, 1967; Bacon, 1987a). Slate has also been mined near Tayatea (in a Precambrian sequence) and used for road material and paving slabs.

Ochre, formed from the precipitation of sediments from mineral springs, has been mined near Smithton and used in paint manufacture (Bacon, 1987b). Samples of ochre derived from the weathering of Tertiary basalt at Spalford were tried by the Serpentine Paint Company in the 1920s, and small quantities have been mined from this deposit. Ochre derived from limonite occurs near Penguin. The material is thought to be derived from Precambrian hematite and was mined intermittently until the mid-1980s.

A weathered Precambrian siltstone was mined near Mawbanna as a paper filler from 1940 to 1951 (Threader, 1976a; Bacon, 1992b). The Mawbanna area was again explored for clay in the late 1960s (TCR 68-534, TCR 69-562).

Potential resources

Most of the mineral potential of the Rocky Cape Element relates to mineralisation styles present, or thought to be present, in the Mesoproterozoic or Neoproterozoic rocks, and to mineralisation associated with exposed Devonian granitoids and their subsurface continuation.

Proterozoic sedimentary sequences

Sediment-hosted copper

There is moderate to high potential for sediment-hosted copper (Model 30b of Cox and Singer, 1986) in the Proterozoic Rocky Cape Group and Togari Group rocks (tracts BM6a/H/B, BM6a/M/B-C). This potential is based on the presence of shallow marine sedimentary rocks, fine-grained copper minerals in mafic rocks, and stratabound copper mineralisation which may be of this style in sedimentary sequences near Balfour.

Sedimentary exhalative Zn-Pb

Proterozoic marine shale and carbonates of the Rocky Cape Group and Togari Group and their correlates have moderate potential for sedimentary exhalative Zn-Pb mineralisation (Model 31a of Cox and Singer, 1986; tract BM7a/M/B-C). The main features supporting this view are:

Pyritic and carbonaceous shales are abundant in the pelitic facies (Cowrie Siltstone, Irby Siltstone) of the Rocky Cape Group. Nodular dolomite and evaporite traces are locally present in the Irby Siltstone.

In the Togari Group of the Smithton Synclinorium, carbonates, black shale and chert are common. Possible debris-flow units, and mapped lateral thickness changes of units, suggest mild syndepositional tectonism. The Kanunnah Subgroup includes mafic volcanic rocks reflecting a regional rifting event. An epicratonic or rift basin setting is likely. Possible exhalite horizons (cherty ironstone) are present in the Kanunnah Subgroup.

The Togari Group has been explored for this deposit type, but no occurrences have yet been reported.

Irish-style carbonate-hosted mineralisation

There is moderate potential for Irish-style carbonate-hosted base metal deposits (Model 31a of Cox and Singer, 1986) in the Smithton Synclinorium in the northern part of the Rocky Cape Element (tract BM3b/M/B-C, map 5.17). This view is supported by the presence of shallow marine carbonate rocks, and a geological setting characterised by active tectonism with possible concurrent volcanic activity. This area has been targeted by exploration companies for this style of mineralisation. The Neoproterozoic rocks of the Smithton Synclinorium unconformably overlie the Rocky Cape Group, and comprise a sequence of dolomite, clastic sedimentary rocks, mafic volcanic rocks, and chert (Seymour and Calver, 1995). Chert lithologies in the Black River Dolomite are apparently derived from silicification of carbonates, the oolitic textures in which are indicative of a shallow marine (shelf) depositional environment. Possible debris-flow units, and mapped lateral thickness changes of units, suggest mild syndepositional tectonism. The overlying Kanunnah Subgroup includes mafic volcanic rocks reflecting a regional rifting event. The Smithton Dolomite, the topmost unit of the sequence, also shows textures indicative of a shallow marine sedimentary environment (Seymour and Calver, 1995).

Dolomite in correlates of the Ahrberg Group along the western side of the Arthur Lineament also have potential for this style of mineralisation.

Occurrences of Irish-style base metal mineralisation have not been reported from the Rocky Cape Element to date.

Basaltic copper

The Rocky Cape Element has high potential for basaltic copper deposits (Model 23 of Cox and Singer, 1986) in areas of the Smithton Synclinorium underlain by the Kanunnah Subgroup (turbiditic volcaniclastic rocks, mafic volcanic rocks and minor diamictite) (tract BM4a/H/B-C). Mineralisation of this style is known in basalt, and copper contents of up to 540 ppm occur in slightly altered basalt (M. P. McClenaghan, personal communication) There is also moderate potential for this style of mineralisation in amphibolite-facies metamorphosed mafic volcanic and volcaniclastic rocks in the Arthur Lineament (tract BM4b/M/B-C). However, no mineralisation of this style has been reported from these rocks.

Arthur Lineament

There is potential for a number of deposit types in the Arthur Lineament (see below). The southern (Savage River mine-Corinna) and northern (Arthur River area) segments of the lineament are fairly well known from recent Geological Survey mapping, and have a certainty level of C associated with the potential for a number of deposit types, whilst most of the central part of the lineament is very poorly known and has a certainty level of B.

Besshi type

The Rocky Cape Element has high potential for Besshi-type massive sulphide (Model 24b of Cox and Singer, 1986) as there are occurrences of this type of mineralisation within the Arthur Lineament (tract BM2a/H/B-C, map 5.16). As noted by Turner *et al.* (1992), the Arthur Lineament displays important similarities with the Japanese Sambagawa Metamorphic Belt which hosts the Besshi 'type deposit'. Most of the known mineralisation in the lineament lies within the Bowry Formation, a sequence dominated by amphibolite and mafic to pelitic schist.

The Arthur Lineament comprises strongly deformed and metamorphosed (locally blueschist facies) chloritic schist with minor phyllite, dolomite and magnesite, and tholeiitic amphibolite. Features such as tectonic setting (near a possible terrain boundary with likely major thrusting), compressional tectonics, strong deformation, high-pressure metamorphism, and the association of continentally-derived clastic sediments and probable rift tholeiites, all appear typical for terrains hosting Besshi-style deposits. Mineral exploration companies have regarded the southern part of the lineament as a target area.

Mineralisation at the Alpine prospect, in the southern part of the Arthur Lineament, comprises pyrite-chalcopyrite with minor sphalerite, magnetite and hematite, and could be considered as typical Besshi type (Turner et al., 1992). In the northern part of the lineament, minor chalcopyrite occurs in pyrite-magnetite lodes at the small Victory prospect on the Arthur River, and in association with the Keith River and Lyons River gossan zones (TCR 71-839; Turner, 1989).

Gold

The Arthur Lineament has high potential for gold-in-ironstone type deposits (tract Au4a/H/B-C, map 5.9). Alluvial gold has been recovered from a wide area in the Corinna-Savage River area at the southern end of the lineament and there is moderate to high potential for this type of deposit (tract Au7/M-H/B). The source of much of this gold is thought to be the Precambrian Bowry Formation, which hosts the Savage River magnetite deposits. The Savage River magnetite deposits were initially prospected for gold, with grades of up to 55 g/t being recorded (Twelvetrees, 1903).

There is little information about primary gold mineralisation associated with these magnetite bodies. Gold is reported to be stratabound, as disseminations and small veins in various schists in the nearby Long Plains prospect. In the Rocky River prospect to the south, gold is reported to be stratabound and hosted by magnetite-rich rocks with nickel, cobalt, copper and silver-bearing sulphides (Twelvetrees, 1903). At Specimen Reef, north of Savage River, Twelvetrees (1903) reported quartz-carbonate-pyrite veins with gold values. The Bowry Formation is currently being explored by a joint venture between Titan Resources NL and Goldstream Mining NL for gold associated with the iron-rich units. These JV partners are undertaking a major exploration project in the Arthur Lineament involving an 18-hole diamond drilling campaign on five anomalies, with a projected expenditure of at least $1 million in 1996/97 in the search for deposits of a similar type to the gold orebody at Homestake, USA and the gold-copper orebody of Selwyn, Queensland (R. Morritt, personal communication).

Volcanic-hosted magnetite

Deposits of volcanic-hosted magnetite (Model 25i of Cox and Singer, 1986) are known in the Arthur Lineament portion of the Rocky Cape Element, especially in the Bowry Creek member (tract Fe1/H/B-C, map 5.27). The largest deposit is the Savage River magnetite, with many other smaller deposits and iron and sulphide-bearing occurrences being distributed throughout the lineament. Such deposits and occurrences are generally identifiable as magnetic anomalies on the existing aeromagnetic coverage of the area.

The potential for Savage River-type iron ore deposits is high and is restricted to mafic metavolcanic and amphibolite units within the Arthur Lineament, essentially along strike from the type deposit. The area of potential is defined by the mapped distribution of amphibolite (unit Lma) and chloritic schist, minor phyllite, dolomite and magnesite (Lac), together with their interpolated and extrapolated extensions beneath thin Permo-Carboniferous sedimentary and Tertiary basalt cover.

Magnesite

Many magnesite (˜ Fe oxide-sulphide-silicate) deposits are known in the Arthur Lineament, especially in the Bowry Formation. The largest are the Savage River, Main Creek and Long Plains magnesite deposits, while other deposits are known at Keith River, Lyons River, Arthur River and at Cann and Syds creeks. Other smaller magnesite occurrences are distributed throughout the Arthur Lineament.

The potential for magnesite in the Rocky Cape Element is high but is probably confined to the Arthur Lineament, in the vicinity of known deposits which occur in association with dolomite, metabasalts and amphibolite (tract Mg/H/B-C, map 5.33). The prospective units also have high potential for Savage River-type iron deposits. The area is defined by the mapped distribution of chloritic schist, minor phyllite, dolomite and magnesite (Lac), and minor amphibolite (Lma), together with their interpolated and extrapolated extensions beneath thin Permo-Carboniferous sedimentary and Tertiary basalt cover.

Granitoid-related mineralisation

The Rocky Cape Element has potential for a number of deposit types associated with the Devonian Interview and Pieman granitoids, which intrude Rocky Cape Group rocks in the southern part of the area and which, on the basis of gravity modelling, may extend north at shallow depth to near Balfour. The certainty level for all of these deposit types is B because of the lack of detailed geological mapping in the relevant areas.

These granitoid bodies are poorly known but consist of granite/adamellite. It is likely that they contain highly fractionated phases with high potential for tin greisen deposits (Model 15c of Cox and Singer, 1986; tract Sn3a/H/C, map 5.25).

A large tract with high potential for tungsten-molybdenum and tin veins (Model 15a, b of Cox and Singer, 1986) surrounds and connects the Pieman and Interview plutons (tract Vn1a/H/B-D, map 5.24). The distribution of this type of vein mineralisation is related to the subsurface distribution of granitoids as determined by modelling of gravity data. The 4 km granite isobath has been used to delineate the area of potential, as known deposits in

other areas lie within this limit and many are within the 1 km isobath (Taheri and Green, 1990). The presence of known mineralisation confirms the high potential for tungsten (-molybdenum) and tin veins.

Another vein-type deposit associated with the granitoids is silver-bearing polymetallic veins (based on Model 22c of Cox and Singer, 1986), for which there is high potential in the Rocky Cape Element (tract BM5a/H/B-D, map 5.19). In Tasmania these vein deposits form the outer haloes of zoned mineral fields around Devonian granitoids(the best known being the Zeehan field). Because of this position, the area within the 6 km depth contour of the granite surface has been used to delineate the zone of potential around the Interview and Pieman granitoids.

There is moderate potential for replacement tin deposits (Model 14c of Cox and Singer, 1986), based on the subsurface continuation of the Devonian- Early Carboniferous Interview and Pieman granitoids as determined by modelling of gravity data. The 4 km subsurface granite contour has been used to delineate the area of potential (tract Sn1c/M/B, map 5.23). These granitoids have the appropriate composition and are associated with known tin mineralisation. The inferred subsurface granitoid is overlain, at the surface, by Neoproterozoic Rocky Cape Group rocks which contain only minor dolomite. However, an interpretation of new regional airborne-survey geophysical datasets, supported by recent geological mapping, has suggested that Rocky Cape Group rocks have, in places, been thrust over Togari Group rocks which contain major dolomite units.

There is moderate potential in the element for skarn-type deposits associated with the Interview and Pieman granitoids. The types include tungsten, tin, copper and iron (magnetite) skarns (Model 14a, b; 18b, d of Cox and Singer, 1986). The area has been delineated based on the 2 km depth contour of the subsurface continuation of the Interview and Pieman granitoids as determined by modelling of gravity data (tract Skrn1c/M/B, map 5.22).

Other deposit types

Dolomite

The Togari Group in the Smithton Synclinorium contains two major sequences of shallow marine dolomite, with a total stratigraphic thickness in excess of 2000 metres. The older of the two sequences is commonly silicified, but the younger and thicker (~1500 m) of the two units (the Smithton Dolomite) is commonly unsilicified, and is quarried for dolomite in the Smithton area. The Smithton

Dolomite either crops out or occurs beneath a relatively thin cover of Quaternary sediments over significant portions of the Smithton Synclinorium, and these areas are all of high potential for dolomite resources (tract Dol/H/B-C, map 5.38). A similar degree of potential applies to dolomite sequences in the Ahrberg Group adjacent to the western margin of the southern part of the Arthur Lineament.

Silica and ochre

The Rocky Cape Element contains resources of silica flour in the Corinna area in the southern part of the Arthur Lineament, where there is an operating mine exploiting a residual silica flour deposit on silicified dolomite. There is high potential for more deposits of the same kind in dolomite areas in the lineament, and also in other areas of dolomite in the Smithton Synclinorium (tract Sifl/H/B-C, map 5.34). There is also potential for silica flour derived from weathered Rocky Cape Group quartzite, which crops out extensively in a number of parts of the Rocky Cape Element. Systematic geological mapping in some areas has indicated that the same lithologies show varying degrees of at least partially diagenetic silicification, and so have varying potential for hard-rock silica resources.

There are large resources of ochre in the Arthur Lineament near Savage River, and a development proposal and environmental management plan for the production of 10 000 tonnes/annum of refined pigment/ochre has been lodged. The ochre is derived from the weathering of underlying magnesite. Other areas of magnesite in the Arthur Lineament also have high potential for ochre (tract Ochre/H/B-C, map 5.35).

Yellow ochre has been produced from deposits of limonite near Smithton, and there is potential for more deposits of the same kind.

Placer deposits and mineral sands

Tertiary alluvial sand and gravel in the Rocky Cape Element are known hosts of tin placer deposits (Model 39e of Cox and Singer, 1986; tract Sn5/M-H/B-C, map 5.26). A large area of Tertiary sediments of this type, immediately north of the Heemskirk Granite, has been and is currently being explored and worked for alluvial tin derived from the granite, and all of the areas underlain by such sediments close to the Heemskirk Granite have moderate to high potential for alluvial tin. Alluvial gold has been won from similar Tertiary clastic sediments over a considerable area in the Corinna-Savage River district in the Arthur Lineament, and any such sequences resting on or adjacent to lineament rocks have moderate to high potential for gold placers (Model 39a of Cox and Singer, 1986; tract Au7/M-H/B, map 5.12). Prospecting for, and mining of, alluvial gold around the turn of the century uncovered several small diamonds in the area of Harvey and Middleton Creeks south of Savage River (Twelvetrees, 1918). The Mount Lyell Mining and Railway Co. Ltd carried out a limited exploration program for diamond in the area in the 1970s, but the source of the gemstones remains unknown. Recent geological mapping has shown that extensive Tertiary basalt sequences, which cover much of the central and northern parts of the Arthur Lineament, commonly conceal sub-basalt Tertiary sand and gravel resting directly on a basement of lineament rocks. These basalt have potential for concealed gold placer deposits.

In the southwestern part of the Smithton Synclinorium, Tertiary quartz sand and siliciclastic gravel host placer deposits of chromite, of unknown origin (Model 39b of Cox and Singer, 1986; tract Cr/M-H/B-C, map 5.30). These Tertiary sediments cover a significant area, and have moderate to high potential for chromite.

Past exploration has identified rutile-zircon-cassiterite ˜ chromite mineral sands in the beach/dune systems of the west coast, including a significant resource near Marrawah. These beach/dune systems are of Recent to Pleistocene age, and in some areas extend some kilometers inland due to higher sea levels in the Pleistocene. They thus comprise a significant total area which has moderate potential for heavy mineral sand (Model 39c of Cox and Singer, 1986; tract MS1a/M/B, map 5.32).

Dundas and Sheffield Elements

Geology

The eastern boundary of the Arthur Lineament marks a transition from the metamorphic rocks of the lineament into the relatively unmetamorphosed Oonah Formation, a Neoproterozoic sequence of dominantly turbiditic quartzwacke and lithicwacke with minor carbonates and basalts, at the western margin of the Dundas Element. Adjacent to the north coast, the less varied sandy turbidite-facies quartzwacke-mudstone sequence (with minor basaltic pillow lava) of the Burnie Formation is considered to be coeval with the Oonah Formation (Turner, 1989a). The Oonah Formation may be unconformably (Brown, 1986) or conformably (Turner, 1990a; Turner *et al*., 1992, 1994) overlain by the Success Creek Group. The latter interpretation suggests that the Oonah Formation may be at least partly coeval with the lowermost, siliciclastic units of the Togari Group in the Rocky Cape Element (Turner, 1990a; Turner *et al*., 1992, 1994). The Oonah and Burnie Formations may thus represent an important link between Neoproterozoic, mainly shallow-marine shelf sedimentation in the Rocky Cape Element, and the commencement of Neoproterozoic to Late Cambrian, mainly deeper marine The Success Creek Group consists of about 1000 m of shallow-marine quartz sandstone, shale, minor diamictite and carbonate. The Group is conformably overlain by the Crimson Creek Formation, which includes at least 5 km of mafic-volcaniclastic wacke, shale and tholeiitic basalt. The basalt has a 'within-plate' geochemical signature (Brown and Jenner, 1988).

Three of the four suites of basaltic rocks distinguished by Brown and Jenner (1988) in the Dundas Element are spatially and genetically related to each other, and have Island Arc-Ocean Island characteristics. The first such suite includes basaltic rocks in the Cleveland-Waratah area north of the Meredith Granite and along the eastern flank of the Huskisson Syncline southeast of the same granite. This suite is a sub-alkaline basalt association with Ocean Floor Basalt geochemical affinities. The second suite comprises high-magnesium andesitic/boninitic rocks, while the third suite comprises low-Ti basalt-andesite. The latter two suites resemble, chemically and isotopically, Eocene to Recent boninitic and associated lavas from the Bonin Islands and Cape Vogel area in Papua New Guinea.

All three basaltic suites, together with associated sedimentary sequences, and the ultramafic-mafic complexes, are considered to be remnants of exotic assemblages tectonically emplaced into the western Tasmanian terrane as a result of a major collision event in the late Early to early Middle Cambrian. The western margins of the ultramafic complexes can be joined by a line which is thought to approximate the major emplacement thrust surface, which was disrupted later in the Palaeozoic (Brown and Jenner, 1988).

Brown (1986) recognised three ultramafic-mafic rock associations in Tasmania which are commonly in fault juxtaposition within the complexes: Layered Pyroxenite-Dunite (LPD); Layered Dunite-Harzburgite (LDH); and Layered Pyroxenite-Peridotite and associated Gabbro (LPG). All the ultramafic rocks are orthopyroxene-rich, and this feature distinguishes them from the dominantly clinopyroxene-rich sequences which are usually associated with mid-ocean ridge and back-arc environments world-wide(Brown, 1989a).

Brown and Jenner (1988) demonstrated genetic links between the ultramafic rocks and the three mafic volcanic suites forming their Island Arc-Ocean Island association.

The complexes were tectonically emplaced into the Dundas/Sheffield Element by about the middle Middle Cambrian (Rubenach, 1974; Padmasiri, 1974; Brown, 1986).

Berry and Crawford (1988) proposed an obduction model, in which the ultramafic-mafic complexes (together with the Island Arc-Ocean Island basaltic suites and associated sedimentary sequences; Brown and Jenner, 1988) are allochthonous relics of a fore-arc terrane which collided with, and was thrust over, a passive continental margin in the Middle Cambrian. A number of other, presently disjunct rock units are also believed to represent allochthons emplaced at this time.

'Osmiridium' has been mined from first and second cycle alluvial and eluvial deposits derived from LDH-association rocks in a number of ultramafic complexes in the Dundas Element. Minor amounts of nickel and copper have been mined from the Heazlewood River, Trial Harbour and Serpentine Hill bodies (Collins and Williams, 1986; Brown, 1989a), and asbestos from the Cape Sorell and Serpentine Hill complexes.

Felsic volcanic and volcano-sedimentary sequences occupy a belt about 30-40 km wide between Elliott Bay in the south and Deloraine in the north, constituting the main part of the Dundas and Sheffield Elements. The sequences along the western part of the belt have complex contacts with the various allochthons and pre-collisional units, but the eastern contact is a relatively simple unconformity (in places faulted) against ?Mesoproterozoic rocks of the Tyennan Element. The proximal part of the volcanic belt, constituting the main part of the Mt Read Volcanics, lies along the Tyennan margin, and is flanked to the west by extensive volcano-sedimentary sequences which grade into locally-derived sedimentary sequences in places.

The Mt Read Volcanics are predominantly rhyolitic to dacitic, but andesites are locally abundant and there are minor but significant basalts. Many of the rocks are strongly cleaved and altered (typically to sericite-chlorite mineralogies). Most of the volcanic units are now considered to be submarine deposits, including extensive pumice-clast breccias previously interpreted as ignimbrites (McPhie and Allen, 1992). Genuine welded ignimbrites are preserved only in the youngest parts of the volcanic sequence (White et al., 1993). Widespread mass-flow volcaniclastic breccia units, typically interbedded with sandstone, are a common feature, as are sill-like porphyry bodies with peperitic margins.

The Mt Read Volcanics form the most conspicuously mineralised belt of rocks in Tasmania, being host to several world-class base-metal and precious-metal deposits (Hellyer, Rosebery, Mt Lyell) and numerous medium-sized (Que River, Hercules, Henty) and small deposits. All of the major deposits have many of the characteristics of volcanic-hosted massive sulphide (VHMS) deposits, believed to have formed on the seafloor during volcanism (Solomon in Corbett and Solomon, 1989). The Mt Lyell deposit is unusual in having most of its metal reserves in disseminated, epigenetic, replacement-type ore. High grade bornite-chalcopyrite mineralisation in chert, developed at the Mount Read Volcanics-Owen Group contact (North Lyell, part of the Lyell Comstock deposit), is probably a product of hydrothermal dissolution and reprecipitation of pre-existing mineralisation during Devonian deformation (Solomon et al., 1987). The origin of native copper-cuprite-chalcocite mineralisation hosted by clay and nodular goethite replacements of the Gordon Group is unresolved (Markham, 1968; Solomon, 1969), but may be due to neutralisation of Cu-rich acidic surface runoff during the Cainozoic (Kevin Wells, Copper Mines of Tasmania, pers. comm.).

Several major faults affect the volcanic belt. The Henty Fault obliquely transects the belt from Que River to Mt Read, and divides into two major splays (North and South Henty Faults) at the southern end. The north-trending Great Lyell Fault intersects the Henty Fault at Red Hills, and was an active structure in the Cambrian. The Rosebery Fault is a major east-dipping thrust near the western margin of the main Mt Read belt.

Cu-Au mineralisation south of the Henty Fault, including the bulk of the mineralisation of the Mount Lyell field, may be genetically related to the intrusion of Cambrian granites (Large et al., 1994).

The Que River and Hellyer deposits more closely resemble typical Kuroko deposits. The Hellyer deposit (McArthur in Corbett and Solomon, 1989) formed as a mound on the sea floor, as demonstrated by the distribution of isopachs of an overlying volcaniclastic breccia unit. The cigar-shaped massive sulphide orebody shows well developed stratigraphic, mineralogical and chemical zonation from a low grade basal cupriferous pyritic section to a zinc-lead-silver-gold enriched top, successively overlain by barite and glassy quartz.

The Ordovician to Devonian Wurawina Supergroup is a largely conformable, shallow-marine sedimentary succession exposed in a number of structural and erosional outliers east of the Arthur Lineament in the Dundas/Sheffield Element. The succession is divided into the Denison Group (Late Cambrian to Middle Ordovician, mostly coarse-grained siliciclastic rocks), the Gordon Group (Ordovician, mostly limestone), and the Eldon Group (Silurian to Early Devonian, mostly fine-grained clastic rocks) (Banks and Baillie, 1989).

The Denison Group is unconformable with older rocks except for local conformity on the Tyndall Group in western Tasmania. Accommodation was created by variable, partly fault-driven subsidence in Cambrian 'troughs', while the Tyennan and Rocky Cape Elements were uplifted source areas. Along the West Coast Range, the Denison Group correlate (known as the Owen Group) forms a strongly westward-thickening meridional prism, up to 2.5 km thick, of quartzitic conglomerate and sandstone derived from the Precambrian rocks of the Tyennan Element.

West of the West Coast Range, in the axial parts of the Dundas Element, a thick, marine, flysch-like succession of turbidites and conglomerate of the upper Dundas and upper Huskisson Groups is a distal equivalent of the Owen Group (Corbett, 1990; Brown, 1986).

Middle Devonian deformation was polyphase in nature, and in some areas intersecting fold trends have resulted in dome and basin structure and overprinting relationships. The structural style is of generally upright to steeply inclined, open to tight folds with horizontal to moderately-plunging hingelines, and associated axial plane cleavage development and faulting.

Many faults are steep thrusts associated with the development of inclined folds, and overprinting and reactivation of earlier (particularly Cambrian) structures is common.

Devonian granitoids occur in a number of smaller batholiths and isolated plutons. The granitoids are generally biotite adamellite or granite, and were intruded post-tectonically and emplaced at relatively shallow depths. The main bodies are the Housetop, Granite Tor, Meredith and Heemskirk granitoids. Small amounts of hornblende are present in parts of the Housetop, Meredith and Heemskirk bodies, while the Heemskirk body also includes alkali-feldspar granite. The granitoids include both I and S types. Geophysical modelling has indicated the presence, at depth, of a large ENE-trending ridge of granitoid almost linking the outcropping Heemskirk and Granite Tor granites (Leaman and Richardson, 1989).

A number of styles of mineralisation are associated with the Devonian granitoids. Stratabound carbonate replacement cassiterite-massive sulphide deposits are hosted by various carbonate units within the Neoproterozoic Oonah Formation (Mount Bischoff, Queen Hill), the Neoproterozoic Success Creek Group and Crimson Creek Formation (Renison, Montana), and Early Cambrian ?allochthonous sedimentary sequences (Cleveland). The cassiterite-massive sulphide deposits mostly occur 500 to 1500 m above the upper surface of underlying granites (Collins and Williams, 1986; Leaman and Richardson, 1989; Kitto, 1992) and as replacement of dolomite and limestone horizons. Economically significant cassiterite mineralisation also occurs in faults, fractures and porphyry dykes.

Skarn-associated tin and tungsten deposits occur adjacent to, or within a few hundred metres of granitoid bodies. Scheelite-bearing skarns are associated with the I-type granites at Kara (Kwak, 1987), while tin-bearing skarns containing minor tungsten are associated with the S-type granites at Mt Lindsay, St Dizier and Tenth Legion (Kwak, 1983, 1987).

Disseminated cassiterite associated with greisenised/altered granite occurs in the southern part of the Heemskirk Granite (Hajitaheri and Solomon, 1984).

Silver-lead vein mineralisation occurs as haloes around some of the granitoid bodies. Such mineralisation in the Zeehan area is thought to be related to a hidden granite body underlying the Queen Hill-Zeehan area (Solomon, 1981; Anderson, 1990), possibly a subsurface continuation of the Heemskirk Granite. Deposits of this type were typically small; the Magnet mine (630 000 t at 7.3% Pb, 7.3% Zn and 427 g/t Ag) was the largest. Some deposits, particularly those hosted by the Mount Read Volcanics, contain minor gold credits (Green, 1990; Taheri and Green , 1990).

A number of the magnetite-bearing skarn deposits contain base metal mineralisation. Secondary alteration of the magnetite skarn adjacent to a fault cutting a deposit at Moina has produced an amphibole-hematite-quartz-sulphide assemblage with notable grades of Zn and Au and significant In, Cd and Cu (Kwak and Askins, 1981). At the nearby Stormont deposit, Au-Bi-Pb mineralisation is related to late-stage chlorite-fluorite-muscovite-calcite-quartz alteration of distal garnet-pyroxene-vesuvianite skarn which had been extensively retrogressed to actinolite prior to the mineralising event (Taylor, 1990).

Recent exploration in the Comstock area, west of Zeehan, has identified a substantial body of sub-economic Zn-Pb-Ag mineralisation in a massive pyrrhotite-pyrite lens replacing a magnetite-serpentine skarn distal to, and partly a replacement of, early diopside-andradite-tremolite skarn (TCR 92-3386).

The Parmeener Supergroup rocks, which contain significant coal resources, are discussed as part of the Tasmania Basin Element. An outlier of Late Carboniferous tillite near Zeehan (the Zeehan Tillite) displays gentle NW-trending folds and an associated, pervasive, subvertical axial-surface cleavage (Goscombe, 1991). There are also minor areas of Jurassic dolerite in the Dundas and Sheffield Elements.

Faulting and basin formation and extrusion of alkali-olivine basalt occurred during the Tertiary. The Devonport-Port Sorell Sub-basin (Cromer, 1989; Burns, 1965) contains 250 m of carbonaceous mudstone, sandstone and minor conglomerate with Palaeocene and early Eocene microfloral assemblages, overlain by 175 m of repetitious thin flows of alkali olivine basalt, 75 m of weakly consolidated sandstone, and 50 m of basalt. The Macquarie Harbour Graben is a shallow, onshore extension of the Sorell Sub-basin and contains a sedimentary fill that is about 500 m thick immediately west of Strahan (Baillie and Corbett, 1985). Basal conglomerate, in places composed largely of Jurassic dolerite boulders, is overlain by Eocene sediments which include marginal-marine interbedded sandstone, siltstone and minor coal overlain by fluvial cross-bedded sandstone (Baillie et al., 1986).

Widespread, patchy developments of Tertiary terrestrial sediments, in many places preserved beneath basalt flows, are almost all latest Eocene or younger in age (Forsyth, 1989a). Surficial Quaternary sediments are widespread and contain placer deposits, including heavy minerals in beach sands.

Mineral Exploration

Dundas Element

Exploration in the Dundas Element has concentrated on the following ore deposit models:

1. Volcanic-hosted massive sulphides;
2. Besshi-style massive sulphide deposits;
3. Irish-style carbonate-hosted base metal deposits;
4. Silver-bearing polymetallic veins;
5. Sedex lead-zinc;
6. Porphyry copper-gold;
7. Epithermal gold-silver;
8. Skarn deposits;
9. Tin greisens, replacement tin;
10. Deposits associated with mid-Cambrian ultramafic rocks; and
11. Placer/alluvial gold, chromite, tin.

The major mineralisation targets have been the VHMS, Irish style, silver-bearing polymetallic veins and replacement tin models.

Eighteen companies, including Pasminco Exploration, Gold Mines of Tasmania, RGC Exploration, Resolute Samantha, Aberfoyle Resources, Titan Resources, CRA Exploration P/L and Plutonic Resources, are currently exploring in the area.

Volcanic-hosted masssive sulphides (including Au associated with massive sulphide, barite, Mt Lyell-type massive sulphide and Cu-bearing clay)

The Mount Read Volcanics contains a number of world-class VHMS mineral deposits and is internationally recognised as one of the most prospective areas in the world for this type of mineralisation. About half of all Tasmania's mineral exploration expenditure is directed towards exploration for this target within the Dundas Element.

Company	Period	Exploration Philosophy and significant results

Que-Hellyer-Charter area and north

Comstaff	1963-1988	gold-rich volcanogenic massive base-metal sulphide deposits of the Rosebery/Que River type (TCR 89-2968). drillhole HP1 (High Point) intersected Hellyer-Que River sequence correlates, including 250 m@>0.2% Zn (TCR 89-2968). Sock Creek mineralisation identified - not of target type, and insufficient tonnages and/or grade (TCR 89-2968).

Company	Period	Exploration Philosophy and significant results
Que-Hellyer-Charter area and north (cont.)		
Aberfoyle	1970-	volcanogenic base metal sulphide deposits. Que River Deposit discovered using airborne EM in 1974 (TCR 74-1020). Hellyer Deposit discovered using UTEM in 1984 (TCR 84-2277, TCR 86-2521, TCR 86-2551).
Billiton/ CRAE P/L	1980-1990	Cattley North/Two Hummocks/Native Track Tier explored for volcanogenic base metal mineralisation (TCR 90-3122). geochemically base-metal anomalous shale was recorded at the porphyry contact. Mineralisation interpreted as local only. a black shale horizon identified under basalt cover, not drill tested, and remains a prospective target on geological grounds.
Outokumpu	1988-1990	volcanogenic base-metals (TCR 91-3304). involved with the sub-basalt drilling program which discovered the complete Hellyer section below Tertiary Basalt.

Pinnacles-Boco-Chester area

Comstaff	1963-1972	gold-rich volcanogenic massive base-metal sulphide deposits of the Rosebery/Que River type (TCR 72-851).
EZ Co/Pasminco	1972-1995	massive VHMS Zn/Pb/Cu deposits of the Rosebery-Que River type associated with thin sedimentary lenses within Cambrian volcanic rocks.

		more distal Pb/Zn/Cu deposits associated with sediments of the Dundas Trough. several small lenses of massive base metal sulphide were found (Browns Tunnel) + Chester pyrite deposit. volcanic-hosted auriferous base metal sulphide bodies similar to those at Rosebery and Hercules (TCR 95-3726, TCR 96-3877, TCR 94-3568). concluded that a small alteration system associated with minor mineralisation exists within the Pinnacles Rhyolite (TCR 95-3726, TCR 96-3877, TCR 94-3568).
CSR Limited	1985-1986	volcanogenic Pb-Zn mineralisation similar to Rosebery (TCR 87-2687).
Pancon Mining/ BHP	1985-1987	volcanogenic base metal sulphides (TCR 87-2740).
Samisen Ltd/ BHP	1988-1989	volcanogenic base metal sulphides (TCR 89-3018).

Pinnacles-Boco-Chester area (cont.)

Shell/Billiton/ BHP	1990	volcanogenic base metal sulphides.
Pasminco	1990-	volcanic-hosted auriferous base metal sulphide bodies similar to those at Rosebery and Hercules. found small alteration system associated with minor mineralisation within the Pinnacles Rhyolite.
Aberfoyle/Placer	1991-1994	volcanogenic polymetallic VHMS within Que-Hellyer or Sock Creek Volcanics. a thickened sequence of Que-Hellyer volcanics was found to be present at depth. a 40 m thickness of basalt within Que River Shale containing significant silica, pyrite and chalcopyrite was encountered (BRD05) (TCR 94-3544, TCR 87-2740).

Tullah-Sterling Valley area

Pasminco	1990-1995	volcanogenic auriferous Rosebery-style VHMS (TCR 95-3770).

Billiton	1988-1990	Henty-style gold along Henty Fault (TCR 88-2772).
EZ/Getty/ Aberfoyle/ Billiton JV	1979-1988	VHMS in sediment lenses in the Eastern Volcanics (TCR 85-2344 , TCR 88-2895).

Rosebery-Hercules area

Mancala	1995-	Hercules VHMS deposit to be re-opened, remaining reserves at time of August 1986 closure: 280 400 t @2.8% Pb, 11.6% Zn, 0.47% Cu, 51 g/t Ag, 1.1 g/t Au. Mancala plan to take anything >10% Zn.
Pasminco/EZ Co	1970s-	large mine lease and associated exploration area controlled by EZ. Along-strike and down-dip extensions examined, deep drilling program has outlined additional reserves, mine total at June 1996: 8.3 Mt @13.1% Zn, 2.6 g/t Au.

Dundas-Renison area

RGC	1988-1994	Henty-style Au along the Rosebery Fault (TCR 93-3434, TCR 94-3577).
Pasminco	1996-	VHMS Zn as replacement bodies.

Clark Valley

BHP	1968-1975	Rosebery-style VHMS deposits.
Aberfoyle	1994-	VHMS deposits (TCR 96-3827, TCR 96-3894).
RGC, BHP	1987-	VHMS deposits (TCR 94-3549).

Mt Darwin-Intercolonial Spur-Garfield Valley

PlatSearch	1994-	VHMS.
RGC & BHP	1991-	VHMS (TCR 91-3252).
Chiefly Mt Lyell M&R Co. and BHP	1940-1989	Sampled old workings for Cu. Airmag, air EM and drilling. Sampling , geophysics and mapping, some drilling. 1974 EZ JV with BHP & Internation Nickel looking for VHMS (Rosebery) in Western Sequence (TCR 74-1010, TCR 75-1122).

		BHP returned in 1989 exploring for Pb-Zn in Western Sequence.

Beatrice-Lake Dora-Basin Lake-Lake Selina

Mt Lyell M&R Co. and later as RGC	1969-1987	Mt Lyell-style mineralisation (TCR 87-2675).
Pickands Mather	1965-1971	Mt Lyell-style mineralisation (TCR 71-729).
Billiton (later with Aberfoyle)	1988-1991	VHMS deposits (TCR 93-3423).
Pasminco	1996-	Cu-Au massive sulphide replacement.

Red Hills-Henty-Comstock area

Early prospectors	Pre-1966	Cu (TCR 51-111).
EZ Co. with Rio Tinto	1957-1961	Geophysical exploration.
Mt Lyell M&R Co.	1966-1984	Focussed on the lava dome. Looking for Cu and Pb-Zn in black shale. Found some Au and a small, banded massive sulphide (TCR 81-1519). Henty-style Au.
CRAE P/L	1985-1988	Au and Base metals. (TCR 86-2586)
Aberfoyle and CRAE	1988-	VHMS base metals (TCR 93-3524).
Plutonic	1994-	VHMS base metals and Cu.
Resolute-Samantha	1996-	VHMS base metals south of Henty mine.

Coupon-Queenstown Airfield

Trikon Int.	1984-1987	VHMS (TCR 83-2008, TCR 85-2441, TCR 86-2582, TCR 87-2672).
Amoco/Posiedon/Placer	1983-88	VHMS and Au (TCR 88-2836).
Bruce Resources	1994-1995	Henty-style VHMS (TCR 95-3758).

Lyell area

Mt Lyell M&R	-1994	Mt Lyell-style VHMS.

Co.		
Gold Mines of Tasmania	1994-	Mt Lyell-style VHMS. Cu replacement in carbonate (Cu-clay).

South of Macquarie Harbour

Plutonic	1992-	VHMS.
Amoco/Posiedon/Placer	1983-1988	VHMS and Au (TCR 88-2836).
BHP	1964-1972	Exploring for everything. Found some Cu associated with Zn and Ni.
Mt Lyell M&R Co. and EZ Co.	1956-1962	No specific target, but most likely is VHMS.
Aberfoyle and CRAE	1988-	VHMS base metals.

Besshi-style massive sulphide deposits

CRA Exploration have targetted tholeiitic volcanic rocks for exploration for copper-gold sulphide mineralisation.

Heazlewood-Mt Lindsay area

CRAE P/L	1990-1995	Cu/Au mineralisation hosted by Cambrian tholeiitic basalts as a secondary target (TCR 95-3777, TCR 95-3705).

Irish-style carbonate-hosted base metal deposits
(including Mississippi Valley style)

CRA Exploration Pty Ltd has recently conducted detailed exploration for Irish-style deposits (and closely related Mississippi Valley-style deposits) with some success in the Gordon Limestone near Zeehan, following the pioneering work by Amoco who first identified this type of mineralisation in the Oceana mine area. Most of the Gordon Limestone is now covered by exploration licences.

Que-Hellyer-Charter area and north

CRAE P/L	1994-	carbonate-hosted massive sulphide in Mt Cripps-Mackintosh River area.

Tullah-Sterling Valley area

Billiton	1988-1990	remobilised strata-bound Au-bearing sulphide deposits (TCR 88-2772).

Zeehan-Heemskirk area

Amoco Cyprus Pasminco	1978- 1987	carbonate-hosted Pb/Zn (TCR 83-2024). most work done around Oceana and Austral mines. Oceana: 4 Mt @19.4% Pb, 4% Zn, 106 ppm Ag.

Pinnacles-Boco-Chester area (cont.)

CRAE P/L (TCR 93-3521, TCR 93-3522)		Irish-style Zn/Pb. MVT style Zn/Pb. drilled out Grieves prospect, good Pb/Zn intersections at Mariposa.

Coupon-Queenstown Airfield

CRAE P/L	1996-	Carbonate-hosted base metals.

Clark Valley

Cyprus	1986	carbonate-hosted Pb/Zn (TCR 86-2616).

Silver-bearing polymetallic veins

Polymetallic veins have been a principal target for many companies up to the 1980s. Since then they have been a typical secondary target. Shear-hosted polymetallic mineralisation is currently a principal target for at least one major exploration company.

Que-Hellyer-Charter area and north

Comstaff	1963- 1988	vein-type lodes of Pb/Ag/Sn (TCR 89-2968).
Pasminco	1996-	Cu in vein stockworks.

Heazlewood-Mt Lindsay area

Metals Exploration	1985- 1988	stringer-style Cu-Au mineralisation along complex fault zones.
	1988- 1990	precious metal/base metals in the overlying andesite and basalt (TCR 89-3054, TCR 88-2804, TCR 87-2644).

Luina-Waratah area - also Meredith Granite

Geopeko	early 1990s	gold in shear zone and vein deposits within basic volcanic rocks (TCR 91-3299).

Tullah-Sterling Valley area

Pasminco	1990-1995	remobilised base metal lode and vein-style deposits of the Farrell Lode type (TCR 95-3770).
EZ/Getty/ Aberfoyle/Billiton JV (TCR 85-2344, TCR 85-2313) (TCR 88-2895)	1979-1988	Ag/Pb mineralisation in the Farrell Slate. Result was an outline of the 'Arsenic Resource', 480 000 t @5% As, present as four separate lenses. Billiton drilled the Lakeside vein-style Au (Sn/Cu) deposit to establish a resource of 750 000 t @2.1 g/t Au.
Billiton	1988-1990	Tullah Flats and Murchison, target is structurally emplaced base metal + Au deposits similar to Farrell and Murchison deposits (TCR 88-2772)

Dundas-Renison area

Geophoto (TCR 74-996)	1968-1974	vein/lode Pb/Zn/Ag. drilling located Pb/Zn/Ag in several thin fissure veins, did not meet corporate objectives.

Dundas-Renison area

CSR (TCR 86-2584)	1976-1987	Oonah mine-type Ag/Pb/Zn + Sn sulphides. Cu/Zn/Ag/Sn associations in Dundas Group acid volcanic rocks.
Pasminco	1996-	shear-hosted polymetallic veins.

Zeehan-Heemskirk area

Placer, Tenneco, Mt Lyell, Aberfoyle/ Gippsland JV	1966-1980	granite-related Pb/Zn/Ag veins (TCR 91-3309).
Miscellaneous companies	historical-present	granite-related Pb/Zn/Ag veins (Crown, Spray, Comstock, Sylvester).

Beatrice-Lake Dora-Basin Lake-Lake Selina

Pasminco	1996-	Pb-Ag (+Zn) sulphide replacement.

Carlin-style gold

Two companies have explored specifically for Carlin-style gold, but others have included the model as a secondary target.

Luina-Waratah area - also Meredith Granite

Geopeko	early 1990s	Carlin-style Au within carbonate/shale associations (TCR 91-3299).

Coupon-Queenstown Airfield

Bruce Resources	1994-1995	Carlin-style Au (TCR 95-3758).

Porphyry copper-gold

Exploration for copper-gold associations has not been undertaken until recently. World trends indicate that exploration for this target is a likely area for growth.

Mt Darwin-Intercolonial Spur-Garfield Valley

PlatSearch	1994-	Porphyry Cu.
RGC and BHP	1991-	Porphyry Cu (TCR 91-3252).

South of Macquarie Harbour

Plutonic	1992-	Porphyry Cu.

Epithermal gold-silver

Polymetallic, gold-rich veins are common in the Dundas Element, and the search for gold-only ore veins has been maintained from the 1980s to the present.

Mt Darwin-Intercolonial Spur-Garfield Valley

PlatSearch	1994-	Epithermal polymetallic Au-rich veins.
EZ Co./Norgold (TCR 88-2861, TCR 87-2706)	1985-1989	Exploring for Au. Found Norms prospect (Au).
Chiefly Mt Lyell M&R Co and BHP (TCR 86-2594)	1940-1989	Found gold in 1981-1982: resulted in a change in emphasis for Au exploration in the area. EZ (later as Norgold) explored for bulk low grade epithermal gold (TCR 88-2566).

Beatrice-Lake Dora-Basin Lake-Lake Selina

Pasminco	1996-	Au-only replacement.

Coupon-Queenstown Airfield

Goldstream and subsidiaries, and JV with Titan	1987-1995	Fault-hosted Au-As replacing carbonate (TCR 95-3796).

Skarn deposits

The prodigious amount of mineralisation associated with granites apparent in the element makes all carbonate rocks above, or adjacent to, granite an exploration target. Exploration has focussed on tin and base metal targets.

Heazlewood-Mt Lindsay area

Metals Exploration	1985-1988 1988-1990	contact Sn/W skarns of the Mt Lindsay/Mt Ramsay style (TCR 89-3054, TCR 88-2804, TCR 87-2644).
Pasminco	1996-	Base metal skarns.

Luina-Waratah - also Meredith Granite

Pasminco	1996-	Zn-rich base metals in skarns.

Dundas-Renison area

RGC	1988-1994	skarns (TCR 93-3434, TCR 94-3577).
Pasminco	1996-	Zn-rich skarns.

Zeehan-Heemskirk area

Miscellaneous companies	historic-present	skarn-hosted base metal deposits.
RGC	1987-	found Sylvester base metal skarn at odds with their exploration model (TCR 92-3386, TCR 92-3379).

Tin greisens, replacement tin

The success of tin mines in the element has been the basis for ongoing exploration for Renison-type and Cleveland-type tin deposits. Copper and other base metals are associated with tin in the Dundas Element. Recent exploration has suffered from anomalously low tin prices.

Que-Hellyer-Charter area and north

Comstaff	1963-1988	replacement tin deposits of the Renison type (TCR 89-2968).

Pinnacles-Boco-Chester area

EZ Co./Pasminco	1972-1995	tin deposits associated with calcareous sediments of the Dundas Trough in proximity to acid intrusive rocks.

Heazlewood-Mt Lindsay area

Comstaff (TCR 78-1316, TCR 85-2316)	1970-1985	structurally-controlled hydrothermal mineralisation hosted by sediments and mafic volcanic rocks, but ultimately related to Devonian granitoids. work in the Magnet mine area was targetted at Magnet-style Zn/Pb/Ag along, or related to, the Cleveland-Magnet-Bischoff line. Deep Gully Creek area was explored for Mt Bischoff style tin mineralisation in the vicinity of altered Devonian porphyries intrusive into the Bischoff Series. drilling encountered some Sn mineralisation in sediments interbedded with Tertiary basalt, but failed to locate 'basement' mineralisation.
Metals Exploration (TCR 89-3054, TCR 88-2804)	1988-1990	replacement tin deposits of the Mt Bischoff/Cleveland type. greisen/breccia pipe Sn occurrences in granite.

Luina-Waratah area - also Meredith Granite

Billiton	1986-1987	near-surface Sn/Cu ((Zn/Pb/Ag) of the Cleveland type (TCR 86-2567)
Aberfoyle	1989-?	replacement-style Sn mineralisation at depth within favourable host rocks intersected by Foley Lineament (TCR 89-3029, TCR 87-2717).
Geopeko	early 1980s	Cleveland-style replacement pyrrhotite/cassiterite.
RGC	1990-1994	carbonate replacement, pyrrhotite-hosted tin mineralisation such as Mt Bischoff/Luina (TCR 93-3428, TCR 94-3576).

Lynch Mining	1996-	plan to reopen Mt Bischoff. Remaining resource is 4.73 Mt @ 0.62% Sn.
Pasminco	1996-	Renison-style Sn.

Tullah-Sterling Valley area

EZ Co./Getty/ Aberfoyle/Billiton JV	1979- 1988	Renison-type replacement tin deposits in the Farrell Slate and the Mt Black Volcanics (west of the Henty Fault) (TCR 85-2344, TCR 85-2313, TCR 88-2895).

Dundas-Renison area

Comstaff (TCR 88-2815)	1970- 1988	replacement tin bodies of the Renison type. located sub-economic 'lode' or vein-type Sn and Pb/Zn/Ag between Pieman River and the Murchison Highway, at odds with their exploration model.
RGC	1988- 1994	Renison/Razorback-style replacement Sn deposits (TCR 93-3434, TCR 94-3577).
Placer	1964- 1966	Razorback-style Sn (TCR 67-489).
CSR	1976- 1987	Renison-style replacement Sn (TCR 86-2584).
EZ Co./Getty, EZ Co./CSR	1978- 1987	Sn/Cu associations. several encouraging drill intersections on Colebrook Hill.
CRAE P/L	1989	Razorback mine extensions. Pyrrhotite/cassiterite replacement; remaining resource approx. 0.24 Mt @ 1.1% Sn (TCR 89-2973).
EZ Co./Getty, EZ Co./CSR	1978- 1987	Sn/Cu associations. several encouraging drill intersections on Colebrook Hill.

Zeehan-Heemskirk area

Placer, Tenneco, Mt Lyell, Aberfoyle/ Gippsland JV	1966- 1980	Sn-replacement bodies. Aberfoyle/Gippsland identified 3.6 Mt @ 1.2% Sn remaining at Queen Hill (TCR 91-3309).
RGC		Queen Hill/Renison-style Sn mineralisation (TCR 92-3386, TCR 92-3379)

Pasminco	1996-	Sn-Cu.

Deposits associated with mid-Cambrian ultramafic rocks

Six companies have explored for nickel and platinum group metals in exposed pods of ultramafic rocks and the associated lateritic deposits that extend for much of the length of the Dundas Element.

Heazlewood-Mt Lindsay area

Metals Exploration	1985-1988	lode platinoid deposits (TCR 88-2804, TCR 87-2644).
Amax	early 1970s	near-surface disseminated nickel, significant segregations of nickel at depth (TCR 70-644).
Theseus Exploration	early 1970s	near-surface disseminated nickel, significant segregations of nickel at depth (TCR 71-795).
CRAE P/L (TCR 95-3777, TCR 95-3705)	1990-1995	low total sulphide nickel mineralisation by analogy with Honeymoon Well and Mt Keith (WA) CRAE quote a figure of 0.5 Mt @1% Ni (maximum resource) in soil/laterite profile on Barnes Hill (originally based on early Enterprise Exploration Co. work).
King Island Scheelite	late 1960s	Lateritic nickel target. outlined a total of 6 Mt @ 1% Ni, 0.06% Co, (0.7% Ni cut-off) in four areas, all in laterite.

Heazlewood-Mt Lindsay area (cont.)

Pasminco	1996-	Ni/PGE/Cu in skarns.

Zeehan-Heemskirk area

CRAE P/L		PGE/Cr/Ni in layered gabbro (Melba Flats) (TCR 93-3521, TCR 93-3522).

Placer/alluvial gold, chromite, tin

A chromite resource has been delineated in alluvial deposits.

Heazlewood-Mt Lindsay area

Callina NL/Creasy	1988-1990	chromite-bearing alluvial sediments. two areas outlined: 860 000 t @ 2% chromite, 843 000 t @ 1.8% chromite.

Others

Crocoite is mined in the Mt Dundas area.

Dundas-Renison area

Private collectors	current	crocoite as a gem collectors item; e.g. Red Lead mine. Lucrative MLs exist.

Tyennan Element

Geology

The term Tyennan Element refers to the belt of metasedimentary and minor meta-igneous rocks and younger cover sequences extending north-south from central western Tasmania to the south coast, bounded to the west by the Dundas Element, to the north by the Sheffield Element, to the southeast by the Adamsfield/Jubilee Element, and overlapped to the east by the younger cover of the Tasmania Basin.

Metamorphic rocks

The extensively exposed metamorphic rocks of the Tyennan Element are subdivided into quartzite-chloritic pelite assemblages of lower greenschist facies, and garnetiferous schist-quartzite assemblages of upper greenschist to eclogite facies (Turner, 1989a). Some transitional contacts are known between the two types of assemblage but many boundaries are thought to be major movement zones. Pressure-temperature determinations indicate that disruption of the original orogenic pile (probably mainly due to major

thrusting during the syn-metamorphic D_2 deformation event) has juxtaposed rocks drawn from depths ranging from about 12 km to well in excess of 30 km (Turner, 1989a).

The quartzite-chloritic pelite assemblage is typified by the Strathgordon area, west of the Adamsfield/Jubilee Element in the southern part of the Tyennan Element (Boulter, 1978; Turner, 1989a). Sedimentary structures and textures, and gross lithological style, indicate deposition in a tidally-dominated shallow-shelf sea. However the sand grain shape characteristics are like those generated by extensive abrasion in a desert environment, and suggest a marine transgression over an aeolian setting (Boulter, 1978; Turner, 1989a). Minor tholeiitic dolerite dykes pre-date the metamorphism. Only greenschist facies mineral assemblages have been recorded and peak metamorphic conditions of 400 ˜50—C and 300 ˜100 MPa occurred just before or during D_2 (Raheim, 1977). Deformation phases D_1 to D_5 were essentially coaxial, with sub-horizontal fold hinges which show a progressive regional swing in trend from N-S to E-W through the area. D_1 folds were originally recumbent isoclinal fold nappes with inverted limbs up to 5 km in length, resulting in common parallelism of bedding and S_1. All D_1 folds face east or northeast, and this sense of over-riding from the west was continued in D_2.

Higher rank metamorphic rocks of the Tyennan Element include the Franklin Metamorphic Complex in the Lyell Highway-Franklin River area in the central part of the element. The dominant minerals in the schist are quartz, muscovite, albite and almandine garnet, and biotite is common. The highest grade rocks in the Franklin Metamorphic Complex occur in the Lyell Highway-Collingwood area (Raheim, 1976; Kamperman, 1984), where metasedimentary rocks consist of garnet-mica schist, mica schist and garnet-mica-kyanite gneiss containing migmatite veinlets. Boudins of eclogite and garnet amphibolite (after basaltic lavas) are present.

Consideration of K-Ar, Ar-Ar and Rb-Sr metamorphic mineral ages alone indicates peak metamorphic ages of 496 to 515 Ma in the Tyennan Element (Turner *et al*., 1992, 1994).

Neoproterozoic sequences

The metasedimentary rocks in the Jane River area, in the central part of the Tyennan Element, are overlain by the Jane Dolomite, which consists of great thicknesses of dolomite with thin basal siliciclastic rocks and associated units of diamictite (Wells, 1955; Spry and Zimmerman, 1959; Gee, 1968; TCR 69-552). The Jane Dolomite is regarded as a possible correlate of the Success Creek Group, Black River Dolomite and Weld River Group (Brown, 1989b). The contact of the Jane Dolomite with the underlying rocks may be an unconformity (TCR 69-552; Gee, 1968). In the Algonkian Rivulet-upper Maxwell River area, just to the south of the Jane River area, correlates of the

Jane Dolomite consist of thin-bedded dolomite, massive dolomite and dolomitic siltstone (Dixon, 1992). The dolomite sequence overlies older Precambrian rocks with low-angle unconformity. The accepted provisional correlation of the Jane Dolomite with the Success Creek Group and correlates places its likely age of deposition well before the recently proposed ca. 505 Ma age for the main metamorphism and D_{1-2} deformation in the metasedimentary rocks on which it rests.

Middle Cambrian intrusive rocks

Near its northern margin with the Dial Range-Fossey Mountain Element, the Tyennan Element is intruded by several small plug-like bodies of granitoid, collectively known as the Dove Granite (Jennings, 1979). The rocks have been described as granodiorites, while other lithologies present include grey biotite granite, aplite and granite porphyry (Leaman and Richardson, 1989). The Dove Granite bodies are considered to be genetically related to, and so probably coeval with, Middle Cambrian granitoids in the Dundas Element, whose ages are well constrained.

Ordovician-Early Devonian sedimentary successions

Following the major ca. 505 Ma tectonometamorphic event, the Tyennan Element was inundated during much of the Ordovician to Early Devonian, when correlates of the marine carbonate and siliciclastic successions of the Gordon and Eldon Groups were deposited. These sequences are preserved in a number of outliers. Basal siliciclastic sequences underlying the Gordon Group sequence are relatively thin compared with equivalent sequences (Denison Group correlates) in the Dundas Element, Sheffield Element and Adamsfield-Jubilee Element, and there are probably one or more depositional hiatuses present in the overlying Gordon-Eldon Group sequences.

Devonian deformation

The most significant Devonian structural effect on the Tyennan Element appears to have been during the later Devonian fold phase (Zeehan/Gormanston trend of Williams, 1979; Williams *et al*., 1989; equivalent to D_4 of Seymour, 1980). During this event the Tyennan Element apparently yielded in a NW-trending narrow zone on a line roughly between Queenstown and the northern end of the Adamsfield-Jubilee Element, and behaved as two blocks. Within the zone separating these blocks, open upright NW-trending folds in the Precambrian rocks geometrically match similar structures in the overlying Ordovician to Devonian sedimentary sequences, and are therefore inferred to be Devonian structures (Williams *et al., 1989*). There are almost certainly other structural effects of the Devonian orogenesis within the Tyennan Element. For example, it is possible that the latest structures in the Precambrian metamorphic rocks in the Strathgordon area

are Devonian. These structures comprise D_5 minor folds and associated crenulation cleavage, and two later generations of minor conjugate kink sets, which have all been dispersed by the regional swing in structural trend from N-S to E-W through the area (Boulter, 1978, and in Turner, 1989a).

Devonian granitoids

Intruding the Precambrian metasedimentary rocks of the Tyennan Element near its northwestern margin is the Granite Tor Granite, which consists of coarse-grained biotite-muscovite granite with megacrysts of K-feldspar (McDougall and Leggo, 1965; McClenaghan *in* Williams *et al*., 1989). Interpretation of regional gravity data shows that the Granite Tor Granite is very nearly connected, at relatively shallow depths, with the Heemskirk Granite on the west coast by a large buried granite spine oriented ENE-WSW beneath the Dundas Trough. The data also show that the exposed part of the Granite Tor Granite is only a small part of a large body which extends some 35 km east and northeast of the present outcrop limits at depths of 2 km and less beneath the Precambrian metamorphic rocks (Leaman and Richardson, 1989). Minor Sn, W and Cu vein deposits are hosted by the Proterozoic rocks overlying the eastern subsurface extension of the pluton.

On the south coast of the Tyennan Element are two small granitoid outcrops. The Cox Bight Granite consists of coarse-grained to sparsely porphyritic light-coloured biotite granite with minor muscovite, while the South West Cape Granite is a coarse-grained foliated biotite granite with phenocrysts of feldspar and biotite (McClenaghan, 1989). Regional gravity interpretation indicates that these two outcrops are small emergents of a large body of granitoid which underlies significant portions of the southern parts of the Tyennan and Adamsfield-Jubilee Elements (Leaman and Richardson, 1992). Tin has been mined at Cox Bight and is still being mined in the Melaleuca area at Port Davey.

Mineral exploration

Tin in southwest Tasmania

Alluvial tin was mined intermittently at Cox Bight, and at Melaleuca mining has been continuous from the 1930s to the present. The current operator at Melaleuca is Rallinga Mining Pty Ltd.

The Broken Hill Proprietary Company Limited and Lyell EZ Explorations explored much of southwest Tasmania at a reconnaissance level in the 1960s and 1970s. Numerous tin anomalies associated with Devonian granites were located and the general Port Davey-Cox Bight area is regarded as a tin province. Minor copper and zinc anomalies are attributed to lithology rather than mineralisation (TCR 66-443). Recent exploration for tin in the Cox Bight area by Ludbrooks Ltd and A. C. P. Webb has been targetted at both alluvial

and primary tin mineralisation (TCR 74-1012; TCR 88-2798). Drilling by A. C. P. Webb failed to intersect significant primary tin mineralisation and it was concluded that there was little potential for other than alluvial deposits (TCR 90-3138).

Alluvial gold in southwest Tasmania

Alluvial gold has been known from the Jane River and surrounding area since 1894. Following the discovery of payable alluvial gold by R. Warne in 1935, it is estimated that 1200 ounces has been produced from the area. Small scale exploration by J. Bennetto and others continued until 1989, with bulk sampling yielding approximately 0.2 g/t of gold (Bacon, 1989a). Mercury as cinnabar and alloyed with gold has also been recognised in the area. Sampling by the then Division of Mines and Mineral Resources showed that most of the major rock types in the area are gold anomalous and commonly gold-tungsten anomalous. The gold in the alluvial deposits is considered to be derived from the underlying formations (Turner, 1990b).

Newnham (TCR 92-3405) proposed two possible models to explain the genesis of the primary gold in the area. The first would involve a distal Devonian heat source with the gold migrating along structural zones into the area and being deposited into the silty and calcareous formations present, and is broadly similar to Carlin-style deposits. The second model involves the presence of Cambrian rocks, overthrust by Precambrian rocks, at shallow depth. Granites acting as a heat source then mobilised gold and forced it to travel along major structures prior to deposition in a favourable repository.

Carbonate-hosted Pb-Zn deposits

Pb-Zn replacement of carbonates has been an exploration target in the Gordon Limestone. Numerous small mineral occurrences are well known in the Gordon Limestone but no large deposits have been found (TCR 86-2600). An exploration program by the Electrolytic Zinc Co. of Australasia Ltd and Amoco Minerals Australia Co. (TCR 84-2139; TCR 84-2190) over the Gordon Limestone at Bubs Hill and to the west gave indications of low grade Mississippi Valley epigenetic style mineralisation with Pb-Zn-Ba. No economic concentrations were located.

Diamonds

Base Resources Ltd considered that eroded material from above the Precambrian rocks in this element could have been the source of diamonds reported from the Corinna area and postulated that the lower parts of kimberlitic pipes may be present in the basement. Exploration of the Forth and Mersey River area found neither diamonds nor definite kimberlitic indicator minerals, although three high-pressure garnets were found (TCR 84-2176).

Tin-tungsten veins

The aureoles of the Birthday, Pine Hill and Lone Pine Granites have been explored for wolframite and tin veins with considerable success. Although the Lone Pine and Birthday prospects are not considered economic (TCR 68-510) the Mt Pelion-Oakleigh Creek area was initially considered to have indicated reserves of 100 000 t of 3.15% WO_3 (TCR 78-1249). The Oakleigh Creek mine was opened by Serem (Australia) Pty Ltd and Central Tasmanian Tungsten Pty Ltd in 1979, with pre-mining reserves estimated at 122 700 t at a grade of 1.17% WO_3 (TCR 81-1557). Diamond drilling failed to intersect further economic mineralisation within the planned workings and operations have since been completed (TCR 81-1612). Later drilling intersected granite 80 m below the lowest mine level and also 0.89% WO_3 in 0.9 m of quartz-tourmaline rock in granite 160 m below the lowest mine level (TCR 82-1685).

Granite Tor area

Prior to the commencement of modern exploration only two small prospects were recorded in the Granite Tor area. The first was the Bluff River tin deposit, where alluvial tin derived from cassiterite in quartz-tourmaline and greisen veins contained in a weathered granite body intrusive into Precambrian quartzite was mined from 1910 to 1945. The other is the White Hawk mine, where small lodes of Pb-Zn with a significant quantity of silver were mined. The initial exploration program of Alcoa of Australia Ltd was orientated towards quartz vein and greisen-type occurrences, replacement bodies and skarn-type mineralisation (TCR 78-1308). After completion of airborne surveys, a number of anomalies related to graphitic phyllites were located and considered prospective for Farrell-type Pb-Zn-Ag mineralisation (TCR 82-1825).

Dove Granite area

Freeport of Australia Inc. initially had a porphyry copper orientated exploration program based upon the discovery of disseminated copper mineralisation and slightly kaolinitic hydrothermal alteration. The areas of alteration defined were considered too small and of too low a grade to allow the development of a porphyry body of sufficient size and grade to warrant further interest (TCR 73-977).

Mt Remus, Back Peak, Fleece Creek area

The Mt Remus molybdenite prospect was discovered in the 1920s and has been explored by Geopeko Ltd and Cleveland Tin Ltd (TCR 81-1637). Assays showed that traces of cobalt and vanadium were also present. Bottrill (1994) suggests that at least some of the mineralisation is pre-Devonian granite. Quartz veins and stockworks carrying galena, sphalerite and pyrite occur at Fleece Creek, and other galena-sphalerite mineralisation occurs in the area

(Pemberton *et al*., 1991). A breccia in the Anio Creek area near Anomaly 13 was sampled by the Department of Mines, and returned gold values of around 1.9 g/t and copper values of 1.06%. The mineralisation is probably granite sourced (Pemberton *et al*., 1991).

Mount Romulus area

Exploration in this area by CRA Exploration Pty Ltd showed rare gold inclusions in a quartz stockwork at Ten Mile Creek (TCR 89-2904).

Identified resources

Disseminated copper

Nicholls Range prospect: A disseminated and vein Cu-pyrite prospect with subordinate Ag-Au, in the Nicholls Range. There are two ore horizons, each four metres wide with 1.5% Cu (TCR 56-126).

Anomaly 13: Disseminated sulphides with up to 1% Cu in breccia within the Precambrian rocks adjacent to a fault in the Mt Remus area. This is a geophysical anomaly that has not been drilled.

Barn Bluff prospect: A disseminated low-grade Cu-pyrite type deposit with subordinate Ag-Au-Sn, west of the Forth River near Barn Bluff. Reserves are estimated at 1.65 to 1.85 million tonnes (TCR 07-10).

Disseminated lead-zinc-silver

Low-grade disseminated Pb-Zn-Ag-Ba mineralisation of Mississippi Valley style occurs in the Gordon Group Limestone at the Bubs Hill prospect but is not considered economic (TCR 84-2139).

Vein-type lead-zinc-silver

Carters prospect: Galena-sphalerite-chalcopyrite-pyrite bearing quartz veins and breccia near the northern margin of the Tyennan Element at Fleece Creek. Mineralisation is poddy, with 2.3-35%, 0.9-2.3% Zn, 16-60 g/t Ag, and 0.08 g/t Au (Pemberton *et al*., 1991).

Prover 1 prospect: Poddy galena-sphalerite mineralisation associated with chloritic alteration and may be linked to Cambrian porphyry (Huston and Large, 1987; Pemberton *et al*., 1991).

Sloanes prospect: A Pb-Ag multiple vein and stockwork deposit close to the Cambrian Dove Granite at the northern margin of the Tyennan Element. *Devon prospect:* A Pb-Ag-Au vein deposit of Pb-Ag-Zn vein-type close to the Cambrian Dove Granite at the northern margin of the Tyennan Element.

Silver Dove prospect: A Pb-Zn-Ag multiple vein deposit near the Cambrian Dove Granite at the northern margin of the Tyennan Element.

Vein-type arsenic (As, Bi, Pb, Ag, Au)

Innes prospect: Arsenic vein-type deposit with As-Bi-Pb-Ag-pyrite, 1.5 km west of south Granite Tor Granite.

Romulus East prospect: A few arsenic vein-type deposits with As-Pb-Ag-Au within graphitic schist are located one kilometre north of the Granite Tor Granite. An additional four Pb-Zn-As-Bi-Co anomalies associated with black shales have been identified in the Granite Tor area (TCR 83-2020).

Disseminated gold-iron

A disseminated Fe-Au deposit, the Powerful prospect, occurs at the very northern margin of the Tyennan Element within the Cambrian Forth/Dove Granite.

Alluvial gold

Alluvial gold and associated mercury has been mined from several localities within the headwaters of the Jane and Maxwell Rivers. There is an estimated 2.3 million cubic metres of gold-bearing gravel at Warnes Lookout (TCR 66-441).

Alluvial tin

There are four areas of alluvial tin in Cainozoic sediments in the Melaleuca-Cox Bight area. All have been mined for a considerable period. These deposits are derived from cassiterite-wolframite-molybdenite quartz veins in Devonian granite. There is significant potential for tin in the area.

Vein-type tungsten-tin

Mt Pelion mine: This is a W-Sn vein-type deposit that has been exploited in the past. An ore grade of 2.90% WO_3 has been calculated (TCR 77-1230), with calculated reserves of 100 000 t at 3.15% WO_3 (TCR 78-1249). Other prospects in the area are Five Mile Rise and Union.

Oakleigh Creek mine: A tungsten with subordinate tin vein-type deposit to the west of Mount Oakleigh in the Forth River valley. Estimated pre-mining reserves are 122 700 t at 1.70% WO_3 (TCR 80-1450). Mining since 1979 produced about 20 000 t at 0.4% WO_3 before closure.

Lone Pine mine: A W-Sn prospect in the aureole of the Lone Pine Granite in the Forth River valley. It is not considered economic.

Birthday Granite prospect: A tungsten vein deposit with W-Mo-Sn-Cu in the aureole of the Birthday Granite in the Forth River valley.

Granite Tor anomalies: Two anomalies containing Sn-veins in greisen and Sn-W-Au anomalies in stream sediments have been identified in the Granite Tor area (TCR 83-2020).

Fleece Creek anomalies: Sn-W anomalies in black carbonaceous sequences have been identified (TCR 82-1881).

Molybdenum

An occurrence of quartz-pyrite-molybdenite veins within Precambrian rocks occurs at the Mt Remus prospect near the northwest margin of the Tyennan Element. The ore contains 0.2-45.67% Mo, 0.19% V and 0.18-1.49% Co. The Mo-Co phase of pyrite crystallisation may be associated with Devonian granites (Pemberton *et al*., 1991).

Quartzite

There are potentially vast resources of quartzite for contruction materials, possibly metallurgical and silicon chip-grade silica, and of material for gravel, roadbase, concrete and construction use.

Potential resources

The Tyennan Element is dominated by multiply deformed and metamorphosed quartzitic to pelitic Proterozoic sequences. The lack of major development of carbonate or volcanic rocks over much of the element makes many ore deposit models inappropriate. Most of the mineral occurrences in the Tyennan Element are associated with and close to either Devonian or Cambrian granitoids. Mineral deposit models are after Cox and Singer (1986).

Applicable models are briefly discussed below.

Granitoid-related models

Tracts for which these models are applicable are defined by proximity to Devonian granitoids as determined by surface geology and gravity studies. The four kilometres depth-to-granite isobath is used, except for silver-bearing polymetallic veins for which areas within six kilometres are considered to have potential. Skarn and carbonate-replacement tin models also require the probable or possible presence of pre-granitoid carbonate rocks.

For the Tyennan Element this means that all but two areas have no potential for these models.

Granite cropping out at Cox Bight and Southwest Cape, together with some nearby alluvial tin and minor tin-tungsten mineralisation, has long been known in the southwest. However the gravity data define a much larger area of shallow granitoid rocks in southwest Tasmania.

In the north, a granitoid intrudes Tyennan Precambrian rocks in a large, poorly known pluton at Granite Tor, and in small exposures in the upper Forth valley (Lone Pine and Birthday granites). Gravity data show that these represent unroofed exposures of a large subsurface granite ridge extending

ENE from the Heemskirk Granite on the west coast. In addition to wolframite vein deposits in the upper Forth valley, As-Bi-Pb-Ag-Au vein-type deposits occur within 1 to 3 km of the Granite Tor Granite.

Applicable models are:

- There is moderate to high potential for tungsten-molybdenum veins (tract Vn1b/M-H/B-C; model 15a of Cox and Singer, 1986) and tin-vein mineralisation in both the southern part of the element, near the largely unexposed southwest Tasmanian granitoid, and in the northern part of the element;
- Silver-bearing polymetallic veins (model 22c of Cox and Singer, 1986). Based upon the available information, the Granite Tor to Barn Bluff area in the north of the element has high potential (tract BM5c/H/B-D). Geophysical data show the presence of extensive, poorly-exposed granitoids in the southern part of the element, and the potential in this area is considered to be moderate (tract BM5b/M/B-C) with a certainty level of B to C.
- Carbonate-replacement tin (Renison type) (tract Sn1b/M-H/B; model 14c of Cox and Singer, 1986). Southwest Tasmania, where there are minor and possible carbonate units in the pre-granitoid sequences, is considered to have moderate to high potential for carbonate replacement tin mineralisation. The Granite Tor area is considered unprospective for this style of mineralisation, as the intruded units appear to be entirely quartzitic or pelitic.
- Skarn deposits of tungsten, tin, copper and iron (models 14a-b, 18b, 18d of Cox and Singer, 1986). The eastern part of the large concealed southwest Tasmanian granitoid intrudes an area containing Ordovician limestone and Proterozoic dolomite, and there is high potential (tract skrn1b/H/B-D, map 5.22) for skarn deposits in these rocks. The remainder of this granitoid is considered to have medium to high potential (tract skrn1b/M-H/B-C, map 5.22) because although outcropping rocks are dominantly quartzitic to pelitic, carbonate rocks may also be present.
- Greisens (model 15c of Cox and Singer, 1986). There is high potential for greisen-style mineralisation in this element (tract Sn3a/H/C, map 5.25). The Granite Tor, Lone Pine and Birthday granites have suitable mineralaogy and geochemistry and are associated with known mineralisation.

Mafic-related models

Few mafic units occur in the Tyennan Element. The main known area is a 12 km long north-trending unit of greenschist amphibolite and associated ironstone in the Atkins Range area four kilometres east of Strathgordon. This was considered prospective for massive sulphide deposits by Higgins *et al*. (1988). There is an accompanying magnetic anomaly, and the limited geophysical coverage may be sufficient to rule out the possibility of similar units of this size elsewhere in the Tyennan Element. Smaller bodies of amphibolite and eclogite occur elsewhere, notably in the Raglan Range, at Mt McCall, and near the Collingwood River. Possibly applicable models are:

- Moderate potential for Besshi-type massive sulphide deposits (tract BM2b/M/B-C, map 5.16; model 24b of Cox and Singer, 1986);
- Low potential for stratiform/stratabound gold in ironstone (tract Au4b/L/B, map 5.9);
- There is moderate potential for ochre related to mafic units in small areas.

Sediment-hosted base metal deposit models

The available data suggest that the mineral potential for sediment-hosted deposits is low to moderate. Models which may apply include:

- Irish-style carbonate-hosted lead-zinc deposits (model 31a of Cox and Singer, 1986). In the Tyennan Element this style has only been recognised at the Bubs Hill prospect, in Ordovician Gordon Group limestone east of Queenstown. However large areas of Gordon Group limestone occur elsewhere, notably in the Gordon, Franklin, Olga, Hardwood and Giblin river valleys. The model requires relatively pure carbonate hosts, and the Proterozoic Jane Dolomite may also be a suitable host. These parts of this element are considered to have moderate potential (tract BM3b/M/B-C, map 5.17).
- Sedimentary exhalative lead-zinc (SEDEX) stratiform lead-zinc-silver deposits (tract BM7a/M/B-C; map 5.21; model 31a). Carbonaceous phyllitic units within Proterozoic sequences and possibly mid-Palaeozoic black pyritic shale units such as the Amber Slate and Bell Shale correlates within the Eldon Group are possible hosts, particularly in the vicinity of any major faults that could be partly synsedimentary. These units are considered to have moderate potential with a certainty level of B to C.

Stratiform sediment-hosted copper deposits (tract BM6d/L/B; map 5.20; model 30b of Cox and Singer, 1986). Shallow marine sedimentary sequences with redox contrasts are common in the Tyennan Element, but the location of the basin margins or basement highs is a matter for speculation, and few copper-rich mafic potential source units are known. The Proterozoic Tyennan region is rated as having low potential with a certainty level of B.

Alluvial deposit models

Gold

Alluvial gold (tract Au7/M-H/B; map 5.12; model 39a of Cox and Singer, 1986) is known in the central Tyennan Element in the headwaters of the Jane River, and this region is rated as high in potential, although the ultimate source of the gold is not well understood. The only other occurrence reported is at the entrance to Bathurst Harbour.

Tin

The area of Cainozoic alluvium between Melaleuca Inlet and Cox Bight overlies very shallow granite and contains economic placer tin mineralisation (tract Sn5/M-H/B-c; map 5.26; model 39c of Cox and Singer, 1986). The potential is rated as moderate to high.

Shoreline placers (tract MS1b/L-M/B; map 5.32; model 39c of Cox and Singer, 1986) occur on the southwest coast, and are considered to have low to moderate potential.

Non-metallic commodities

Extensive units of Ordovician limestone with high potential occur in the element (tract Lst1b/H/B, map 5.39). The dominant quartzite of the Proterozoic units is considered moderately to highly prospective for lump silica and derived silica sand, and as construction materials (tracts conmat:/M-H/B-C, map 5.41; silica/H/B-C, map 5.42). The low unit value of some of these commodities makes it unlikely that extraction would be economic in the foreseeable future.

Other styles

There are several minor mineral occurrences within the Tyennan Element which do not readily fit into the above. Many are associated with Cambrian granitoids (the Dove Granite, including the bodies on the upper Forth and Mersey rivers) which intrude the northern margin of the Tyennan Element. The metallogeny of this area is complicated by the presence of Devonian granite, which crops out just to the north.

A variety of disseminated and vein-type Cu-pyrite deposits, with subordinate Ag-Au-Sn, are widespread, and some potential possibly exists throughout the Tyennan Element. Two occurrences are associated with the Cambrian Dove Granite and two are in the headwaters of the Forth River within five kilometres of outcrops of the Devonian Birthday Granite. One occurrence occurs in the central Tyennan Element and is not associated with any granites. Disseminated gold may also be prospective within the Cambrian granites.

There are three occurrences of Pb-Zn-Ag-Au quartz-vein and stockwork deposits within one to two kilometres of the Dove Granite. There is also an occurrence south of the Raglan Range.

The alluvial gold in the Jane River area (see above) is associated with cinnabar and may be of epithermal origin.

Adamsfield / Jubilee Element

Geology

The Adamsfield-Jubilee Element is the area of deformed but relatively unmetamorphosed Proterozoic and Lower Palaeozoic rocks exposed in central southwestern Tasmania, mainly in the vicinity of the upper Gordon, Florentine, Weld and upper Huon rivers, but extending in a narrow belt south to the coast around New River Lagoon. Regional geological mapping has been completed in most of the northern part of the element but the southern part includes some of the geologically least well known parts of Tasmania.

The main exposed part of the element consists of a large southern area of mainly Proterozoic rocks (the Jubilee region); a northwestern area of mainly Cambrian or inferred Cambrian age (the Adamsfield district); and to the north, a large synclinorium (the Florentine Synclinorium) containing a succession of Late Cambrian to Early Devonian age, the Wurawina Supergroup.

To the west the Adamsfield-Jubilee Element is bounded by the Tyennan Element. The relationship between the Proterozoic sequences of the two elements is uncertain. The broad lithological similarity and observed overlap in tectonometamorphic grade suggest that the relationship may be a metamorphic transition affecting essentially coeval sequences (Calver, 1989a), but an unconformable relationship on the Tyennan Element has also been suggested (Spry, 1962; Godfrey, 1970).

To the east the Adamsfield-Jubilee Element is concealed beneath unconformably overlying Parmeener Supergroup rocks of the Tasmania Basin and Jurassic dolerite. However a large subsurface extent in southeast Tasmania is inferred on the basis of small inliers, drill-hole intersections, xenoliths in igneous rocks, and a regional gravity/magnetics interpretation (Leaman, 1990). Late Proterozoic successions

The Proterozoic Clark Group and correlates (the Mt Anne and Pandani Groups) consist of a shallow-marine orthoquartzite unit, 1 to 2 km thick, underlain and overlain by similar thicknesses of pelitic rocks with minor siltstone and carbonate. Locally the younger units contain stromatolites and evaporite indicators. The base of the succession is unknown and the age is poorly constrained.

The Weld River Group overlies the Clark Group correlates with gentle angular unconformity or paraconformity (Calver, 1989a). The Weld River Group is a thick (at least 2-3 km) succession dominated by dolostone. Diamictites, some of probable glacial origin, occur near the base and top (Calver, 1989b; unpublished).

The glacigene rocks suggest a Cryogenian (850-600 Ma) age for the Weld River Group, and lithostratigraphic correlation with the Success Creek Group of the Dundas Trough and the Togari Group of the Rocky Cape Element has been proposed (Calver, 1989b). However there are no rift volcanic rocks (Crimson Creek Formation correlates) in the Weld River Group.

Deformation of Proterozoic rocks

A deformation (D_1) resulting in northwest-plunging, upright to overturned (NE-facing) major folds and associated axial-plane cleavage preceded deposition of the Middle Cambrian successions. S_1 decreases in intensity in a general northeasterly direction across the Jubilee region, reflecting a decline in metamorphic grade from lower greenschist facies to unmetamorphosed. Locally there are upright F_2 folds, coaxial with F_1, and an associated crenulation cleavage. D_1 and D_2 predate a Middle Cambrian conglomerate (possible Trial Ridge beds correlate) just north of Mt Bowes (Calver *et al.*, 1990).

Cambrian successions

The Ragged Basin Complex is an extensively disrupted (broken) formation in fault contact with other Cambrian and Proterozoic units, and consists of lithic sandstone, chert, red mudstone and minor mafic volcanic and shallow intrusive rocks (Turner, 1989b). Serpentinised ultramafic rocks with faulted margins consistently occur within, or in contact with, the Ragged Basin Complex. The ultramafic rocks are compositionally closely related to those of the Dundas Element. They formed as cumulates in shallow crustal magma chambers, rather than being ophiolitic in origin (Brown, 1986). The Ragged Basin Complex is a lithological correlate of the 'Cleveland-Waratah association' (Turner, 1989b) and like the Cleveland-Waratah association, has been interpreted as allochthonous, emplaced together with the ultramafic rocks by westward overthrusting in the early Middle Cambrian (Crawford and Berry, 1992; Corbett, 1994).

A Middle Cambrian sequence of quartzitic conglomerate (including coarse alluvial fans and submarine fans), turbiditic quartzwacke and fossiliferous mudstone (Trial Ridge Beds) overlies the allochthonous() sequences with inferred angular conformity north of Adamsfield. Similar fossiliferous sequences occur near Mt Wedge. Several structurally separated, unfossiliferous, turbiditic quartzwacke-lithicwacke-conglomerate successions occur in the east and south of the element, extending to the south coast. Near Glovers Bluff is an altered, talcose conglomerate mainly of ultramafic and mafic derivation. These successions are tentatively correlated with the Middle Cambrian fossiliferous rocks (Calver *et al.*, 1990; Findlay, in press).

Late Middle to early Late Cambrian deformation

A significant period of folding and faulting preceded deposition of the Wurawina Supergroup. Two folding episodes are seen in the Adamsfield district (Turner, 1989b; 1990c). In places, Proterozoic and Cambrian rocks are structurally interleaved through faulting. An interpretation involving an imbricate series of east and north-dipping thrust slices is consistent with the broad structural pattern (Seymour and Calver, 1995).

Wurawina Supergroup

A thick, essentially conformable, Late Cambrian to Devonian succession, the Wurawina Supergroup, unconformably overlies older rocks. The Supergroup is divided into the Denison, Gordon and Tiger Range Groups. The Denison Group consists of thick siliciclastic rocks of Late Cambrian to Early Ordovician age, over 3 km thick on the Denison Range but onlapping basement and becoming thinner to the east. The Ordovician Gordon Group comprises predominantly shallow-water platform carbonate rocks 1.8 km thick. Platformal facies occur as far south as Lune River but on the south coast at Surprise Bay, the Gordon Group correlate consists of deep-water basinal graptolitic shale and carbonate turbidite (Burrett *et al.*, 1984).

The Silurian-Lower Devonian Tiger Range Group, a correlate of the Eldon Group of western Tasmania, consists of shallow marine siliciclastic rocks conformably overlying the Gordon Group, and is about one kilometre thick (Baillie, 1979; Baillie, 1989).

Devonian deformation

In the Devonian, the Wurawina Supergroup was folded into a large, gently north-plunging synclinorium (Florentine Synclinorium), with a related subvertical cleavage in pelitic lithologies. Locally developed, weak north to northwesttrending crenulation cleavages in the Proterozoic and Cambrian rocks of the Adamsfield-Jubilee Element may be Devonian in age (Turner, 1989b). Conodont alteration indices in the Florentine Synclinorium suggest maximum burial temperatures of 110-200—C (Burrett, 1984). The effects of the Devonian Orogeny appear to have been weaker in southern Tasmania, as folding in the Wurawina Supergroup around Ida Bay is very open and conodont alteration indices suggest maximum burial temperatures of less than 100—C (which may have been attained during the Late Cretaceous rather than the Devonian, e.g. Sharples and Klootwijk, 1981).

Cover rocks

To the east the older sequences described above are overlain by younger cover rocks (see Tasmania Basin Element) with a few small inliers at Glovers Bluff and in the Huon-Picton and Hastings-Lune River areas. Within the main part of the Adamsfield-Jubilee Element the cover rocks are restricted to small caps at Mt Wedge and on the Mt Anne plateau. Extensive Quaternary cover occurs on low-lying buttongrass plains.

Mineral exploration

Adamsfield district

Located in the northern part of the Adamsfield-Jubilee element, the Adamsfield district has produced over 15,000 ounces (480 kg) of 'osmiridium', or about half of Tasmania's total production. Alluvial and eluvial workings were scattered over most of the Adams River catchment (Nye, 1929; Bacon, 1992c). The last recorded production was in 1968.

Both the 'osmiridium' (predominantly iridosmine, $Ru_{0.1}Os_{0.5}Ir_{0.4}$) and alluvial chromite are derived ultimately from the Adamsfield Ultramafic Complex (AUMC), a fault-bounded, meridional anticlinal core approximately 8 * 1 km in outcrop extent. This complex consists of erosionally resistant, elongate north-trending masses of deformed, layered peridotite-dunite, dunite-harzburgite and massive orthopyroxenite, surrounded by sheared serpentinite (Brown, 1989c). There is a lode deposit in a 700 m * 2-3 m wide zone of sheared black serpentinite with local pyroxenite and chromite nodules, lying close to and parallel with the eastern boundary of the AUMC. The lode deposit was intermittently worked by surface trenching and shallow underground shafts. The few analyses available from the lode show 10-50 g/t PGE and a trace of gold.

Thin (mostly <5 m) Quaternary alluvial and eluvial deposits, several square kilometres in extent, have been the source of most production of PGE in the Adamsfield district. Much of this, together with some of the associated gold and chromite, is thought to be second-cycle material derived from the Late Cambrian siliciclastic rocks, while some of the alluvial sediments may be reworked Tertiary lateritic profiles. Recent exploration in the central Adam River Valley-lower Main Creek area has shown that best PGE and chromite grades are located in shallow (<3 m) gravel that is underlain by poorer, probably-lacustrine clay. Typical basal gravel is largely absent (TCR 88-2884).

From 1965 to 1976 the district was explored by the Broken Hill Proprietary Company Ltd (BHP). A ground magnetic survey was conducted over the northern part of the AUMC (TCR 66-418), followed by EM and SP surveys (TCR 68-523) which failed to reveal any conducting mineralised zones. A soil sampling program (Cu, Zn, Ni, Co, Cr) over the southern part of the AUMC, designed to seek Cu-Ni mineralisation, revealed no significant anomalous results (TCR 71-859).

Between 1985 and 1991, Metals Exploration Ltd (Metals Exploration) searched for PGE and chromite. Twelve percussion holes, drilled to the bedrock mineralised zone, gave encouraging results. Elevated chromite intervals constituted 36 per cent of the core in eight holes, and the best one-metre intervals from four holes yielded 10 to 30 g PGE/t (TCR 87-2729). Drillholes on Football Hill confirmed the underlying Late Cambrian sandstone to be a source of PGE. The main exploration effort, bulk-sampling of the alluvial sediments, yielded disappointing PGE grades (maximum of 0.39 g/m^3) but chromite grades were up to 5%, with the relatively high-grade samples derived from the contiguous shallow (<3 m) gravel. An exploration potential for five million tonnes of gravel at 2.5 wt.% chromite, at a 1:1 stripping ratio, was suggested, and a follow-up program of close-spaced pitting and/or reverse circulation drilling was foreshadowed (TCR 88-2884) but not carried out.

Boyes River area

A poorly exposed ultramafic complex, northwest of Adamsfield and north of Lake Gordon, crops out discontinuously for about 10 km in the Boyes River valley. It is partly overlain by the Trial Ridge Beds and the Wurawina Supergroup, although Brown (*in* Brown *et al*., 1989) described it as tectonically emplaced after the former. The rock is almost totally serpentinised, but remnant textures and mineralogy suggest that it is similar to the layered dunite and harzburgite (LDH) association at Adamsfield and elsewhere (Brown *et al*., 1989), with which osmiridium is associated. Alluvial osmiridium was reported in the area by Reid (1925) but there is no recorded production, although BHP reported finding old pits in the area (see below).

A reconnaissance stream sampling program by BHP in 1967/68 returned some Ni, Zn and As (but no Cu) anomalies in some streams draining the ultramafic rocks (TCR 69-555). Later sampling by Callina Mining and Exploration NL returned low assays for PGE (maximum 17.8 ppb Ru), although fine to very fine-grained osmiridium and abundant chromite was observed in panned concentrates (TCR 87-2691).

Scree and talus cover is extensive in the Boyes River valley and may downgrade the potential for workable alluvial and eluvial PGE deposits, and explain the lack of recorded production.

Mt Wedge-Gordon River Road area

This area consists of Cambrian rocks assigned to the allochthonous() Ragged Basin Complex, small faulted slivers of ultramafic rocks, and the fossiliferous Island Road and Boyd River Formations (see above).

The area was held by BHP from 1965 to 1972, the company conducting limited reconnaissance mapping and a small rock-chip and stream-sediment survey along the Gordon River Road between The Needles and Mt Wedge (TCR 69-555). Some streams which drain Cambrian Ragged Basin Complex lithologies and small ultramafic bodies northeast of Mt Wedge returned anomalous Ni, Cu and Zn values. A follow-up soil sampling survey in the area was discouraging (TCR 72-890).

Cambrian sedimentary rocks returned negative phosphate tests (TCR 69-555).

Maydena area

The geology of this area is varied and includes Clark Group dolomite, Cambrian basalt-sandstone-chert, Late Cambrian quartz sandstone and Ordovician limestone, covered to the east by Tasmania Basin sequences. Fault-bounded bodies of serpentinite occur south of Mt Mueller in the Weld River headwaters (Turner *et al*., 1985).

Between 1979 and 1984 BHP explored west of Maydena for skarn or replacement-style tin-tungsten deposits of the Renison type, on the basis of unexplained magnetic anomalies, extensive carbonate sequences, early reports of tin and topaz in the Styx and Weld rivers, and known Cu-Pb vein mineralisation (Humboldt and Mt Mueller prospects). Limited sampling yielded a few samples weakly anomalous for gold, arsenic and base metals (TCR 81-1658). Airborne EM revealed three anomalies of interest, all southeast of Mt Mueller. One anomaly was drilled, the hole intersecting pyritic graphitic black shale of probable Cambrian age. Surface investigations were conducted over the other two anomalies with generally negative results. The company concluded that the regional potential for tin mineralisation appeared to be poor and that the significance of sparse gold values is unknown (TCR 84-2179).

From 1979 to 1982 BHP also explored an adjacent area around and to the southeast of Maydena. The main target was oil shale in the Tasmania Basin sediments and two holes were drilled in the Permian Woody Island Siltstone in the upper Styx River area. The maximum hydrocarbon yield obtained was only seven litres/tonne, and analysis of core samples for gold and base metals failed to show any anomalies (TCR 81-1657, TCR 82-1780, TCR 82-1866). In 1984/85 Amoco Minerals Australia Co. sought Carlin-style gold deposits in an area immediately west of Maydena (TCR 85-2375). Analysis of samples for a range of elements (including Au, As and Hg) returned discouraging results. Samples from the Mt Mueller prospect returned up to 0.76% Cu from weakly mineralised bornite-malachite-chalcopyrite-quartz-carbonate veins averaging less than 0.5 m in width.

Cambrian chert and quartz sand near Pine Hill, have been prospected for silica (TCR 89-2982), with a one thousand tonne sample from the chert deposit being successfully trialled at Electrona (TCR 90-3202). The sand deposit includes silica flour residual after Proterozoic dolomite similar to the deposit at Corinna. A mining lease has been granted over a Proterozoic dolomite resource at 'Kallista Hill' (TCR 92-3397). An industrial limestone resource of 5.5 million tonnes at 93% $CaCO_3$ in Ordovician Gordon Group at Roberts Hill has been indicated by Department of Mines drilling (Wrigley, 1993).

Florentine Valley area

The Shell Company of Australia Ltd considered the area of Gordon Group limestone in the Florentine Valley had potential for Mississippi-type lead-zinc and fault-related tin-tungsten skarn deposits in the Ordovician limestone, and stratiform (Mt Isa or Zambian type) copper in conglomerate and sandstone in the underlying Denison Group (TCR 82-1821). The skarn model was supported by a weak gravity low in the area, which suggested granite at depth (small if present at all; R. G. Richardson, pers. comm.). Weakly anomalous Sn-W results were supported by the presence of tourmaline in a panned concentrate, but not followed up before the licence was relinquished. No anomalous Cu-Pb-Zn results were reported.

Shell applied for, but was not granted, an area including the Denison Range and Adamsfield to the west, considered to have potential not only for limestone-related mineralisation but also for Cr-Ni-Au-PGE associated with mafic/ultramafic bodies, Cambrian volcanogenic base metal deposits, and possibly kimberlitic intrusive rocks in the Precambrian basement.

Glovers Bluff

This inlier of Proterozoic quartzite and dolomite, and Cambrian ultramafic-derived conglomerate on the lower Weld River, is surrounded by Jurassic dolerite. The dolomite and Cambrian rocks have undergone silicification and skarn-like alteration of uncertain, probably Mesozoic age, in a style unknown elsewhere in Tasmania.

There has been historical exploration for nickel and PGE. Reward leases for nickel and alluvial osmiridium were granted in the 1930s, and an adit driven reputedly for gold, but there was no recorded production. Recent exploration has been for silica, talc, marble, nickel, PGE and gold.

Evaluation of the Proterozoic quartzite silica resource began in 1968 and the deposit was trial mined for Electrona in the 1980s (see Bacon and Pemberton, 1995 for a summary). Drilling showed a resource of 15 million tonnes, with the highest grades being a product of surficial enrichment by weathering (TCR 75-1088, TCR 82-1669). Silicified Cambrian rocks are also prospective for silica (TCR 85-2480).

Marble and talcose rocks, the latter with locally anomalous PGE and gold, were found by shallow drilling in the late 1980s (TCR 88-2806; TCR 88-2855, TCR 90-3166). Recent drilling results have been highly encouraging for gold, including a shallow depth 29 m intersection of 2.4 g/t at the 'Forster prospect' (stock exchange announcement by Sedimentary Holdings NL, 9 May 1996). The gold mineralisation is mostly in silicified rocks and is of uncertain origin.

The 'marble' appears to result from contact metamorphism of Proterozoic dolomite by Jurassic dolerite.

Surprise Creek area

In this area on the south coast, a small, poorly-exposed ultramafic body is located in dense forest a few kilometres inland, and is presumably the ultimate source for the 'osmiridium' occurrences in the district.

Beach and stream sands have been worked for osmiridium, with total production being probably less than 100 ounces (Blake, 1938). Detrital chromite is also abundant in creeks draining the ultramafic body and largely accounts for the black sand on Osmiridium Beach (Twelvetrees, 1915; TCR 59-260; TCR 71-836A).

In 1970 a joint venture of Australian Paper Manufacturers Ltd and UC Services (Australia) Pty Ltd conducted a ground magnetometer survey and soil sampling for copper, nickel, platinum and palladium on a grid over the serpentinite body. Minute grains of pentlandite were reported in a serpentinite outcrop. No results were considered anomalous and the licence was relinquished.

Hastings-Lune River area

A number of small inliers of Late Proterozoic dolomite and Ordovician quartz sandstone and limestone are known in this area and can be considered extensions of the Adamsfield-Jubilee Element. The resources of the surrounding Permian to Jurassic cover are grouped with the Tasmania Basin Element.

Ordovician quartz sandstone forms the Hogs Back, and was quarried for use in ferrosilicon manufacture. The reserves of quartzite have been tentatively assessed at four million tonnes (Summons, 1981).

Surficial gravel, residual after partially-silicified Proterozoic dolomite in the Hastings area, is marginally prospective for silica (Bacon and Pemberton, 1995) and has been used for road construction.

A quarry in the Ordovician Gordon Group at Lune River (Forsyth and Green, 1976; Summons, 1981; MRT, 1991) was formerly a major producer of industrial limestone (50 000 tpa) but was closed in 1992. The limestone was also used as road base and for agricultural purposes.

Hydrocarbon potential in Ordovician limestone

Burrett (TCR 87-2698A) reviewed the hydrocarbon potential of central-southern Tasmania for Conga Oil Pty Ltd. He concluded that in the Ordovician Gordon Group, organic-rich shales and nodular carbonates provide possible source rocks beneath possible platform margin carbonate reservoirs, with the Parmeener Supergroup providing suitable seals. Conodont alteration indices indicate that much of the Ordovician sequence is thermally within the oil window. However dolerite intrusion, Tertiary faulting and possibly erosion during the Carboniferous degrade the prospectivity of the area.

Identified resources

The most significant historical resource of any metallic commodity identified in the Adamsfield-Jubilee Element is the osmiridium in the Adamsfield area (production 480 kg, see above). Although the alluvial/eluvial deposits were rapidly depleted in the 1920s, there is little doubt that a substantial resource remains which might now be mined with improved technology if markets appear. Unfortunately present demand is mainly for platinum, palladium and rhodium (mainly as catalysts, jewellery and in electronics) with little interest in either osmium or iridium.

Following a recent drilling program for gold at the 'Forster Prospect', Sedimentary Holdings NL has announced an indicated resource of 1.14 million tonnes of ore grading 0.45 g/t Au (Sedimentary Holdings NL, Quarterly Report to the Australian Stock Exchange for June 1966).

Large resources of limestone exist in the Ordovician Gordon Group. Total production at Lune River was less than one million tonnes before the quarry was closed in 1992. The remaining resource in the immediate vicinity of the quarry is 15 million tonnes, with further untested limestone in the surrounding area. Drilling by the Department of Mines at Roberts Hill, near Maydena, indicated a resource of 5.5 million tonnes at 93% $CaCO_3$ (Wrigley, 1993).

Significant occurrences of industrial minerals, including silica, chromite, dolomite and limestone, occur in the element. With the exception of a 15 million tonne quartzite silica resource at Glovers Bluff (TCR 75-1088, TCR 82-1669) and a tentatively assessed reserve of four million tonnes of quartzite in the Lune River area (Summons, 1981), most other occurrences must be classed as potential rather than identified resources. The low unit value of some of these makes the feasibility of extraction and transport an important consideration.

Precambrian quartzite occurrences within this element have been, and are still, quarried for use in construction work (road making etc.). Quartzite has been extensively used by the Hydro-Electric Commission for dam construction and road surfacing.

Potential resources

The paucity of volcanic rocks, especially felsic volcanic rocks, invalidates or downgrades the applicability of many ore deposit models for the Adamsfield-Jubilee Element. Most areas of moderate to high potential, for metallic resources, are for mafic/ultramafic related, sediment-hosted, or granitoid-related mineralisation.

Granitoid-related mineralisation

Geophysical interpretation of field data suggest that Devonian granitoid rocks occur at relatively shallow depths (less than 4 km) under parts of the southern and western Adamsfield-Jubilee Element, notably in the area of the upper Huon catchment and the Picton catchment. These areas are therefore rated as of moderate to high potential for granite-related vein deposits (Ag-bearing polymetallic veins, model 22c of Cox and Singer 1986, tract BM5b/M/B-C, map 5.19; W-Mo veins and Sn veins, models 15a, b of Cox and Singer 1986, tract Vn1b/M-H/B-C, map 5.24). Because carbonate rocks are abundant and widespread in the Proterozoic and Ordovician successions, these areas are considered to have moderate to high potential for skarn (models 14a, b, 18b, d of Cox and Singer 1986, tracts Skrn1a/H/B-D, map 5.22; Skrn1b/M-H/B-C, map 5.22) and replacement tin (Renison-type) deposits (model 14c of Cox and Singer 1986, tracts Sn1b/M-H/B, map 5.23 and Sn1c/M/B, map 5.23). The Tasmania Basin covers the prospective basement rocks in the Picton area.

Mafic/ultramafic-related mineralisation

The Adamsfield ultramafic complex is judged to have high potential for ultramafic-related deposits (PGE, chromite) (models 5a, b, 8a, b, c of Cox and Singer 1986, tract PGE1a/H/C, map 5.28), while the Boyes River complex and smaller occurrences in the upper Weld catchment are considered of moderate potential (tract PGE1b/M/B-C, map 5.28).

Sediment-hosted mineralisation

The thick, essentially unmetamorphosed Neoproterozoic and Ordovician carbonate successions (Weld River Group, Gordon Group) are considered to have moderate potential for Irish-style carbonate-hosted base metal deposits (model 31a of Cox and Singer 1986, tract BM3b/M/B-C, map 5.17) and also for Carlin-style deposits (tract Au8/M-H/B-C, map 5.13). Proterozoic rocks of the element (the older Clark Group as well as the Weld River Group) are considered to have low to moderate potential for sedimentary exhalative lead-zinc deposits (model 31a of Cox and Singer 1986, tract BM7b/L-M/B, map 5.21), but at a relatively low level of certainty. The Ordovician limestone is thought to be of moderate potential for sedimentary exhalative lead-zinc deposits (tract BM7a/M/B-C, map 5.21).

The Proterozoic rocks are thought to have a low potential for sediment-hosted copper deposits (model 30b of Cox and Singer 1986, tract BM6d/L/B, map 5.20).

Other models

Gold mineralisation is associated with silicification and skarn-like alteration of Neoproterozoic dolomite and Cambrian rocks at Glovers Bluff. The mineralisation is possibly of Mesozoic age, and is of a style unknown in the rest of Tasmania. The potential for this style of gold mineralisation elsewhere in the Adamsfield-Jubilee Element is unknown.

On the basis of geophysical interpretations, the Proterozoic and Lower Palaeozoic rocks of the Adamsfield-Jubilee Element extend under the Tasmania Basin as far east as Storm Bay. The basement rocks are overlain by cover sequences which are typically one kilometre or more thick. A drill hole near Hobart intersected intermediate volcanic rocks similar to the Mt Read Volcanics, suggesting the possibility of potential for other mineral deposit types (e.g. massive sulphide) in the concealed parts of the element. A newly discovered basement inlier of Cambrian rocks occurs at the junction of the Weld and Huon rivers. Some alteration, similar to that at Glovers Bluff, is present. There is a potential for further outcropping basement 'windows' to be found in the poorly-known Picton catchment and other areas.

There are areas of potential for placer chromite and PGE (model 39b of Cox and Singer 1986, tract Cr/M-H/B-C, map 5.30) and a small area near Glovers Bluff with potential for placer gold (model 39a of Cox and Singer 1986, tract Au7/M-H/B, map 5.12). Higgins *et al*. (1988) considered that the Adamsfield district had high potential for small eluvial and alluvial PGE and associated gold and chromite deposits, but that the chances of finding a large commercial deposit were small. Palaeoplacer PGE deposits occur in the basal part of the Late Cambrian Denison Group siliciclastic rocks of the Adamsfield district (TCR 52-115).

Non-metallic commodities

The Adamsfield-Jubilee Element has a large potential for industrial minerals. Silica flour deposits are associated with Proterozoic dolomite near Maydena, and this rock type is rated of high potential for this type of deposit (tract Sif1/H/B-C, map 5.34). There are very large potential resources of silica in Proterozoic quartzite and Cambrian chert (tract Silica/H/B-C, map 5.40). Siliceous gravel and sand, derived from partially silicified Neoproterozoic dolomite, are widespread in the Huon Valley (e.g. Weld Plains, Arve Plains) and are a potential source of silica, aggregate and sand for concrete (tract Conmat:/M-H/B-C, map 5.41). There are very large resources of dolomite in the Neoproterozoic Weld River Group (tract Dol/H/B-C, map 5.38), and of limestone in the Ordovician Gordon Group (tract Lst1/H/C, map 5.39).

Northeast Tasmania Element

Geology

The Northeast Tasmania Element is characterised by lower Palaeozoic turbidite rocks (the Mathinna Group) and an absence of known Proterozoic rocks, contrasting with the post-Cambrian shelf deposits and extensive Proterozoic rocks to the west. The western boundary of the Northeast Tasmania Element is nowhere exposed but the different lower Palaeozoic successions and structural styles are separated by only a 20 km-wide cover of younger rocks in the Tamar Valley (Williams, 1979). A major crustal fracture, the Tamar Fracture System, has been postulated (Williams, 1979) to trend southeast along the axis of the Tamar Valley and then continue under the Tasmania Basin. However, there is no compelling geophysical evidence for such a major crustal fracture, as the major gravity gradient lies not at the postulated site of the fracture but some 40 km west (Leaman, 1994). Some recent interpretations favour a shallow thrust contact, with the Northeast Tasmania Element thrusted over essentially western Tasmania-style basement (Powell and Baillie, 1992; Keele *et al*., 1994; Roach, 1994).

In the Beaconsfield area the Early Palaeozoic geology is similar to that of the Dundas-Sheffield Element. Marine clastic sedimentary rocks of Cambrian age, consisting of a number of fault slices, are overlain by Ordovician conglomerate, sandstone and limestone. Serpentinite, in fault contact with one of the Cambrian sedimentary units, was emplaced at a temperature of about 500 ¦C (Gee and Legge, 1979).

The Parmeener Supergroup rocks, which contain significant coal resources, are discussed as part of the Tasmania Basin Element.

Mathinna Group

The Mathinna Group consists of a succession of turbiditic sandstone and mudstone and forms the pre-Carboniferous sedimentary basement to eastern Tasmania.

The base of the succession is not known and the oldest formation consists of a quartzose turbiditic sandstone succession about one kilometre thick overlain by a 1-2 km thick black pelite containing an Early Ordovician graptolite (Banks and Smith, 1968). This pelite succession passes conformably upwards into an approximately two kilometre thick succession of quartzose turbidites of sublithic composition, and then into a ~2 km thick succession of feldspathic composition (Powell *et al*., 1993). The distribution of the formations is only established west of Scottsdale. Sparse fossil data indicate a regional younging of the sequence from west to east.

Early Devonian deformation

Late Early Devonian deformation (D_1) produced NNW-trending, upright to locally east-facing overturned folds (Williams, 1978; Turner, 1980) accompanied by low-grade regional metamorphism. D_1 preceded the St Marys Porphyrite, a dacitic ash-flow pile dated at 388 ˜1 Ma (Turner *et al.,* 1986), and preceded the emplacement of related granodiorite plutons as old as 395 Ma (Cocker, 1982).

Devonian granitoids

The Devonian granitoids (395-368 Ma) include three large composite batholiths (the Scottsdale, Blue Tier and Eddystone Batholiths), shown by geophysical modelling to be all part of a large northerly-trending elongate subsurface mass that underlies most of the Northeast Tasmania Element (Leaman and Richardson, 1992). A major north-trending gravity gradient reflects the steep western boundary of the less-dense granites and adamellites (Leaman and Richardson, 1992). Emplacement was at high crustal level (<6 km), and contact-metamorphic aureoles are narrow (Cocker, 1982; McClenaghan, 1985). There are four granitoid types: granodiorite (I-type); biotite adamellite/granite; biotite-garnet adamellite (S-type); and alkali-feldspar granite (McClenaghan, 1985; McClenaghan, in Williams et al., 1989). The proportion of I-type granitoids decreases to the east, and unequivocal S-type granites are restricted to the Eddystone Batholith in the far northeast.

Devonian mineralisation

Auriferous quartz reefs are widespread in the Mathinna Group. Many deposits, including the largest known (the New Golden Gate deposit at Mathinna), lie within the 70 * 6 km NNW-trending corridor of the Mathinna-Alberton Gold Lineament between the Scottsdale and Blue Tier Batholiths (Keele, 1994). Gold-bearing quartz veins within this zone were deposited by fluids of deep-seated regional metamorphic origin (Taheri and Bottrill, 1994), and veins were genetically associated with wrench faulting associated with D_2 (see below) (Keele, 1994). Some other gold deposits (e.g. Lisle, Golconda) appear to have a close genetic association with hornblende granodiorites (Klominsky and Groves, 1970).

The marginal, altered phase of the Mt Pearson biotite-adamellite granite pluton is genetically associated in the zoned Scamander field, with W-Mo, Sn-Cu, and Ag-Pb-Zn vein deposits arrayed successively further away from the pluton (Groves, 1972).

Disseminated cassiterite deposits are found within greisenised alkali-feldspar granite in the Blue Tier Batholith (Groves, 1977), and dilational quartz-wolframite vein deposits occur in Mathinna Group country rock over altered granite cupolas (e.g. Aberfoyle, Storys Creek). The absence of skarn and replacement-type Devonian deposits in the Northeast Tasmania Element reflects the absence of carbonates in the country rocks (Collins and Williams, 1986).

Mid-Devonian to Carboniferous deformation

There is local evidence for at least two phases of deformation during and after granitoid emplacement (e.g. Turner, *in* McClenaghan *et al*., 1982). Granodiorites and granite/adamellites in the Blue Tier and Scottsdale Batholiths have a predominantly NNW-trending tectonic foliation, and similarly orientated crenulation cleavages are locally present in the Mathinna Group. Upright NNW-trending F_2 folds occur in the west (Bridport-George Town area, Powell and Baillie, 1992). Keele (1994) recorded north to NE-trending D_2 folds and fracture cleavage in the Mathinna area, and associated north to WNW-trending dextral wrench faults that were conduits for gold-bearing fluids.

Jurassic-Cretaceous igneous activity

A large volume of tholeiitic dolerite was intruded into the Tasmanian crust in the Middle Jurassic, mainly as sheets and sills in the flat-lying sediments of the Tasmania Basin. The sheets and sills are typically 400-500 m thick, and remnants of Jurassic dolerite are predominantly exposed in the west and south of the Northeast Tasmania Element. An appinitic suite comprising andesite, lamprophyre and porphyrite occurs as small flows, dykes and

irregular plug-like intrusions near Cape Portland (Jennings and Sutherland, 1969). These rocks were dated at 101.3-102.3 ˜2.6 Ma (McDougall and Green, 1982). 'Basalt' and lamprophyre intruding the Lower Parmeener Supergroup at nearby Musselroe Bay have been dated at 98.7 ˜0.8 Ma (Baillie, 1984).

Onshore Tertiary sediments

Fluvial and lacustrine gravel, sand and clay fill shallow depressions in northeast Tasmania, and are locally important sources of placer cassiterite. Three broad age groupings of tin-bearing deposit are recognised (Morrison, 1989):

- probably Eocene deposits filling narrow channels north and west of Mt Cameron;
- late Oligocene braidplain deposits in the Ringarooma Valley, from which most of the recovered tin has been sourced; and
- deposits in the terraces of the present Ringarooma and Musselroe Rivers, that post-date the extrusion of widespread mid-Miocene basalts.

Chromite-rich Tertiary sand derived from the Andersons Creek Ultramafic Complex has been mined near Beaconsfield (Summons *et al*., 1981).

Cainozoic volcanic rocks

Erosional remnants of alkaline basalt cap hills above 500 masl in the Weldborough area. Partly dissected flows in the nearby Ringarooma Valley gave late early Miocene ages of 16.0 to 16.4 Ma (three dates, Brown, *in* McClenaghan *et al*., 1982; Sutherland and Wellman, 1986) and locally overlie the early Miocene terrestrial gravel.

In the northern part of the element, a variable suite of flows, ranging in age from probably middle Eocene to at least early Miocene, filled valleys draining northward into Bass Strait (Sutherland and Wellman, 1986).

Quaternary

Surficial Quaternary sediments, including glacigenic, slope, coastal, aeolian, fluvial and cave deposits, are widespread in Tasmania (see Colhoun, 1989). Quaternary placer deposits include alluvial cassiterite and gold in northeast Tasmania (Threader, *in* Colhoun, 1989).

Mineral exploration

Metallic minerals

Metallic mineral exploration in the Northeast Tasmania Element has been dominated by the search for gold and tin-tungsten.

Gold

Gold exploration can be divided into an early phase, which started in the mid-1800s and continued to the 1920s, and a second or modern phase which started in the late 1950s. The early phase was carried out by prospectors using traditional techniques that directly located only near-surface veins. These methods discovered all the goldfields in the element, the principal fields being at Beaconsfield, Lefroy, Back Creek, Lisle-Golconda-Denison, Warrentinna, Gladstone, Alberton, Dans Rivulet, Mathinna and Mangana. The targets of the early explorers were narrow, high-grade sulphidic quartz veins. Economic grades were 20-30 g/t gold, with cut-off grades of 15 g/t. It was recognised at an early stage that the veins were structurally controlled and occurred within zones of shearing and tectonic deformation. Many of the quartz veins did not crop out and were only discovered during underground development of other veins. Activity was restricted to depths of less than 30 m for all but a very few prospects. Most early phase production and exploration had finished by 1920.

One of the early major exploration programs of the modern phase was carried out by Geophoto Resources Consultants and involved regional studies including airborne scintillometer surveys, stream-sediment sampling and reviews of the geology (TCR 69-593). It was concluded, on the basis of fracture analysis, that the gold in the Mathinna-Mangana area was dominated by a primary northwest trend overprinted by a later northeast-trending direction, and Geophoto suggested that mineralisation was located where northeast-trending tension zones crossed the northwest trend. Geophoto also considered that the Golden Ridge area had potential. The final phase of exploration included detailed ground surveys over several former mines in the Mathinna area and evaluation the alluvial sediments in the region (TCR 74-994).

In the late 1980s Goldfields Exploration Pty Ltd carried out a detailed review of the gold potential of northeast Tasmania (TCR 90-3140), including documenting most of the mines and prospects in the element. The company's target was bulk mineable quartz vein stockwork gold mineralisation.

Billiton Australia considered that northeast Tasmania had potential for a large tonnage open-cuttable gold deposit. To assess this potential, the company undertook a variety of reconnaissance office-based studies, field mapping and regional stream-sediment surveys (TCR 92-3337). Landsat imagery was used to complete a fracture analysis of northeast Tasmania designed to identify dominant structural trends, and these results were then integrated with regional gravity, geology and metallogenic data. Billiton developed three deposit models. These were:

- sheeted or stockwork quartz vein systems in hornfelsed country rock aureoles in structural zones near granodiorite intrusions;
- epithermal Au-Ag mineralisation associated with the St Marys porphyry; and
- structurally controlled gold mineralisation in late-stage differentiates of the Scottsdale and Blue Tier Batholiths.

Forty areas which met most of the exploration and model criteria were investigated with reconnaissance mapping and regional stream-sediment sampling programs. Later work concentrated on the Golden Ridge area, which was found to have potential for low-grade bulk gold mineralisation, and the Mathinna-Mangana area (TCR 92-3337).

Numerous companies have carried out minor exploration programs throughout the goldfields in the last twenty years without thoroughly testing the potential. The greatest amount of work has been in the zone that contains a large number of the old prospects and mines between Mangana and Warrentinna.

After the closure of the Tasmania mine in 1914 there was little activity in the Beaconsfield area apart from the prospecting of localised detrital deposits by small operators. In 1962 the Department of Mines started investigating the gold potential of the area and deep exploratory diamond-drilling, completed in 1967, showed that significant gold mineralisation continued below the previous Tasmania mine workings. Subsequent work by companies involved in the Beaconsfield Mine Joint Venture has identified a viable gold resource, and the mine is currently being refurbished in preparation for reopening. Active exploration for similar deposits is occurring in the area near the mine lease.

Macmin NL started gold exploration in the old Lisle Goldfield in 1992 and has since reported widespread low-grade gold in the granodiorite host rock. The granodiorite-hosted vein and disseminated gold are interpreted as suggesting that the Lisle Goldfield may be similar to the Fort Knox style of mineralisation.

In 1993 Mineral Resources Tasmania carried out a project to promote gold exploration in northeast Tasmania, with a data package, including aeromagnetic coverage of the main host rocks to gold mineralisation and other data useful to gold explorers, being prepared. As a result of this project there was a considerable increase in gold exploration in the element. New explorers included Resolute Samantha Ltd, Herald Resources Ltd, Central Kalgoorlie Ltd and Anglo Australian Resources NL. Exploration by these companies has included stream and soil geochemistry and drilling. Low levels of gold mineralisation have been reported by the first three of these companies. Herald Resources Ltd has since withdrawn from the area but Resolute Samantha Ltd has started exploration for gold in the area to the west of Beaconsfield.

Tin

The most important primary tin deposits in the element were the Aberfoyle and Storys Creek mines in the Ben Lomond area. These quartz-wolframite-cassiterite-sulphide vein deposits were hosted by Mathinna Group rocks and are related to aplitic cupola highs in the underlying Devonian Ben Lomond Granite. The Storys Creek mine dates from the 1890s and the Aberfoyle mine from 1931. A third major zone of mineralisation was drilled at the nearby Lutwyche prospect in the 1960s, with some subsequent development and mining. Production from the Aberfoyle mine, until shortly before its closure in 1980, was 2.1 million tonnes at 0.91% Sn and 0.28% WO_3 (TCR 89-3055). All mines in the area closed in the early 1980s. Not all of the major veins in the area were exploited and there is also a remaining resource in intervening minor veins.

Tin was mined from a steeply dipping greisen zone within Devonian Granite at Royal George between 1911 and 1922. Since then the deposit has been evaluated by a number of companies, including CRA Exploration Ltd who estimated the reserves as 0.59-1.17 million tonnes at 0.34% Sn (2400-4000 tonnes of contained tin). The deposit was also reported to contain 12 g/t Ag and 0.21% Zn (TCR 81-1662).

Greisen tin deposits also occur in the Blue Tier area, where they are related to the Lottah and Mt Paris alkali-feldspar granite bodies. Ore bodies in this area were discovered in the 1860s, with mining at the Anchor mine starting in 1892 and continuing until 1942. The Aberfoyle Tin Development Partnership explored the Anchor mine area between 1963 and 1966 (TCR 66-423), and the area was again explored by Renison Ltd and Hellyer Mining and Exploration Pty Ltd in the 1970s. This exploration program resulted in extensive drilling in the mine area. A resource was established and the mine is now being operated by Mancala Pty Ltd.

Alluvial tin mining started in 1874, with most production occurring before 1900 but continuing at a reduced level until the 1980s. The tin, which occurs as cassiterite in basal gravel in deep leads in the Tertiary sediments stretching from near Branxholm to Ringarooma Bay, was derived from erosion of the tin-rich alkali-feldspar granites of Mt Paris, Lottah and other smaller bodies in the Blue Tier Batholith. The main mines were the Briseis, Pioneer, Endurance, Valley and Arba. Mining also occurred in the Tertiary sediments west of St Helens. Recorded production until the early 1960s was about 41 660 tonnes of metallic tin (TCR 64-381). Most of the mining was by hydraulic sluicing but some dredges were used including the Dorset dredge which operated from 1944 to 1971. The Utah Development Company carried out a major assessment of the alluvial tin resources of the element in the 1960s (TCR 64-381). Since that time a number of other companies have also made assessments of the resource, including Santos Ltd and Hellyer Mining (TCR 87-2692), Mineral Holdings Aust. Pty Ltd (TCR 85-2404), and Australian Anglo American Ltd, Buka Minerals NL and Triako Mines NL (TCR 84-2101, TCR 85-2358). Lower grade resources still remain and may be economic to exploit in the future.

Mineralisation of a different style occurs in the Scamander area, where there is a zonation of lodes adjacent to the Mt Pearson adamellite. The lodes display a progression from W-Mo to Sn-Cu to Pb-Zn-Ag at greater distances from the adamellite. Production from mines in this mineral field has been small but the area has been explored by various companies including Geophoto Resources Consultants (TCR 71-818) and BHP Ltd (TCR 65-397). An area which includes the Great Pyramid tin mine is currently being assessed for tin by the Merrywood Coal Company Pty Ltd.

Other metallic minerals

Uranium associated with the Devonian granitoids is another commodity that has been explored for in the element and an occurrence is known from the Royal George area (TCR 55-119), although the deposit is thought to have no commercial significance (TCR 56-130, TCR 56-131). An adit was dug into the deposit in 1957 (TCR 57-161). Drilling in the vicinity in 19801, TCR 85-2358). Lower grade resources still remain and may be economic to exploit in the future.Mineralisation of a different style occurs in the Scamander area, where there is a zonation of lodes adjacent to the Mt Pearson adamellite. The lodes display a progression from W-Mo to Sn-Cu to Pb-Zn-Ag at greater distances from the adamellite. Production from mines in this mineral field hurce, including Santos Ltd and Hellyer Mining (TCR 87-2692), Mineral Holdings Aust. Pty Ltd (TCR 85-2404), and Auside mineralisation similar to the Honeymoon Well and Mt Keith deposits of Western Australia. The lateritic nickel potential of the area is currently being assessed by Allegiance Mining NL.

Another mineralisation style that has been suggested for this element is stratabound shale-hosted lead-zinc, similar to that in the Cobar Trough in NSW (TCR 83-1975).

Non-metallic minerals

An exploration program near south Mt Cameron in the 1960s, aimed at delineating reserves of clay for use in paper manufacture, resulted in the location of 200 000 tonnes of proven reserves and a similar quantity of indicated reserves (TCR 63-355). Drilling for clay for use in paper manufacture was also undertaken in other tin mining districts within northeast Tasmania (TCR 72-919). However, a 1979 exploration effort looking at old tin workings concluded there was no single deposit or group of deposits remaining which could support a processing plant (TCR 79-1322), although there were enormous quantities of clay available for other applications.

Exploration in the Scottsdale area resulted in the discovery of kaolin deposits at Tonganah and mining started in 1977, with the kaolin being used in paper manufacture.

An exploration program near Pipers River in 1989 was aimed at finding a white pottery clay. Whilst clay was found, none was suitable for that application.

Identified resources

There are two operating mines in the element, the Tonganah mine where kaolin is being extracted for paper making, and the Anchor mine where cassiterite is being mined from a greisen tin deposit. The Tasmania mine at Beaconsfield contains a considerable gold resource and the operator expects this mine to be reopened in 1997. Other identified resources are tin and tungsten in the Ben Lomond area, tin at the Great Pyramid mine in the Scamander area, and alluvial tin in Tertiary sediments between Branxholm and Ringarooma Bay. These resources and past production are tabulated in Tables 1 and 2.

Large kaolinised granite and Tertiary-aged kaolin placer deposits are known to occur in northeastern Tasmania. Kaolin has been mined from near St Helens and South Mt Cameron for use as a paper filler clay. Reserves of around 400 000 tonnes have been estimated near south Mt Cameron (TCR 63-355). Kaolinised granite is currently mined from the Tonganah mine, which had reserves of nine million tonnes at the start of mining (TCR 77-1195), for use in paper manufacture. In 1994/95 40 000 tonnes were produced from this site.

The best potential for building stone in the element is considered to be the Devonian granitoids, Triassic sandstone, Tertiary basalt and Jurassic dolerite (Sharples, 1990). Pink granite is being quarried from the Scottsdale Batholith for use as ornamental stone.

Tertiary sand is currently being extracted in the Scottsdale area for building purposes. Reserves are poorly documented but are thought to be very large.

Beach sand along the northeast coast has local concentrations of various heavy minerals, including rutile, zircon, cassiterite, topaz, gold and ilmenite. Few have been systematically tested, but significant reserves are known at Seymour (TCR 75-1131), Ringarooma Bay (TCR 81-1620) and Friendly Beaches (TCR 70-621).

Ordovician quartzite at Cabbage Tree Hill is being used for metallurgical purposes and road material.

Chrome-bearing oxides of iron occurring near Andersons Creek in the Beaconsfield area have been successfully used in the manufacture of paint. The oxides come in a large range of colours and are derived from lateritic weathering of serpentine (Bacon, 1987b).

Slate, derived from the Mathinna Group rocks, has been quarried intermittently from two areas near Bangor since 1872. Slate is currently mined from one of these Bangor locations and from Turquoise Bluff, where tiny amounts of turquoise can be found on joint planes within the slate (Bacon, 1987a).

Weathered and disaggregated granite is used for road building in various parts of the Element.

Table 5.5: Pre-mining resource and production from Northeast Element mines

Mine / Deposit Style Resource Grade Production Grade
(Mt) (Mt)

Anchor greisen 5.44 0.25% Sn 2.09 0.22% Sn
Royal George greisen, vein 0.32 0.5% Sn 0.16 0.4% Sn
Storys Creek vein 1.1 1.09% WO_3
0.18% Sn
Lutwyche vein 0.88 0.47% Sn
0.47 WO_3
Aberfoyle vein 2.1 0.91% Sn
Great Pyramid vein 3 0.33% Sn
Tasmania (Beaconsfield) vein 2.09 24 g/t Au 1.09 24 g/t Au
4 g/t Ag
1% Cu
Lefroy (7 mines) vein 0.08 31 g/t Au
New Golden Gate vein 0.3 26 g/t Au
Tas Consols vein 0.02 14 g/t Au
Beaconsfield laterite 6.1 1.04% Ni

Table 5.5: Pre-mining resource and production from Northeast Element mines (cont.)

Mine / Deposit Style Resource Grade Production Grade
(Mt) (Mt)

0.06% Co
Barnes Hill placer 0.234 12.4% chromite 0.027 chromite

South Rifle Range placer 0.230 15.1% chromite

North Rifle Range placer 0.2 7.5% chromite

Resource is the estimated pre-mining size of deposit based on total production plus total reserves. Where no resource data are given, the size is equivalent to total production, as there are no published reserves. Data to June 1994.

Table 5.6: Remaining resources for alluvial tin mines

Mine / Deposit	Resources	Grade
	(million m^3)	(g/m^3 Sn)
Bowlers Lagoon	53.8	78
Braithwaites prospect	21.2	102
Macgregors Deposit (Dorset)	5	83
Pioneer	21.3	127
Scotia Lead	12.2	104
Endurance	8.4	160

Monarch	4.23	224
Ringarooma Bay	21.23	174
Briseis	7.44	1367

Potential resources

Metallic minerals

Gold

Historically, much of the gold produced in Tasmania has come from northeastern Tasmania, which is geologically and metallogenetically closely related to the Victorian goldfields.

There is a high potential for slate-belt (Model 36a of Cox and Singer, 1986) in the Mathinna Beds (tract Au1a/H/B-C, map 5.6). About one thousand such deposits are known, the largest being the New Golden Gate mine at Mathinna which produced about eight tonnes of gold and was once Tasmania's most important gold mine. To date, about 140 years after the initial discoveries, little systematic exploration program has been carried out within the goldfields, and there is no geological evidence to suggest that further deposits similar to the New Golden Gate mine do not exist in the area.

There is also a high potential for Nagambie-Fosterville style gold mineralisation (stockworked slate and sandstone) in Mathinna Beds. Mineralisation of this type occurs with slate-belt gold at the Linton mine near Forester (Taheri and Bottrill, 1994).

Most of the gullies draining the goldfields were worked for alluvial gold, but deeper valleys have generally not been explored. Many deposits are known, and while most are small, deposits in the Lisle area produced about ten tonnes of gold. Old reports (e.g. Twelvetrees, 1907) indicated the occurrence of gold nuggets up to 11 ounces in the area. Palaeoplacers with gold also occur in the overlying Permian conglomerate (Finucane, 1932). Therefore, there is locally a high potential for more discoveries of placer gold deposits in areas of both Cainozoic alluvial sediments near primary gold deposits and in the basal terrestrial units of the Parmeener Supergroup (model 39a of Cox and Singer, 1986, tract Au7/M-H/B, map 5.12).

Ignimbrite sheets in the St Marys Porphyrite have moderate potential for epithermal gold-silver mineralisation (model 25b of Cox and Singer, 1986, tract Au6a/L-M/C, map 5.11). The ignimbrite sheet is part of a Devonian magmatic complex which is interpreted to be co-magmatic with the I-phase magmatism. Although dacitic ignimbritic rocks constitute favourable hosts for epithermal gold-silver type mineralisation, no significant wall-rock alterations, favourable structures or mineral occurrence of epithermal gold and silver are reported in the area.

Tin-tungsten

Tasmania is considered to be a world-class tin and tungsten province.

Tin and tungsten deposits, as well as silver, lead, zinc, copper, uranium and bismuth mineralisation, were formed during the emplacement of the Late Devonian granitoid rocks in northeastern and western Tasmania.

Significant greisen-style cassiterite deposits (model 15c of Cox and Singer, 1986) occur in northeastern Tasmania. Major deposits include the Anchor mine, with a total resource (production and reserves) of 5.44 million tonnes of ore at 0.25% Sn, and Royal George, with a total resource of 0.32 million tonnes of ore at 0.5% Sn. There is high potential for more deposits of this style

in the Ben Lomond/Royal George, Lottah and Mt Paris areas (tract Sn3a/H/C, map 5.25) and moderate potential in some other granitoids (tract Sn3b/M/C, map 5.25).

There is also high to moderate potential for tin and tungsten vein-type deposits (models 15a, b of Cox and Singer, 1986). The areas of potential lie within the four kilometre subsurface granite depth contour, as modelled from gravity data (tracts Vn1a/H/B-D, Vn1c/M/B-C, map 5.24). Mineralisation may be in either the granite or country rock, but the larger deposits occur in the latter. Important historical mines occur in the Ben Lomond district, where the Aberfoyle and Storys Creek deposits produced ore from late last century to the 1980s. These deposits are yet to be fully exploited. The nearby Lutwyche deposit contains 0.88 million tonnes of ore at 0.47% Sn and 0.47% WO_3. Known vein-style mineralisation also occurs at the Great Pyramid mine in the Scamander area, with an estimated resource of three million tonnes of ore at 0.33% Sn.

There is considerable potential for major new discoveries of tin and tungsten, as the recent gravity data have provided better understanding and modelling of the underlying granites in northeast Tasmania. Available geological, geophysical, geochemical and mineral deposit data may be examined more effectively using the recently compiled digital databases provided by Mineral Resources Tasmania.

Placer tin produced in the Northeast Tasmania Element has been a major source of tin in Tasmania (model 39e of Cox and Singer, 1986). Although production has declined considerably in the last 50 years, there is still a high potential for new placer tin deposits in areas of Cainozoic alluvial sediments near primary tin/tungsten deposits (tract Sn5/M-H/B-C, map 5.26). The richest concentrations of placer tin occur in the tributary 'deep leads' to the Tertiary Basins exhumed by the present Ringarooma River (Collins, 1982), but palaeoplacers may also occur in basal Permian sediments (e.g. Royal George). About 40 000 tonnes of alluvial tin was produced from the region by 1967, mostly from the Ringarooma River valley. Exploitation of known deposits awaits a rise in tin prices.

Base metals

Silver-bearing base metal vein deposits commonly occur as haloes around tin deposits (modified model 22c of Cox and Singer, 1986), where the underlying source granite surface is at deeper levels (2 to 6 km). Base metal vein deposits have long been known in the Scamander area and because there are numerous tin granites in the Ben Lomond, Royal George and Blue Tier areas (tract BM5a/H/B-D, map 5.19), it could be considered that there is a high potential for new discoveries in the Northeast Tasmania Element. Because most of this area lies within the one kilometre granite depth contour, it is considered that the level of erosion in these areas is such that pre-existing argentiferous veins may have been removed, and these areas have not been included in the tract map.

Bauxite

There is low to moderate potential for bauxite in areas of deeply weathered basalt and dolerite in Tertiary grabens.

Industrial minerals

Clay

There is a high potential for kaolinite in the Scottsdale area (currently being exploited at Tonganah), the Gladstone and possibly other granite areas, and in Tertiary basins (e.g. Longford area). Kaolinite occurs in altered and/or weathered granites but may also be present as a secondary deposit in the Tertiary sediments.

There is low potential for bentonite in areas of weathered Tertiary basalt and Cretaceous sediments (e.g. Gladstone area).

There is high potential for brick clay in areas of Parmeener Supergroup rocks (e.g. Fingal and Lilydale areas, Bottrill, 1995).

Heavy mineral sands

There is moderate potential for heavy mineral sands (model 39c of Cox and Singer, 1986), particularly in the Friendly Beaches-Chain of Lagoons area (tract MS1a/M/B, map 5.32). The derivation appears to be largely from granite. The sands are rich in zircon, ilmenite and rutile, with minor monazite, cassiterite and gold. Only small, low-grade reserves are known.

Silica

There is low potential for silica sand and gravel along the north coast, and in tailings from old tin and gold workings (Bacon, 1988).

Zeolites

There is moderate potential for zeolites in Tertiary basalt and conglomerate (tract Zeol/M/B-C, map 5.40), and Triassic tuff and sandstone (Bottrill and Everard, in prep.).

Building and dimension stone

There is high potential for slate, especially in the Back Creek and Pipers Brook areas (Bacon, 1989b; Sharples, 1990) and high potential for granite in the Devonian granitoid areas. The Triassic sandstone has high potential as a building stone (e.g. at Nunamara). The potential for 'black granite' is high in areas of dolerite and basalt (Sharples, 1990).

Fuels

Uranium

There is moderate potential for uranium in granite, Permian black shale, Triassic sandstone, and Tertiary sand (tract U/M/B, map 5.31). There are small occurrences in all of the above rock types, but no large deposits are known (Blissett, 1959; TCR 56-131; TCR 57-161; TCR 73-939; TCR 78-1266; TCR 81-1528; TCR 82-1701). The certainty level is B.

Construction materials

Aggregate

There is high potential for aggregates, especially Jurassic dolerite (Weldon, 1993; Turner, 1993b), but proximity to markets and ports is a restrictive factor.

Sand

There is high potential for sand in the Scottsdale area, where large reserves are known in the Tertiary sediments. There is also high potential in other areas of Cainozoic sediment derived from granite (Bacon, 1988; Bacon, 1992d; Matthews and Donaldson, 1994) (tract Conmat:/M-H/B-C). The certainty level ranges from B to C, depending on the deatil of the geologicl mapping.

Precious and semi-precious stones

Several small occurrences of precious and semi-precious stones, including sapphire, topaz, zircon, pleonaste, chrysoberyl, spinel, emerald, garnet, turquoise and ruby, and these mostly occur in alluvial tin-bearing deposits (Jennings et al., 1967; MRT, 1994), have been reported within the element. Amethyst and various other varieties of quartz have also been found in the same deposits. Devonian granitoid rocks are the source for the topaz and quartz, but the sapphire, spinel and much of the zircon are probably sourced from alkali basalts.

Diamonds are known to occur associated with alkaline basalts in New South Wales, and the Tasmanian basalts may have a similar origin. Such basalts are widespread in Tasmania, and diatremes occur (e.g. Brooks Creek). The potential for diamonds is unknown.

Granite and basalt are important source rocks for alluvial accumulations of precious and semi-precious stones, but the source rocks are poorly studied and their potential for precious and semi-precious stones is unknown.

The alluvial Cainozoic strata have known accumulations of precious and semi-precious stones. However the available information is not sufficient to assess the potential.

Moderate to high quality turquoise occurs in the Northeast Tasmania and Rocky Cape Elements, but the deposits are poorly known and the potential is unknown.

Tasmania Basin

Geology

The Tasmania Basin covers most of central and eastern Tasmania and overlaps most of the older elements. The basin contains a succession of predominantly flat-lying sedimentary rocks of Late Carboniferous to Late Triassic age known as the Parmeener Supergroup, and thick sheets and sills of Jurassic dolerite that presently occupy most of the outcrop area of the basin. The total maximum thickness of the succession is about 1.5 km. The present basin limits are erosional, not depositional, and the original basin was probably considerably larger. Proterozoic metamorphic rocks of the Tyennan Element and granitic rocks of the Northeast Tasmania Element are basement highs, and the main depocentre for Tasmania Basin sediments was situated along the axis of the postulated Tamar Fracture System. The thin and incomplete succession in far northeast Tasmania suggests proximity to a basin margin in this area.

Lower Parmeener Supergroup

The Lower Parmeener Supergroup, consisting mainly of glacigene and shallow-water glaciomarine rocks, rests on a landscape unconformity with a relief of about 1000 metres.

In most areas the succession begins with a unit of tillite, diamictite and minor rhythmitic claystone which reaches a maximum thickness of greater than 500 metres. Ice flowed eastwards from a source west of Tasmania. Tillite is absent from the major highs of the northern Tyennan Element and parts of the Northeast Tasmania Element (Hand, 1993).

The basal glacigene rocks are succeeded by a sequence of carbonaceous, pyritic siltstone (the Woody Island Siltstone in southern Tasmania, the Quamby Mudstone in the north) passing up into richly fossiliferous siltstone, sandstone and minor limestone (the Bundella Formation and correlates, including the Golden Valley Group in the north). Thickest developments are found along the axis of the main depocentre (>400 m) but elsewhere the thickness is typically 150 to 180 metres. A bed of oil shale near the base of this sequence, usually about two metres thick, is widespread in the north and in a small sub-basin at Douglas River in the east (Calver *et al*., 1984). The oil shale ('Tasmanite') is immature in these areas, with a maturity corresponding to a vitrinite reflectance of 0.5%. The carbonaceous siltstone is typically around 1% in total organic carbon (Domack *et al*., 1993).

The siltstone passes laterally into littoral and sub-littoral sandstone and conglomerate where the succession onlaps basement highs in eastern and northern Tasmania.

This sequence is succeeded by a thin (20-40 m) unit of fluvial to paralic origin (the 'lower freshwater sequence', including the Faulkner Group and its lateral equivalents, the Liffey Group and the Mersey Coal Measures). A thin marine intercalation is present in southeast and central Tasmania. Lateral equivalents of the 'lower freshwater sequence' are wholly marine in the far southeast (Farmer, 1985). Thin (<1 m) coal seams are present in the north and northeast, around the landward margin of the basin. Vitrinite reflectances of 0.31 to 0.58% have been measured.

Small palaeoplacers of tin and gold occur where the 'lower freshwater sequence' onlaps basement in northeast Tasmania (Twelvetrees, 1907; Reid and Henderson, 1929; Finucane, 1932).

In southeast and east Tasmania the 'lower freshwater sequence' is succeeded by marine calcareous siltstone (Nassau Formation and correlates), then bioclastic (bryozoal-crinoidal) limestone (Berriedale Limestone and correlates), totalling about 100 m in maximum thickness.

A disconformity exists between the underlying strata and the marine sedimentation of the lower Lymingtonian Stage (Farmer, 1985). These rocks (Malbina Formation, Deep Bay Formation and correlates) are dominantly fossiliferous siltstone and poorly-sorted sandstone in which ice-rafted lonestones are common.

Upper Parmeener Supergroup

The Upper Parmeener Supergroup, a non-marine succession of Late Permian to Late Triassic age, has been divided into four lithological units (Forsyth, 1989b).

Unit 1 corresponds to the Late Permian Cygnet Coal Measures (*sensu* Farmer, 1985) and correlates. Thin coal seams are present in the far southeast (Cygnet-Bruny Island) and in the northwest (Mt Ossa). Palaeocurrents indicate low-sinuosity, east-flowing rivers.

Unit 2 is 200-300 m thick but thinner in the northeast, and consists predominantly of well-sorted quartzarenite. The unit is widely distributed and may have originally extended across western Tasmania, but wedges out against high basement in the northeast.

Unit 3 begins with an impersistent quartz granule sandstone around five metres thick, of early Middle Triassic age, followed in the southern Midlands by an interval of interbedded lithic sandstone and lutite about 80 m thick. Unit 3 concludes with an interval, 100 m thick in the Midlands but thinner elsewhere, of quartz sandstone interbedded with carbonaceous lutite and

minor lithic and feldspathic sandstone. Thin coal seams are locally present. In far eastern Tasmania, this interval overlaps all older units of the Upper Parmeener Supergroup to rest directly on eroded Lower Parmeener Supergroup. Near St Marys, the lower of two alkali-olivine basalt flows, each up to 30 m thick, has been dated at 233 ˜5 Ma (whole-rock K-Ar minimum age, Calver and Castleden, 1981).

Unit 4 is predominantly lithic sandstone with minor lutite and coal, with the thickest preserved sections being in the northeast (maximum about 350 m). Unit 4 contains all of Tasmania's economic coal reserves, which are mostly in the northeast (Bacon, 1991) where eight or more seams or groups of seams are present. The base of Unit 4 is transitional on Unit 3 and is diachronous, being slightly older in the northeast than elsewhere. The lithic sandstone is mainly of intermediate to felsic volcanic provenance, and there are rare, thin (<1 m) felsic tuff horizons high in Unit 4 (Bacon and Everard, 1981). Rare conglomeratic horizons, which include common rhyolitic clasts, occur at similar levels. A calc-alkaline volcanic source, probably to the east of Tasmania, is indicated. Unit 4 is characterised, almost throughout, by Carnian microfloras. The youngest preserved part of Unit 4 is a lutite-dominated interval about 100 m thick near

Douglas River, with Norian microfloras. An ash-fall tuff at the top of the Carnian interval contains biotite dated at 214 ˜1 Ma (Bacon and Green, 1984).

Jurassic dolerite

A large volume of tholeiitic dolerite was intruded into the Tasmanian crust in the Middle Jurassic, mainly as sheets and sills in the flat-lying sediments of the Tasmania Basin. These sheets and sills are typically 400-500 m thick, and Jurassic dolerite is currently exposed over most of the area of the Tasmania Basin.

Sills, unroofed by erosion, are underlain by rocks as young as Norian. A younger cover of unknown thickness, now entirely removed by erosion, can be inferred.

Limited areas of basalt in a graben at Lune River in southern Tasmania are the only known extrusive occurrences of this phase of magmatism. The basalt is associated with sedimentary rocks containing plant fossils of probable Jurassic age, and is comagmatic with the dolerite on petrographic, geochemical and isotopic evidence (Hergt *et al*., 1989).

Tertiary sediments

The Tamar Graben is an onshore southern extension of the Bass Basin. Oldest known sediments are 100 m of latest Cretaceous and Palaeocene mudstone, sandstone and conglomerate intersected in a well in the southern part of the graben. The basin contains post-basalt, siliceous gravel of probable late Pliocene age (Forsyth, 1989c).

The Longford Sub-basin is a southern extension of the Tamar Graben, and contains up to 800 m of clay, sand and gravel, with basalt towards the top of the succession. The sediments are mainly Eocene in age. Palaeocene sediments are present in the deepest part of the basin (Matthews, 1983).

The Devonport-Port Sorell Sub-basin (Cromer, 1989; Burns, 1965) contains up to 250 m of carbonaceous mudstone, sandstone and minor conglomerate with Palaeocene and early Eocene microfloral assemblages (Harford beds), overlain by 175 m of repetitious thin flows of alkali olivine basalt, 75 m of weakly consolidated sandstone, and 50 m of basalt.

The Derwent Graben similarly contains a thick sequence of sand, gravel and clay overlain, in part, by basalt.

Quaternary

Surficial Quaternary sediments, including glacigene, slope, coastal, aeolian, fluvial and cave deposits, are widespread in Tasmania (Colhoun, 1989).

Quaternary placer deposits include alluvial cassiterite and gold in northeast Tasmania, and osmiridium and chromite in western and southern Tasmania (Threader, *in* Colhoun, 1989).

Sub-Parmeener rocks

The existing regional gravity and aeromagnetic data provide an insight into the general distribution and nature of the rocks at or near the base of the Parmeener Supergroup in the Tasmania Basin. Two-dimensional modelling of the data by Dr

D. E. Leaman of Leaman Geophysics was used to produce a semi-quantitative map showing this distribution (Sub-Parmeener geology map submitted to RFA reference centres) and suggests a series of thrust slices underlying the basin. Rock types inferred include Precambrian quartzitic, pelitic and dolomitic rocks, Cambrian volcanic and ultramafic rocks, Wurawina Supergroup rocks, and a number of combinations of granitoids and Mathinna Group materials.

The following tracts include contributions from these units:

Tract	Rock type
Cambrian ultramafic bodies	Ultramafic rocks
Besshi-type massive sulphides	Cambrian mafic volcanic rocks
Tungsten-molybdenum veins	Mathinna Group
Tin veins	Mathinna Group
Slate belt gold deposits	Mathinna Group
Basaltic copper deposits	Cambrian mafic volcanic rocks
Kuroko-style VHMS deposits	Cambrian felsic volcanic rocks
Gold associated with massive sulphide	Cambrian felsic volcanic rocks
Epithermal gold-silver deposits	Cambrian felsic volcanic rocks
Irish-style base metal	Wurawina Supergroup
Sediment-hosted copper	Wurawina Supergroup
Sedimentary exhalative zinc-lead	Wurawina Supergroup
Irish-style base metal	Precambrian carbonate rocks
Sediment-hosted copper	Precambrian carbonate rocks
Sedimentary exhalative zinc-lead	Precambrian carbonate rocks

Mineral exploration

Coal

The pattern of discovery of coal outcrops and deposits followed that of the white settlement of Tasmania. Coal is widespread throughout the Tasmania Basin, having been found in almost 70 localities, and mined since the early days of settlement (Bacon, 1991).

Interest was shown in the East Coast coalfields in the 1960s when an exploration licence was taken out by Industrial and Mining Investigations Ltd, who wanted to find coal to combine with the iron ore deposits held in the west of Tasmania and so develop an indigenous steel industry.

The Department of Mines started a coal investigation program on Fingal Tier in 1959 which continued until 1988. The Hydro-Electric Commission drilled several holes on Fingal Tier in the 1970s. In the early 1980s the possibility of the State Government choosing a coal-fired power station as an energy source proved to be an incentive to coal exploration. Extensive studies were made of the East Coast coalfields by The Shell Company of Australia Ltd, who found *in situ* reserves totalling more than 200 million tonnes (measured and indicated).

Exploration programs were conducted at Woodbury by Victor Petroleum and Resources Ltd, in the Midlands and near Colebrook by CRA Pty Ltd, and near Catamaran by Marathon Petroleum of Australia Ltd. The Catamaran and Strathblane areas were explored in 1974/75 by Earth Resources Australia Pty Ltd in an effort to find a source of coal for use by the local paper mill.

The Cornwall Coal Company NL and the Merrywood Coal Company Pty Ltd have both undertaken a number of exploration programs, primarily in the northern part of the basin, to secure a long-term future for their respective operations.

In 1979 an exploration program by Capricorn Mining Ltd identified a subeconomic deposit of four million tonnes of coal near Hamilton. This deposit is still undeveloped.

Lignite

The resource of lignite near Rosevale was evaluated in 1981/82 by AAR Ltd, in partnership with CSR Ltd, as a potential source of fuel for a coal-fired power station. The exploration program defined three deposits with combined (measured and indicated) reserves of 118 million tonnes (TCR 82-1809).

Oil shale

Extensive investigations have been made into the chemical nature of *Tasmanites* and distillation fractions were made from 1939 to 1968 (Cane, 1941; 1968).

Over twenty holes were drilled in the Mersey Valley area by the Mersey Valley Oil Company and the Adelaide Oil Exploration Company in the 1920s, some of which intersected the oil shale horizon. In 1974 an exploration licence was granted to Endeavour Resources Ltd. Forty-six holes were drilled in 1975 (TCR 75-1099). The Department of Mines experimented with production of a Tasmanites concentrate by grinding and flotation (Rhodes and Wellington, 1977). In 1981 two more holes were drilled into the oil shale by an Endeavour Resources/CRA joint venture partnership. An inferred resource of 69.2 million tonnes of shale containing 130 litres of oil per tonne was estimated in eight separate areas (TCR 88-2801).

Oil

Traces of petroleum hydrocarbons have been found in a number of rock types in Tasmania for over a century, and this has led to some flamboyant and energetic efforts in the search for economic oil deposits onshore. A number of shallow holes have been drilled without encountering confirmed, properly documented, or reproducible oil or gas shows. Many seeps of oil and gas have been reported, although subsequent investigation has usually shown that the reported observations are not indicative of petroleum hydrocarbons. Pieces of transported asphaltum have been found at various localities around the Tasmanian coastline. Petroleum has never been produced in Tasmania (Bacon, Morrison and Boreham, 1996). An occurrence of natural bitumen is known from Lonnavale. This has been derived from a *Tasmanites* source (Revill, 1996).

Clay

An investigation was made in 1981 of the potential for clay/kaolin deposits in the Longford district (TCR 81-1632). Further study matched the available deposits with possible uses (TCR 81-1632). The clay resources of the Longford area were described by a 1983 exploration assessment as 'large' (TCR 83-1963B).

The establishment of a pottery factory near Deloraine around 1989 encouraged a small boom in clay exploration. Most of this work was of a prospecting nature only, and not done under exploration licence. Sufficient quantities of pottery clay (for stoneware) were not found and the raw material was imported from Victoria.

Stone and sand

Most quarry sites are found by prospecting, rather than an ordered exploration effort. One of the main considerations is the distance to local markets and transport costs, hence most quarries/sand pits are located close to the market. Many small gravel pits service local needs in rural and forestry areas. These are almost all found by prospecting.

There are currently 220 leases in Tasmania held for the production of sand, gravel, crushed rock and concrete aggregate. The CONMAT database contains some hundreds of sites from which sand/gravel/rock has been extracted for construction material used at some time.

The Readymix Group undertook an exploration program to locate sources of dolerite close to the Hobart market in 1989. One area near Mt Faulkner was estimated to contain 150 million tonnes of *in situ* dolerite (TCR 89-2976). The weathering profile was determined by seismic investigations (TCR 89-2976A). Other sites in the Hobart area were examined (TCR 90-3142), but as yet no development has been planned. Although potential reserves are large, the establishment of a new quarry in close proximity to urban development is problematical.

Building Stone

Most quarry sites which eventually produce building stone blocks are also located by prospecting.

Uranium

A number of occurrences of uranium in northeast Tasmania are in areas that could be potential sediment sources for the materials in the Tertiary basins near Launceston. In the early 1970s Getty Oil Development Co. Ltd and Tenneco Australia Inc. recognised that the basins could be a possible sedimentary uranium environment. A comprehensive drilling program failed to find significant uranium mineralisation but did confirm that the sediments formed a suitable host for the deposition of sedimentary uranium (TCR 73-939).

Identified resources

Coal

Although coal has been found at three stratigraphic intervals within the Tasmania Basin, all the economically important coal reserves are hosted in the Late Triassic coal measures. Two smaller intervals of coal-bearing strata are of Early Permian and Late Permian age.

The bulk of the State's coal reserves are in the northeastern part of the State, in the Fingal-Mt Nicholas-Dalmayne coalfields.

Coal was discovered in the Mt Nicholas area, northwest of St Marys, in the 1840s and has been mined almost continuously since 1886. The only currently operating mine on the Nicholas Range is the Blackwood Colliery, owned by the Cornwall Coal Company NL, which in 1994/95 produced about 360 000 t of coal.

Coal outcrops southeast of Fingal were first described by Milligan (1849), and minor mining works in this area were visited by Thureau (1883). A number of mines have operated in the Fingal coalfield, but all have now closed except for the Duncan Colliery owned by the Cornwall Coal Company NL.

The Merrywood coalfield is a southern extension of the Fingal-Mt Nicholas coalfield and once supported a small open cut and underground mine. The seam is four metres thick, but is interbedded with many mudstone bands. Underground operations ceased in 1963 due to loss of markets, but an open-cut mine, extracting the pillars left by the former workings and surrounding coal, commenced operations in 1990. Raw coal production for 1994/95 totalled almost 150 000 tonnes.

The Dalmayne coalfield is located 11 km south of St Marys, and may be considered to be an easterly extension of the Fingal coalfield. One coal seam has been mined in the area, although several seams exist within a fluvial sequence of lithic sandstone, siltstone and mudstone. The Dalmayne Colliery first opened in 1915, with extensive infrastructure such as bins and an aerial ropeway which transported the coal to Piccaninny Point. These operations closed in 1917. The mine was reopened in 1939 and coal was transported to St Marys until the mine closed in 1955.

Small amounts of coal have been mined from Late Triassic rocks in eastern Tasmania and from Lower Parmeener rocks at Preolenna and between the Mersey and Don Rivers (from the Mersey Coal Measures and the Preolenna Coal Measures). In southeastern Tasmania the Upper Parmeener Cygnet Coal measures have been worked in the past at Cygnet and on Bruny Island (Bacon, 1991).

Total *in situ* black coal resources have been estimated at around 570 million tonnes. However, the deposits are geologically complex, and whilst the in-ground resources are large, only a small quantity of this coal can be regarded as an economically mineable resource.

Lignite

Deposits of lignite have been found within Tertiary sequences in many parts of Tasmania. The largest deposit is at Rosevale, near Westbury, where a sub-economic *in situ* deposit of 118 million tonnes was delineated by exploration in 1981/82 (TCR 82-1809).

Ochre

Deposits of oxides of iron suitable for the manufacture of pigments occur at a number of places within the Tasmania Basin. Oxides have been mined at Spalford near Ulverstone, where a red ochre has been derived from the decomposition of basalt, and at Mowbray (near Launceston), where red and yellow ochres have been produced from weathered dolerite and the product was used for some years in the manufacture of paint (Threader, 1976c; Bacon, 1987b). There is no current extraction of ochre and resources are thought to be small.

Limestone

The Permian limestone is generally of a lower grade when compared to the Ordovician limestone sequence in Tasmania. Permian limestone has been quarried in a number of places (Glenorchy, Granton, Maria Island) for use as an agricultural limestone, in cement manufacture, or for road metal. The total *in situ* resources of Permian limestone would be very large, and well in excess of the quantities required by the currently available market.

Limestone was burnt in a lime works at Granton earlier this century to produce an agricultural product. Substantial quantities of limestone with a $CaCO_3$ content of 60-70 per cent (suitable for the production of agricultural limestone) have been identified on the East Coast and in the Break O'Day valley (Hughes 1957, Jennings 1969).

Some smaller occurrences of Permian limestone have been used for building construction in the Midlands.

The Permian limestone and mudstone also provide a source of gravel and road base material in municipal areas. Resources for these purposes are quite large.

Building stone

Triassic sandstone occurs throughout the Tasmania Basin and has been extensively quarried to provide decorative facing and building stone, particularly during the early years of settlement. Public and private buildings and bridges, dating from earlier this century, were primarily constructed with Triassic sandstone blocks, and the stone is still quarried for building purposes. Resources are considered to be large.

Three leases are currently held for production of sandstone building blocks. Some material suitable for paving and garden landscaping is also produced. Some 360 tonnes of sandstone blocks (freestone) was produced in 1994/95. Resources of sandstone are extremely large.

Jurassic dolerite is also used to a limited extent as a building stone, although the darker colour of basalt is usually preferred for headstones. Tertiary basalt was mined for this purpose from Miena, although the resources in this locality were considered to be small.

Construction materials

Rock

Tertiary-aged quartz gravel is found at various locations along the northwest coast, near Beaconsfield and Launceston, at Forester, in the Macquarie Harbour basin, and in the Huon valley. In all these areas the gravel has been, and still is, extracted for use in concrete making and road construction.

In areas of the Midlands, where the better Tertiary gravel is unobtainable, indurated zones in the Permian and Triassic rocks are used to provide road making materials. Some 2000 tonnes of crushed sandstone was produced in 1994/95.

Decomposed dolerite is also quarried and used in road making in various areas, sometimes extracted in conjunction with a current quarrying operation.

Dolerite and basalt are quarried and crushed for use in concrete making and are extensively used in road construction throughout Tasmania. In 1994/95, 1.1 million tonnes of crushed dolerite and almost one million tonnes of basalt were produced for use by local industry. The resources of dolerite and basalt within Tasmania are extremely large. Investigations have been made in recent years towards establishing an export market for dolerite to the Pacific region, where hard construction rock does not occur naturally (TCR 91-3281). The dolerite could be shipped in blocks to be used in building breakwaters and crushed for use in concrete and road making.

Sand

Sand deposits of late Tertiary to Recent age occur in abandoned channels of the South Esk River near Launceston, and deposits of Tertiary age have been quarried in the Launceston Basin.

Small deposits derived from weathered Parmeener Group sediments can be found throughout the Midlands, although such deposits are usually of limited extent.

Dune sand is extensively used in the manufacture of concrete aggregate, as bedding sand, and as a source of silica for glass manufacture. In southern Tasmania dune sand is mined from a number of pits on South Arm, but this resource is likely to be exhausted within the next 10 to 15 years.

Municipal zoning and urban encroachment have sterilised some potential resources, especially those close to population centres, such as the deposits at Carlton Beach and Primrose Sands. An extensive deposit underlies a pine plantation near Hobart Airport, but the municipal zoning does not permit extractive industries in this area, which is also close to a popular beach.

Estuarine sand from the Rubicon River is used for foundry moulding, sand blasting, water filtration and as a concrete aggregate. Almost 600 000 tonnes of sand were mined in 1994/95. Building sand was produced on nine leases, concrete sand on fourteen, and at 27 leases sand for 'general purposes' is produced. The total value of construction materials (rock, sand, gravel) mined in 1994/95 was $28 million.

Kaolin

Kaolin was mined from Surges Bay between 1944 and 1959. The source was a weathered alkali intrusive rock. The clay was of sufficient quality to be used as a paper filler but mining ceased due to the exhaustion of the deposit (Bacon, 1992).

Clay

Clay for ceramic purposes (brick and pipe manufacture) has been derived from the Tertiary sedimentary basins and from weathered Parmeener Supergroup mudstone. Clay is currently mined for use in brick manufacture near Hobart, and has been mined for the same purposes at Longford. A wood-fired kiln was used near Railton by one manufacture of bricks and terracotta pots, but this has now closed. Clay is mined for use in cement manufacturer near Railton. There are currently six mining leases are held for clay, with 120 000 tonnes being produced in 1994/95.

Small quantities of clay are mined in various places for use in local pottery operations. Resources are thought to be large and can be found in the Launceston, Coal River, Longford and Macquarie Basins and in the Derwent Valley, where a 200 m thick deposit was worked until recently to provide clay for production of terracotta pipes.

Oil shale

Small deposits of oil shale in northern Tasmania have been investigated as a potential source of hydrocarbons or road bitumen. The shale has been mined intermittently since the 1860s. During the 1930s a number of experimental retorts were used by different companies to produce a variety of fuels and fuel products, although none of the retorts operated as a commercial success (Bacon, 1986).

The oil in the shale is derived from microfossil algal cysts or algal bodies, which release oil when heated. The host sediment is of marine origin. The shale is of Late Carboniferous age and is older than the Mersey and Preolenna Coal Measures, and not a facies variant thereof. Recent exploration has defined indicated *in situ* reserves of 40 million tonnes of oil shale (TCR 82-1789), although no commercial application exists for the products which can be produced.

Oil / gas

An occurrence of bitumen is known from Lonnavale. This has been shown to have been derived from *Tasmanites* (Revill, 1996).

Heavy minerals

Deposits of heavy minerals (topaz, zircon, ilmenite and rutile) are known from the Seven Mile Beach spit. To date this deposit has not been mined. The reserves are reasonably small, and extraction would be dependent upon favourable commodity prices.

Potential resources

Basement

The complex basement geology underlying the Parmeener Supergroup (Tasmania Basin) rocks in the central, eastern and southeastern parts of the State has been inferred in broad outline from gravity and magnetic data. The basement rocks are essentially subsurface extensions of the surrounding Proterozoic-Lower Palaeozoic elements, but their mineral potential is briefly discussed in this section. The thickness of the cover rocks is typically one kilometre or more. The basement rocks are unexplored and the potential for the mineral deposit model types mentioned below is considered low to moderate, with a relatively low level of certainty (L-M/B).

Numerous narrow belts of Cambrian ultramafic rocks are inferred to occur west of a line running approximately from Beaconsfield to the Tasman Peninsula ('Tamar Fracture' of previous work). These have potential for ultramafic-related (Cu-Ni-PGE-chromite) mineralisation (Models 5a, b, 8a, b, c of Cox and Singer, 1968; tract PGE1c/L-M/B, map 5.28). A number of areas of Cambrian mafic volcanic-rich successions, similarly distributed, have potential for basaltic copper (Model 23) and Besshi-style (Model 24b) mineralisation (tracts BM4c/L-M/B, map 5.18; BM2c/L-M/B, map 5.16).

Numerous areas in southeastern and central Tasmania are interpreted to be underlain by carbonate-dominated successions of either Neoproterozoic (Weld River Group) or Lower Palaeozoic age (Wurawina Supergroup). These areas are considered to have potential for Irish-style and sedimentary exhalative lead-zinc base metal mineralisation (Model 31a of Cox and Singer, 1968) and sediment-hosted copper (Model 30b of Cox and Singer, 1968; tracts BM3c/L-M/B, map 5.17; BM7b/L-M/B, map 5.21; BM6c/L-M/B, map 5.20).

A few small areas of Cambrian felsic rocks are interpreted to underlie the Tasmania Basin in central and southeast Tasmania, and intermediate volcanic rocks have been intersected in a drill hole near Hobart. These areas have potential for Kuroko-type massive sulphides (Model 28a of Cox and Singer, 1968), VHMS-related gold, and epithermal gold (Model 25b) deposits (tracts BM1c/L-M/B, map 5.15; Au2c/L-M/B, map 5.7; Au6b/L-M/B, map 5.11).

Mathinna Group sediments of the Northeast Tasmania Element are inferred to underlie much of the area east of the Beaconsfield-Tasman Peninsula line. These rocks have potential for slate-belt gold (Model 36a of Cox and Singer, 1968) and tin-tungsten-molybdenum vein deposits(Models 15a, b of Cox and Singer, 1968; tracts Au1b/L-M/B, map 5.6; Vn1d/L-M/B, map 5.24).

Coal

The Permian 'lower freshwater sequence' (Mersey Coal Measures and correlates) in northern Tasmania, and Unit 4 of the Triassic Upper Parmeener Supergroup, have high potential for coal deposits.

Unfortunately the distribution of Unit 4 has not been mapped in all areas. Undifferentiated Triassic rocks are considered to have, in general, a low potential for coal (tracts Coal1c/L/C, Coal1d/L/B, map 5.36). In the Fingal Tier area, location of most of the State's known economic coal reserves, Unit 4 has a high potential, including subsurface extensions beneath Jurassic dolerite that have been proved by drilling (tract Coal1a/H/C, map 5.36). The Hamilton area, also the site of a known resource, is also indicated as of high potential. Other mapped areas of Unit 4 are considered to have moderate potential with a relatively high degree of certainty (tract Coal1b/M/C, map 5.36). There are numerous areas, less well known than Fingal Tier, where Unit 4 extends beneath younger rocks (particularly Jurassic dolerite). These areas, some of which may be large (e.g. beneath the Central Plateau), are not shown on the tract map.

The Permian Mersey and Preolenna Coal Measures in northern Tasmania are considered to be of moderate potential (tract Coal1b/M/C, map 5.36). Although exploited in the past, these deposits are not presently worked.

Oil shale

The lower marine part of the Lower Parmeener Supergoup (excluding the basal diamictite) is considered to have potential for oil shale deposits. The stratigraphic location of known oil shale near the base of this succession (Quamby Mudstone, Woody Island Siltstone and correlates) is reasonably precise, and the stratigraphic unit is sufficiently accurately mapped in northern Tasmania and in the Maydena-Styx valley areas to enable exploration to be well targetted. Areas in northern Tasmania, where exploitation has occurred in the past, are considered to have moderate potential (tract Oshl1a/M/B-C, map 5.37), as have areas in central-southern Tasmania where disseminated *Tasmanites* is known, and where a *Tasmanites*-derived bitumen seep has recently been discovered.

Outcrop areas of the lower marine sequence in eastern and northeastern Tasmania are considered to have a low potential (tract Oshl1c/L/B, map 5.37). The distribution of the prospective stratigraphic interval in the deeper subsurface, beneath cover of younger rocks, is poorly known and the occurrence of oil shale difficult to predict, as illustrated by an isolated occurrence of oil shale in a drill hole at Douglas River on the east coast. Extensive areas covered by younger rocks in eastern Tasmania should therefore be considered as having some potential, but are not shown on the tract map (map 5.37).

Petroleum

No tract map has been compiled for hydrocarbons, but there are potential source rocks in the Parmeener Supergroup such as *Tasmanites* oil shale and the enclosing organic-rich Quamby Mudstone and correlates. Other necessary factors, such as an appropriate thermal history, reservoirs and traps, are poorly known. The potential for hydrocarbons sourced from older rocks, such as the Ordovician Gordon Group, being reservoired within rocks of the Tasmania Basin is also poorly known. Jurassic dolerite intrusion is likely to have disrupted existing hydrocarbon accumulations but may have also locally aided thermal maturation. High heat flow in the Cretaceous may have provided peak thermal conditions, but potential source rocks, at least in northern Tasmania, are immature except near dolerite intrusions. Exploration, including drilling, by one company is currently underway in southern Tasmania.

Brown coal

Brown coal or lignite is common in Tertiary freshwater deposits, particularly those of Palaeocene to Eocene age. In central northern Tasmania, and probably other areas as well, the possibility of growth faults acting during the Palaeocene and early Eocene suggests broader or less deformed peat basins may have developed from about middle Eocene times. This is in accord with the age of the Rosevale deposit.

Somewhat later during the Oligocene-Miocene valley fill and volcanic phases, deposits of lignite were probably of limited lateral extent, except possibly in flat-lying coastal areas.

Many of the other recorded brown coal deposits are of Palaeocene to early Eocene age. It is necessary to take into account the basin and growth fault geometry and the depositional environment before extrapolating likely potential from the recorded deposits.

The major Tertiary basins with Palaeocene-Eocene sequences, and other areas with extensive middle and late Eocene deposits, have high potential for lignite deposits, especially within the middle Eocene interval. Valley fill and deposits interbedded with volcanic rocks have high potential for lenses of lignite, but interbedded sequences dominantly of volcanic rocks, thin sequences beneath lateritic profiles, and high energy mid and Late Tertiary fluviatile deposits have a low potential for significant lignite deposits.

Bauxite, chrome-rich laterite, ochre, kaolinite

Periods of deep weathering during the Late Mesozoic and Cainozoic produced lateritic profiles on a variety of older and contemporaneous rock types. Some profiles survived erosion and were then protected by burial beneath Tertiary deposits. Some Tertiary rocks, both sediments and basalt, were subsequently lateritised. They form a slightly resistant duricrust on the present land surface, particularly in areas that were removed from active erosion.

A pallid zone of residual kaolinitic clay is common to many lateritised source rocks, but is especially well developed on Tertiary and Lower Parmeener strata and in places on Jurassic dolerite. It is locally developed on Devonian granitoids and Cretaceous syenite. The potential for kaolinite is high in some areas.

Lateritic profiles developed on aluminous rock types, including Tertiary basalt and sediments and Jurassic dolerite, locally contain bauxite deposits (tract bauxite/H-M/C-B/, L-B and L-M/C-B). Small ochre deposits have also developed on the laterite on ultramafic rocks, basalt and dolerite.

Chrome-rich laterite near Beaconsfield developed on or near chrome-bearing mafic or ultramafic rocks. There is a high potential for ochre in this area, with a certainty level of B (tract Ochre/H/B-C, map 5.35). Silica, as silica stone, is present in some lateritic profiles developed on Tertiary strata (tract Silica/H/B-C, map 5.42).

Miscellaneous

Uranium

Permo-Triassic and Tertiary sedimentary rocks derived from Devonian granites with known uranium mineralisation contain redox interfaces, and small occurrences of uraium are known (tract U/M/B). These rocks have moderate potential for uranium deposits (Model 30c of Cox and Singer, 1986) with a certainty level of B. The indicated areas on the tract map (map 5.31) are based on the distribution of Tertiary sediments, but the model could also apply to parts of the Parmeener Supergroup, particularly Unit 4 of the Upper Parmeener Supergroup.

Phosphate

Dispersed phosphatic nodules occur in one or two horizons within Tertiary sediments of the Longford Basin and in the upper marine sequence of the Lower Parmeener Supergroup in northeast Tasmania. There is an unknown, but probably low, potential for this type of deposit.

Zeolite

Abundant zeolite cement is common in Tertiary deposits of dolerite conglomerate and sandstone in the Tamar area and in some nearby sub-basalt Tertiary sandstone. Zeolite is also present in some Tertiary volcanic sequences and is particularly abundant in some pyroclastic rocks. It also occurs as joint, vein and rare vesicle fillings in Jurassic dolerite. There are also zeolite occurrences in volcaniclastic units of the Parmeener Supergroup, and tuff beds occur which have moderate potential. The potential is moderate with a certainty level B to C, depending on the detail of geological mapping in the area (tract Zeol/M/B-C; map 5.40).

Lead-zinc vein mineralisation

Small veins with galena and sphalerite have been reported in thermally metamorphosed Upper Parmeener siltstone overlying a Jurassic dolerite sheet but are very irregularly distributed. These may indicate basement mineralisation.

Copper

Native copper occurs in zeolite veins on Bruny Island, with unknown potential (possible basaltic copper style).

Placers

Small areas of moderate to high potential for gold, tin, PGE and chromite placer deposits (Models 39a, b of Cox and Singer, 1986) occur in the Tasmania Basin Element (tracts Au7/M-H/B, Cr/M-H/B, Tin/M-H/B; maps 5.12, 5.26, 5.30), mainly in Quaternary sediments in the Beaconsfield and Cygnet areas. The certainty level for these areas is B. Cassiterite and gold palaeoplacer deposits are also known in the Tertiary and Parmeener Supergroup rocks but the potential for other deposits of this type in the element is unknown.

Clay for bricks and associated industries

There is a moderate to high potential for clay resources and blendable resources for brick manufacturing industries within the Tasmania Basin (tract Conmat:/M-H/B-C; map 5.41).

Clay abounds in the Tertiary deposits of the Longford Basin and Tamar area and is common in other areas of Tertiary sediment. The clay is dominantly kaolinitic, and has been exploited as ball clay and fire clay.

Weathered Parmeener Supergroup rocks locally provide an important resource of brick clay. Overall the pospectivity is locally enhanced in proximity to Tertiary land surfaces. Some weathered Jurassic dolerite in this situation also becomes a resource and has been utilised in some clay pits. Quaternary clay is locally exploited for construction purposes.

The non-lateritic weathering of Tertiary basaltic volcanic rocks, Tertiary dolerite-derived sediments, Jurassic dolerite, and Cretaceous, Triassic and Permian tuff and volcaniclastic rocks, has locally produced dominantly montmorillonite clay (bentonite). Little exploration has been carried out and the potential for economic deposits is unknown.

Sand for construction material

Quaternary coastal aeolian and marine sand generally has a high potential, which varies depending on sand specification. There is a moderate potential for inland Quaternary sand deposits where aeolian deposits have been blown from rivers, lakes and Upper Parmeener Supergroup quartz sandstone terrain, in some alluvial deposits, and as some slope and lag deposits derived from Upper Parmeener quartz sandstone or Tertiary strata (tract Conmat:/M-H/B-C; map 5.41).

Gravel for construction material

Poorly-graded gravel occurs as shingle on high energy Holocene beaches and in river channels, and occasionally as scree deposits. Most other gravel deposits are better graded and may be sandy and clayey. There is high potential for gravel to clayey, well-graded gravel in a variety of late Cainozoic alluvial and slope deposits, in particular in Tertiary nearshore and freshwater sequences and occassionally as lag deposits developed on pebbly Parmeener Supergroup lithologies and Tertiary lateritic surfaces (tract Conmat:/M-H/B-C; map 5.41).

Crushed rock

The potential for high-quality crushed rock is high in dolerite terrain and moderate basalt terrain. The potential for poorer quality crushed stone is moderate in areas of Cretaceous syenite and of thermally metamorphosed or limestone layers in the Parmeener Supergroup (tract Conmat:/M-H/B-C; map 5.41).

Building stone

A variety of rough stones, including Tertiary basalt and ferricrete, Jurassic dolerite and Permian glaciomarine siltstone and limestone, have been used as building stone, but the Unit 2 quartzose sandstone of the Upper Parmeener Supergroup and the Lower Freshwater sandstone of the Lower Parmeener Supergroup have been the main units worked for cut stone. Poor quality stone abounds, and a high potential exists for superior stone in Unit 2 throughout its area of occurrence (tract Dim1a/H/B-C; map 5.43).

Limestone

The potential for low-grade limestone deposits is high in some Lower Parmeener Supergroup formations such as the Darlington Limestone, Counsel Creek Formation, Berriedale Limestone, Harts Hill Limestone and equivalents. The available information on the distribution of these deposits is not sufficient to include them in the tract map for limestone (Lst1a/H/C), which was drawn based on the distribution of Ordovician limestone which contains higher grade deposits (map 5.39).

Heavy mineral sand

There is a low to moderate potential for coastal heavy mineral sand (topaz, zircon, monazite, ilmenite, rutile, etc.) and there are deposits at Seven Mile Beach, Bruny Island and Friendly Beaches (tracts MS1a/M/B, MS1b/L-M/B). The coastal areas are generally not mapped in detail and the certainty level is B.

Gemstones

Sapphire, possibly derived from Tertiary basalt, occurs in the Launceston area. The potential is unknown. Alkali basalt intrusions occur in some areas and may be potentially diamond bearing. These have not been explored and the potential is unknown.

Conclusions

The assessment of identified (known) mineral resources confirmed the importance of deposits of copper, zinc, lead, gold, silver, tin and tungsten in the Dundas/Sheffield Element (Mt Lyell, Rosebery, Hellyer, Henty, Renison, Mt Bischoff, Cleveland, Queen Hill).However, a comparison of pre-mining and remaining resources shows that known resources in these world-class deposits have been extensively depleted and continuing exploration needs to be maintained to sustain continuing mining activity with new mineral discoveries, either in new areas or as extensions of known deposits as at Rosebery, Mt Lyell and Renison.

The remaining resources at former mines or unworked deposits are often of lower grade than the currently operating mines and will require either improved mining and processing technology or identification of higher grade zones for resumed mining or the commencement of a new operation.

Extensive resources of magnesite, dolomite, silica, magnetite, ochre and clay have been identified in the Rocky Cape Element.The future exploitation of industrial commodities such as magnesite, limestone, dolomite, silica, ochre, and even some types of construction materials such as aggregate from Jurassic dolerite, are subject to the identification of suitable markets. Although such low unit value commodities are particularly vulnerable to the cost of transport, improved transport systems with lower costs and the relative proximity of Tasmania to major industrial centres on mainland Australia may upgrade the potential for some of these types of deposits.

High-grade silica sand from Cape Flatterty and magnesite from Kunwarara in Queensland are being shipped to overseas markets, and improved transport systems and decreased cost could alter the commercial viability of industrial commodity resources in remote areas such as those in Tasmania. These resources may also offer an opportunity for new processing industries to be established in the State.

A joint State/Commonwealth airborne survey over a selected area of the Rocky Cape Element near the Arthur Metamorphic Complex showed a number of positive features for mineral potential including:

- Possible deep-seated structures which may be penetrating mid-crustal levels and may have acted as conduits for ore forming fluids;
- Narrow but strong magnetic anomalies adjacent to some of the inferred structures may indicate fault-controlled mineralisation;
- Magnetic signatures in Proterozoic sedimentary rocks in the vicinity of granitoids may be due to granitoid-related mineralisation;
- Unexplained linear and 'bulls-eye' magnetic anomalies in Proterozoic carbonate sequences may be due to granitoid-related mineralisation;
- Complex structural areas where concealed carbonate rocks may host replacement mineralisation in proximity to granitoid rocks.

Other identified resources include gold, tin, tungsten, nickel, kaolin and chromite in the Northeast Tasmania Element; large resources of quartzite, limestone and small quantities of tungsten, copper and gold in the Tyennan Element; large resources of limestone, silica and probably small quantities of 'osmiridium' in the Adamsfield-Jubilee Element; and substantial resources of coal, lignite, oil shale, low-grade limestone, and important resources of construction materials (rock, sand, gravel) in the Tasmania Basin.

Most of the known metalliferous deposits in all of these elements are relatively small and require continuing exploration to locate more substantial resources.

The assessment of potential mineral resources has identified a potential for twenty-five types of mineral deposits in the Rocky Cape Element (of which 15 would be new types of deposits to the element), twenty-seven in the Dundas-Sheffield Element (11), twelve in the Northeast Tasmania Element (4), nineteen in the Tyennan Element (13), twenty in the Adamsfield-Jubilee Element (12), nine in the Tasmania Basin (2), and eleven in the sub-Parmeener basement, none of which are known to be present in the basement rocks.

The assessment shows that there is potential for the discovery of further major deposits, such as base/precious metals in volcanic-hosted massive sulphides and various types of tin and tungsten deposits, of which there are already examples of world class deposits in Tasmania.

There is also potential for types of deposits of major significance which have so far not been found in Tasmania, or are only represented as relatively small deposits such as low-grade, large tonnage slate-belt gold deposits, Irish-style carbonate-hosted base metals, sediment-hosted copper, and carbonate-hosted gold.

As stated previously, because geological knowledge is never complete it is not possible to have a 'final' assessment of potential (undiscovered) mineral resources. Increased geological knowledge and other factors can result in discoveries of world-class deposits, both in highly prospective areas and in areas not considered to be of very high potential. This is particularly applicable to Tasmania, where the geological framework is still being very substantially revised. This growth of geoscientific knowledge, new concepts of mineral deposit formation, and changes in the mineral commodities needed by society will necessitate periodic re-evaluation of potential mineral resources. The current assessment has established a computerised system which should assist in future revisions of Tasmania's potential mineral resources.

With regard to the sub-Parmeener Supergroup basement underlying the Tasmania Basin, future improvements in geological knowledge and advances in exploration and mining technology will lead to substantial revisions of the understanding of the mineral potential of the basement rocks.

Value and significance of minerals based industries to Tasmania

5.2.1 Economic contribution

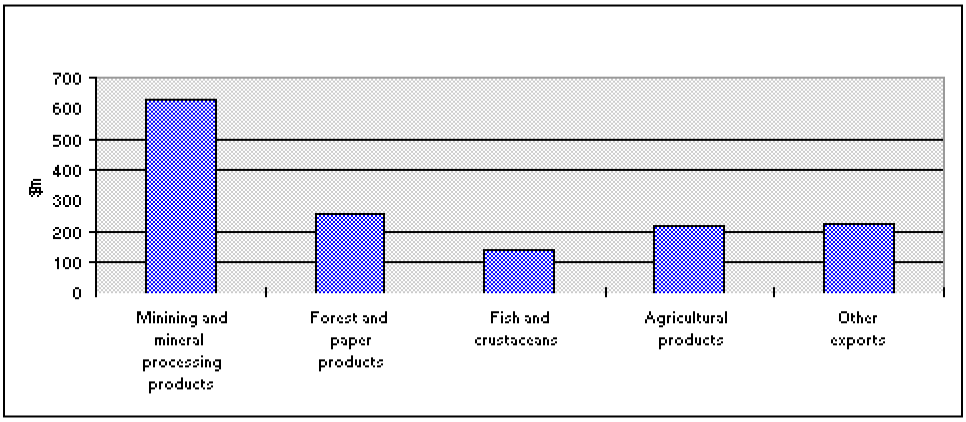
Tasmania hosts a number of mining and mineral processing operations (Figure. 5.5), including base metal mines (zinc, lead and copper), an iron ore mine and zinc, aluminium and iron ore processing facilities. Direct employment in Tasmania's mining and mineral processing sectors in 1994/95 totalled approximately 3700 persons, around 1.7 per cent of the total Tasmanian workforce (Australian Bureau of Statistics, 1996). The gross value of mining and mineral processing output in 1995 was over $1.2 billion mining and mineral processing exports for 1993/94 were $627, increasing to $641 million in 1994/95, equal to around 40 per cent (by value) of Tasmania's total exports (Figure. 5.4).

Figure 5.4: Composition of Tasmania's exports 1993/94a.

Tasmania's exports 1993-94

Minining and mineral processing products	627.1
Forest and paper products	257.2
Fish and crustaceans	140
Agricultural products	217.4
Other exports	219.9

Composition of Tasmania's exports 1993-94 a



Mining and mineral processing products are iron and steel, metalliferous ores and non-ferrous minerals. Forest and paper products are cork, wood, paper and paperboard. Agricultural products are dairy products and birds' eggs, vegetable products and fruit

footnote: Source: Australian Bureau of Statistics (1996).

Mining

The output and employment at the major mining operations in Tasmania for the financial year 1994/95 is shown in Table 5.2.1. Most of the direct employment in the mining industry is attributable to five major mines, which primarily produce zinc, lead, copper, tin and iron ore.

Pasminco Mining-Rosebery operate a base metals mining operation which produces zinc, lead and copper concentrates and a gold/silver doré. The Rosebery deposit has been mined since the 1890s. Pasminco are currently undertaking a four year, $45 million development and exploration program to define additional reserves below the mine's existing working levels.

Aberfoyle Limited operates the Hellyer zinc-lead-silver mine. The Hellyer deposit was discovered in 1983 and the Hellyer mine was officially opened in 1989. Around 250 000 tonnes of zinc concentrate, 60 000 tonnes of lead concentrate, 40 000 tonnes of bulk concentrate and 10 000 tonnes of copper/silver concentrate is produced annually. It is expected that reserves will be depleted at Hellyer by around 2001.

RGC (Tasmania) Ltd are currently expanding the Renison tin mine through the development of additional deeper reserves. The $34 million dollar project, which began in 1994, will extend the Renison mine's expected operating life from three years to 10-16 years.

The Mt Lyell mine temporarily ceased operations in December 1995 after 101 years of continuous operation. The mine was re-opened by Copper Mines of Tasmania Pty Ltd in October 1995, with a special Act ratified through parliament which ensured that the new owners were not liable for the environmental costs resulting from previous mining. Copper Mines of Tasmania Ltd has spent around $20 million to date on the expansion of the mine, and it is expected that the total cost of the project (to reach full capacity by 1998/99) will be around $100 million (Haine, 1996).

The Savage River iron ore mine ceased operations in April 1996. However, the company has delineated additional mineable resources, and the Tasmanian Government has signed a memorandum of understanding with Goldamere Pty Ltd to produce a feasibility study by November 1996 into continuing the operation.

Production at the Henty gold mine commenced in 1996. The mine, which is owned by RGC (Tasmania) Ltd, has an expected life of 4.5 years at a production rate of 100 000 ounces of gold per annum.

The Cornwall Coal Company NL and Merrywood Coal Company Pty Ltd produce steaming-quality Triassic black coal in the Fingal Valley. The coal produced is mainly used as boiler fuel by local industries.

Table 5.7: Major mining operations: products and direct employment for 1994/95

Company	Deposit	Products	Direct employment	Ore mined (Mt)
Pasminco Mining	Rosebery	zinc, lead and copper concentrates, gold/silver doré	299	0.50
Aberfoyle Resources Ltd	Hellyer	zinc, lead, copper and silver concentrates	278	1.30
RGC Renison Bell	Renison Bell	tin concentrate	241	0.66

Savage River Mines	Savage River,	iron ore	a	4.00
The Mount Lyell Mining and Railway Company (b)	Mt Lyell	copper and pyrite concentrates, gold and silver by-product	200	0.77
The Cornwall Coal Company NL	Fingal	coal	76	0.53
Merrywood Coal Co. Pty Ltd	Merrywood	coal	30	0.15
David Mitchell Ltd	Mole Creek	limestone products	26	0.10
Australian Paper	Tonganah	kaolin	23 (c)	0.20
Tasmania Mines Ltd	Kara	tungsten, magnetite	22	0.20
Spectrum Resources Australia Pty Ltd	Anchor	tin concentrate	15	0.01
RGC (Tasmania) Ltd	Henty	gold	d	d
n/a	Various quarries	construction materials	n/a	n/a

a This mine ceased operations in April 1996. 203 people were directly employed at both the mine and the processing operations at Port Latta.

b In October 1995 ownership of the Mt Lyell operation was transferred to Copper Mines of Tasmania Pty Ltd.

c As at March 1996 (Mineral Resources Tasmania, 1996).

d The Henty project began production in 1996, with expected output to be 100 000 ounces of gold per annum and 70 persons directly employed in the operation.

Source: Mineral Resources Tasmania (1995).

Mineral processing

The majority of Tasmania's mineral production is exported for further processing interstate or overseas, however, downstream processing of zinc and iron ore takes place. The Risdon zinc refinery, operated by Pasminco Metals-EZ, consumes zinc concentrates from the Hellyer and Rosebery mines in addition to concentrates sourced from outside Tasmania. Pasminco Metals-EZ have plans to increase the capacity of the Risdon refinery.

The iron ore pellet plant operated by Savage River Mines is the other major Tasmanian processor of locally-sourced minerals. The long term future of this plant, however, will depend on production from the Savage River iron ore mine restarting.

Due to the good port facilities and relatively low price of electricity, Tasmania hosts a number of mineral processing operations which rely on imported raw materials, notably Comalco Aluminium and BHP-TEMCO's operations at Bell Bay. The mineral processing sector directly employs over 2000 people in Tasmania (Table 5.8).

Table 5.8: Mineral processing activities, 1994/95

Company	Location	Product	Employment	
			Direct	Contract
Pasminco Metals-EZ	Risdon	zinc metal, alloys, cadmium and sulphuric acid	659	107
Comalco Aluminium (Bell Bay) Ltd	Bell Bay	primary Al alloys	637	195
BHP-TEMCO	Bell Bay	ferromanganese, silicomanganese, sinter	357	93
Savage River Mines	Port Latta	iron ore pellets	a	a
Tioxide Australia Pty Ltd b	Heybridge	titanium dioxide pigment	191	55
Goliath Portland Cement Ltd	Railton	cement	186	47
K & D Bricks and Pavers	New Town	bricks and pavers	47	
Nubrik	Longford	bricks and pavers	47	
Impact Fertilisers	Risdon	superphosphate	44	2

a This operation is due to close in December 1996. 203 people were employed at both the mine and Port Latta during 1994/95.

b This operation closed in 1996. *Source:* Mineral Resources Tasmania (1995)

Current projects

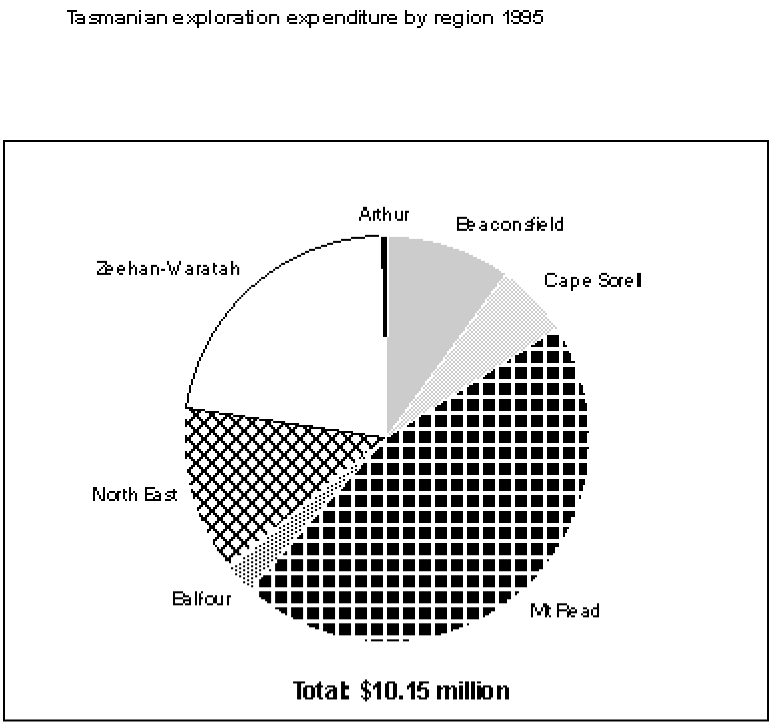
In addition to the Mt Lyell and Renison expansions and the recently opened Henty gold mine, the Beaconsfield deposit near Bell Bay is expected to begin production in 1997. This project involves dewatering and extending a mine that was closed in 1914. The project is expected to cost $30 million, providing a mine capacity of 65 000 to 100 000 ounces of gold per annum and mine life of four to eight years (Haine, 1996). Direct employment at the mine is expected to be between 150 and 200 persons (Ian Kirkham, Allstate Exploration NL, personal communication, July 1996).

Exploration activities

Exploration expenditure in Tasmania in 1995 totalled $10.2 million from 105 exploration licences and 14 retention licences. Expenditure was concentrated in the Mt Read area, with the Zeehan-Waratah, North East and Beaconsfield areas also the targets of significant exploration (Figure 5.6). A more detailed profile of exploration expenditure is provided later in the report.

Figure 5.6: Tasmanian exploration expenditure by region, 1995

Province	1995
Beaconsfield	1,021,951
Cape Sorell	588,666
Mt Read	4,658,300
Balfour	234,696
North East	1,355,218
Zeehan-Waratah	2,229,379
Arthur	65,196



5.2.2 Mineral resources assessment

In addition to the current mining operations outlined above, Tasmania contains a number of other known mineral deposits and may contain a number of undiscovered deposits. Provided access for exploration is allowed, 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 region's 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, it has not been possible to do this. However, the major factors affecting potential economic value are outlined and some indicators of that value are examined.

As part of the Comprehensive Regional Assessment of Tasmania, a regional-scale study of identified and potential mineral resources was undertaken by the Bureau of Resource Sciences (BRS) and Mineral Resources Tasmania (MRT), and this study is detailed in Section 5.1.

5.2.3 Economic mineral potential of Tasmania

Developments in world metals markets will have a large bearing on development opportunities for the minerals industry in Tasmania. As base metals (copper, lead and zinc) and gold are expected to be the focus of development, the outlook for these markets is reviewed. Mineral exploration expenditure trends in Tasmania are examined, and the value of two hypothetical base metal deposits is calculated in order to provide an indication of the potential value of these types of deposits.

Outlook for base metals

The outlook for zinc prices is for a firming trend in 1997 and 1998, followed by easing prices to 2001 as new production comes on stream. Lead prices are expected to peak in 1997 and then to fall over the medium term as supply increases. Copper prices declined in 1996 after reaching a five-year high in real terms in 1995, and are projected to continue to follow a downward trend over the medium term, with strong demand exceeded by an even stronger supply.

Steady and sustained increases in world base metals consumption are projected throughout the outlook period. The bulk of the projected growth in base metals consumption will come from steady increases in industrial production in the developed Western economies and from sustained strong industrial production growth in developing economies, particularly in Asia.

Developed market economies, which account for over 85 per cent of world base metals demand, will continue to have a significant influence on base metals consumption. Asia, including Japan, accounted for about one-third of world base metals consumption in 1996, compared with 19 per cent in 1980. While Japan's share marginally declined in this period, the share of developing Asian countries tripled and is projected to rise further over the outlook period, reflecting relatively fast and metal-intensive economic growth in these countries.

In contrast, the share of global base metals consumption of the former Soviet Union and Eastern Europe has continued to fall. Consumption levels in these economies are projected to recover over the outlook period as economic growth continues in the Eastern European countries and finally becomes positive in countries of the former Soviet Union.

World mine supply of the three base metals is forecast to rise substantially in 1997. World refined copper production is also forecast to increase substantially in 1997, with more modest increases forecast for refined zinc and refined lead production.

World mine and metal production of base metals is projected to increase strongly over much of the outlook period. A few large committed and planned development projects are expected to be major sources of the projected rise in base metals supply.

Zinc and lead production is expected to be encouraged by projected higher zinc and lead prices in the first half of the outlook period. Copper prices have been at high levels for some time, and a projected substantial increase in copper supply is expected to lead to a fall in prices. Large quantities of additional copper production are expected to come on stream from low cost producers in South America using the relatively new solvent extraction/electrowinning production technology. Projections for world base metals consumption, production, stocks and prices are presented in Table 5.9.

Table 5.9: Key base metals projections

	Unit	1994	1995	1996p	1997z	1998z	1999z	2000z	2001z
World consumption									
Copper	kt	11539	11794	12120	12520	12930	13420	13860	14260
Zinc	kt	6987	7366	7430	7650	7825	7965	8105	8275
Lead	kt	5355	5543	5650	5780	5920	6050	6155	6260
World mine production									
Copper	kt	9400	10038	10520	11140	11510	11755	12020	12230
Zinc	kt	6825	6895	7250	7410	7650	8195	8250	8260
Lead	kt	2709	2657	2730	2870	3050	3250	3400	3400
World metal production									
Copper	kt	11155	11565	12420	13130	13640	13920	14100	14200
Zinc	kt	7129	7277	7405	7550	7950	8150	8300	8450
Lead	kt	5368	5404	5505	5680	5975	6100	6250	6350
World stocks									
Copper	kt	702	641	740	1120	1570	1870	1950	1810
Zinc	kt	1645	1135	950	730	680	850	900	1000
Lead	kt	624	439	400	390	510	580	660	700
Prices (LME)a									
Copper	US$/t	2307	2936	2265	2100	1955	1935	1930	2100
Zinc	US$/t	998	1031	1030	1155	1350	1180	1150	1050
Lead	US$/t	549	631	816	880	820	743	695	600

a nominal prices. **p** preliminary. **f** ABARE forecast. **z** ABARE projection

5.3.1 Scope

This section deals largely with on-shore exploration and mining practices and environmental outcomes in Tasmania.The intention is to address exploration and mining activities in or adjacent to forested areas. In Tasmania that essentially embraced the whole industry.

With respect to the mining industry, the section deals with actual extractive mining (removal of rocks and minerals from the earth's crust) and processing of these materials on site. Further processing of mineral products is commonly undertaken at locations distant to the actual extractive mine site, often in more densely populated, non-forested areas; eg Bell Bay and Risdon smelters. These operations are not discussed in this section.

The section deals with the **present and the future** and not with the past. It describes contemporary technical and environmental management practices and reviews possible future trends in the exploration and mining industries.

The section of the details the legislative and regulatory framework within which these industries currently operate in Tasmania.

5.3.2 Nature of exploration and mining

Definitions

Mineral exploration is the scientific assessment of the earth's crust to determine if mineral deposits are present which can be commercially mined.

Mining is the commercial extraction of mineral deposits from the earth's crust, and is generally (but not always) interpreted to include some degree of upgrading or processing on site.

Whilst there is often a close relationship between the activities of exploration and mining, they are effectively two quite separate industries.

Exploration is a resource assessment industry and, in order to assess resources access to land is required, usually in a short term transient but repetitive manner.

Mining is a land-use industry.

Economic aspects of exploration, mining and land access arrangements

The nature of exploration

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

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 region's geology. There are many cases in Australian exploration history where information gained from previous work (successful or unsuccessful) was later used to locate mineral deposits that were either overlooked by earlier explorers or located in regions where prospectivity was previously considered low.

Because exploration is primarily an information gathering process it is necessarily dynamic, and as noted in section 5.1, most regions can never be regarded as 'completely explored'. Many recent Australian discoveries have occurred in known mineral provinces that have been the subject of exploration efforts for over 100 years. There is a number of reasons why exploration has continued in such areas. Technology and scientific understanding of geological processes continue to develop with time. These advances not only encourage exploration in areas where prospectivity was previously considered low, but also lower the costs and increase the efficiency of exploration. In addition, changing economic conditions (for example, changes in metal prices or the costs of extraction) affect the expected returns from exploration and can have a significant impact on the level, and type, of exploration.

The advent of carbon-in-pulp and carbon-in-leach gold extraction technologies in the 1970s provide an example of the way in which technological (and economic) change can affect exploration. These technologies dramatically reduced both the costs of gold recovery and 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 gold deposits in weathered and oxidised rocks at considerably lower cut-off grades than were previously considered economic (Blain, 1992). Carbon-in-pulp and carbon-in-leach processing is also used for the treatment of low grade primary gold ores. A Tasmanian example of the

application of novel technology to the discovery of new orebodies is the success of Aberfoyle Exploration in finding the Hellyer orebody at a depth of 120 metres below the surface in 1983 using the then newly-developed UTEM (University of Toronto Electromagnetic) system (Eadie *et al.,* 1984).

New geological models can also affect exploration. The discovery of the Olympic Dam copper-uranium-gold deposit is an example. This deposit, discovered in 1975, is concealed 350 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). Similarly, exploration for the Benambra copper zinc deposit in Victoria began mainly 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 geologists' understanding of the prospectivity of particular sequences of Silurian (438-408 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.

In summary, exploration is a dynamic information gathering process. Past evidence suggests that even in highly explored areas, it is unwise to assume that no further discoveries will be made. Changes in technology, economic conditions, or improvements in the understanding of ore formation processes can make areas which have previously been explored attractive exploration targets.

Global Industries

The distribution of many industries is influenced by biospheric factors such as climate, vegetation cover, soils and water. To varying extents, the locations of such industries can be influenced by modification of the biosphere or selection of appropriate biospheric conditions - trees can be planted, soils improved, water transported, climates modified by hothouses.

The mining industry however is controlled by lithospheric factors and, with few exceptions, the location of the mines cannot be determined by modification of the lithosphere. Mineral deposits only form where natural geological factors are favourable. They can not be moved from one location to another, nor can they necessarily be found where it would be most convenient to find them.

Mineral resources are therefore truly globalised. Not all areas of the earth are equally endowed in mineral resources. Some regions are far more geologically prospective than others. The recognition of high prospectivity and the realisation of benefits to be derived from that prospectivity are often determined by political factors.

Australia is well endowed in mineral resources.

Risk

Investment risk in mineral exploration is high. This is because deposits occur beneath the surface of the earth and we can not see them or count them from the surface. They are usually discovered by remote techniques such as geological mapping, geophysical and geochemical surveys, and defined by drilling small diameter holes deep beneath the surface.

Various studies have suggested that one in a thousand exploration programs results in the discovery of a commercially viable mineral deposit. On average, several tens of millions of dollars must be expended on these 1000 programs to locate the one substantial commercial deposit.

It follows that unless exploration effort is maintained above a critical level, exploration will either fail to locate any deposits or the discovery rate will be slow and insufficient to sustain a major mining industry sector.

Exploration risk is the summation of geological or prospectivity factors plus investment regime factors.

Exploration companies are reluctant to invest in areas where significant investment risk exists on top of prospectivity

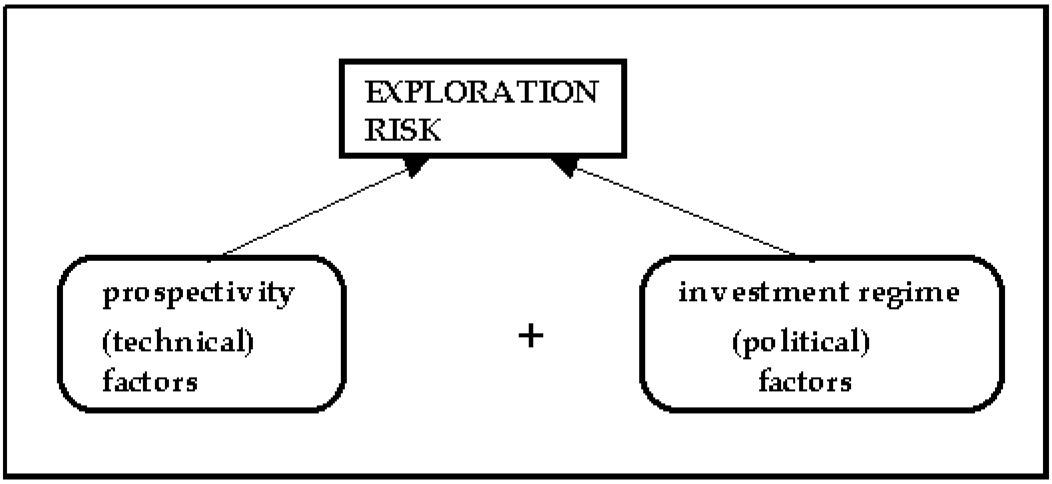


Figure 5.9 : sources of exploration

Once a mineral deposit has been located and defined, the technical risk factors of mining that deposit are relatively low provided the operation has been professionally evaluated.

Mining risk is largely the summation of world mineral commodity market factors and the stability of the investment environment.

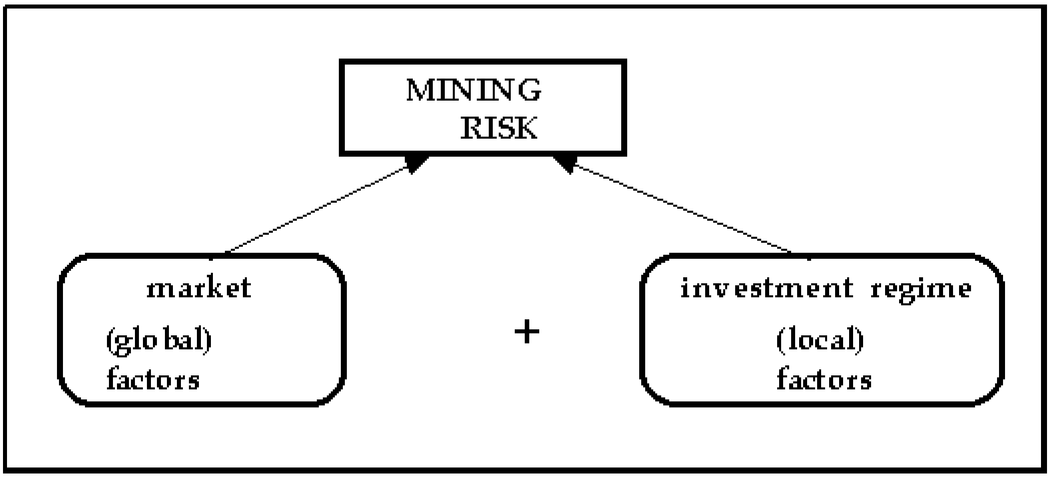


Figure 5.10 : sources of mining

Repetitive Access to Land

The demand by society for metals is continually evolving and it is extremely difficult to predict which metals will be in greatest demand in the future (Figure 5.11).

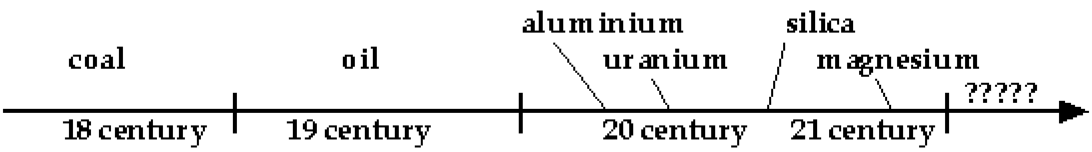


Figure 5.11 : evolving commodity needs

The ability to locate and develop mineral deposits concealed beneath the surface depends on the technical effectiveness of the exploration, mining and mineral processing industries.

Technologies are continually improving.

New **exploration methods** enable the explorer to search both deeper and more efficiently (Figure 5.12).

Evolving **mining methods** enable the extraction of both lower grade deposits and deeper deposits.

New **processing methods** enable more efficient recovery previously untreatable deposits.

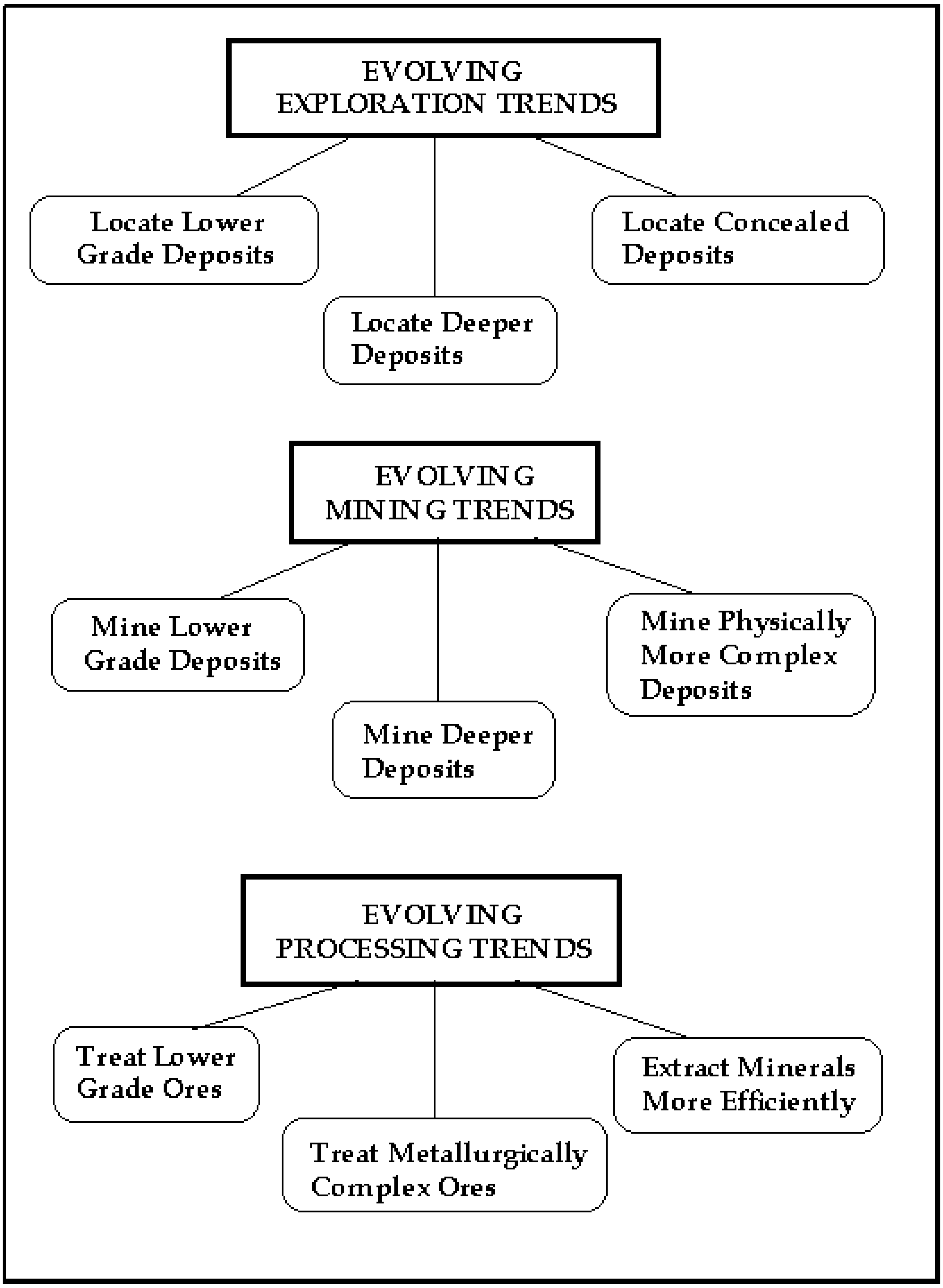


Figure 5.12 : evolving technical trends in the minerals

The continuing evolution in exploration and mining technologies and society's commodity demands make it difficult to define all of the mineral resources beneath any one area of land, at any one point in time.

Hence, the argument for repetitive long term exploration access (Figure 5.13).

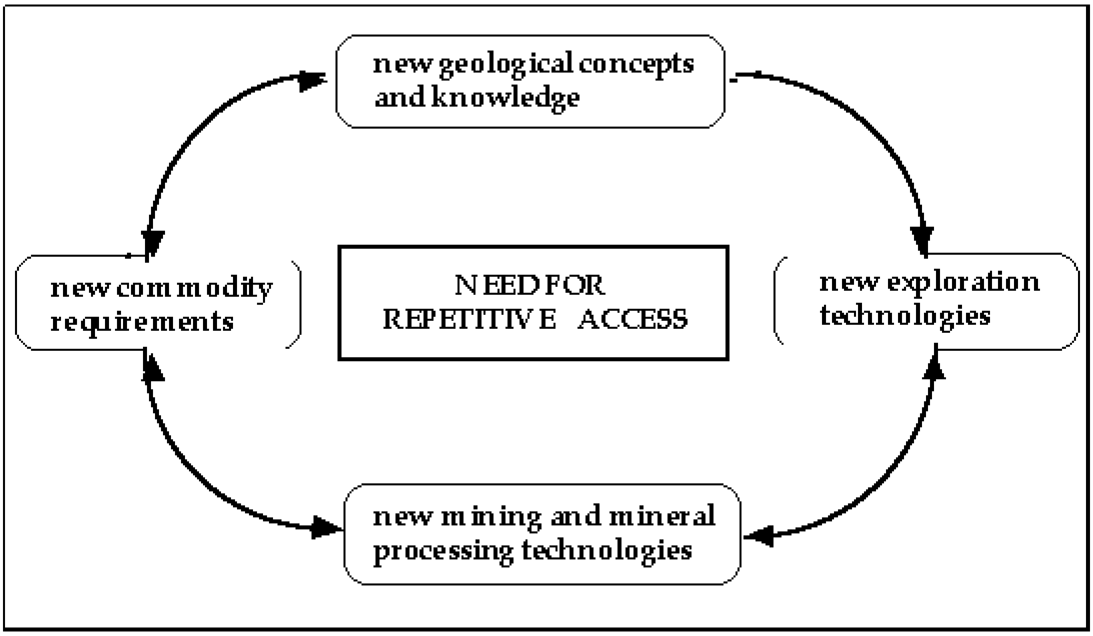


Figure 5.13: repetitive access requirement

Land access issues for exploration and mining

This section outlines some of the economic issues relevant to any new exploration and mining access arrangements that may be considered as part of the Comprehensive Adequate and Representative (CAR) reserve system options within Tasmania.

Two broad options are available for regarding access:

completely disallowing exploration and mining within a reserve;

allowing exploration and the possibility of mining subject to various approval and operating conditions.

Excluding exploration and mining activities

A decision to ban exploration and mining from a region will only be optimal where it can be determined that any present and future costs to society of exploration and mining (including all environmental, recreation and other costs) will always be greater than any present and future benefits that may accrue to society from exploration and mining in the region. Although this condition may be met in some regions (for example, in regions with unique environmental characteristics) it will generally be the case that such decisions will not be optimal because it is not possible to obtain all of the information required to make them.

Clearly, information is required about the range of attributes and values of areas which offer alternative uses. This will encompass information about both the environmental attributes and conservation values of an area, as well as the mineral potential of the area and the mining options for those resources. A third category of information that is crucial to making decisions about efficient resource use is market information. This refers to information about mineral prices, extraction costs, environmental control costs and so on; information which is central to the decision on whether or not to mine and hence whether or not to explore.

It is important to note information about environmental and mineral values, and the availability, usefulness and implications of this information can change over time. Continuation of the advances in environmental research, exploration geoscience and mining technologies may render information obsolete and previous land use decisions may need to be reconsidered. That is, once-and-for-all initial resource assessment and decision making will, in many cases, not be socially optimal in the long run.

Mineral prices and extraction costs, may change substantially over time. Exploration may reveal reserves of minerals that are subeconomic (amongst other reasons, this may be due to high environmental costs associated with their development) and, if market conditions remain unchanged, exploitation of these resources would clearly not be appropriate. But if demand for or relative scarcity (and hence price) of these commodities increases over time, the development and extraction of these resources in an ecologically sound manner may become an appropriate resource use option for society. Similarly, the value of particular environmental resources may change through time.

In addition to these information problems, it was argued in the previous section that the different stages of exploration can involve significantly different environmental costs. It would seem that the initial stages of exploration involve minimal environmental impact (for example, aerial surveys or rock-chip sampling) and that, in the majority of cases, little would be gained by prohibiting these activities.

Allowing exploration and mining

Ideally, mining companies would be guided in their choice of exploration and mining investments by indications of the likely costs of obtaining approval and meeting environmental standards in particular areas. There are two key requirements for this to occur. Firstly, transparent and predictable processes for government approval are required. These processes would cover both obtaining approval for exploration and the means by which companies move from exploration to mining. Secondly, clear expectations are required of the environmental standards to be met by mining companies in particular areas. These standards would cover the exploration, extraction and rehabilitation stages of mining operations and

would vary according to the environmental sensitivity of areas. If such standards could be established, the mining industry itself would be able to make socially optimal decisions on the appropriate level of exploration and mining investment, by proposing only those programs which it considers could meet the relevant costs of environmental compliance.

Area - Environmental Impact Relationship

An inverse relationship exists between the area required for exploration and mining and the potential for environmental impact.

The early stages of an exploration program are typically directed towards assessments of large areas, even whole states or countries. The particular exploration methods used in these early assessment stages arguably have no environmental impacts.

As the program advances, exploration is focused on increasingly smaller areas. Non-intrusive minimal impact methods such as geochemistry and geophysics are typically applied over areas of several tens of square kilometres. Initial test drilling applies to even smaller areas, and resource definition drilling is usually confined to areas of less than five square kilometres.

If mine development follows exploration success, the environmental impacts of contemporary mining operations are small in area, with potentially high impact activities confined to areas of less than one square kilometre (Figure 5.14).

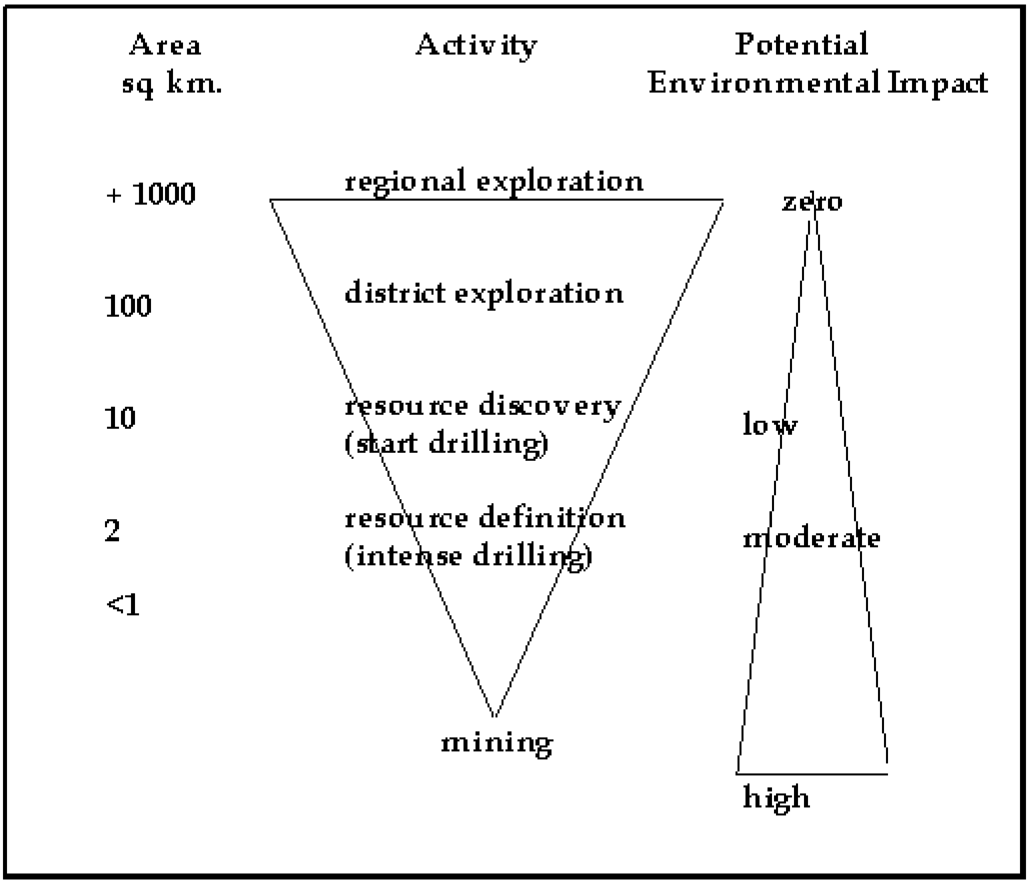


Figure 5.14 : relationship of activity and potential environmental

5.3.3 Legislative and regulatory framework

Introduction

Mineral exploration and mining in Tasmania, including tenement management and most aspects of environmental protection, are governed by the *Mineral Resources Development Act* 1995 (MRDA), administered by Mineral Resources Tasmania (MRT), a division of Tasmania Development & Resources. The MRDA provides for environmental conditions to be imposed on mining and exploration leases.

Environmental management of mining operations is also regulated by Environment Tasmania, a Division of the Department of Environment and Land Management. The principal regulatory tools comprise a package of legislation known as the Resource Management and Planning Legislation. The regulation of premises under this legislation package is primarily by the *Environmental Management and Pollution Control Act* 1994 (EMPCA), administered by Environment Tasmania.

The Workplace Standards Authority administers the *Dangerous Goods Regulations 1994*, which prescribe specific measures for the storage and handling of various classes of dangerous goods such as fuels, oils explosives and corrosives, which may have the potential for environmental harm.

Mineral tenements

Essentially, three kinds of mineral tenement are available in Tasmania: exploration licences, retention licences, and mining leases. A number of land categories are unavailable for any kind of mineral tenement. These include land reserved under the *National Parks and Wildlife Act* 1970 (State Reserves, National Parks, Historic Sites, etc.); public and municipal reserves under the *Crown Lands Act* 1976 (State Recreation Areas, Coastal Reserves, River Reserves, Crown Reserves, etc.), Commonwealth land and Forest Reserves. Forest Reserves, and some public and municipal reserves, may be brought back under the auspices of the MRDA to allow for exploration if a sufficiently good case can be made. Any such exploration would be subject to approval by the Mineral Exploration Working Group (see below).

Land categories that may be subject to mineral tenements include uncommitted Crown Land, private land, State Forest (if brought back under the MRDA after being proclaimed), Deferred Forest Land, HEC vested lands (except lakes, dam sites and work areas), Conservation Areas (except the Central Plateau Conservation Area), and Protected Areas and Forest Reserves (if brought back under the MRDA after being proclaimed).

Under the *Mining (Strategic Prospectivity Zones) Act* 1993 the status of large parcels of Crown Land within designated Strategic Prospectivity Zones can only be changed, in general, with the approval of both houses of Parliament. If such a change were to have the effect of revoking a mineral tenement, the holder is entitled to compensation. Details of the process of granting exploration licences and mining leases are available as a separate document on request from the Public Land Use Commission.

Environmental controls under the MRDA

The MRDA authorises Mineral Resources Tasmania to set environmental conditions for exploration and mining. MRT enforces a policy of responsible and careful mineral exploration, according to standards set out in the Mineral Exploration Code of Practice.

The Code sets out standards on most kinds of exploration activities that have an impact on the environment, including the cutting and use of grid lines, and the construction and rehabilitation of tracks, drillpads, costeans and pits. The Code also provides guidelines on fire prevention, minimal-impact camping, avoidance of spread of weeds and *Phytophthora*, liaison with landowners, the use of helicopters, and rehabilitation and revegetation.

Mineral Exploration Working Group

Exploration activities proposed in Protected and Conservation Areas, and other areas considered to be environmentally sensitive, must be approved by the Mineral Exploration Working Group (MEWG), which consists of representatives from MRT, the Department of Environment and Land Management, the Parks and Wildlife Service, and Forestry Tasmania. This body assesses the impact that any works may have on historical, archaeological, botanical, zoological or ecological values, and may advise MRT of conditions to be placed on the activities so that these values are not permanently adversely affected. MEWG may request that studies (archaeological, historical, botanical, etc.) be carried out prior to the work to properly assess the impact of the proposed activities.

Mining Leases

Applicants must supply basic environmental impact information and a mining plan to MRT. Applications are circulated to other Departments and MEWG following the same protocol as Exploration Licences. Unlike Exploration Licences where approval must be sought for each activity, Mining Leases are issued with all the conditions to be imposed on that operation included in the lease document. Mining operations are generally also subject to approval and conditions from Environment Tasmania (see next section).

Operations are expected to be carried out in accordance with current best practice in environmental management. Regular monitoring of compliance with safety and environmental conditions is carried out by government Mining Inspectors. The Chief Inspector of Mines may require specific approval of mining infrastructure which may require consideration of potential environmental impact. For example, impounded volumes of

greater than 2000 cubic meters require full details of dam design to be submitted to the Chief Inspector of Mines for approval. This includes water supply dams and tailings impoundments.

The Rivers and Water Supply Commission may also be required to approve modification to river hydrology as a result of water storage or tailings dam impoundments.

Under the MRDA, bonds are held on mining leases to ensure compliance with environmental and rehabilitation obligations. Bonds will be at least commensurate with the cost of any restoration work which is likely to be needed.

The MRDA provides for the establishment of a Rehabilitation of Mining Lands Trust Fund to carry out environmental rehabilitation of abandoned mine sites or land affected by former exploration activities.

Environmental management of mining operations

Environmental Management and Pollution Control Act

Environment Tasmania through the Environmental Management and Pollution Control Act 1994 (EMPCA), regulates air and water emissions, waste management, noise, domestic solid fuel burning appliances and prohibited fuels applicable to mining operations

An integrated development approval process

The environmental assessment and approval process for all new developments including mines occur as an integrated part of the development approval system under the *Land Use Planning and Approvals Act* 1993. The Act provides for assessment at local Government through Councils, State Government through the Board of *Environment Management and Pollution Control Act 1994*, and under certain circumstances through Ministerial approval.

Environmentally significant developments are designated as Level 1, Level 2 or Level 3 activities. In respect to mining developments, the level of activity is determined on the volumes of materials extracted and/or processed.

All new extractive industries generally require a permit under all Planning Schemes administered by local government. All applications must be submitted to the relevant planning authority (generally a local council) for assessment, and most applications will require public advertisement of the application.

If a project is designated as a Project of State Significance under the *State Policies and Projects Act* 1993, development is assessed by The Sustainable Development Advisory Council (SDAC). SDAC will undertake an integrated assessment of the project in accordance with Environmental Impact Assessment Principles, derived from ANZECC principles.

This integrated assessment takes the place of the usual process undertaken by the planning authority.

Table 5.16: Level 1 and Level 2 Activities.

Extractive Industries	**Level 1 Activities**	**Level 2 Activities**
Mineral Works	Mineral works - processing up to but not including 1 000 tonnes of raw materials per year.	Mineral works - processing 1 000 tonnes or more of raw materials per year.
Quarries	Quarries - producing up to but not including 5 000 cubic meters of product (rock or gravel) per year.	Quarries - Producing 5 000 cubic meters or more of product (rock or gravel) per year.
Extractive Pits	Extractive Pits; producing up to but not including 5 000 cubic meters of product,(Sand or Clay) per year.	Extractive Pits; producing 5 000 cubic meters or more of product,(Sand or Clay) per year.
Mines	Mines; producing up to but not including 1 000 tonnes of minerals per year.	Mines; producing 1 000 tonnes or more of minerals per year.
Materials Handling		
Crushing Grinding or Milling	Processing of up to and including 1 000 cubic meters of rock, ores or minerals per year.	Processing more than 1 000 cubic meters of rock, ores or minerals per year.
Coal Handling and Washing	Coal Handling and Washing; total handling or washing capacity of up to (but not including) 100 tonnes per day.	total handling or washing capacity of more than 100 tonnes per day.

Enabling Legislation

In addition to existing environmental legislation, a number of major mining operations in Tasmania operate under Enabling Legislation which delineates the extent of environmental liability under which the development will proceed. Enabling legislation for specific mining operations is required to pass both houses of Parliament prior to ratification.

Mineral exploration

Large areas of Tasmania are covered at any one time by on-shore mineral exploration tenements - typically around 10,000-15,000 square kilometres or 15-20 per cent of the State.

Tenements cover most physiographic areas represented in the State including alpine areas, rainforest, coastal lands, agricultural areas, forested lands and urban areas.

The commodities and deposit styles sought are extremely variable, from shallow gravel and sand deposits to deep gold and base metal deposits. This variation in target type necessitates the application of a vast array of different exploration technologies which in turn are evolving.

Management of the potential environmental impacts of such a variable and dynamic industry requires a blend of local knowledge and commitment to best practice procedures.

The objectives of this section are to:

- describe exploration methods commonly used in Tasmania
- identify and quantify potential environmental impacts
- describe rehabilitation processes
- describe best practice management strategies
- describe possible future trends in exploration

Exploration procedures in Tasmania are often substantially different to elsewhere in Australia for the following reasons:

- generally rugged country
- extensive forest cover
- high rainfall and consistently high water table
- seasonal access problems

Additional information on exploration methods, and best practice environmental management are contained in *Mineral Exploration Code of Practice* (TDR 1995), *Mineral Exploration Minimal Impact* (TCM 1992) and *Onshore Minerals and Petroleum Exploration* (EPA 1995). Increasingly companies are developing internal exploration environmental policies, codes of best practice and self auditing procedures.

Exploration access

In order to conduct any mineral exploration program, access must be obtained to the area.

The type of access will vary greatly depending on the exploration program and the nature of the country over which the exploration is to occur. The *Mineral Exploration Code of Practice* proscribes methods for exploration access.

Many factors influence the potential environmental impact of exploration access. These are summarised in Figure 5.15.

Actual impacts will depend on a host of factors including: prevailing climate, topography, geology, flora, fauna, operator skills, of access

Each of the major access categories is described in general terms below and more specifically in the following sections on exploration methods.

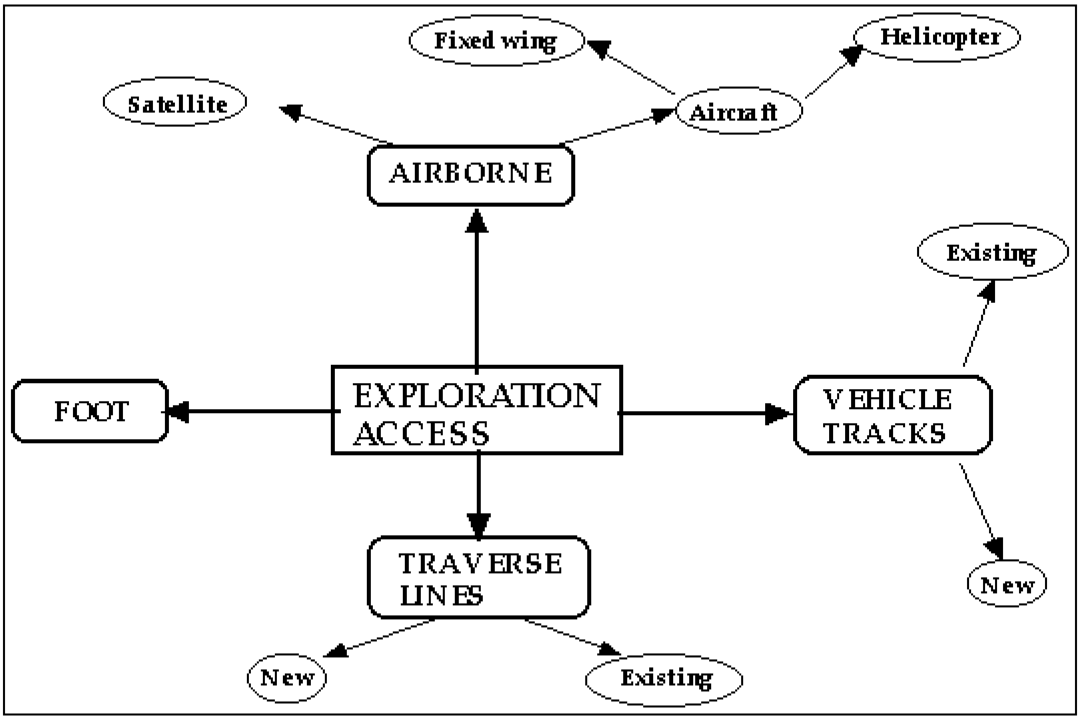


Figure 5.15 : Factors which influence the impact of exploration

Airborne. Increasingly, contemporary exploration is being undertaken with airborne access, either as a means of direct data gathering or for support of ground crews.

Satellites are commonly used to gather geographical and geological data usually on a regional basis. They also play a role in ground communication and positioning systems which can reduce the need for other more intrusive ground access methods.

Satellite based exploration has no environmental impact on the area under investigation.

Aircraft, both fixed wing and rotary are used extensively in exploration for data gathering and ground crew support. Geographical, geophysical, geochemical, geological data can be acquired from aircraft flying at heights varying from 15-15,000 m above ground.

In Tasmania, helicopters are commonly used to support ground exploration crews involved in a range of survey activities, including drilling.

Environmental impacts are restricted to:

- noise, during low altitude surveys
- helipads

Noise can impact on farm animals such as lambs and lambing ewes, and birds. However, the duration of exposure is extremely short, and no extended term negative impacts are known. Low level flights over penguin rookeries are not allowed.

Helipad impact varies depending on vegetation, topography, and the exploration activity. Helipad construction does not affect top soil or low vegetation but for operation and safety reasons, pads have to be of certain minimum sizes depending on the size of helicopter and the duty in hand. The *Mineral Exploration Code of Practice* defines minimum helipad size as 20 m x 18 m, together with an obstacle free approach path. The average exploration helipad occupies an area of 0.04-0.05 hectares, which is approximately half the size of a suburban building block.

Cross Country and Foot Access

Defined as ground exploration access where no constructed tracks are required, this style of access may be undertaken either on foot or in specialised vehicles for the purposes of gathering geological, geochemical and geophysical data, and to undertake certain types of drilling programs.

Foot access generally involves small numbers of people and is non-repetitive, thereby minimising potential for the formation of compacted trails. Some shallow drilling programs can be completed in this manner using state of the art person-portable light weight drills

The environmental impact of foot access is comparable to low traffic recreational bushwalking and is thus rated as low impact.

Cross country access by specialised vehicles is principally by track mounted drills operating in moderate terrain open-country areas such as button grass or open grass lands. These rigs tend to have very wide low pressure tracks designed to prevent the vehicle sinking and bogging in soft or marshy ground. In other words, they tend to walk on the surface. Provided the traffic is not excessively repetitive over the same access route, the environmental impact is negligible.

Traverse Lines

In order to acquire exploration data on a regular and controlled basis on the ground, it is common practice to mark out a regular grid of traverse lines.

Traverse lines are typically spaced at regular intervals; eg 50 m or 100 m and can be up to several kilometres long. Distances along the lines are marked with short wooden stakes, often carrying an aluminium marker tag and highlighted with colored flagging tape.

A grid of such lines may cover an area up to several tens of square kilometres.

Geological, geophysical and geochemical surveys are then conducted along the traverse lines on foot by exploration crews.

Where lines cross open ground, there is no environmental impact other than the marker pegs (which can be removed when the program is completed) and the low frequency passage of field crews.

In densely vegetated or forested areas, the lines have to be cleared to facilitate foot passage. This is usually done with small chain saws and bush-hooks. Cut lines are typically about 700 mm wide, 2000 mm high and require no disturbance of top soil or large mature trees. Thus on a grid with lines 200 m apart, the cut lines affect approximately 0.3 per cent of the area.

Vehicle Tracks and Roads

Collation and assessment of all the geological, geophysical and geochemical data acquired during the early low environmental impact phases of an exploration program may highlight geologically anomalous areas worthy of more detailed follow-up work.

Such anomalous areas tend to be relatively small compared with the original area explored.

Detailed follow-up work may involve drilling or, less commonly, trenching.

Some forms of drilling and trenching require access to the anomalous area by vehicles, which may require the development of tracks or roads.

The environmental impact of these is dependent on a wide range of factors:

- vegetation density
- topography
- soil and rock outcrop types
- length of access development
- rehabilitation effectiveness

It is a condition of every Exploration Licence that no vehicle tracks can be developed without government approval.

Explorers are encouraged to use existing tracks wherever possible, even if this means re-opening old inaccessible ones. Tracks are normally constructed by excavators to four-wheel-drive standard.

Once exploration is completed on a licence, the explorer is required to re-habilitate vehicle accessible tracks by returning top soil, providing effective drainage so as to minimise erosion, fertilise and re-seed larger exposed areas.

Trenching and pitting to expose surface rocks for further examination are not common exploration methods in Tasmania, primarily because they are a relatively expensive way of obtaining limited data, especially in remote areas. Trenches are typically short (5-50 m) and contemporary practice is to dig these with an excavator which can trench to depths of 5-6 metres. Excavators minimise ground disturbance and can replace all soil and rock on completion of work, thereby minimising environmental impacts.

Trenching is most widely used in areas where the mineral resource under investigation is shallow and large samples are required for testing; eg sand, gravel, clays.

Permission must be sought prior to any such work and, if granted, these best practice procedures would be followed. Principal features are:

- avoid sensitive or high impact areas

- stack topsoil and subsoil separately
- back fill as soon as practicable
- rehabilitate fully as soon as practicable

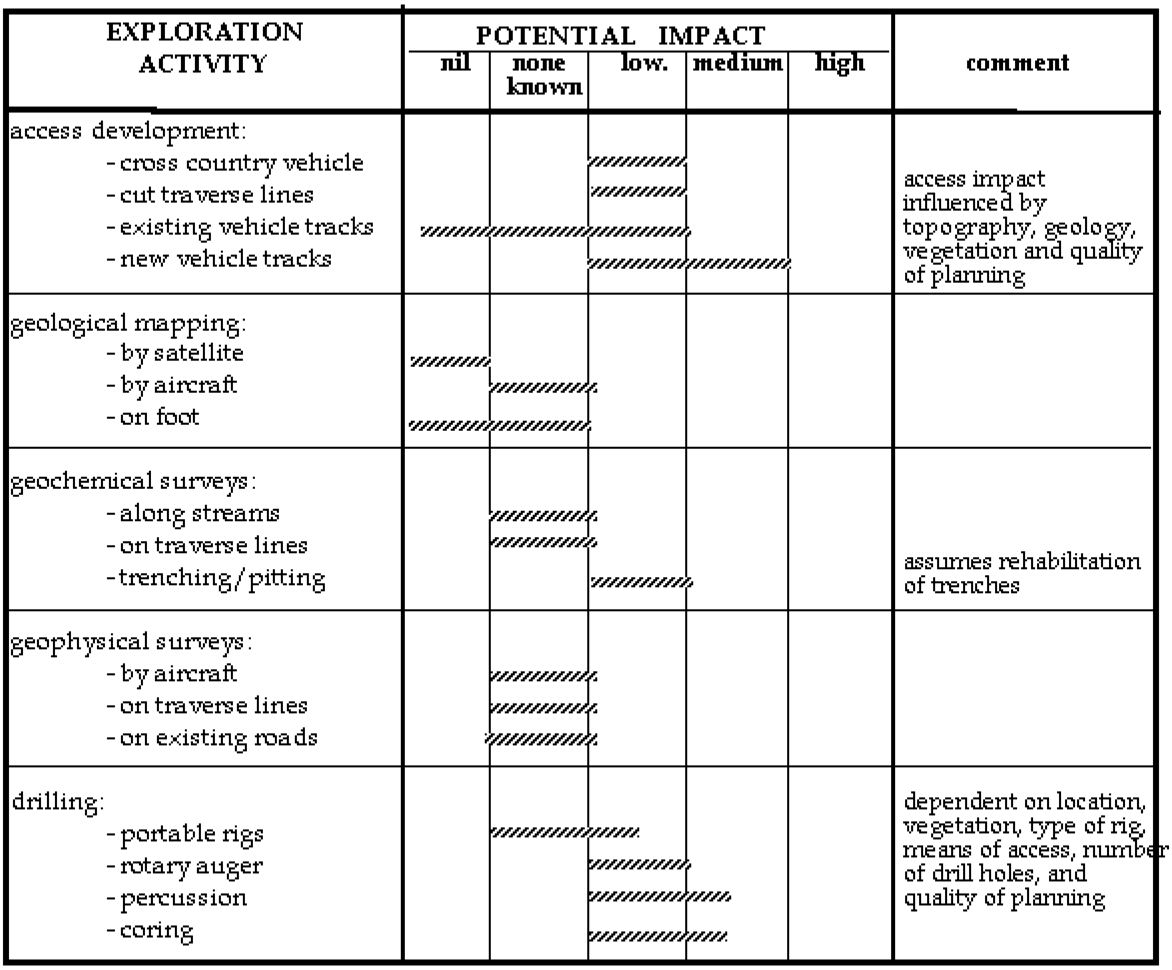
Exploration methods and impacts

The principal contemporary exploration methods can be grouped into four categories: geological mapping, geochemistry, geophysics and drilling. Within each of these groups, there exists a wide variety of different methods.

The manner in which specific methodologies are applied varies greatly between countries and states. Factors which influence the potential environmental impact of different exploration methods and the potential levels of impact are shown below.

EXPLORATION ACTIVITY	ENVIRONMENTAL FACTORS								comment
	flora	fauna	water	air	noise	visual	heritage	fire	
access:									
- satellite									
- aircraft		✓			✓				
- cross country	✓	✓	✓			✓	✓	✓	
- traverse lines	✓	✓				✓	✓	✓	potential impacts of tracks and traverse lines reduced if existing ones used
-vehicle tracks	✓	✓	✓		✓	✓	✓	✓	
geological surveys							✓	✓	
geochemical surveys	✓	✓	✓		✓	✓	✓		applies to mechanical pitting and trenching
geophysical surveys					✓			✓	fire risk limited to use of generators
drilling:									
- portable	✓		✓		✓	✓		✓	factors vary greatly depending on location and type of drill rig
- rotary auger				✓	✓			✓	
- percussion	✓				✓	✓		✓	
- core	✓		✓		✓ ✓			✓	

potential environmental impact factors which should be considered in exploration program design



potential level of environmental impact

Geological Mapping:

Because deposits of a particular mineral or of a particular style preferentially form in certain rock formations or are associated with certain structures in the crust, the development of geological maps which show the distribution of rock types and structures both on surface and sub-surface is a pre-requisite to successful exploration.

Data used in the development of such maps may be collected by airborne surveys, ground surveys or subsurface drilling. Airborne or remote-sensing surveys are conducted from both aircraft and satellites and may include visible wavelength, infra-red and radar imaging. These techniques are particularly useful in defining major structures and geological features not apparent at ground level.

New technologies based on computer enhancement of images is widening the application and effectiveness of remote-sensing mapping.

No known environmental impacts result from such surveys.

Ground geological mapping typically involves a geologist studying rock outcrops and taking small 'fist' sized samples with a hammer for further studies in laboratories. In the early stages of an exploration program, ground mapping is conducted on foot without the development of special access. In more advanced programs, mapping may be undertaken along cut traverse lines in association with other surveys. Under prevailing regulations, the impact of this work is rated as low.

Samples collected from drill holes are used to create geological maps of the sub-surface. Impact is limited to the impact of the drilling process and this is discussed in greater detail in the Drilling section below.

Geochemical Surveys

The formation of some mineral deposits can result in changes in the chemistry of the surrounding rocks.

These natural chemical changes can influence quite large volumes of rock and thus form a type of 'halo' effect around the deposits.

Elements may also leak out of deposits as a result of natural fracturing and weathering processes. Such geochemical leakages may reach the surface and be capable of detection by either airborne or ground surveys.

Geochemistry is the study of chemical variations in the earth's crust which may indicate the presence of a concealed mineral deposit especially a base or precious metal deposit.

Geochemical data is collected by airborne and surface surveys and drilling.

Airborne geochemical surveys have been undertaken only sparingly in Tasmania. Methodologies depend upon low flying aircraft collecting air samples which are then analysed for airborne anomalous elements emitted by concealed mineral deposits.

The technology has been used in exploration for both base metal and hydrocarbon deposits and whilst its use has not been extensive to date, it is reasonable to predict its wider use in the future as the technology evolves.

There are no known environmental impacts from such surveys.

Surface geochemical surveys come in many different forms, principally by stream sediment, soil and rock sampling. Other less widely applied methods include water and vegetation sampling.

Stream sediment sampling typically involves a two-person crew walking along water courses, systematically taking samples of sediments from the banks or bed of the drainage. Samples are generally 1-5 kg in size and are taken by hand on intervals generally 0.5-1.0 km apart. The samples are taken to a laboratory for analysis.

There are no known environmental impacts from such surveys. In some instances where access to drainage patterns or along the drainage courses is extremely dense, some track cutting may be required. This usually occurs in areas which have either been burned or cleared by previous land-users, and the regrowth is dense.

Geochemical soil sampling is a common exploration method in Tasmania. It is based on the theory that elements present in concealed mineral deposits will leak to the surface as a result of natural weathering and ground water movement, and there accumulate in the soils.

Soil sampling may be undertaken on a regular grid of cut traverse lines or at random without the aid of a grid; eg along the base of ridges.

Samples are typically 1-2 kg in size and may be collected by shovel (0-0.5 m depth), hand auger (0.5-2.0 m), and person-portable power augers (up to 15 m depth). On traverse line grids, samples are taken on regular intervals, generally 20-50 m apart. Holes 40-100 mm in diameter are typical.

Best practice requires holes be filled in on completion of sampling and equipment be cleaned off between sites to reduce both spread of diseases and geochemical contamination.

There are no known environmental impacts from geochemical soil sampling other than that attributed to cut grid lines.

Rock sampling for geochemical analysis normally involves taking hand specimen sized samples with a hammer from rock outcrops. This is typically done by a geologist accessing an area on foot and carefully collecting samples either on a random basis wherever suitable rock outcrops occur, or from rock outcrops along a grid of cut traverse lines. Samples are removed from the area for analysis and there are no known environmental impacts from this activity other than that attributed to grid lines.

Where a larger or more continuous exposure of rock is required for both mapping and geochemical sampling, pits or costeans may be dug using mechanical equipment. Best practice techniques for doing this were described previously and their application ensures minimum impact and rapid rehabilitation.

Geochemical drilling is undertaken where deeper samples are required and this is dealt with in detail in the section on drilling below.

Geophysical Surveys

Many mineral deposits have physical characteristics that are substantially different to those of their surrounding rocks. Techniques designed to detect these differences are collectively known as geophysical techniques, and they are based on any of the following physical properties of rocks

- density;
- magnetism;
- electrical properties;
- radioactivity; and
- sound or energy transmission.

Geophysical data is collected in several ways including airborne surveys (magnetic, electrical, radiometric), ground or surface surveys (magnetic, electrical, density, radiometric, energy transmission) and sub-surface down drill holes (magnetic, electrical, radiometric).

Airborne or remote-sensing geophysical surveying has been used for over sixty years, but has been stimulated in recent times by the rapid development of computer based data handling systems.

Instrumentation mounted in either a helicopter or a fixed wing aircraft continuously records the relevant geophysical data as the aircraft traverses back and forth over the survey area on a regular grid pattern, typically 50-100 m above ground surface.

Data so collected is then computer processed to determine if any anomalous areas have been defined. Distortions or anomalies in the earth's magnetic, electromagnetic or radiometric fields may be due either to buried mineral deposits or natural geological phenomenon not directly associated with deposits.

Airborne geophysical surveys may potentially affect environmental factors but there are no known environmental impacts.

Ground or surface geophysical surveys are typically of a more detailed nature than airborne surveys and are carried out over smaller areas.

Magnetic and gravity surveys which measure local distortions in the earth's magnetic and gravity field respectively are carried out either along traverse lines or existing roads and tracks by one or two people carrying portable measuring instruments.

Such surveys may potentially affect environmental factors but there are no known environmental impacts attributed directly to such surveys.

Seismic methods are designed to study the manner in which energy such as sound or vibration waves move through the crust. The energy source is typically either a hammer blow to a point on the ground, or a small explosive charge placed in regularly spaced auger holes. The transmitted energy waves are recorded in a set of geophones placed in shallow holes some distance from the energy source.

In Tasmania, seismic surveys are generally conducted along existing roads and tracks. Best practice principles require that the geophone and shot holes are backfilled immediately after use. Environmental impact is limited to the short duration noise associated with those surveys which use an explosive energy source. Such surveys are limited to remote areas by various regulations and best practice procedures which limit their use in populated areas.

Electrical geophysical methods embrace a wide variety of techniques which study distortions in electrical fields that occur either naturally in the earth or are induced. Main methods used in Tasmania are electromagnetic (several methods), induced polarisation (several methods) and self potential.

The potential environmental impacts of electrical methods are:

- **grids** of cut traverse lines required in many cases
- shallow hand-shovel **holes** for placement of SP and IP electrodes. Holes are backfilled and electrodes removed when survey completed
- **fire,** which may be started by petrol generators. Regulations prohibit use of generators during total fire ban periods

- **rubbish**, resulting from electrical wire and electrodes left in bush. Best practice requires removal of this material on completion of survey
- **disease**, which can be transported on shovels, electrodes, boots etc

Adherence to all regulations and best practice environmental management principles ensures the impact of electrical geophysical methods is very low.

Sub-surface geophysical surveying involves lowering geophysical measuring instruments down existing drill holes which were drilled for other purposes such as to test a geochemical or geophysical anomaly or to better define a known mineral deposit. By lowering electrical, magnetic or radiometric measuring instruments down a drill hole, a much greater volume of deeper ground can be explored than would have been possible from the surface.

There are no known environmental impacts from such surveys. The use of petrol engines is prohibited in total fire ban periods.

Drilling

Geological mapping, geochemical and geophysical surveys are low environmental impact exploration methods, and generally carried out over large areas, typically tens or hundreds of square kilometres.

Such surveys normally do not directly locate mineral deposits. Rather, they point to much smaller areas of interest known as anomalies, which **may** contain a mineral deposit. The only positive way to determine whether a deposit does in fact occur beneath an anomalous area is to drill.

There are many drilling methods available to the modern explorationist, and the environmental impacts can vary significantly.

Drilling methods in Tasmania are also substantially different to those widely used on the mainland due to climate, topography and generally high ground water tables.The various factors which influence the environmental impact of exploration drilling in Tasmania are illustrated in Figure 5.18 and discussed in detail below.

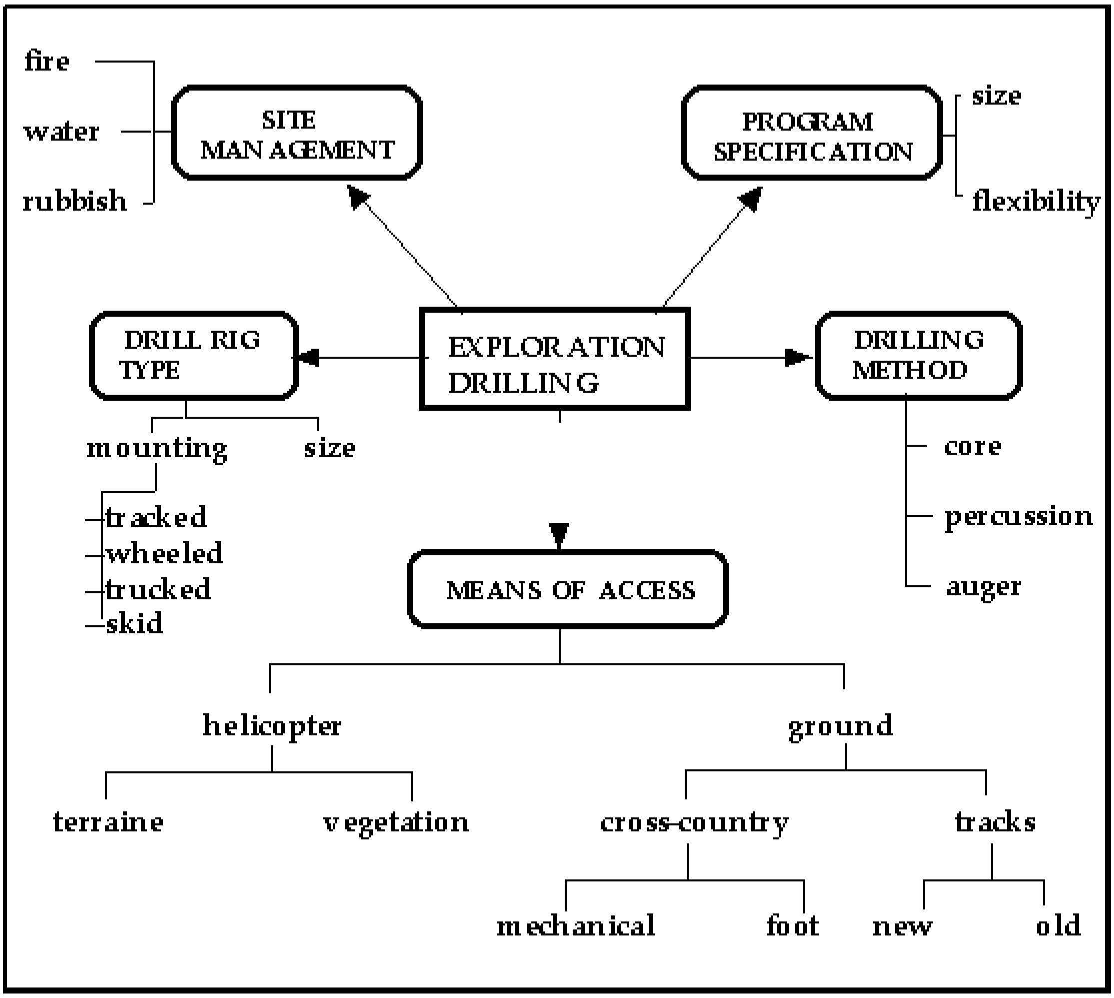


Figure 5.18 : Factors which influence the environmental impact of exploration drilling

Drilling Method

The three main drilling methods are:

- rotary auger; normally shallow holes drilled with a truck or tractor mounted rig, not common in Tasmania;
- percussion; drilled with a hammer, driven by compressed air, using either open-hole or reverse circulation (RC)technologies. Hole depths typically 50-200 m, and only modest usage in Tasmania; and
- core; a core of rock 35-120 mm in diameter is extracted at depths up to 2000 m. This is the most widespread method in Tasmania.

Rig Type

There is a number of different drilling rigs used. The selection is determined by the drilling method required, depth of drill holes, location, availability and number of holes to be drilled.

Rotary auger drills are usually truck, tractor or occasionally track mounted. Percussion drills are either truck or track mounted, and are accompanied by a compressor which may be mounted separately. Core drills range from small person-portable drills capable of drilling up to 50 m depth, to larger truck, track, or skid based rigs. The largest rigs operating in Tasmania weigh up to 30 tonnes.

Means of Access

Access for drilling is either with helicopters or on the ground.

The decision on whether to ground support or helicopter support a drill program is often complex, and influenced by both commercial and environmental factors such as the location of the program, the number and depth of holes to drill, and rig availability (Newnham, 1982).

Helicopter drilling is influenced by the fact that helicopters generally available in Tasmania can lift a maximum 1000 kg, which therefore eliminates rotary and percussion drilling methods and limits core drilling to holes < 600 m deep.

Helicopter drilling requires a drill pad. The pad size is influenced by whether equipment reaches the site on a 'long-line' beneath the helicopter, and the requirement for a landing pad adjacent to the drill rig. Important safety factors must be addressed, when considering the merits of long-lining, landing pads and overall operational requirements. The size of helipads is also determined by topography and height of vegetation. (CRAE LTD 1995, CRAE LTD, unpublished)

The environmental impact of helicopter supported drilling is largely restricted to the size and number of drill pads and can vary from very low impact on flat open areas to high impact on vegetation in rugged tall timbered country, where a number of pads may be required.

Considerable experience on the part of the explorationist is required with helicopter drilling programs to balance technical, safety and environmental issues to ensure the technical objectives of the program are met whilst applying best practice environmental and safety procedures.

Ground supported drilling can be accessed in various ways, on foot; mechanised cross-country; and along constructed tracks.

Small person portable drill rigs are now available in Tasmania for drilling holes up to 56 mm diameter to depth of 50 m. Substantial physical effort is required to move them and in dense bush a cut walking track similar to a traverse line is required.

Track mounted drills capable of core and RC drilling to 1000 m and 200 m respectively are now available in Tasmania. These have the ability to cross-country access drill sites in open country such as quartzite hills and button grass plains. Because of their wide low pressure tracks, they have low impact on the ground.

In most forested areas, ground access to drill sites requires the development of access tracks suitable for carriage of the drill rig and four-wheel-drive support vehicles. At the drill site, a pad has to be developed in which the rig can operate efficiently and safely.

The impact of drill access tracks and pads depends on: length of track and size of drill; topography; bedrock and soil types; vegetation; and duration of use.

Guidelines for the construction of tracks and pads are contained in *Mineral Exploration Code of Practice* and permission must be given by Mineral Resources Tasmania before any work can commence.

The two basic principles for good drill track and pad construction are: minimise clearing and erosion; and maximise effectiveness of post drilling rehabilitation.

During the drilling operation, the potential sources of environmental impact are: waste fluids; noise; fire; groundwater; hydrocarbon spills; and rubbish.

Core drilling requires the circulation of pumped water to the drilling bit to both cool the bit and bring fine drill cuttings to surface.

It is also common practice to circulate varying additives to this water to improve ground stability, reduce rod and bit wear and improve the cutting performance of the drill bit. Most additives used today are claimed by their manufacturers to be biodegradable.

If drilling water and additives returning to surface can not be prevented from leaving the drill site, they have the potential to cause erosion and possible contamination of any adjacent water courses. Containment is typically achieved by establishing sumps with underflow protection or collection tanks.

Drilling can be a relatively noisy operation because of the large motors and compressors used. This only represents a significant environmental problem in populated areas, in which cases drills can be specially sound modified.

As with any machinery, hot motors and exhausts present a fire risk in dry weather. Regulations require rigs be equipped with extinguishers and may require a cessation of drilling in extreme fire risk conditions. Core drills are equipped with water tanks and high pressure pumps.

In Tasmania, it is not uncommon for drill holes to intersect ground water under pressure, which will flow water onto the ground surface. Because such flows may cause local long term erosion, it is now a statutory requirement that such flows be stopped by plugging the hole on completion of drilling.

Hydrocarbon spills can occur on drill sites from fuel spills, hydraulic leaks or during maintenance. Best practice procedures now require drill crews to carry hydrocarbon absorbent matting or 'sausages' to contain and clean up any such spills.

Because drill sites are occupied for relatively lengthy periods, rubbish can accumulate. Regulations and best practice procedures require sites to be cleared of all rubbish on completion of program.

Drill Site and Track Rehabilitation

When an exploration program is completed, regulations and licence conditions require all tracks and drill pads be rehabilitated. Guidelines for this are presented in the *Mineral Exploration Code of Practice*. Typically this requires:

- replacing top soil and vegetation stacked on the side of the track during construction;
- re-profiling of the surface;
- provision of drainage as dictated by track gradients; and

- seeding and fertiliser application, especially in broad exposed areas.

Evidence suggests that rehabilitation of drill tracks and pads is rapid and effective if they are constructed and rehabilitated in accordance with best practice principles.

5.3.5 Exploration auditing

Contemporary self-regulation of exploration programs includes auditing to ensure optimisation of best practice principles.

Exploration audits are most commonly conducted by major companies undertaking significant ground programs which may involve potential environmental impacts.

Such audits consist of a check list covering all planning, implementation and post-activity phases of an exploration program.

An example of an audit checklist is presented in the EPA *Onshore Minerals and Petroleum Exploration* Best Practice publication (EPA 1995).

Exploration self-auditing is currently not regulated, apart from periodic inspections and exploration completion reports required by government. However, all exploration programs must be approved in writing by MRT prior to commencement and are subject to site specific conditions.

5.3.6 Exploration trends

Because mineral deposits are concealed at varying depths beneath the surface, we can not see them and therefore it is not possible to develop maps showing the locations of all mineral deposits.

Exploration depends on the ability to develop new technologies which will enhance opportunities to discover deposits missed by past exploration programs.

With new exploration technologies comes new methods of completing programs on the ground. A number of the more significant trends are listed in Figure 5.19 below.

Contemporary exploration trends are achieving two principal outcomes; more efficient in discovery of deposits and reducing environmental impacts of exploration.

With regard to environmental impact, the most significant trend in the exploration industry in Tasmania is the improvement in design of access tracks and drill sites.

Past practice in track construction sometimes resulted in the development of tracks which were highly visible, poorly constructed, and slow to rehabilitate. The trend in contemporary track development is to better design, construction, and rehabilitation. This is reinforced by a stringent regulatory regime.

The main challenge to achieving best practice in exploration access development is to ensure that explorationists operating in Tasmania are familiar with local conditions.

ACTIVITY	TREND
Geological mapping	Greater use of satellite imagery to map regional trends not recognised by ground surveys Repetitive re-mapping of areas to incorporate rapidly evolving knowledge on the formation of mineral deposits
Geochemical exploration	More sensitive, quicker, lower cost analyses of rocks, soils, sediments Improved understanding of geochemical haloes as indicators of the presence of mineral deposits
Geophysical exploration	Greater use of more sophisicated technologies, particularly airborne Development of ground technologies which result in more effective exploration to greater depths
Drilling	Development of smaller drills which require less access construction Drilling technologies which increase productivity, thereby reducing program duration Increased depth capacity of drills
Access Development	Increased use of helicopters in remote areas reducing need for tracks Almost exclusive use of excavators in track development Rehabilitation of disturbances

Fig. 15 : major trends in principal exploration activities

Mining

Introduction

Mining involves the commercial extraction of a mineral deposit. In most cases, but not all, the mined material is processed on the mine site into a saleable product which is then transported to an end user or to a facility off-site for further processing.

The mine extraction process is extremely variable, ranging from shallow surface operations extracting sand and gravel to deep underground precious and base metal mines.

Similarly, surface processing facilities vary from quarry crushing and screening operations to large complex sulfide concentrators.

Mining and on-site processing activities in Tasmania are often substantially different to elsewhere in Australia because of high rainfall, often rugged topography of mine sites, and extensive forest cover. Most of the major mines are located in forested areas; eg Renison, Hellyer, Rosebery, Henty, Que, Savage, and it is reasonable to predict that future discoveries and mine developments will also occur in forested regions.

This section deals with the following:

- extractive mining
- on-site processing
- integrated life of mine environmental management systems
- small mine operations
- future trends in operations and environmental management

Principal data sources were:

- company environment management plans (EMPs) which are public documents
- Environment Protection Agency (EPA) series of booklets on *Best Practice Environmental Management in Mining* which individually address:
  - overview of Best Practice Environmental Management (BPEM) in Mining
  - impact asessments
  - workforce training
  - community consultation
  - management systems
  - mine planning
  - tailings containment
  - rehabilitation and revegetation
  - monitoring and performance
  - environmental auditing

- State Government and industry publications on best practice and codes of practice
- personal communications with industry and government environmental practitioners

Environmental Impact Factors

Whilst mining and on-site mineral processing operations are confined to relatively small areas, aqueous and airborne emissions have the potential to affect environments distal to the operation. The emissions which occur during the operating life of the mine, have the potential to continue to affect the environment long after mine closure; eg tailings contaminations at Rossarden-Storeys Creek. continue to affect the South Esk catchment after the cessation of mining.

Environmental impacts can be broadly grouped as proximal or distal as illustrated in Figure 5.20.

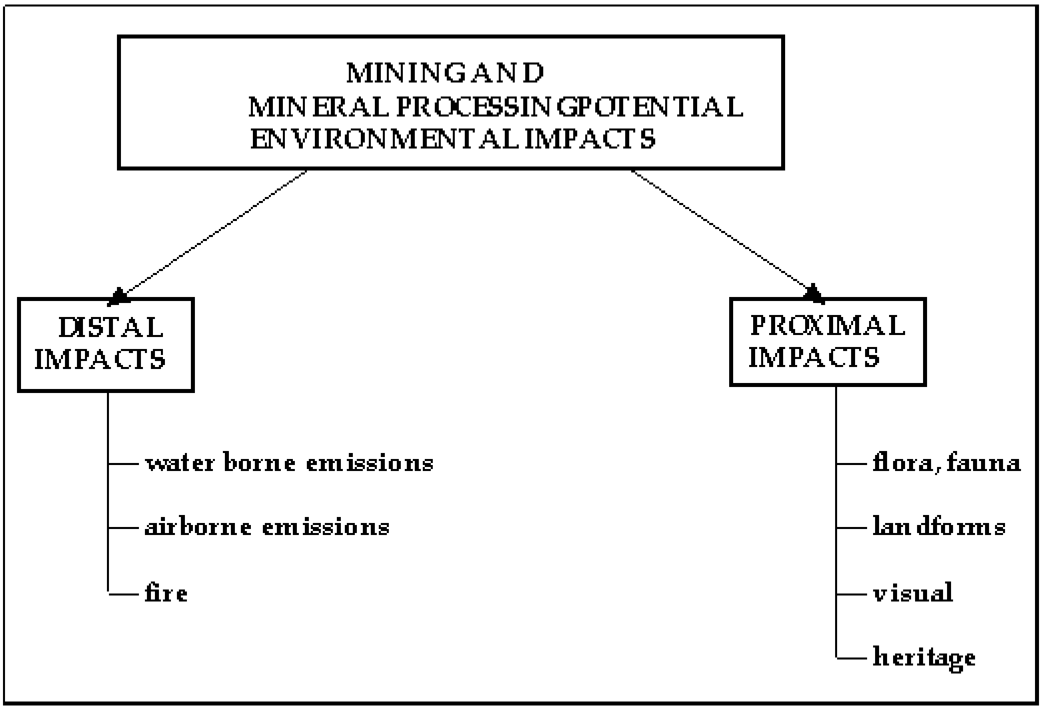


Figure 5.20 : potential environmental

The two groups are linked because it is the potential proximal impacts which may lead to the distal impacts.

Environment Management Plans for contemporary operations are required to address both proximal and distal impact issues for both life of mine and closure.

Proximal Factors

Flora and Fauna

All mining and mineral processing operations will have some impact on local flora and fauna. The site EMP is required to scientifically identify, quantify and address these impacts. They will vary depending on the nature of the operation and its location.

Impacts can be minimised by innovative technical planning, utilisation of existing areas of disturbance and positioning of infrastructure in least sensitive areas. For example, at the new Henty Mine (NSR 1990) these impacts were minimised by:

- placing the shaft headframe underground
- utilising existing disturbed areas for access roads, mill and office sites.
- disposing of waste rock in existing government quarries
- siting tailings dams on open plains distal to forest areas.

The resultant disturbance of forest lands was restricted to several hectares.

It is, however, not always possible to limit disturbance to such an extent. The Savage River iron ore open-cut has disturbed several square kilometres of forest because it was not technically and commercially possible to do otherwise.

Landform, Visual and Heritage Factors

These factors are interlinked in mining operations. Open-cut operations, including quarries as well as major metal mines, have the potential to modify landforms, create visual impacts and influence heritage values. EMPs are required to identify and quantify potential impacts and investigate methods to minimise them.

Visual impacts can be addressed by construction methods which protect and develop vegetation screening. The *Quarry Code of Practice* (DELM 1994) deals at length with techniques for minimising visual and landform impacts.

Heritage factors can often be avoided or integrated into an operation if appropriately identified. For example, at the Beaconsfield Mine, the new shaft winder has been constructed within the historical winder house, and all the doors and windows replaced with reproductions. All remaining historical structures have been preserved and any historical mining artifacts located during redevelopment of the mine are placed in the adjacent museum, which was specifically developed for that purpose.

Distal Factors

These factors are those which have the potential to affect the environment some distance from the actual mining or processing operation.

Waterborne Emissions

This is the environmental impact factor of greatest concern to contemporary operations and the source of most environmental problems associated with historical (closed) operations. The principal sources of water borne emissions are illustrated in Figure 5.21.

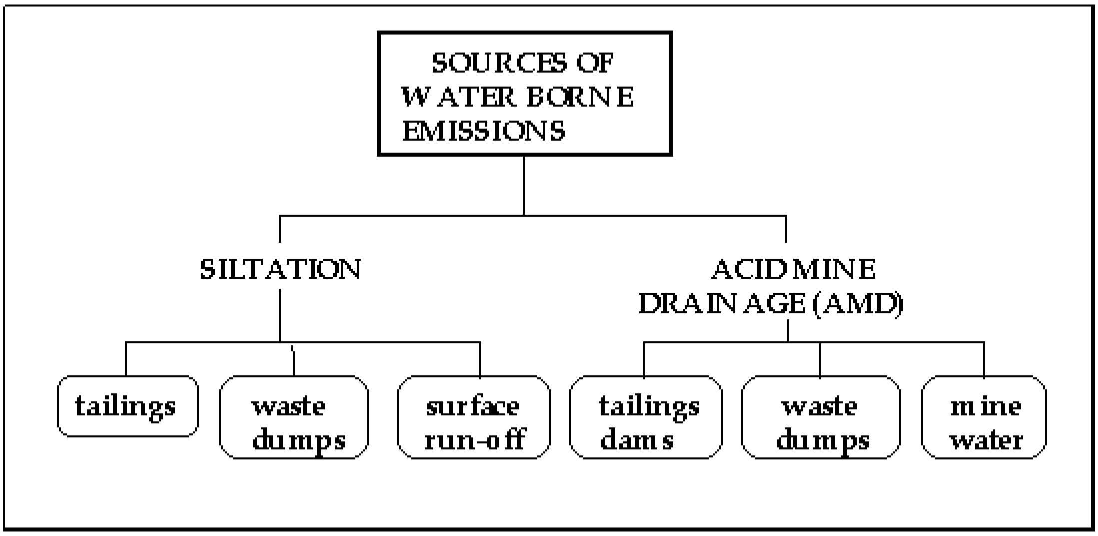


Figure 5.21 : water borne

These sources are discussed in greater detail in following sections.

Airborne emissions

Airborne emissions can include noise, dust, odours, fumes and shock waves. They are confined to the operating life of the mine and can usually be minimised by careful planning.

Noise, dust and blasting shock waves are usually associated with open-cut mines, whilst odours and fumes are generally associated with on-site processing.

Fire Impacts

Any human activity in a forest area has the potential to cause fire. All modern EMPs contain plans to reduce the risk and manage fire hazards. It is in the interests of all operations to prevent forest fires because they have the potential to severely impact or destroy the operation; the Shepherd & Murphy Mine mill was destroyed by fire in the early 1920s and the Renison operation was threatened in 1982.

Past practice of reducing fire risk by clearing vegetation has been today replaced by policies of minimum clearing accompanied by strict fire management plans; For example, the Henty Mine EMP encompasses a comprehensive Fire Action Plan which acknowledges that the mine has been developed in a sensitive alpine rainforest area containing a number of pine species.

The Fire Action Plan, developed in conjunction with the Henty Valley Fire Management Plan prepared by Tasmanian Parks and Wildlife Service, incorporates the following points:

- total fire ban on the Lease
- ground patrols during the fire season
- extensive equipping of all facilities with appropriate fire fighting equipment
- establishment of an integrated communications system
- employee training in fire detection and prevention

Extractive Mining

Mining Methods

Because Tasmania's mineral products are sold on highly-competitive world markets, they must be mined in a manner which is cost competitive. The choice of mining method depends on the grade, size, shape and depth of the deposit, the commodity to be extracted and the ground conditions surrounding the deposit.

Deposits may be extracted by either open-cut or underground methods.

Some operations combine both open-cut and underground operations (Anchor, Cornwall).

Others might start as an open-cut and change to underground as the depth of the open cut increases. The ultimate depth of open-cut mining is fundamentally influenced by the ratio of waste rock to ore. As most open-cuts become deeper, the amount of waste rock, which has to be removed in order to extract the ore, increases. Eventually a point is reached where deposit specific studies indicate it would be more economic to mine the ore underground. Examples of this are the Renison and Anchor mines.

The reverse is also possible, where underground mines may revert to open-cut mines as new discoveries are made and new mining technologies develop. An example of this is the Kalgoorlie super-pit in Western Australia, which started life as a series of small underground mines. The operation was recently converted to a large open-cut operation and may be replaced by a deep underground mine.

The Merrywood Mine is an open cut coal mine developed on a former underground mine in order to recover remaining resources.

The change in mining methods from open-cut to underground and vice-versa is also well illustrated by the operations at West Lyell at Queenstown. Mining at West Lyell commenced last century as a small underground operation mining narrow high grade veins. With the development of new truck and shovel technology, it was converted into a large open-cut mine in the 1930s, mining at an average grade of approximately 0.7% Cu. By the 1970s, the then economic depth of open-cut operations was reached, but high grade ore still remained beneath the open-cut. It was decided to mine these deposits using underground methods (Prince Lyell Mine) and this mine is still operating today at depths approaching 1000 metres. However, new open-cut technologies have again been developed which may justify the development of an even larger open-cut to recover the low grade mineralisation remaining adjacent to the former open-cut.

There is a cost differential between open-cut and underground mining ranging from a factor of zero up to a factor of 10 or even 20-fold in favour of open-cut mining. Some low valued products such as crushed rock for the construction industries simply cannot be produced economically by underground mining. The decision on whether to mine a deposit by underground or open-cut methods is normally determined by a combination of technical and financial considerations.

The nature of the various operations around Tasmania are listed in Figure 5.22.

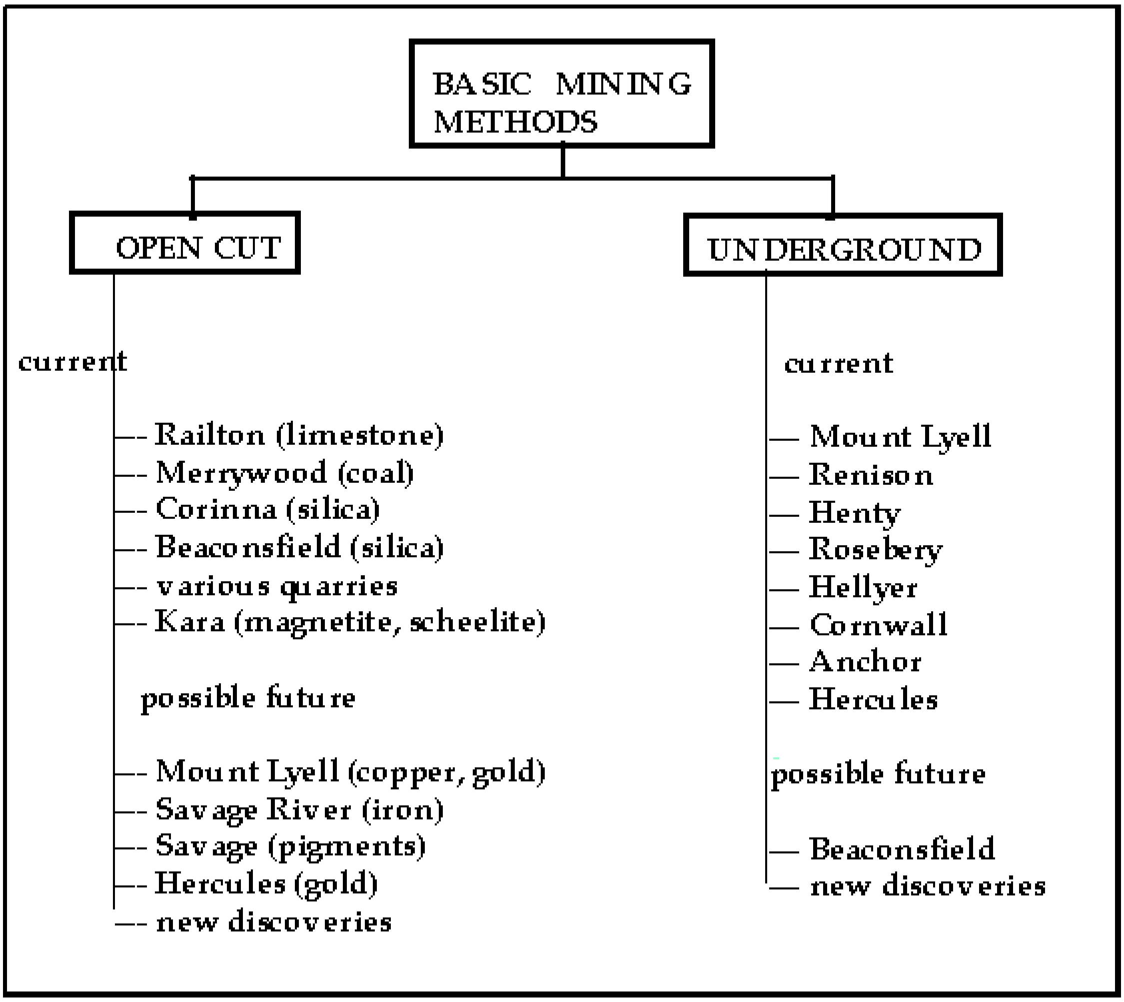


Figure 5.22 : basic division of mining methods in Tasmania

Open-cut (surface) Mining

Open-cut mining usually requires the sequential removal of overburden, waste rock, and ore.

Overburden includes soil, decomposed rock and vegetation. Current practice requires that any vegetation so removed be either utilised as a forest product or stockpiled along with soil and decomposed rock for later rehabilitation.

At the Anchor mine timber removed was used for veneer, saw-log and wood chip production.

At the Corinna silica and Merrywood coal operations soil and decomposed overburden are separately stockpiled for rehabilitation.

Some open-cut operations generate very little overburden; eg proposed Halls Creek limestone and most of construction materials quarries.

Waste rock is the term given to the uneconomic rock surrounding a mineral deposit which must be mined separately to facilitate removal of the deposit.

Waste rock disposal is one of the major environmental issues addressed by current mine operators, as it can have both proximal (visual, landform) impacts and distal (acid mine drainage) impacts.

There are basically two ways of handling waste rock: either placing it in waste rock dumps adjacent to the open-cut; eg Savage River, Railton, or progressively back-filling the open-cut as it advances; eg Merrywood (coal) and Melaleuca (tin). Back-filling is generally only possible with relatively shallow, flat lying deposits such as open-cut coal mines and alluvial tin and gold mines, where the lower limit of the deposit is known and uniform. With steeply dipping deposits, the depth of the open-cut progressively increases and it is therefore difficult to dispose of waste rock in the pit.

The chemical nature of waste rock can vary from relatively inert, mineralised rocks to mineralised rocks which may acidify any water passing through the waste dumps.

Ore (economically mineralised rock) is typically mined, briefly stockpiled on surface, then processed. Stockpile management is important because it can be a source of both AMD and water course siltation with certain mining operations.

Mining of both waste rock and ore typically requires drilling and blasting, loading into trucks with excavators or large mechanical shovels and draglines, and trucking to surface stockpile areas or directly to processing plants.

Underground Mining

There are many different underground mining methods practiced in Tasmania. The choice of method is usually determined by the value of the ore, the shape of the deposit and the nature of the enclosing waste rocks.

All methods require the drilling, blasting and removal of both waste rock and ore.

Ore is brought to surface either by truck, up an underground network of inclined roads, or vertically up a shaft. On the surface, the ore is either placed in stockpile areas or trucked/conveyed directly to the processing plant. Some mines bring their ore directly to surface following blasting whilst others crush the ore underground prior to bringing it to surface; eg Mount Lyell. (Thompson and Brett, 1995)

Waste rock management, as with open-cut mines, is an issue of environmental importance. Waste is either brought to surface and stockpiled (Mount Lyell) or used to back-fill underground mining voids (Renison). The choice of mining method, which is determined by cost-competitive factors, governs whether waste is brought to surface or back-filled.

Environmental Impact Factors

The key environmental issues directly related to the actual mining operation are shown in Figure 5.23.

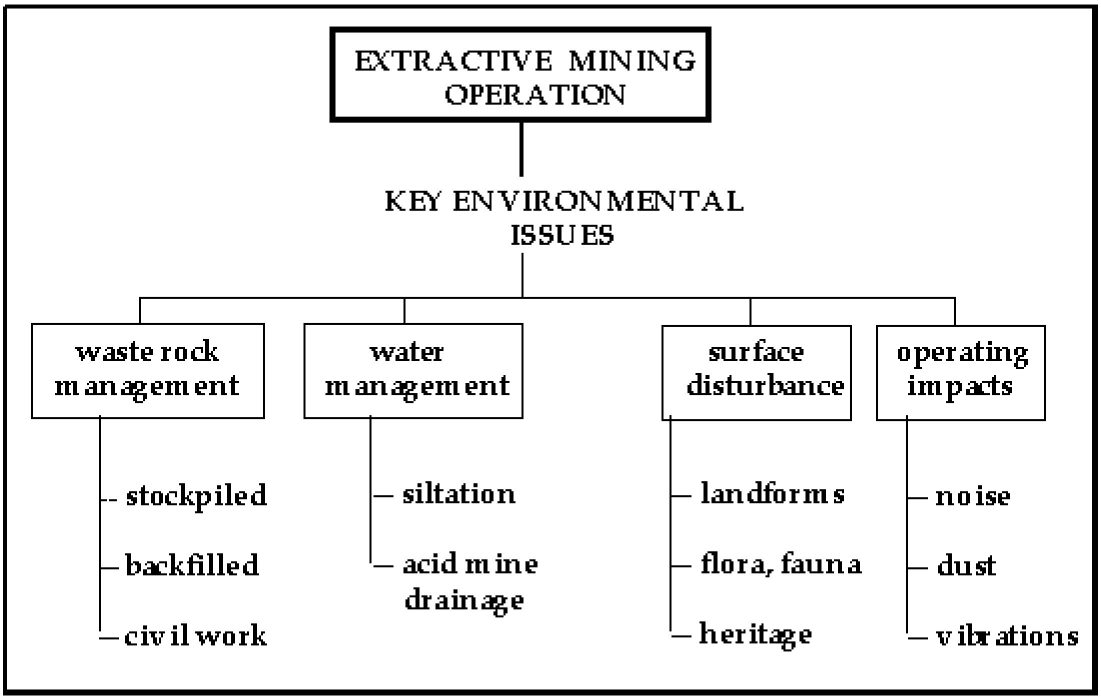


Figure 5.23: mining key environmental

These issues are all interlinked and also linked with key issues associated with the processing side of the operation.

Waste Rock Management

The principal impacts from waste rock are: visual and contribution to AMD.

The visual impact is reduced or eliminated if the waste is back-filled underground. If waste is disposed of on the surface, its visual impact is reduced if:

- dumps are profiled and vegetated. For example, at Railton waste dumps are visually integrated into adjacent landforms, top dressed and vegetated.

  waste is used to fill existing surface voids; eg Henty are currently placing waste in former quarries developed for dam construction

- waste is used for other surface activities. At the Rosebery Mine, waste not returned underground is generally used for road and civil construction works around the Rosebery township.'
- co-disposed with tailings in dams.

A prime concern with waste rock management is its ability to contribute to acid mine drainage both during the operational life of mine and after mine closure. Basically rock has the ability to produce AMD if it contains sulfides. This effect is increased if the surface exposure of sulfides is increased such as by blasting fragmentation. The effect is reduced by several means:

- returning acid forming waste underground as back-fill (Henty, Hellyer).
- compacting waste dumps to reduce void space
- sealing waste dumps to reduce percolating water by covering with clay, soil and revegetating.

Not all waste is of course potentially acid forming. Many mines and quarries produce a benign waste rock which rehabilitates easily and presents no long term problems; eg Corinna silica, Anchor, Merrywood.

The thrust of contemporary best practice waste rock management is to minimise the amount of exposed waste rock on the surface, particularly if it is acid forming.

Water Management

Mine site water management is a key environmental issue for all contemporary operating mines because it has the potential to affect whole catchment areas, distal to the mining operation, both during the life of mine and long after mine closure. The subject will be addressed further in the following section on processing methods.

The two principal impacts on water quality relating to the actual mining operation are: siltation and acid mine drainage.

Siltation can result from:

- erosion of exposed or unrehabilitated surfaces
- pumped mine water
- rain water movement through stockpiles.

Current best practice requires sources of siltation to be identified and corrected where possible or appropriate siltation traps such as small dams, sumps etc to be developed.

Acid mine drainage results when rain water and ground water passes through mine workings and becomes acidified due to the leaching of exposed sulfides.

The process has been the subject of much research and detailed investigation (TCM, 1992; Minerals Council of Australia, 1995). Solutions are not always readily apparent and it remains one of the major environmental issues confronting mines which operate in geological conditions which generate acid water. This includes most of the major west coast mines in Tasmania.

The two basic approaches to reducing and controlling the problem are:

- reduce the amount of exposure of acid forming sulfidic rocks
- channel AMD into one outlet where neutralisation and management are more efficiently effected.

Reducing the exposure of acid forming sulfidic rocks is currently being addressed in several ways:

- compaction and sealing of waste dumps
- back-filling acid forming waste underground in combination with paste or cemented fill (Henty, Hellyer). This reduces exposure of both waste rock and exposed rock faces underground.
- flooding of mines on closure by sealing workings. Acid formation is greatly reduced in the subaqueous environment.
- reduction of surface intakes into underground mines by sealing former surface workings (Hercules).

Treatment of AMD is more readily handled if it is directed into controlled outlets; eg into processing plants where it can be neutralised by the addition of lime, into tailings dams where it can similarly be neutralised prior to discharge (Rosebery).

At Mount Lyell most acid mine water is directed either into the mill where the milling process neutralises it, or into the Queen River (Figure 5.24). Scope exists in future to treat this latter stream by developing a copper recovery plant on the outlet.

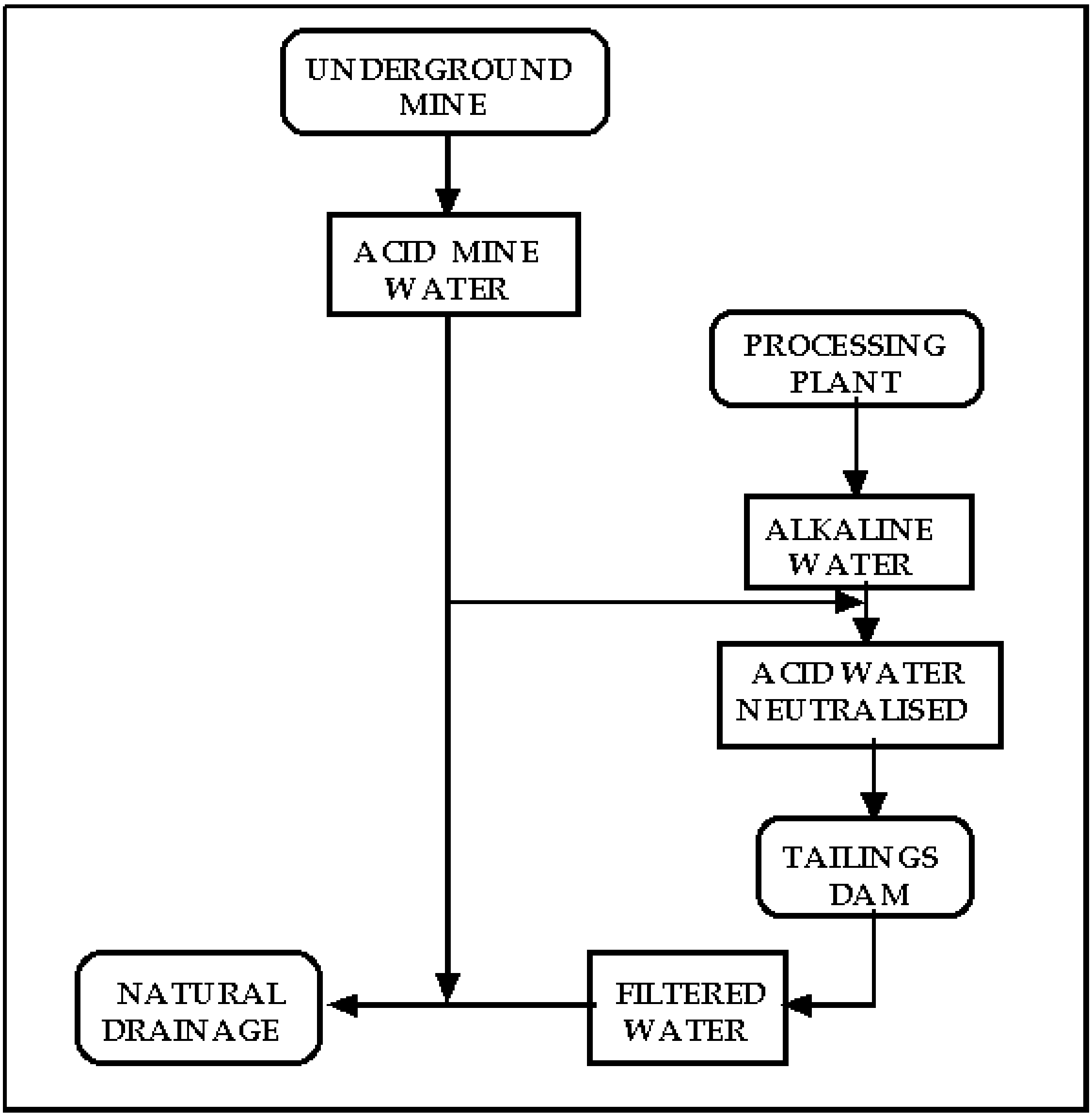


Figure 5.24: mine water management at Mount Lyell Mine

Surface Disturbance Impacts

Open-cut mines, including quarries will have a high impact on landforms, flora and fauna. Codes and best practice procedures have been developed to minimise these impacts.

Underground mines have a much lesser impact on the surface. The new shaft headframes at Renison and Henty were both developed underground, rather than the more traditional surface structures, which dramatically reduced their visual and surface disturbance impact. Careful design can reduce the overall surface impacts of major modern mines to very small areas - often only several hectares.

The Beaconsfield and Henty mine sites each affect less than five hectares, similar in size to a small hobby farm.

Operating Impacts

Mining can cause direct operational environmental impacts such as noise, dust and vibrations (airborne and terrestrial).

These impacts can be controlled - dust by use of water on roads in open-cuts, vibrations by better blasting practices (Cabbage Tree Hill quarries) and noise by machinery modifications (Beaconsfield).

The Beaconsfield operation is an example of how operating impacts have been reduced to the point where significant mining operations are undertaken directly beneath the town with virtually no impact on the town environment.

On-site Processing

Processing Methods

A wide range of processing technologies are practised in the Tasmanian minerals industries and are broadly summarised in Figure 5.25.

COMMODITY	PROCESS	EXAMPLES
construction materials (sand, gravel, aggregate, limestone, dolomite, silica)	crushing, screening	Railton, CabbageTree, quarries in general
coal	crushing, washing	Cornwall, Merrywood
heavy minerals (beach sands, tin, some gold)	gravity, sometimes flotation	Anchor, Renison,
base metal sulfides	crushing, grinding, flotation	Hellyer, Rosebery
precious metals (some gold)	crushing, flotation, gravity, cyanidation	Henty

Figure 5.25 : broad grouping of mineral processing technologies in Tasmania

In the quarrying industries where sand, stone, rock are mined, the on-site treatment process is typically very simple, being limited to crushing and screening. Some operations require washing. The end product and any wastes produced are typically inert.

In coal mines such as Cornwall, the process is again simple and involves crushing and washing the coal to remove waste rock. The coal is then dried and the effluent carrying any fine waste is pumped into a series of settling ponds.

Minerals such as tin, gold and heavy mineral beach sands are often concentrated by gravity techniques which rely on the heavy nature of the minerals to separate them from the waste rock. Often the gravity process is preceded by crushing and grinding of the product to liberate the minerals of interest. Because of the relatively simple, low cost nature of gravity technologies, they have traditionally been the basis of small operators and prospectors as well as large companies.

Alluvial tin is mined and gravity concentrated at Melaleuca Inlet in south west Tasmania. At Anchor on the East coast, granite mined underground is crushed and ground to liberate the tin which is then gravity concentrated on special shaking tables and jigs. At Rosebery, free gold is recovered following crushing and grinding by a Knelson Concentrator, tables and jigs, all based on gravity principles (Environment and Technical Services). At Renison the ore is more complex and the tin is recovered following crushing and grinding, by removing waste sulfides and then concentrating the tin minerals by gravity means (tables, Knelson Concentrators, jigs).

Several of Tasmania's largest mines use a method known as sulfide flotation to recover various products including copper, lead, zinc. Following crushing and grinding to liberate the sulfides from each other and various other minerals, they are passed into a flotation cell. The flotation process separates the minerals into specific metal concentrates by relying on the different physical and chemical characteristics of the metals. The slurry in the flotation cell is aerated, agitated and chemically treated. The minerals to be concentrated attach themselves to air bubbles and rise to the surface where they are collected and dried.

The recovery of gold which is not free gold, such as in either most alluvial deposits or in some ores containing coarse gold, requires a more complex recovery process such as that at the Henty Mine. The ore is crushed and ground to liberate the gold. It is then passed through leach tanks where the gold is dissolved by a cyanide solution. The dissolved gold is then collected on carbon and the gold pressure leached from the carbon. The gold bearing solution from the pressure leach vessel is then subjected to electrowinning and smelting processes to produce gold bars.

Mineral processing technologies, like all other technologies in the minerals industry, is continually changing. New processes to recover more of the valuable minerals at lower cost are being developed. Sometimes these new techniques offer environmental benefits as well, such as the Knelson gravity concentrators at Renison which largely replaced the cassiterite flotation process that relied on the use of chemicals.

Environmental Impact Factors

The principal environmental impact factors associated with processing plants are shown in Figure 5.26.

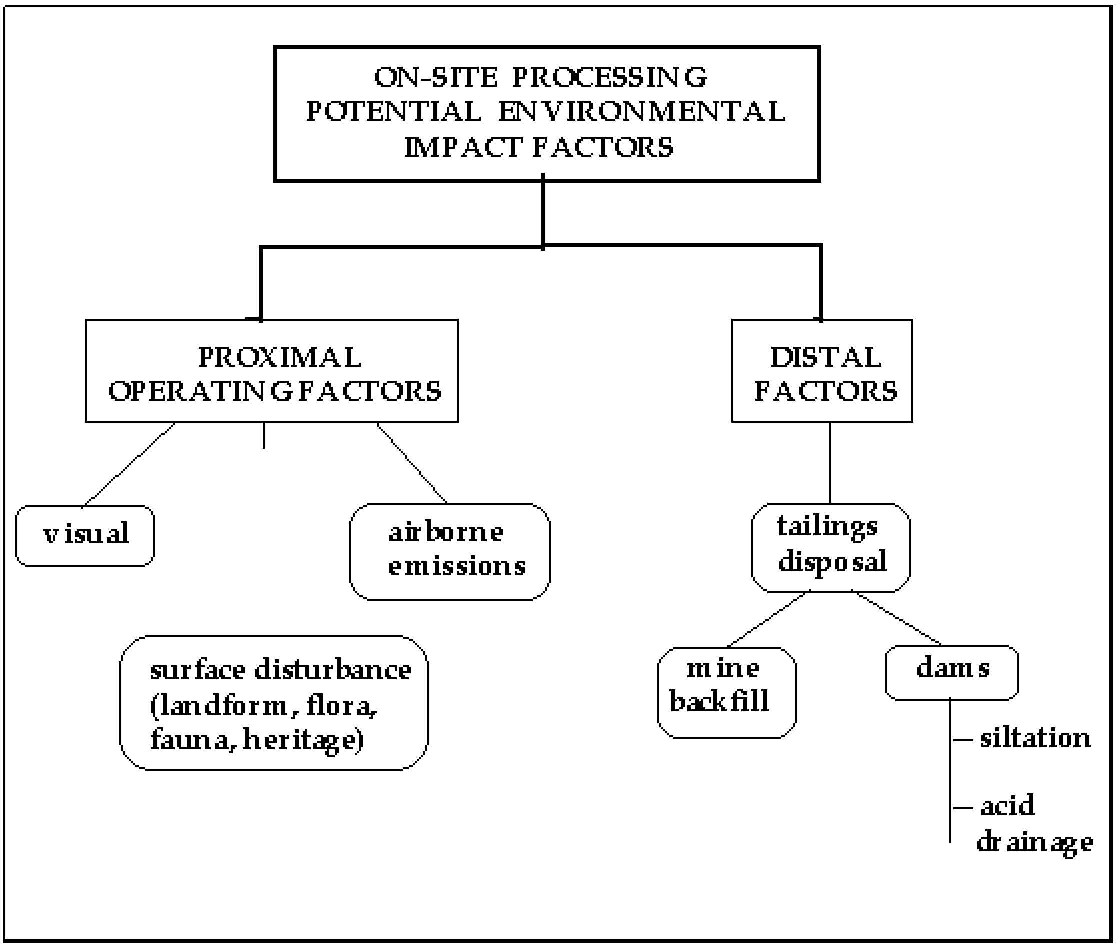


Figure 5.26: processing potential environmental impact factors

Tailings Disposal

The source of greatest potential environmental impact is in the storage of mine tailings.

Tailings is the collective name for the finely ground waste products produced in the processing plants. The potential problems are greatest in those operations which mine sulfidic ores and use chemicals in the processing operation.

Arguably, the worst environmental impact of tailings has been associated with tailings pumped directly into river systems. This is an historical practice which is not now permitted under any circumstances by current or future operations. Two examples of this discontinued practice are the Que-King Rivers at Queenstown-Strahan and the Golden Fleece-George Rivers at St Helens, both of which degraded river systems and formed deltas in the receiving harbours.

Whilst not condoned, the impact of this practice on forest values adjacent to the rivers is probably no greater than the historical impacts of other land use activities such as farming, forestry and urban development eg. the development of Hobart on the Derwent River. In cases where the tailings were non-sulfidic, the forest values have recovered relatively quickly eg. the Groom River adjacent to the former Anchor Mine open cut which closed in the 1920s.

Today, tailings are stored both underground and in surface dams. The underground storage of tailings is not a recent concept, and was practised on the Royal Tharsis mine as early as the 1930s. Obviously, the more that can be returned underground the better. However, this procedure is often limited by the unsuitability of either the mining method (Mount Lyell) or the chemical nature of the tailings (Renison).

At Rosebery, all coarse tailings are returned underground and at Henty approximately 50 per cent of tailings are returned underground as a paste. An increasing number of operations around Australia are actively researching underground disposal of tails in conjunction with other waste materials.

Tailings stored on surface in dams have traditionally presented environmental impact problems both during the life of mine and following closure. These problems are associated with:

- failure of dam walls
- leakage from dams
- acid mine drainage and toxicity problems
- visual impacts

These problems are being appropriately addressed by contemporary operations.

Dam walls are constructed to high engineering standards (Mount Lyell's new dam).

Leakages are eliminated by improved dam wall construction and appropriate sealing of potentially permeable dam floors; eg the Henty Mine dam is plastic lined.

Acid mine drainage or acid drainage from dams is being addressed in conjunction with the actual mining operation by capping and rehabilitating dams once filled, developing sub-aqueous storage dams, co-disposal of mine waste in tails dams and development of wet lands to receive and biologically treat dam effluent. Acid mine drainage is not always present from all dams as a number of mines actually produce alkaline tails; eg Henty, Mount Lyell.

Siltation in tailings dam overflows is closely monitored and addressed by construction of wetlands or settling ponds downstream of the dams (Hellyer).

Proximal Operating Factors

Processing plants and tailings dams will result in some degree of surface disturbance which will impact to variable degrees on landforms, flora, fauna and heritage. Unlike the location of a mineral deposit, the location of processing plants and tailings dams can be moved to some degree to minimise these impacts.

For example, at Henty the mill and offices were located in an area previously cleared for dam construction purposes and the tailings dams were located well to the south in an area of open (non-forested) areas. Similarly the mill and tailings ponds at Hellyer were located some distance from the mine where impacts were reduced. The mill and tailings dams at Anchor are contained entirely within the former open-cut.

Processing plants are a compact industrial complex, so their visual impacts can be significant but are confined typically to an area of 1-2 hectares. During their operational life, this impact can be reduced by vegetation screening and careful planning. On closure, mills are dismantled, removed and the site rehabilitated.

Tailings dams have a visual impact during their operational life, which similarly can be reduced by careful planning and vegetation screening. For example, it is difficult to see dams at Renison, Hellyer and Henty from public roads. On closure, best practice now requires sub-aerial dams to be capped and vegetated.

Airborne emissions from on site processing plants currently operating in Tasmania are strictly monitored and regulated. Impacts such as noise, dust and odours are addressed and minimised on the basis of their occupational health and safety aspects rather than their environmental impacts.

Airborne gaseous emissions such as those from the former Mount Lyell and Zeehan smelters do not currently occur on any Tasmanian operations and would be required to conform to much stricter controls in any relevant future operation.

Integrated Life of Mine Environmental Management

Section 4 detailed the legislative and regulatory framework within which current and future mines operate in Tasmania.

However, all of the major mines and most of the smaller ones go well beyond this framework in addressing their environmental responsibilities and a number of factors is common to all significant operations (Figure 5.27).

- All major operators demonstrate a clear commitment at company board level to conducting their mining operations in best practice environmental management (BPEM) principles. This is achieved firstly by way of written policies which define goals, procedures and responsibilities and secondly by committing to the appointment of senior environmental managers in the field to give effect to these policies. These managers have a responsibility to develop a BPEM culture in their operations.
- All operations now operate under an Environment Management Plan (EMP). Operations can not commence until the EMP is approved by government.

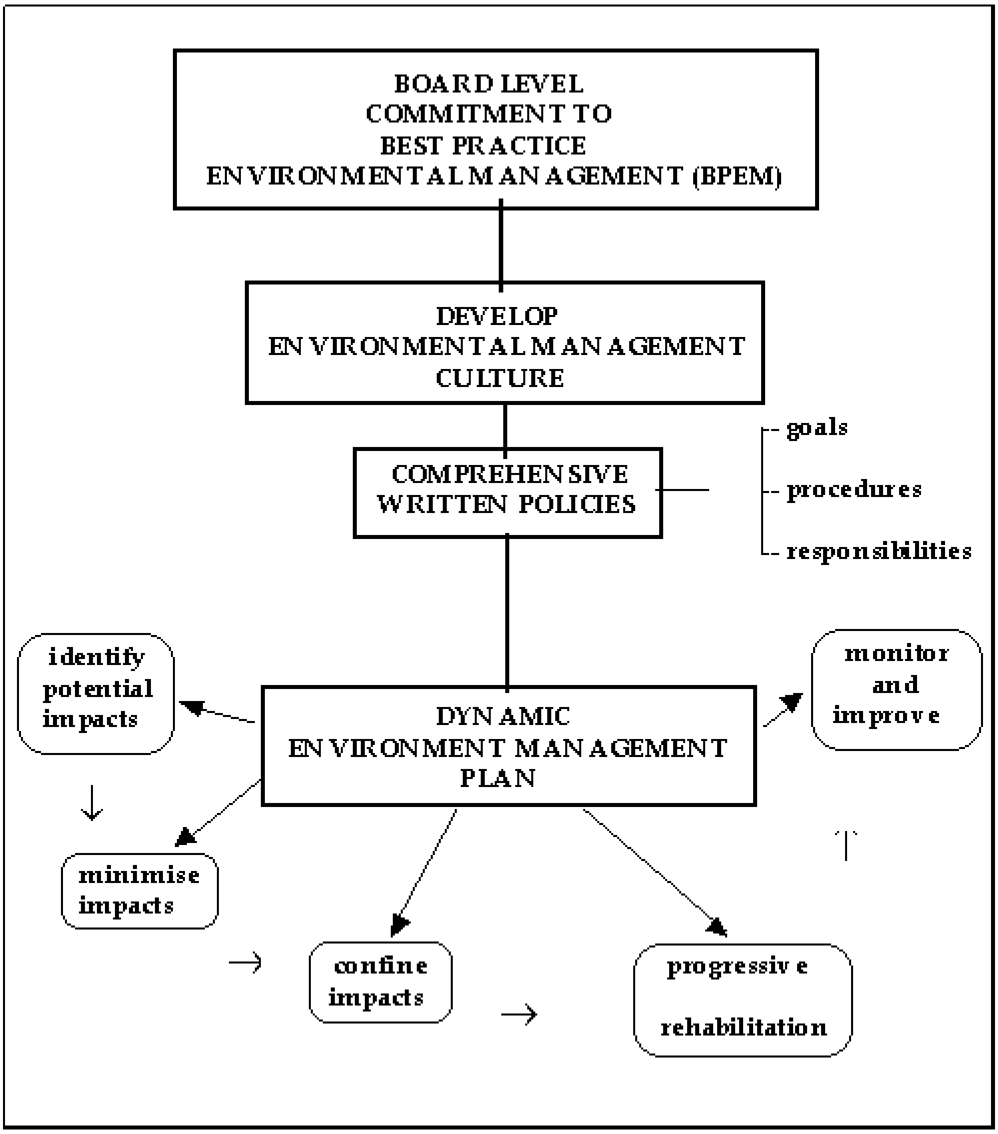


Figure 5.27 : contemporary environmental management

Most EMPs are designed to be dynamic documents which can be varied with government approval if improvements in procedures are identified during the life of an operation. The five key features in all EMPs are:

- **identification** of potential environmental impacts, based on scientific and professional assessments
- **minimise** impacts by careful and innovative planning, integrating all aspects of the operation
- **confine** impacts to the operational site, including following closure
- progressive **rehabilitation** of the operational area. This is important in minimising impacts and overcomes the problems so often left in the past on mine closure. Most mines now commence rehabilitation on day one, of any new operation.
- **monitoring** and **improving** environmental performance, by auditing and adopting various quality control procedures such as ISO 14000 or BS 7750.

BPEM is defined in the *Environmental Management and Pollution Control Act* 1994 as:

> "*... the management of the activity to achieve an on-going minimisation of the activity's environmental harm through cost-effective measures assessed against the current international and national standards applicable to the activity*".

To embellish this principle and provide guidance to operators, governments have prepared a range of BPEM booklets and *Codes of Practice* (Elton; DELM 1994).

To further inform project developers of requirements, DELM has also published a comprehensive manual on environmental assessments (DELM 1996).

Information transfer of the substantial quantity of data on BPEM is also effected by way of industry workshops organised by Minerals Council of Australia, Tasmanian Minerals Council.

Small Mine Operations

Small scale operators have been an important component of mining history in Tasmania for over a century and they continue to operate a range of mines, many of which occur in forested areas.

They include operations such as:

- quarries for road metal
- open-cuts for silica, limestone, dolomite (Corinna, Halls Creek)
- underground mines for tin, base metals (Anchor, Hercules)
- alluvial gold and tin mines (Lefroy, Anchor)

Many of these operations are based on relatively simple processing technologies such as crushing and screening in quarries, whilst some have developed small but sophisticated processing plants; eg, Anchor Mine has developed a gravity and flotation mill within the historical open-cut mine.

Small scale alluvial mines develop simple, traditional processing plants, usually based on gravity techniques; eg, Melaleuca (tin), Heemskirk (tin).

Other small scale operations without on-site processing, simply mine the deposit and transport the ore to an existing mill; eg, Hercules Mine is an underground base metal mine which freights ore directly to the Rosebery mill.

Small scale operators play a very important role in the mining industry. They tend to operate mines which the larger companies are not prepared to develop, either because they are too small or because of higher costs associated with the scale of operations.

As such they ensure the benefits derived from the mineral deposit inventory of a region are maximised.

Trends

Mining Trends

One obvious trend will be to mine deeper deposits. Several mines in Tasmania are currently operating close to 1000 m depth beneath original surface (Renison, Rosebery, Mount Lyell) and their resources clearly extend beyond that.

Improved materials handling technologies will also make the development of larger open-cuts possible; eg larger open-cuts may be developed at Mount Lyell, Savage River.

It is not correct to assume that with continuing exploration all near surface deposits will have been found and the long term trend will be to underground mines. Evidence throughout Australia confirms that near surface deposits, amenable to open-cut mining, are still being discovered with new exploration technologies eg Kanowna Belle in Western Australia.

Processing Trends

The basic future trend in mineral processing will be towards new technologies which enable the commercial development of currently uneconomic deposits. They may be uneconomic because the grade is too low or the mineralogy is too complex.

There are a number of such deposits in Tasmania including magnesite at Keith River, nickel near Beaconsfield, tin on Queen Hill and St Dizier.

Another trend in Tasmania may be towards centralised milling whereby ores from distal mining operations are brought to a centralised mill for treatment. This is not a new concept, having its origins in so called State batteries. It has also been practised in more recent times with mines at Comstock, South Comet, Que River and currently Hercules all transporting their ores to Rosebery for treatment.

Centralised milling should result in centralised waste management and improved impact containment and control.

Environmental Management

The trends in environmental management will probably be directed at improved management of:

- waste (rock and tailings)
- water management (acid mine drainage)
- final voids
- rehabilitation

Waste Management

The trend towards recycling waste back underground or into surface voids created by previous mining operations will probably accelerate with the development of new paste and cemented fill technologies.

Tailings dam design will continue to evolve so that they become increasingly stable and inert either by capping, sub-aqueous or co-disposal technologies.

Water Management

The quality of water leaving a mine site after closure is probably the biggest problem confronting industry and is attracting a large amount of scientific research. In Tasmania, the problem is essentially AMD. Efforts to reduce this will probably focus on:

- recycling acid forming tails
- recycling acid forming waste
- limiting oxygen and water exposure on acid forming rocks by intake minimisation

- sealing (flooding) mines on closure
- reducing exposures of acid forming rocks by using cemented fill, capping dams and waste dumps.

Final Voids

Mining has traditionally left substantial open-cut and underground voids.

A trend will probably be to better use these voids for waste rock and tailings disposal. Not only will this lessen the impacts of waste and AMD but it will also reduce the degree of long term landscape modification.

Infilling voids is not new technology to the minerals industry elsewhere in Australia, especially in the coal and heavy beach sands industries where all waste is replaced progressively following mining, and landforms restored to replicate original appearance as closely as possible. Several Tasmanian operations are currently to the fore of research studies into recycling tails and waste rock into voids.

Rehabilitation

Progressive rehabilitation for any new mining operations in Tasmania will commence from the beginning of operations.

Commitment to this approach ensures that on closure, there is not an unrehabilitated mine site with debated liabilities.

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Appendix A

1. 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 Step Method' used for quantitative assessments of potential mineral resources that was thoroughly evaluated and subsequently supported by a panel of experts in 1993 (Harris and Rieber, 1993). There has been no quantitative assessment in Tasmania.

An assessment of the potential mineral resources of a region combines knowledge of the region's 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 geological processes and environments. Geological 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 being 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. These have distinct features and have formed in different ways. It is 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.

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 qualitative assessment methodology is described by Marsh, Kropschot and Dickinson (1984), Taylor and Steven (1983), and Dewitt, Redden, Wilson and Buscher (1986).

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 5.2). 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 is also categorised according to levels of certainty, denoted by letters A to D (Figure 5.3).

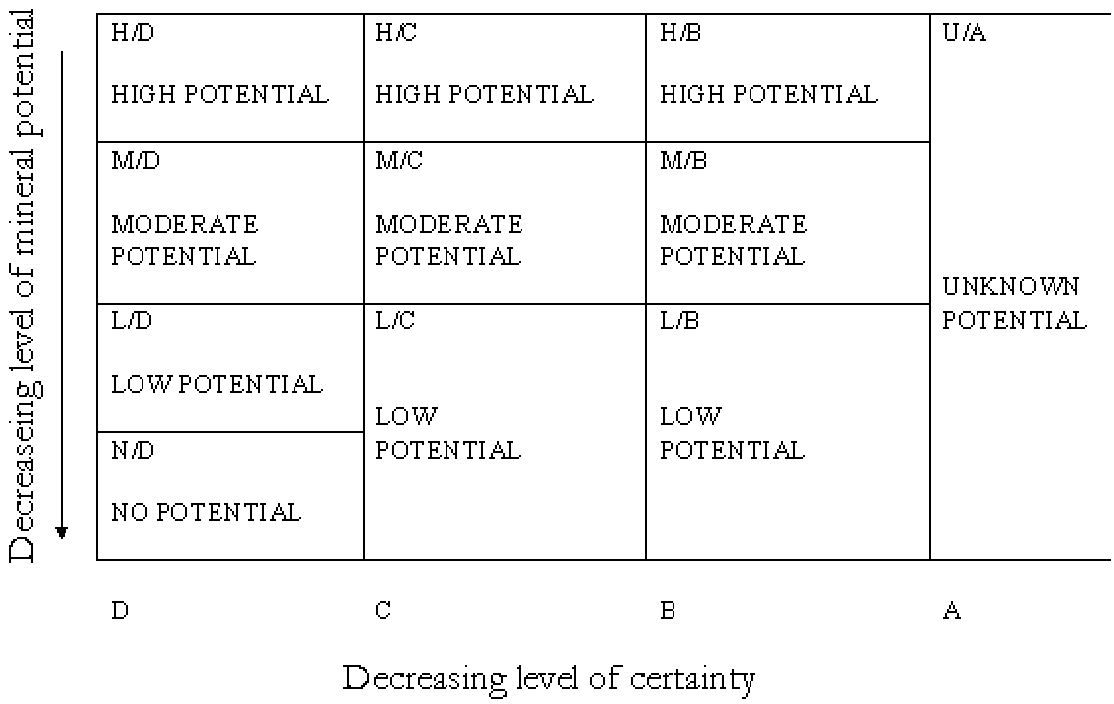
A: The available data are not adequate to determine the level of mineral resource potential. This level is used with an assignment of unknown mineral resource potential.

B: The available data are adequate to suggest the geological 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 geological environment and the level of mineral resource potential.

D: The available data clearly define the geological environment and the level of mineral resource potential.

Figure 5.3: Relationship between levels of resource potential and levels of certainty



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Glossary

AMC	Arthur Metamorphic Complex
AMG	Australian Map Grid
AUMC	Adamsfield Ultramafic Complex
BRS	Bureau of Resource Sciences
CONMAT	Construction materials database
CRAE	CRA Exploration Pty Ltd
CVC	Central Volcanic Complex of the Mt Read Volcanics
DIGHEM	A modern helicopter-borne EM system
EL	Exploration licence
EM	Electromagnetics - a geophysical technique commonly used in the search for massive electrically conductive mineralisation
GIS	Geographic Information System
IP	Induced Polarisation-a geophysical technique commonly used in the search for disseminated electrically conductive mineralisation
JV	Joint venture between one or more parties
LDH	Layered Dunite-Harzburgite (see Brown, 1986)
LPD	Layered Pyroxenite-Dunite (see Brown, 1986)
LPG	Layered Pyroxenite-Peridotite and associated Gabbro (see Brown, 1986)
Ma	Million years (normally used as before present)
MASL	Metres above sea level
MIRLOCH	Mineral Resource Location and Characterisation database
ML	Mining lease
MRT	Mineral Resources Tasmania
MRV	Mount Read Volcanics
PGE	Platinum Group Elements
QUESTEM	A modern fixed wing EM system
RL	Retention Licence
SP	Self Potential-a geophysical technique for measuring the amplitude of the natural voltages generated by oxidation of geological materials
SPZ	Strategic Prospectivity Zone
TCR	Company exploration report, housed in Mineral Resources Tasmania library
TURAIR	An early helicopter-borne EM system

USGS	United States Geological Survey
UTEM	A modern ground-based EM system (after University of Toronto EM)
VHMS	Volcanic Hosted Massive Sulphides

Chapter 6 Other Forest Uses

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Introduction

This chapter provides an overview of Tasmania's surface water resources, their use, and allocation. There is a section on the specific aspects of forestry practices and water. The purpose is to compile data to describe the role, importance and sensitivities of forest practices on water and water related catchment uses. The description has taken a holistic approach to put forestry in context of all landuses that make up water catchments in Tasmania.
Nineteen (19) river basins across the State are used as the basis for the overview. These river basins were identified by the former Australian Water Resources Council (see DNR 1976) and are a convenient means of presenting gross information. Figure 6.1 shows each of the 19 river basins and the 17 focus catchments used in this report.

The scale of the river basins, and the differences between them, means that it is not possible to provide a "profile" of water resource information other than in the broadest sense. To help overcome this limitation a "focus catchment" has been chosen from each river basin (see Appendix 6.1). The use of focus catchments provides more comprehensive information and an understanding of the situation on-the-ground. In some cases focus catchments provide an typical example of other catchments within a basin; in other cases specific catchments have been chosen to highlight a significant point or management direction.

Overview of river basins

The availability of information

Tasmania has some of Australia's longest continuous streamflow records due to the early recognition of hydro-electricity as a major potential power source. Unfortunately these records are mostly confined to the West Coast and Central Plateau. There were only a limited number of stream gauging stations in the remaining areas of the State until the late 1960's. From this time until the end of the 1980's a significant increase in station numbers occurred largely as a result of Commonwealth initiatives to assess the continent's water resources. Since that time the stream gauging network has contracted.

Overall, there is reasonable knowledge about the average water yields from medium to large sized catchments in Tasmania, however, the variability of flows in medium to large catchments and the hydrology of small catchments (including some significant tributaries) is relatively unknown.

As with other climatic variables, long periods of record are typically required to provide a good understanding of the hydrological cycle, particularly the extremes of flood and drought which pose the greatest challenge to resource management and development. For example, it is generally recommended that at least 15 years of data are collected before estimates of flood and drought probabilities are undertaken, and that the average recurrence intervals (ARI) of estimated events from such analyses are kept within, say, 1.5 times the record length. In the more populated areas of Tasmania the typical maximum record length is of the order of 20 years suggesting that design events with ARI's of no greater than 30 years are used. Many design situations require a much greater security than this and typically ARI's of 50 to 100 years (or even greater) are required.

Water quality sampling in Tasmania is carried out by many groups from within both the Government and Private sectors. Most studies are very localised and short term with very few running for longer than three or four years. There is a recognised shortage of long term, baseline monitoring of water quality in the State. Only recently has a policy on water quality been produced by the Tasmanian Government, and a sub-committee of the Land and Water Management Council has been formed to identify the need for, and recommend ways of achieving, long term strategies for water quality monitoring.

(Map of Tasmania AWRC Basins and Focus Catchments)

Map S&E 6.2

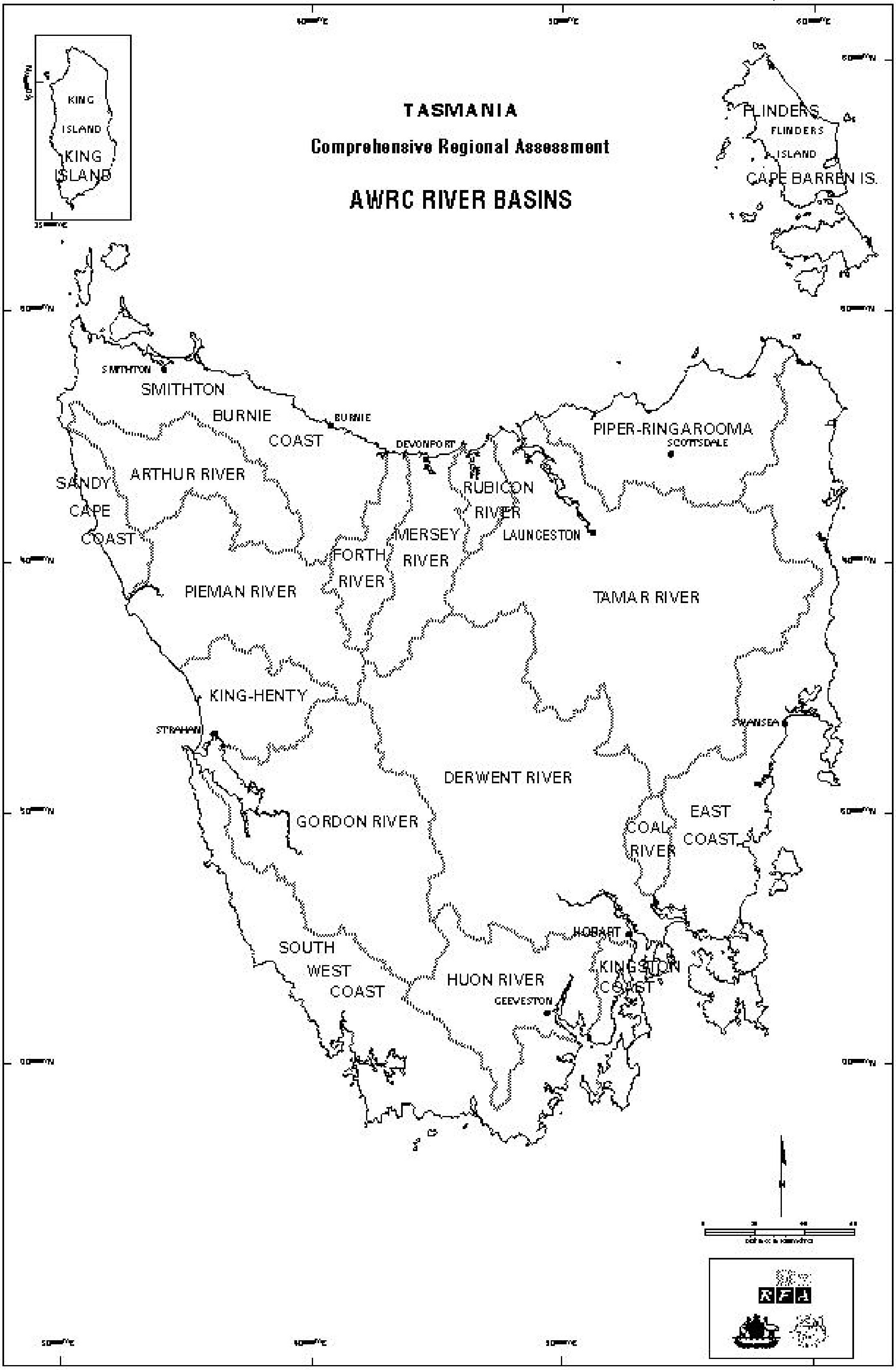


Table 6.1 : Mean flows and measurement statistics of Tasmanian drainage basins

River Basin	Drainage Basin Statistics		Estimated Mean Annual Runoff		Error in Mean	Salinity of Major
	Area (Km^2)	% Gauged	(Mm^3)	(mm)	(%)	River
Flinders - Cape Barren Islands	2070	1	280	130	+/- 36	Fresh
East Coast	6840	52	1630	240	+/- 24	Fresh
Coal River	735	41	50	75	+/- 27	Marginal
Derwent River (H)	9160	85	3910	430	+/- 15	Fresh
Kingston Coast	775	15	200	260	+/- 34	Fresh
Huon River (H)	2990	63	3740	1300	+/- 18	Fresh
South West Coast	5465	16	8360	1500	+/- 33	Fresh
Gordon River (H)	5935	77	9640	1600	+/- 17	Fresh
King-Henty Rivers (H*)	1815	31	3480	1900	+/- 28	Fresh
Pieman River (H*)	4175	75	6900	1700	+/- 17	Fresh
Sandy Cape Coast	880	0	620	700	+/- 37	Fresh
Arthur River	2500	61	2680	1100	+/- 21	Fresh
King Island	1100	4	270	250	+/- 36	Fresh
Smithton-Burnie Coast	4690	51	3520	750	+/- 25	Fresh

Table 6.1 : Mean flows and measurement statistics of Tasmanian drainage basins (cont.)

River Basin	Drainage Basin Statistics		Estimated Mean Annual Runoff		Error in Mean	Salinity of Major
	Area (Km^2)	% Gauged	(Mm^3)	(mm)	(%)	River
Forth River (H)	1125	95	1300	1200	+/- 13	Fresh
Mersey River (H)	1965	82	1610	820	+/- 15	Fresh
Rubicon River	685	57	170	250	+/- 23	Fresh

Tamar River (H)	11670	86	3620	310	+/- 17	Fresh
Piper - Ringarooma Rivers	3624	34	1420	390	+/- 27	Fresh

Notes : H) Basin modified by HEC diversion of water H*) Basin modified by HEC diversion of water after compilation of table.

Source: Modification of Table IIIa in (DRE 1983 (1)).

Recent years have seen the development of biological monitoring as a resource management tool. This type of monitoring is in its infancy in Tasmania and for this reason the preliminary results from current monitoring programs are not discussed in this document.

An overview of Tasmanian stream flow statistics

Tasmania's average annual surface runoff is 53 000 000 +/- 11 000 000 Megalitres. The relatively large error is a function of the areas in the State which have either not been monitored or have only been monitored for a short period of time. Approximately 12% of Australia's runoff occurs from Tasmania which represents only around 1% of the land area of the continent.

Based upon these figures it may appear that Tasmania's surface water is more than plentiful but the truth is that most of the State's developed areas experience regular, dry summer periods. There is a strong gradient of runoff from the west to the east. The average annual rainfall in the Midlands is approximately one sixth of that on the West Coast and runoff varies from 80 -90% in the Pieman River area to only 10-15% in the Coal River region.

An overview of Tasmanian water quality

The following information is based upon Fuller and Katona (1993) who presented a summary of inland water quality data based on samples which had been sporadically collected over a twenty year period by State and Local Government. A discussion of each of the major parameters used to describe water quality is given and results are summarised in relation to the Australian Water Quality Guidelines for Fresh and Marine Waters (ANZECC 1992).

Temperature

Tasmanian stream temperatures reflect the general location of the measurement site (eg latitude), proximity to the ocean, and altitude. There is a general trend towards cooler water temperatures in the West of the State. This trend is especially evident over summer months when low flow in eastern streams allows greater heating of the water. Catchments which have the majority of their waters rising in alpine areas generally exhibit cooler water temperatures at their outlets.

pH

The pH or acidity of Tasmanian streams is typically in the range 5.5 - 7.5. Streams on the West Coast are generally more acidic probably as a result of the high humic acid input from button grass plains. There are also some rivers which are affected by acid mine drainage. The remainder of the State has rivers which are only very slightly acidic except in the region around Hobart where waters tend to be slightly alkaline.

Colour

Colour is a term which indicates the true colour of water after turbidity (ie suspended material) has been removed. Protection of the optical properties of waters is necessary to ensure adequate penetration of light in order to sustain the growth of aquatic plants and to ensure sufficient visibility for predatory fish and birds.

Humus and peat materials in rivers of the west and northwest coast and parts of the Central Plateau gives them a characteristic brown colour. Those rivers tend to have about twice the level of apparent colour than waters from the Northern Coast, East Coast and Midlands areas.

Salinity

Electrical conductivity (EC) is most commonly used to determine salinity because of its sensitivity and ease of measurement. The guideline for Australian fresh waters is less than 1500 uS/cm. Tasmanian waters typically exhibit conductivity of the order of 150 uS/cm or less. Notable exceptions are Flinders Island which has an EC of around 500 uS/cm and the Coal River about 800 uS/cm. Increasing levels of salinity are being found in other areas of the State and are generally associated with agricultural activity. Scientific monitoring is currently being carried out in the Cressy-Longford area and the Coal River Valley.

Erosivity

Total suspended solids and turbidity may be considered as rough indicators of the erosion occurring in a catchment. However, it is extremely difficult to characterise the erosivity of entire river basins from these measurements because of the large effects that local land use and geology have upon individual measurement sites. Nevertheless, it can be said that there is a general tendency for east coast streams to be more erosive than west coast streams. Typically, Tasmanian streams have a low sediment load compared with mainland streams.

Those rivers which exhibit high suspended solids loads are the George and Ringarooma rivers (previously subject to sluice mining), the Elizabeth River (subject to substantial erosion during past forestry and current agricultural practices), the Davey River (large deposits of gravel from glacial activity), and the Coal River (significant agricultural activity and removal of vegetation). Other rivers of concern are the Break O'Day and the Meander rivers (agricultural). Only recently has an effort been made to collect information of this type in a consistent and long term fashion. Records such as those maintained by the West Tamar Water Supply and the Hobart Regional Water Board are an exception.

Riverine health

Dissolved Oxygen (DO) is an extremely rough indicator of riverine health. Typically daylight DO levels in streams are around the 8-10 mg/l level although it must be realised that there can be significant variations with season and also during the day because of photosynthesis by water plants. The Rubicon and Meander rivers have average daylight DO levels which are slightly lower than those in other areas and may require further investigation, nevertheless, all Tasmanian rivers investigated by Fuller and Katona (1993) had acceptable DO readings when compared with national guideline values.

Preliminary results from the State of River report for the South Esk Basin suggest low levels of DO in the Break O'Day River and exceptionally low levels in Quamby Brook, both these catchments are subject to significant agricultural activity.

Heavy metals

Heavy metal pollution is typically associated with mining activities and some industrial discharges. Fuller and Katona (1993) used copper concentration as a convenient indicator of heavy metal pollution because it was the most popularly tested metal. Despite this there was insufficient copper data to provide an overview of heavy metal pollution across the State. Of those areas with data, the King River and the Savage River exhibit copper concentration levels well above national standards. Both of these catchments are subject to mining activity. Other streams which show impact from heavy metal pollution are Story's Creek and the Pieman River, both of which have had specific investigations into mining related pollution.

Nutrients

Nutrients containing Nitrogen and Phosphorous stimulate the growth of plant matter. Excessive levels of nutrients, in combination with other physical factors such as elevated water temperature and/or sunlight, can lead to algal blooms. Typical nutrient sources are fertiliser runoff, excrement from animals having direct access to streams, sewage disposal, dairy shed effluent disposal, and soil erosion into waterways.

Apart from recent work in the South Esk Basin there is only sparse nutrient data available for Tasmania. Those results which have been collected suggest that the State's waters naturally have low levels of nutrients. Significant enrichment has occurred in catchments subject to intensive agricultural land uses and in rivers downstream of sewage or intensive animal industry outfalls.

Microbiological pollution

The Coliform group of bacteria is the principal indicator used for microbiological contamination of water. The levels of coliforms in a waterway give a indication of the suitability of the water for drinking, swimming or other domestic and industrial uses. In Tasmania there seems to be a general trend of increasing microbiological activity across the state from the south west to the north east. Areas subject to intensive agricultural practices generally show elevated levels of pollution. In the South Esk Basin State of River study levels were found to increase towards the downstream reaches of most catchments in the Meander River system.

According to ANZECC guidelines, most Tasmanian river waters (including pristine systems) should be disinfected prior to consumption. This is especially the case during the summer period when high temperatures can promote bacterial growth.

Forestry and water - general

Forestry operations and other land uses form part of the many land uses that occur in catchments. Catchments can contain a mix of native forest, plantations, pastures and cropping. The location of forestry operations in Tasmania are conducted in the upper reaches of water catchments, and as such are in source areas for the many streams that flow down through lower portions of catchments, and out to the sea. It is for this reason that water and forestry are intimately related.

The mosaic of landuses in catchments present many circumstances where water quality and quantity can be affected. There are long rotations associated with forestry operations compared to annual soil disturbances in agriculture.

Forestry operations are characterised by the use of heavy machinery, requiring roading, and the removal of vegetation, followed by regeneration. The effect of this on water values is often difficult to prevent but can be controlled. The Tasmanian Forest Practices Code (FPC, 1993) forms part of a system governing public and private forestry practices, and is designed to protect among other things water quality and flow.

The interactions of forestry and water are usually expressed in terms of quality and streamflow. It is convenient to separate these two attributes as they can operate independently. For example the flow of streams may remain unaffected by disturbance, whereas the amount of sediment in the water may be temporarily increased.

Forestry and water yields

Water falling in a catchment can evaporate, flow overland or seep underground. The relative proportions of each component vary enormously depending on the nature of the catchment and the precipitation. In addition, different amounts of water are used by different vegetation types growing in the catchment. This water use is called evapotranspiration, and is a combination of transpiration and interception by vegetation, and evaporation from the vegetation and soil. Cornish (1989) provides a detailed discussion of the water use components in relation to forests.

In any one catchment the surface runoff or yield, is a balance of precipitation, evapotranspiration, groundwater input and landcover. The landcover is the type, proportion and distribution of vegetation across the landscape. As a general rule, forests have higher evapotranspiration than pastures. Higher water use is expected from forested as compared to pastured catchments. As a consequence water flow is related to the amount and type of forest cover in any given catchment.

The Tasmanian Forest Practices Code (Forestry Commission 1993) through the 3 year plan system attempts to limit the amount of clearfelling in major water supply catchments to 5% annually. Some clarification may be needed in the code on the definition of water supply catchments. For other catchments the requirement for coupe dispersal and prompt reforestation ensures a patch work of variable forest age. The code does not cover clearing for agricultural use (only applicable outside public land). The proportion of forested and cleared lands in catchments is not regulated in Tasmania.

Experimentation is difficult to conduct and problematic in relation to water yield and the alterations in vegetation cover as a result of forestry operations (Doeg and Koehn 1990). The patchwork of logged, unlogged, regrowing forest and cleared areas in catchments leads to stream flow response that is difficult to relate to forestry operations (Commonwealth 1996). The inter-year variability in precipitation is another difficulty in easily relating measurements of stream flow effects from land use or management change (Dargavel et al. 1995). Calibration of stream measurements is very important (Doeg and Koehn 1990), but this leads to lengthy and expensive experiments.

Some research in Tasmania has been investigating the pre and post logging effects on water yield in the Musselboro Creek (Wilson et al. 1995), but results are preliminary and require further analysis. There appears to be very little if any, other evidence currently published in regard to water yield and forestry in Tasmania. This means that results from mainland Australia in eucalypt forest are the closest in terms of forestry effects and water yield.

Areas of high precipitation like Tasmania are characterised by high growth rates of vegetation, and ample surface water runoff in favourable climatic conditions. Nevertheless, variability in water yields can be expected. There is some evidence from outside Tasmania to show that the higher the mean annual precipitation, the greater the evapotranspiration (Holmes and Sinclair 1986) and the lower the yield from catchments (Cornish 1989) irrespective of the vegetation type (forests and pastures). There were however differences in magnitude of evapotranspiration between vegetation types.

Comparisons between regenerating and older forest are well documented for the Mountain Ash forests near Melbourne (Kuczera 1985). Experiments in mixed species forests of the Lerderderg catchment Victoria with 1000 mm annual rainfall, show that at least 20% of the catchment have to undergo a change in vegetative cover (harvesting or fire) in any one year for the effects on water yield to be detectable (O'Shaughnessy, Fletcher and Bren 1995).

Some general rules of thumb can however be accumulated from similar forest types from various sources outside Tasmania. In general some aspects of water yields can be summarised:

- water yields are higher from pasture than eucalypt catchments (Holmes and Sinclair, 1986)
- water yields are proportional to the percentage of the catchment afforested (Cornish, 1989)
- water yields are lower for pine than eucalypt plantations because of greater canopy interception of pines (Cornish 1989)
- there is no evidence for a difference in water yield between native eucalypt forest and plantation eucalypt at same age and density
- water yield increases immediately following clearfelling and then decreases as regeneration appears (Nandakumar and Mein 1993)
- water yields are lower for actively transpiring regrowing forests than mature forests (Kuczera 1985)
- where silvicultural thinning favours increased growth rates resulting in higher canopy interception and evapotranspiration, water yield is likely to decrease

The issue for management is not for maximum water production, but the reliability of water supply and how this affects water users further down stream.

Forestry and water quality

Water quality is a particular issue in relation to forestry where sediments, chemicals and fertilizers can enter waterways. This remains an issue because of the lack of conclusive and comprehensive information from research (SOE 1996). Research on water quality and effect of forestry is typically site specific (SOE 1996) and difficult to extrapolate to other locations (Tasmanian Woodchip Export Study Group 1985).

Codes of practice in forest operations have been formulated to reduce and contain impact of forest management practices on water quality.

Erosion and sediments

Roading and forestry snig tracks are considered to be potential major contributors to increased sediment loads in streams and resultant decline in water quality (Doeg and Koehn 1990, King 1988). One storm event can wash out a culvert and supply a large sediment load into a stream. Road crossings have been known to contribute large amounts of sediment 30 - 50 years after construction (Davies and Nelson 1993). Comprehensive guidelines for snigging, and road construction and maintenance are now in place, and can be found in the Forest Practices Code.

Two monitoring projects which aim to quantify the impact of 'best practice' forestry operations on water quality in streams are currently on-going in Tasmania. These projects target two very different regions of interest. The first set of monitoring sites is situated in a dry sclerophyll forest on highly erodible granitic soils in NE Tasmania near St Helens. The second set of sites is located in a wet sclerophyll forest on stable dolerite soils near Launceston. This trial was established on Musselboro Creek to provide quantitative data on the impact of forest harvesting on site and water values, to gauge the duration of any changes and to compare these figures with those recorded in an adjacent agricultural catchment. The main issues which concerned the Forestry Commission (now Forestry Tasmania) in the two regions were rilling and gullying which had occurred after early logging attempts on the erodible granites, and possible high turbidity associated with storm runoff during winter logging activities in the dolerite terrain around Musselboro creek which feeds the Launceston water supply. The turbidity levels in Musselboro creek are typically very low, yet during both the pre and post logging periods the 5 NTU drinking water standard was exceeded for short periods during the rising limb of the flood hydrographs.

The data from these studies include paired sets of water quality samples from undisturbed and logged sub-catchments for a range of storm events. A preliminary analysis of the data from Musselboro Creek shows that the negative impacts of the logging are low on average when the proportion of area logged is low relative to the total area monitored. (Only 10% of the area monitored was logged at Musselboro Creek). Maximum turbidity levels recorded downstream of agricultural areas reached 4 times those recorded at the forest site. These findings are consistent with findings summarised by Doeg and Koehn (1990) from other studies in Australia. A brief report on the impact of logging and fire on soil erosion in the granitic soils near St Helens is given by Wilson (1993).

Sediment fluxes in streams have been known to take 5 years for return to normal levels following logging (Davies and Nelson 1993). This study also found that ephemeral headwater streams on steep slopes have a significant role in the export of fine sediments from logged coupes. A number of changes and additional prescriptions are proposed in the draft review of steep country logging of the Forest Practices Code.

The Forest Practices Code stipulates a range of stream side buffers widths depending on the stream type. Watercourses are classed from 1 to 4 with the latter being the most minor. These are specifically designed to protect water quality by reducing soil disturbance near watercourses and serve as a filter for overland flow.

Plantations established in native forest areas under the Forest Practices Code must have uncut native forest buffer zones left during the logging operation prior to the establishment of the plantation. Plantations established prior to 1987 may have been planted right up to the streambanks. This means that some older plantations and plantations established on land that was cleared without the Forest Practices Code, may not have native vegetation streamside buffers, or when replanted on second rotation may only have 20 m buffers on streams (Class 1 & 2) and none on smaller watercourses.

Chemicals and fertilizers

Chemicals usage in forestry is mainly associated with plantations. Application of herbicides and insecticides are made through aerial spraying or ground based methods and guidelines appear in the Forest Practices Code. Aerial applications must comply with the Department of Primary Industry and Fisheries Code of Practice for Aerial Spraying in Tasmania (DPIF 1995). Forestry Tasmania and some timber harvesting companies have adopted more stringent control and use of chemicals. These include additional manuals and policies governing chemical usage, spray supervisors course, pre and post application water sampling, and alternative treatments aimed at minimising chemical use.

A range of herbicides are available for use in forestry operations. The type of herbicide used depends on suitability to conditions, method of application, cost and purpose. Triazine compounds such as Atrazine and Simazine are herbicides used for weed control in plantation establishment. Other herbicides used include Glyphosate (Roundup) Hexazinone (Velpar) and Amitrole. Only herbicides approved by the National Registration Authority can be used, and must fall within the guidelines set by government health and environmental authorities. Forestry Tasmania has not used chlorinated Triazine herbicides (Atrazine, Simazine) for the last two years, nor Amitrole for the last four years (Brian Hodgson, Forestry Tasmania, pers. comm.).

Herbicide usage in forestry has been common with establishment of plantations, and is usually applied in winter as a single spray event. This contrasts with agricultural applications of similar herbicides in spring and early summer, often as annual events. Other means of weed reduction prior to establishment of plantations to replace or minimise reliance on herbicides are possible, for example developments by Forestry Tasmania (Forestry Tasmania research paper on development of new weed management strategies, 1994).

Chemicals in waterways can affect invertebrates and vertebrates, and is of concern for domestic usage. Detectable levels of atrazine have been measured in Tasmania streams draining forestry plantations (Davies et al. 1994). The same study recorded low levels of atrazine persisting up to 16 months following an isolated single spray event. The concentrations were likely to cause significant short term but infrequent impacts on the stream biota. This study however, was carried out prior to the Forest Practices Code and hence buffers were not the widths as now stipulated.

Whenever chemicals are used in any field based applications the possibility exists for inadvertent contamination. Spray drift and surface run-off can carry contaminants into streams. The provision of stream buffer zones minimises such additions. Worst case scenarios such as Olivers Creek at Lorinna where chemicals were applied late in the season and the Cascade River at Derby where unintentional over spraying of an upper catchment drainage line highlight the need to take precautions with pesticide use. Application techniques in forestry are being constantly refined with chemical use being minimised and broadcast techniques being replaced with strip and spot spraying.

No spray zones or buffers adjacent to streams are important measures to reduce contamination by herbicides and insecticides in forestry operations (Barton and Davies 1993). Tasmanian research indicates that at least 30 metres is needed for the aerial application of Atrazine and 50 metres for pyrethroid insecticides (Barton and Davies 1993). Interestingly the study found that width was more important than quality of buffers.

Buffers widths recommended in the course notes for spray supervisors (written by Forestry Tasmania) are 50m, 30m and 10m for aerial, ground based and hand applications of herbicides respectively. Insecticides aerial application recommended at 50m and 20m for synthetic (eg. pyrethroid) and Bacillus types respectively.

There is a need to draw together the guidelines and apply to all forest practices (public and private), i.e. make best practice by some more universal and regulated in specific codes. In conjunction with the new Agricultural and Veterinary Chemicals (Control of Use) Act, three codes of practice for use of chemicals are being prepared. One of which relates to forest use of chemicals, the other two are for vegetable and fruit crops.

Insecticide usage is irregular in Eucalypt plantations, and is usually timed with outbreaks of insect pests. Both synthetic compounds (eg. pyrethroids) and natural compounds (eg. Bacillus type) compounds are used. The aerial application of pyrethroids where buffer zones fell below 50m have been associated with short term responses in invertebrate drift (Barton and Davies 1993).

Fertilizers can be applied by aerial application in plantations. When required the application of Nitrogen is generally more frequent than Phosphorus. Fertilizer application directly to streams or as high concentration runoff could raise stream nutrient levels leading to significant effects on stream ecosystems (King 1988). Adherence to buffer zone distances will reduce the possibility of water contamination.

The Forest Practices Code recommends that aerial fertilising should be carried out in such a way as to minimise the chance of fertilizer being dropped or drifted onto open water bodies. Forestry Tasmania use differential Global Positioning System (GPS) on board aircraft as part of an automatic system to ensure fertilizers and sprays are applied to the correct location, considering buffer zones and sensitive areas.

Legislation and reforms in water management

Existing legislation

The principal vehicle for control, allocation and management of water resources in Tasmania is the *Water Act 1957* which confers powers on the Rivers and Water Supply Commission (RWSC). Other legislation regulates and oversees the performance of local government and other agencies in the performance of duties relating to water quality, water supplies, sewerage, drainage and irrigation.

From time to time, parliament has legislated for specific provisions and has conferred powers on other bodies to allocate water resources. Other rights have been established under common law by usage confirmed in the provisions of the Water Act.

The rights of the RWSC to take and therefore allocate water, are subject to the following restrictions:

- Riparian rights - These are limited to the water requirements of landholders adjoining streams for their stock and domestic requirements and as such generally do not involve significant quantities of water.
- HEC Rights - The rights for the HEC to take, store and use water for power generation are embodied in legislation administered by the HEC. Since 1958 the Water Act has required the declaration of HEC water districts to be approved jointly with the RWSC.
- Rights granted prior to 18 January 1930 - These are rights established by usage prior to the commencement of the HEC Act 1929. These (Prescriptive Rights) have been registered with the RWSC.
- Rights in any local or private Act - There are at least 12 Acts providing for specific rights not subject to the Water Act.
- Public water supply sources approved under the Local Government Act.

Council of Australian Governments reforms

In 1994 the Council of Australian Governments (COAG) agreed that action was needed to stop widespread degradation of our natural resources and to minimise unsustainable use of our precious water resources. COAG then agreed to implement a strategic framework to achieve an efficient and sustainable water industry.

The COAG package of reforms includes arrangements for water entitlements and trading, environmental requirements, institutional reform, public consultation and education, water pricing, as well as research.

Under the COAG requirements the State is required to implement:

- comprehensive systems of water allocations or entitlements, backed by separation of water property rights from land title and clear specification of entitlements in terms of ownership, volume, reliability, tradability etc;
- formal determination of water allocations or entitlements, including allocations for the environment as a legitimate user of water; and

- trading of water allocations or entitlements within the social, physical and ecological constraints of catchments.

COAG requires water trading arrangements to be in place by 1998 with comprehensive implementation of all reforms by 2001. However, fundamental changes are required to Tasmanian water legislation to enable implementation of the COAG reforms. A review of the Water Act is expected to commence in early 1997.

National principles for the provision of water for ecosystems

The Agricultural and Resource Management Council of Australia and New Zealand and the Australian and New Zealand Environment and Conservation Council have jointly developed a set of 12 national principles for the provision of water for ecosystems. The purpose of these provisions is to provide a policy direction on how the specific issue of water for the environment should be dealt with in the context of general water allocation decisions. These principles will be used in the COAG reform process in Tasmania.

Principle 1: River regulation and/or consumptive use should be recognised as potentially impacting on ecological values.

Principle 2: Provision of water for ecosystems should be on the basis of the best scientific information available on the water regimes necessary to sustain the ecological values of water dependent ecosystems.

Principle 3: Environmental water provisions should be legally recognised.

Principle 4: In systems where there are existing users, provision of water for ecosystems should go as far as possible to meet the water regime necessary to sustain the ecological values of aquatic ecosystems whilst recognising the existing rights of other water users.

Principle 5: Where environmental water requirements cannot be met due to existing uses, action (including reallocation) should be taken to meet environmental needs.

Principle 6: Further allocation of water for any use should only be on the basis that natural ecological processes and biodiversity are sustained (i.e. ecological values are sustained).

Principle 7: Accountabilities in all aspects of management of environmental water provisions should be transparent and clearly defined.

Principle 8: Environmental water provisions should be responsive to monitoring and improvements in understanding of environmental water requirements.

Principle 9: All water uses should be managed in a manner which recognises ecological values.

Principle 10: Appropriate demand management and water pricing strategies should be used to assist in sustaining ecological values of water resources.

Principle 11: Strategic and applied research to improve understanding of environmental water requirements is essential.

Principle 12: All relevant environmental, social and economic stakeholders will be involved in water allocation planning and decision-making on environmental water provisions.

Water quality management

The draft State Policy on Water Quality (DELM 1996) recommends the adoption of a value based approach to water quality management. The idea is to establish water quality objectives which seek to achieve all of the nominated Protected Environmental Values for surface and ground waters. Protected Environmental Values can and will vary from water body to water body.

The draft policy does not establish an administrative system for setting the PEV's of a waterway as it is envisaged that this will be a community driven process through integrated catchment management (ICM). As ICM is not yet implemented in Tasmania the draft policy provides a process for setting interim PEV's based upon consideration of the following potential list of values:-

A. Protection of Aquatic Ecosystems

B. Recreational Water Quality and Aesthetics

C. Raw Water for Drinking Water Supply

D. Agricultural Water Uses

E. Industrial Water Suppply

Summary

- Generally lots of water in Tasmania
- Most water flow in Tasmania is peaked rather than sustained flow
- Water quality is relatively good across the State
- There are some specific water quality issues, ie. mining and heavy metals, agriculture and nutrients, forestry and sediments
- Use of water has grown exponentially for irrigation, water supply and HEC
- Use is now starting to plateau possibly because all the easily available sources have been accessed. This is certainly the case with the HEC.
- Values of water use are wide ranging, for instance it is an integral component of sightseeing and recreation.
- Forestry practices can effect water quality and yield.
- Forest Practices Code is currently being reviewed with regard to soil and water.
- Sediments or chemicals can enter waterways as a result of forestry practices, but there are buffers, rigid supervision and other guidelines aimed at minimising risks.
- Roading, and snig tracks are the main issues in sediment entry to streams.
- The impact on water quality of chemical applications to plantations, is a sensitive issue and subject to review of codes, policy and legislation.
- The Forest Practices Code is in place and its success is reliant on the appropriateness of measures, compliance and effort devoted to monitoring and development.
- Forestry Tasmania and some timber harvesting companies employing practices that are additional to those required under the relevant codes.

National Water Quality Management Strategy and draft State Policy on Water Quality directions reflect the range of values placed on water.

6.1.2 Tourism and recreation in Tasmanian forests

Introduction

The aim of this section is to document available information on the resource, economic and social characteristics of tourism and recreation in Tasmanian forests, and to explore the outlook for these activities and any potential conflicts between tourism and recreation and other land uses. The economic and social information in this section is complemented by data collected as part of the comprehensive regional assessment process, including a survey of tourist operators and a community survey which includes questions about recreation. The results of these studies are reported in Chapter 3.

Tasmanian forests are used for a number of activities including tourism and recreation. Visitors to Tasmanian forests come from overseas, interstate and Tasmania. Forests provide opportunities for bushwalking, recreational four wheel driving and other popular recreational activities.

Tourism is an important economic activity in Tasmania. It is estimated that the contribution of tourism to gross state product in 1992 was 6.9 per cent (DTSR 1995). Tourism is also a growing industry for Tasmania, as demonstrated by recent growth in visitor numbers, length of stay and total expenditure, reported in the section to follow. Tourism supports regional economic activity, for example, accommodation establishments are located throughout the state.

On a regional basis, tourism supports communities undergoing a transition from resource industries to service industries. In line with this, Tasmania has experienced a growth in the range and accessibility of tourist facilities with a shift from accommodation to experiential, environment and natural attractions.
The experiences sought by visitors cover a wide range but commonly include nature (including flora and fauna), culture, history, education, and scientific research as well as other special interest topics.

Tasmania's natural environment, including its forests, is an important component of Tasmania's appeal. Between 1993 to 1995 an average of 75 per cent of interstate and overseas visitors to Tasmania visited natural attractions (DTSR 1995). Outdoor recreational pursuits are popular with Tasmanians. Australian Bureau of Statistics survey data reveals that 65.7 per cent of Tasmanians over the age of 15 had visited a National Park during 1991 (Australian Bureau of Statistics 1994).

The economic contribution of tourism in Tasmania

Over the decade 1985 to 1995, the growth rate for visitors to Tasmania was 5.3 per cent a year on average. The growth rate for interstate tourists was 4.7 per cent per annum, and for international visitors, it was 10.5 per cent per annum. Tasmania has increased its share of Australia's interstate tourist market from 2.5 per cent to 3.1 per cent. Tasmania's share of international visitors remained steady at around 2 per cent (DTSR 1996).

It is estimated by the Centre for Regional Economic Analysis at the University of Tasmania that the contribution of the Tasmanian tourism industry to gross state product increased from 6.2 per cent in 1986 to 6.9 per cent in 1992 (DTSR

1996). Over the same period, total direct and indirect employment in the tourism sector increased from 7.7 per cent of the state's workforce to 9.1 per cent. In 1994 - 95 an estimated 19 000 people (10 per cent of the workforce) were employed either directly or indirectly in the tourism industry.

The economic contribution of tourism is measured in many ways, including direct visitor expenditure. Over the five year period, 1991 to 1995, total expenditure in Tasmania by international and interstate visitors increased by approximately 45 per cent from $399 million in 1991 to $578 million in 1995 (DSTR 1995). The average daily expenditure by visitors in 1995 was $120, an increase of 20 per cent over 1991.

Tourism infrastructure has been expanding in recent years. From 1990 to 1995, the number of motel rooms in Tasmania grew by 12.4 per cent and the number of hotel rooms increased by 1.7 per cent (Australian Bureau of Statistics 1995).

Table 6.8: Expenditure by visitors to Tasmania

	1991 $'000	1992 $'000	1993 $'000	1994 $'000	1995 $'000
Accommodation	135 000	149 000	147 000	168 000	204 000
Transport	85 000	89 000	81 000	92 000	129 000
Other	179 000	192 000	177 000	192 000	245 000
Total expenditure	399 000	430 000	405 000	452 000	578 000
Per capita	$985	$1 079	$962	$992	$1 200
Daily	$100	$98	$93	$106	$120

Source: Tasmanian Visitor Surveys, 1991 - 1995 (DTSR 1995a)

Visitors to Tasmania: interstate and international

In 1990, 366 600 people visited Tasmania from overseas and interstate. By 1995, this number had risen to 480 500 an increase of 31 per cent in six years (DTSR 1995).
In 1995 international visitors made up 15.5 per cent of visitors to Tasmania, the largest group of international visitors coming from Europe. The majority of interstate visitors came from Victoria (36 per cent) and New South Wales (22 per cent) (DTSR 1995a).
In 1995, the majority of visitors to Tasmania (72 per cent) were on holiday. From 1990 to 1995, holiday visitors increased by approximately 35 per cent. The percentages of visitors travelling for holiday, or business and other purposes were stable over this period (DTSR 1995). The average number of nights spent in Tasmania by visitors fell from 10.7 nights in 1991 to 9.9 nights in 1995 (DTSR 1996). This general downward trend has been caused by the increasing numbers of shorter-stay visitors, staying less than a week (DTSR 1995). In 1995, the total number of visitor nights increased notably (DTSR 1996).

Table 6.9: Adult visitors to Tasmania 1990 to 1995

	1992	1993	1994	1995
Number of visitors	398 100	421 000	456 400	480 500
Number of visitor nights	4 377 100	4 320 800	4 258 500	4 776 000
% change in visitor numbers from previous year	-1.6	5.7	8.4	5.3
% change in visitor nights from previous year	1.4	-1.2	-1.4	12.1

Source: DTSR 1996

Intrastate visitors in Tasmania

Intrastate travel is also an important contributor to the Tasmanian economy. Intrastate visitors are those Tasmanian residents who travel at least 40kms from their home and who stay at least a night away from home (the 40km rule does not apply for purposes of holiday and recreational activities).
In 1995, the average number of nights per trip was 2.6, the average expenditure per night was $47 and per trip was $119. These characteristics have been relatively stable over the period 1990 to 1995 (DTSR 1996).
There was a general decline in intrastate travel from 1993 to 1995. The decline in total trips of one night or more was approximately 20 per cent during this time. This decline could be attributed to a combination of increasing numbers of business visitations and falling numbers of holiday visitations. The share of business trips within Tasmania increased from 14 per cent in 1993 to 18 per cent in 1995 (DTSR 1996).
Intrastate visitors staying with friends or relatives decreased from 1993 to 1995. At the same time, the intrastate visitor numbers increased for hotels and motels (DOT 1996).

Nature based tourism

Nature based tourism is a broad term encompassing all forms of tourism occurring in natural areas (Forestry Tasmania 1994a). Subsets of nature based tourism include ecotourism, guided nature based tourism and adventure tourism. The popularity of nature based tourism in Tasmania is an important indicator of current trends and potential future interest in tourism and recreation in Tasmania's forests. Tasmania offers a range of attractions set in natural areas. State government and private sector marketing activities are drawing on Tasmania's natural areas as major drawcards and place strong emphasis on natural heritage, promoting Tasmania as having 'wilderness' and 'World Heritage' attractions (Forestry Tasmania 1994b).

There are numerous reports in the tourism literature that nature based tourism is an important component of global tourism and that the absolute number of visits are increasing annually, perhaps at a faster rate than tourism as a whole (Boo 1990, Lindberg 1991). Over 50 per cent of international visitors to Australia visit a National Park or other natural area (Blamey 1995).

Ecotourism is sometimes referred to as 'responsible tourism', and is defined in the National Ecotourism Strategy as 'nature based tourism that involves education and interpretation of the natural environment and is managed to be ecologically sustainable' (Allcock et al. 1994, p. 17). The National Ecotourism Strategy suggests four elements that comprise ecotourism. These consist of:

- the natural environment
- ecological and cultural sustainability
- education and interpretation
- provision of local and regional benefits.

Guided nature based tourism involves using the services of professional tour guides and may utilise specialised equipment.

Adventure tourism is a form of guided nature based tourism aimed at deliberately challenging the hazards of a natural environment using specialised skills and equipment, and endurance. It is marketed as an adventure experience and the research of Forestry Tasmania indicates that it is used as a stimulating means of exploring an area (Forestry Tasmania 1994b).

Nature based tourists to Tasmania

Around 75 per cent of international and interstate visitors to Tasmania during the period 1993 to 1995, participated in nature based tourism. Ninety per cent of all international visitors participated in nature based tourism, in comparison to 75 per cent of interstate visitors (DTSR 1994c).

This information has been drawn from an analysis of the Tasmanian Visitor Survey (DTSR 1996). Nature based tourists are defined by DTSR as visitors to one of 22 identified sites in national parks, state forests or other natural areas and who participated in; caving, a river cruise, trout angling, four wheel driving, rafting, boating, sailing, canoeing, sea kayaking or bushwalking.

In 1993, bushwalking was an activity for 59 per cent of these nature based tourists. The majority of walks were two hours or less. Relatively small numbers of nature based tourists, less than 10 per cent, participated in any of the soft adventure activities. These include four wheel driving, rafting, sailing and canoeing or sea kayaking. Thirty four per cent of these tourists took a river cruise and 16.6 per cent visited a cave. Nature based tourists to Tasmania spent 3 389 000 nights in the state in 1993, of which 122 000 nights were spent in a wilderness cabin or lodge (DTSR 1994c).

Tourism and recreation in Tasmania's forests

This section describes tourism and recreation in national parks and other conservation reserves administered by the Department of Environment and Land Management, state forests and forest reserves administered by Forestry Tasmania, and private forests. This provides a broad overview of tourism and recreation in forests. Most of Tasmania's national parks contain forests, although forest is not a feature of over half of the Tasmanian Wilderness World Heritage Area.

The type of tourism and recreation that occurs in national parks and state forests and other reserves is governed by regulations on allowable activities, and these vary with tenure and with management plans for specific reserves. Thus the opportunities and constraints for recreation and tourism in national parks differ somewhat from those in state forests. Generally, tourism and recreation in national parks and similar reserves is more constrained than that in state forests, for example, people are not allowed to take dogs into national parks. However, the extra protection accorded the natural environment in conservation reserves can provide for specialised ecotourism and recreation. In state forests, the availability of logging roads in particular, and fewer constraints on visitors, can provide for different types of recreation activity. The distinction is not clear-cut, for example, ecotourism activities are supported in areas of state forests while fishing is permitted in some National Park areas.

This difference in activities permitted and provided for in different reserves is relevant to the comprehensive regional assessment process as any change in classification of an area may have implications for tourism and recreation opportunities. It is relevant to try to identify whether there are particular trends towards types of tourism that are favoured by particular management conditions. Across all areas used for nature based tourism, bushwalking was the most common activity offered by commercial operators in 1993. In general, guided walks primarily occurred in protected areas such as national parks and reserves, while a range of other nature based activities (see state forests section) occurred in state forest in 1993 (Forestry Tasmania 1994a).

The Public Land Use Commission reported that information collected in a recent Inquiry into Tasmania Crown Land Classifications revealed a strong demand for recreational use of public forests. Tasmanian recreational groups include 'clubs and associations of anglers, recreational vehicle drivers, trail and high country horse riders, shack owners, beekeepers, field and game hunters, hound owners and a number of other general recreation groups' (PLUC 1996, p. 115). It was observed that such groups identify with a culture of traditional recreational use of the land.

The following descriptions establish the extent of tourism and recreation, trends, resources and issues, for the crown tenures and private forests.

Tourism and recreation in state forests

Within Tasmanian state forests, selected areas have been set aside as forest reserves specifically for purposes other than wood production. The total area currently designated as forest reserves is 46 400 hectares, of which 3 400 hectares is part of the Tasmanian Wilderness World Heritage Area. These areas have been formally gazetted. They are managed for recreational, scientific, aesthetic, environmental or protection purposes (Forestry Tasmania 1994c). A further 37 300 hectares are to be proclaimed later this year, subject to parliamentary approval, bringing the total area of forest reserves to 5.2 per cent of Tasmania's state forest estate.

With some minor exceptions, most forest reserves do not allow timber harvesting or the removal of plants and animals. Mineral exploration is only permitted in those forest reserves that have been brought under the provisions of the *Mineral Resources Development Act 1995*. While there are no legislated limitations placed on activities that are allowed in forest reserves, reserve-specific management plans may limit activities in some forest reserves. However, tourism and recreation are encouraged on all state forest, which includes forest reserves (with the exception of areas where forest operations are current).

Sites and infrastructure

In Tasmanian state forests, there are 126 designated visitor sites. Thirty four of these are 'primary' sites which are currently managed as key visitor sites, 14 are 'secondary' sites and 76 are 'tertiary' sites, with the latter two categories less actively managed.

Visitor numbers and activities

Forestry Tasmania's information on visitor numbers is based on a combination of different data collection methods including surveys and traffic counters. The information gathered is therefore a series of estimates only. Some of the data was collected in 1992 and is somewhat dated.

In 1993 Forestry Tasmania recorded 300 000 visitors to major attractions in state forest. Including those visitors to lesser known areas within state forest, Forestry Tasmania estimates that the number of visitors to all Tasmanian state forest would be in the order of 400 000. Over the period 1992 to 1994, visits to forest sites increased by 5 to 6 per cent annually following a stable 10 year period (Forestry Tasmania 1994b).

Current visitor numbers are available for some of the most popular sites, see Table 6.10. The significant increase in visitor numbers may be partly the result of the introduction of entry fees to national parks and partly due to better provision of facilities and promotion of opportunities.

Table 6.10: Visits to selected forest reserves

Site	1994-95	1995-96	% change
Tahune	38 697	45 812	+18.4
Liffey	19 266	26 425	+37 1
Evercreech	2 849	3 296	+15 7
Hollybank	6 534 (Apr-Jun)	8 623 (Apr-Jun)	+31.7
Teepookana	3 769 (Jan-May	5 462 (Jan-May)	+45.0
Milkshake Hills	na	4 251	na

Source: Forestry Tasmania

Forestry Tasmania sees recreation and tourism (of which nature based tourism is a sub-set) as a part of the multiple-use management of state forests and is keen to further promote and develop nature based tourism opportunities (Forestry Tasmania 1994b). Visitor management is guided by the *Tourism Policy for Tasmania's State forests*, developed after public consultation (Forestry Tasmania 1995).

In managing recreation and tourism in state forest, Forestry Tasmania identifies four groups of visitors. Independent visitors, those who prefer to visit in a self-reliant manner, make up 83 per cent of tourists to Tasmanian state forests. Visitors on guided tours, preferring assistance from knowledgeable professionals, make up 12 per cent of visitors. Special event visitors are infrequent visitors following events that are not routine. They make up 3 per cent of all visitors to Tasmanian state forests. Service sector visitors prefer to use transport services to access state forests and make up 2 per cent of visits (Forestry Tasmania 1994b). Some of the nature based activities undertaken by tourists in Tasmanian state forests include bushwalking, camping, rafting, fishing, four wheel driving and horse-riding. Over the period 1991 to 1993, short easy walks of between 10 and 30 minutes were by far the most popular activity undertaken and the most popular type of walk was one which visited a distinctive and unique natural attraction, such as a waterfall or a big tree (Forestry Commission Tasmania 1992).

Visitation to state forest is seasonal, with the majority of visits occurring during the summer months December to March. The three most popular sites in 1992 were Hollybank, Oldina and Fortescue. Visitors to forests in Tasmania are attracted by transport routes, distinctive experiences and easy accessibility by vehicle in a short time. The traditional sites, Hollybank and Oldina, experienced a return visitation rate of 85 per cent in 1992, with 26 400 visitors to this site being regular visitors and the remaining 6 600 were first time visitors. Growth in the visitation rate to various Tasmanian sites has been attributed to improved facilities and marketing (Forestry Commission Tasmania 1992). The high number of independent visitors and repeat visitors suggests that Tasmanians make up a relatively high proportion of visitors to state forests, but further research is required to establish proportions accurately.

Commercial operations

Many areas of Tasmania's state forests are used by commercial nature based tourism operators. A list of tourism operators in state forest was first compiled in 1993 and listed 60 operators. Forestry Tasmania now has approximately 80 commercial operators registered to operate in state forests (Forestry Tasmania unpublished). A list of the number of operators and activities, by forest districts, is included in Appendix 6.2. The most commonly offered activities are four wheel drive touring (available on 20 tours), bus tours (18 tours) and walking (11 tours). It is not apparent that any types of tours are increasing at a faster rate than others.

Forestry Tasmania is currently exploring opportunities for the private sector to develop tourism infrastructure in state forests. Forestry Tasmania intends to seek expressions of interest in developing tourism infrastructure in a number of broad areas where opportunities have been identified. The successful applicant for providing accommodation at Fortescue Bay, on the Tasman Peninsula, is currently being selected.

Visitor fees

Entry fees are not charged to state forest reserves. Camping fees are charged at a number of sites. Revenue raised is used to maintain the site.

Capacity of sites

Intensity of facility use in state forests is critical in the management of sites. During peak periods, some facilities may not be able to meet demand and increased pressure can place stress on the environment. In off-peak periods, some facilities may not be fully utilised. It was estimated by a vehicle survey undertaken in 1991, that peak traffic levels can be up to 11 times greater than the average levels of daily traffic. The greater the intensity, the more stress that can be placed upon the resource and the facilities. Visitor enjoyment may also decrease. The sites with a growing, high level of use have been identified as those requiring immediate attention (Forestry Commission Tasmania 1992). Forestry Tasmania identifies direction for its visitor sites and infrastructure via visitor management strategies, developed at a district level (there are seven districts in Tasmania). The visitor management strategies include three year programs of works for infrastructure, maintenance and development, subject to budget limits.

Tourism and recreation in national parks and other public land

Twenty per cent of Tasmania's total area is now classified as the Tasmanian Wilderness World Heritage Area . This stretches from Cradle Mountain in the north to South West Cape and the islands beyond (Parks and Wildlife Service 1996). national parks are areas, generally larger than 4000 hectares, set aside to reserve outstanding natural and cultural features. Other reserve areas include state reserves, conservation areas and nature reserves. These reserve classifications ensure the conservation of areas and provision for different types of recreation. The Department of Environment and Land Management, through the Parks and Wildlife Service, Tasmania is responsible for managing national parks and other conservation reserves (DTSR 1994a,b,c).

Reserves and activities permitted

The Department of Environment and Land Management is responsible for managing a number of different types of reserves, as declared under the *National Parks and Wildlife Act*, *1970* or the *Crown Lands Act 1976*. Reserves under the National Parks and Wildlife Act are given in Table 6.11.
Land managed under the *Crown Land Act 1976* includes protected areas, coastal reserves, river reserves, state recreation areas and unallocated Crown land. Various recreation activities may be conducted in all categories of land and include bushwalking, camping, four wheel driving (on formed roads), sightseeing, photography, swimming, picnics, orienteering, climbing and bird watching. Under the two Acts, there is little difference in the types of recreation that may occur in the different reserve types, apart from regulations relating to hunting and animals such as dogs and horses. The management objectives of the reserve type and the peculiarities of the reserve largely determine the extent of recreation activity in a given area.

Table 6.11: Reserves under the National Parks and Wildlife Act.

Major conservation category	Reserve title	Total area (ha)

State reserves	National parks	1 366 809
	State reserves	19 906
	Nature reserves	41 280
	Historic sites	16 066
	Aboriginal sites	713
Game reserves	Game reserves	11 634
Conservation reserves	Wildlife sanctuaries and conservation reserves	107 596
	Muttonbird reserves	8 466

Source: DELM 1995

State reserves and conservation areas can be considered the most strict categories. Activities generally not allowed include hunting and taking in domestic animals such as dogs and horses. State reserves are usually set aside for the protection and maintenance of natural or cultural values, features or landscapes, while providing for ecologically sustainable recreation consistent with the area's values.

However, game reserves are often set aside specifically to allow for the taking of specific types of wildlife including muttonbirds and wallaby. In other respects they have the same status as a state reserve (Parks and Wildlife Service Tasmania 1994).

The management objectives of lands under the Crown Lands Act gives some idea of how they are to be managed for recreation. Protected areas are managed to allow the 'controlled use of resources while protecting the natural environment and encouraging community recreation', while state recreation areas are managed 'to provide for community recreation, with some controlled commercial use of resources, whilst protecting the natural environment' (Tasmania Land Map 1992).

Visitor numbers and activities

The information collected by the Parks and Wildlife Service on visitors to national parks utilises a number of approaches, combining data from traffic counters, head counts and ticket sales. This data is complemented with that from the Tasmanian Visitor Survey which provides some detail of the interstate and overseas component.

Table 6.12: Visits to national park centres and other state reserves

Centre	Total visits / visitors (est) 1994-95	Total visits / visitors (est) 1995-96
Freycinet	194 000	209 000
Cradle Mountain (Lake Dove)	171 000	169 000
Mount Field	120 000	140 000

Lake St Clair	92 000	99 000
Asbestos Ranges (Bakers Beach)	26 000	32 000
Newdegate Caves	26 866	29 407
Thermal Pool	31 785	32 921
Marakoopa Cave	24 839	24 306
King Solomans Cave	21 954	21 002
Maydena Gate	40 000	40 000
Maria Island (Darlington)	12 000	11 700
Mount William (Northern End)		31 000

Source: Parks and Wildlife Service 1996

Visitor numbers over time have varied from site to site over the past 20 years. For instance, Lake St Clair experienced a four-fold increase in the number of visitors in the mid to late 1970s, and there has been little growth in the absolute numbers since this time. Visitor numbers to Lake Pedder have halved since the 1970s, while visits to Cradle Mountain have doubled since the mid 1980s . However, in terms of the larger world heritage parks, there is some evidence to suggest that while the numbers may have been changing, the type of visitor has not, at least not over the past 15 years. The majority of visitors to these parks are from interstate and stay for less than one day, often in transit between places of accommodation. They do not stray out of the immediate visitor zones (Carlington 1988, and TVS unpublished).

The introduction of entry fees in 1993 led to a decrease in attendance at parks which were characterised by local day use. Anecdotal evidence suggests that these users were displaced to other sites for their activities, be they other Parks and Wildlife Service sites where fees were not collected, or other reserves outside Parks and Wildlife Service jurisdiction. The introduction of a revised schedule of fees has met greater acceptance by the local population, with the result that attendances at the affected parks are now approaching pre-1993 levels.
The Tasmanian wilderness world heritage area provides tourists with various recreational pursuits. Walking, boating, rafting, canoeing, fishing, skiing, caving and climbing are but a few. Several major roads provide access to the world heritage area, and although the number of off-road tracks for four wheel driving is limited, the world heritage area provides enthusiasts with the opportunity to visit otherwise remote locations (Department of Parks, Wildlife and Heritage 1992).

Commercial operations

There is a range of commercial tours and other commercial activities in Tasmanian national parks. The Parks and Wildlife Service requires that operators in state reserves are licensed. A number of operators are members of industry associations in the process of developing accreditation standards. A listing of the number of operators licensed to operate in national parks and other conservation reserves, and activities offered, is included in the Appendix 6.2.

The most common form of tour is walking, whether bushwalking, guided walks or nature walks. The total number of walking tour possibilities offered by operators in state reserves is 130. The next most common form of tour is four wheel drive tours, with 11 tours offered.

The Tasmanian government has supported the construction of accommodation in and adjacent to national parks. There are currently five accommodation establishments licensed to operate in national parks. Where there are management plans for national parks, these set guidelines for the appropriate location, type and degree of infrastructure. If there is no management plan, assessment of proposals for infrastructure development occurs case by case.

Visitor fees

Entry fees have been charged to visit Tasmanian national parks since 1993 -94. Tourists in Tasmania in 1993 were surveyed on their perception of value received from National Park fees. Fifty-four per cent had no experience with fees, 36 per cent said they received value from fees and 9.4 per cent found no value in fees (DTSR 1994c). In 1994, a review of the then-current fee structure for national parks was undertaken and on November 1 in that year, fees were charged per car, instead of per person entering the park.

The Tasmanian National Park fee structure is based on the length of time spent in national parks and the mode of transport within the parks. Stays in national parks are classified as daily, short-term (up to two months) and annual.

The total revenue collected for 1994-95 was $1 368 570, compared with a similar total collected in 1993-94 (DELM 1995). About 52 per cent of this revenue was put back into Tasmania's national parks and reserves, being used for the general upgrading of facilities in parks and reserves (DELM 1995). Total revenue for the 1995-96 was approximately $970 000, down considerably on previous years possibly because of the introduction of fees at some facilities.

Capacity at sites

The issue of appropriate levels of tourism and recreation at sites in the Tasmanian Wilderness world heritage area is being addressed in the current review of the management plan. The first management plan was implemented in 1992. Tourism and recreation are deemed appropriate uses because 'presentation' of the world heritage area is one of the objectives for management. However, the objective of long-term protection of the environment over-rides all other objectives. The present management plan delineates four zones and sets policy guidelines on appropriate visitor infrastructure and use in each zone. A major issue is finding the right balance between wilderness and provision of facilities. This is an issue not only for conservation reasons but also in terms of retaining the attractiveness of areas to visitors and allowing for a range of visitor experiences. Due to the multiple objectives of the world heritage area, and to provide a variety of visitor experiences, there are limits on the capacity of the world heritage area to support growth in tourism. It is suggested in the existing management plan that some facilities should be developed on land adjacent to the world heritage area (Parks and Wildlife Service Tasmania 1996).

Tourism and recreation in private forests

Private forests in Tasmania are used for a range of recreational activities. The community derives value from tourism and recreation in private forests, and in some cases, landowners earn income from these activities.

There have been no documented studies of the overall extent of tourism and recreation in private forests. A brief description of use has been compiled, based on discussions with some private operators.

The activities undertaken in private forests include fishing, hunting, four wheel driving and horse-riding. Access is gained by knowledgeable Tasmanian residents who make agreements with landowners and commercial operations, including lodges and tours.

The use of private forests for fishing includes agreements with landowners for access to stream banks (usually at no fee) and commercial operations. Hunting of deer and native animals occurs on private lands. A number of private farms have property based management plans which incorporate the private licensing of hunting rights. In some cases, hunters provide a service to landowners in the form of culling wildlife and may compensate landowners for vegetation damage. There are some commercial game farms in forest areas where hunters pay a fee . A number of farm stay establishments have a private forest backdrop. Activities in forests originating from such accommodation range from casual walks to riding trails.

Further research is needed to assess the social and economic value to the community of tourism and recreation in private forests. Should areas of private forests be considered during the comprehensive regional assessment process for addition to the conservation reserve system, the extent of use for tourism and recreation should be investigated and the potential impact of a change in access rights on the community and landowners will be evaluated.

Economic value of tourism in national parks and state forests

Around 75 per cent of visitors to Tasmania visit at least one natural site or participate in a nature based activity. Although only a proportion of each tourist's total visit to Tasmania is spent visiting forests and other natural sites, the ability to do this may be an important determinant of their entire trip to Tasmania. In a 1987 survey of visitors to national parks, approximately one third of tourists interviewed indicated they would not have travelled to Tasmania at all if the national park localities they visited had not existed (Centre for Regional Economic Analysis 1987). Thus, the setting of boundaries for defining the economic value of tourism and recreation in national parks and state forests should incorporate more than just the direct use value presented here.

An important source of information on the economic contribution of natural areas is a study of *The Contribution of the Department of Parks, Wildlife and Heritage to the Tasmanian Economy in 1991-92* (Centre for Regional Economic Analysis 1993). This study employs input output analysis to estimate some economic impacts of expenditure in the Tasmanian economy related to the existence of the sites administered by the Tasmanian Department of Parks, Wildlife and Heritage (now the Parks and Wildlife Service). Four sources of contribution were identified:

- expenditure by visitors to localities (national parks, historic sites and state reserves) administered by the Department of Parks, Wildlife and Heritage and for travel to localities;
- spending by the Commonwealth government on behalf of the Department of Parks, Wildlife and Heritage (contribution to World Heritage area management);
- spending by the Tasmanian government of revenue raised as fees; and

- spending by tourists on commercial tours in Department of Parks, Wildlife and Heritage localities, and on products from these areas.

The total expenditure by visitors to sites was estimated from a 1986-87 survey. The estimated expenditure, including transport to the site and some accommodation, at all Department of Parks, Wildlife and Heritage sites was $62.5 million, in 1986-87 prices. A result of a similar order of magnitude was obtained by Driml (1994) who estimated the gross expenditure associated with visits to the Tasmanian Wilderness world heritage area was $59 million in 1991-92, including the costs of visiting and staying two nights in accommodation in the adjacent regions, but excluding the cost of transport to southwest Tasmania.

The Centre for Regional Economic Analysis (1993) estimated the contribution of the Department of Parks, Wildlife and Heritage to the Tasmanian economy in terms of three separate indicators; aggregate income, employment and wages income. The Centre for Regional Economic Analysis stressed that these were three alternative contribution estimates and not measures of contribution to welfare. The direct contribution is that directly attributed to the four expenditure categories above, while the indirect contribution is the economic activity generated in the rest of the economy that would not have occurred in the absence of the Department of Parks, Wildlife and Heritage.

This type of analysis is useful in emphasising that areas with seemingly little infrastructure or economic activity actually do make a tangible economic contribution to the state by virtue of the expenditure by visitors in reaching the area and purchasing commercial services in the area.

Research work currently underway by Centre for Regional Economic Analysis and the Australian Bureau of Agriculture and Resource Economics, using regional general equilibrium modelling, will provide updated estimates for forest based tourism and recreation, including in state forests, for use in the comprehensive regional assessment.

Table 6.13: The contribution of the Department of Parks, Wildlife and Heritage to the Tasmanian economy

Measure	Contribution	Proportion of total for Tasmania	Fraction contributed directly	Fraction contributed indirectly
Employment	2117 jobs	1.1% of total state employment	55%	45%
Aggregate income	$66 801 000	0.8% of gross state product	46%	54%
Wages income	$41 371 000	0.9% of state wages income	53%	47%

Source: Centre for Regional Economic Analysis 1993

There is increasing commercial activity associated with Tasmania's national parks and state forests. The number of commercial operators has been detailed in Appendix 6.2. This sector has expended considerably in recent years. Specialist accommodation has also developed adjacent to, and in some cases inside, national parks and state forests. The level of investment or profitability of this sector has not been documented.

Entry fees are charged for Tasmanian national parks, but not for State forests. These fees are set administratively by the Parks and Wildlife Service and as such are not an indication of the willingness to pay for entry that would be achieved in a market. However revenue from fees is an indication that willingness to pay for entry is *at least* this amount. The total revenue collected in National Park fees in 1994-95 was $1 368 570. Around 52 per cent of this was returned to management of Tasmanian national parks (DELM 1995).

The market price of a resource is its revealed value. There is no existing market for the use of forests for tourism and recreation. An important economic indicator of relevance is the economic value that would be used in an economic efficiency analysis. This is the value that visitors place on the ability to gain access to forest resources. As this value is not revealed in dollar values in a market, it is necessary to use economic valuation methodologies to estimate willingness to pay for access. Methodologies such as the travel cost method and contingent valuation are available for such assessments. There have been no such studies identified for forest areas in Tasmania.

Employment

As noted above, the 1993 Centre for Regional Economic Analysis study estimated that the total employment in Tasmania attributable to the existence of the sites of Tasmanian Department of Parks, Wildlife and Heritage was 2117 jobs, made up of a direct component of 1160 jobs and an indirect component of 957 jobs. No similar assessment for state forests is available at this time.

In addition, there are accommodation establishments, transport services and service industries throughout Tasmania that are dependent to some extent on the tourism and recreation that is attracted to Tasmania's national parks and state forests. No current assessment of the proportion of the industry directly dependent on this resource, and therefore the direct employment generated, is available.

Research work currently underway by the Centre for Regional Economic Analysis and Australian Bureau of Agriculture and Resource Economics will provide updated employment estimates for use in the comprehensive regional assessment.

A study of guided nature based tourism in Tasmania found that a typical operation had nine employees during the peak operating period (Forestry Tasmania 1994a).

Outlook and strategies

Regional Forest Agreements are proposed to stand for 20 years, so it is relevant to look at outlooks and strategies for tourism and recreation that go beyond the current situation. This is especially relevant for tourism, which in recent years has grown significantly and is predicted to continue to grow. In this section, the outlook for the demand for forest access for tourism and recreation and the implications for the forests is considered.

Demand for tourism and recreation in forests

The future demand for tourism and recreation in Tasmanian forests will be determined by a number of factors including levels of international and domestic tourism in Australia, Tasmania's share of this tourism, trends in nature based tourism and perceptions of the attractiveness of Tasmanian forests for tourism

and recreation. These factors are discussed in turn.
Predictions about the future of international tourism to Australia, made by the Tourism Forecasting Council, are for a continuation of the high rates of growth experienced in the last decade. In the 10 years to 1995, overseas visitor arrivals tripled; visitor numbers are projected to double to 8.8 million in 2005 (DIST 1996).

Domestic tourism over the last decade has shown a pattern of growth and decline, aligned to national economic conditions. From 1984-85 to 1993-94, the average annual growth rate in the number of trips taken was 0.7 per cent. The Tourism Forecasting Council predicts a higher growth in domestic tourism over the next five years, with a 2.0 per cent per annum increase in visitor nights (DIST 1996).

Tasmania's share of Australia's international tourism market has remained fairly constant at a share of 2 per cent over the last decade. The number of interstate visitors has grown by 4.7 per cent annually, a higher rate than the national average noted above. Tasmania's share of national interstate trips has increased from 2.5 per cent to 3.1 per cent over the decade (DTSR 1995b).

There were 480 500 international and interstate visitors to Tasmania in 1995 (DTSR 1996). A conservative estimate of future tourist numbers has been developed for this profile based on Tasmania retaining its 2 per cent share of international tourists to Australia and the national projected rate of growth in domestic tourism of 2 per cent per annum. This estimate indicates that the number of tourists to Tasmania could increase by 40 per cent over current numbers by 2005.

The 1995 *Strategies for Growth* document from the Tasmanian Department of Tourism, Sport and Recreation adopts a 3.5 per cent growth rate for future projections (DTSR 1995b). It is also projected that Tasmania's share of international tourism could increase to between 2.1 per cent and 2.5 per cent by the year 2005. These higher projections incorporate an assumption that the natural attractions of Tasmania will be sought increasingly as the popularity of nature based tourism grows. Based on a 3.5 per cent growth rate for interstate tourism and 2.5 per cent of international tourists, the number of visitors to Tasmania could increase by 59 per cent by 2005.

The implications for tourism and recreation in forests is that increased numbers of tourists to Tasmania will flow on to visits to national parks and state forest areas. This is particularly likely if nature based tourism is a major attraction to the people who visit Tasmania. The higher tourism projections reported above imply there could be a doubling of visitors to forest areas between 1995 and 2010. The economic value of forests to tourism is therefore likely to increase over the period of a Regional Forest Assessment.

It is difficult to predict future demand for visits to forests by Tasmanians. The Tasmanian intrastate visitor survey (DTSR 1996) recorded a decline in the number of intrastate visits between the years 1993 and 1995, yet visits to State forest sites are increasing. One reason for this may be the different methodologies used for data collection by these two surveys.

Future facilities for tourism and recreation in forests

As well as indicating an increasing value of forests for tourism, the projected growth rates raise questions about the future availability of sites and facilities for future tourism and recreation in Tasmania's forests. Consideration of the capacity of existing dedicated sites, tracks and roaded areas to provide quality experiences for a larger annual number of visitors without adverse environmental impact is relevant. Additional facilities and sites may need to be developed or prices increased to ensure ecologically sustainable tourism.

The options for accommodating increasing numbers of visitors include allowing visitor numbers to increase at existing sites and providing additional sites. If visitor numbers are to be accommodated at existing sites at ecologically sustainable levels and without reducing the quality of visitor experiences, adequate and appropriate infrastructure will be required.

Experiences at the wilderness end of the spectrum will not be able to be maintained if visitor numbers to sites increase. The review of the management plan for the Tasmanian wilderness world heritage area suggests that some sites may have reached capacity, in terms of visitor experiences and environmental impact (Parks and Wildlife Service 1996).

It may be that only a small proportion of visitors will seek a true wilderness experience. For example, the proportion of visitors to Tasmania who took an overnight bushwalk was 3.1 per cent in 1995 (DTSR 1996). A larger proportion of future visitors may be satisfied with wilderness type experiences that may be provided in national parks or state forests where management is directed towards providing these conditions. As mentioned previously, the ability to spread the load from national parks to state forests has been suggested. This might imply dedicating further state forest areas to tourism and recreation.

A further issue is the accommodation of Tasmanian residents who may be displaced from their traditional recreational pursuits in sites where upgraded visitor infrastructure is provided. Introducing entry fees to national parks has displaced some Tasmanians.

Potential conflicts between different types of tourism and recreation

The different regulations regarding tourism and recreation on different Crown land reserve types has led to some differentiation between the types of activities supported in national parks and reserves in state forests. In particular, the types of tourism and recreation that depend upon highly protected areas are most likely to be provided in national parks.

Alternatively, state forest reserves allow for a range of tourism and recreation uses that are not permitted in national parks.

> What is the impact on tourism and recreation of a transfer of land from state forest tenure to other conservation reserve tenures, for example National Park?

It seems that future demand for forest tourism and recreation will favour activities in both national park type reserves and state forest type reserves. Assessment of the impact of forest use options on tourism and recreation in any particular area will need to be assessed case by case. Such assessment would however be assisted if it were in the context of a statewide strategy.

Conclusions

This profile has identified that tourism and recreation in Tasmania's forests is economically significant, not only in direct terms but also because in terms of employment opportunities indirectly generated by tourism and recreation which are significant to Tasmania as a whole and in a number of communities.

Tourism and recreation are compatible with land managed for wood production and other forest values. This is supported by estimates that visitation to state forests is growing at between 5 and 10 per cent per annum.

State Forests and state reserves are substitute resources for some types of tourism and recreational activities in that the same activities can be undertaken on both types of land. For other tourism and recreational activities state forests and state reserves are complementary resources.

Tourism and recreation are likely to grow, and visitors to Tasmania fore nature based tourism will perhaps double over the period of a Regional Forest Assessment. Achievement of the potential economic benefits of tourism and recreation growth requires that the attraction on which it is based is secure. This requires not only the provision of an adequate number and quality of sites and facilities but also the maintenance of perceptions of quality natural attractions.

Meeting future demand for sites and facilities the essential issue for allocating forest land for tourism and recreation in the comprehensive regional assessment process.

Apiculture

Tasmania has good conditions for commercial beekeeping. Tasmania's apiculture industry is important to the State's economy and employment. The number of hives has increased in recent years, although the State has few large apiaries compared to the rest of Australia. The industry depends (60 - 70 per cent of total production) on the State's leatherwood forests. Tasmanian beekeepers gear their operation to produce the maximum amount of honey from leatherwood. The remainder is mostly 'white honey' derived from blackberries and clover. Tasmanian honeys are of particularly high quality. European honeybees (*Apis mellifera)*, were introduced to Tasmania in 1831. Honey production is the primary focus of the beekeeping sector. Other products are beeswax, honeycomb and pollination services.

Leatherwood honey is unique to Tasmania commanding a price premium due to its distinctive appearance and taste. It was commercially produced for the first time in the early 1920s by a beekeeper at the west coast port of Strahan. Around 20 years later, beekeepers began taking hives to the leatherwood country from other parts of the State. Now, some 80 beekeepers take over 12 000 hives to work the leatherwood blossom every summer. On average these hives produce a total of 280 tonnes of honey.

Australia has over 2000 commercial beekeepers with between 40 and 2000 hives each. Total annual honey production averages 25 000 tonnes varying between years because of seasonal factors. In 1993-94, Australian production was 25 990 tonnes with 623 tonnes produced in Tasmania. Tasmania's share of the national market varies due to seasonal fluctuations (in 1991-92 it was over 6 per cent whilst in 1993-94 it was about 3 per cent). In 1990-91, Tasmanian honey production was 972 tonnes which represented a farm gate value of $1.7 million and $4.4 million (0.05 per cent of gross state product) in value-added terms. In addition, industries reliant on bees for pollination services contribute an estimated $111 million (1.5 per cent of gross state product) to the economy. Pollination services to a variety of horticulture and small seed crops is a developing aspect of the apiculture industry.

Sales of honey and honey products (pure, blended, candied and creamed honeys and beeswax) are to the domestic market (Tasmania 20 per cent, inter-state 50 per cent) and the overseas market (30 per cent). In 1994-95, Tasmania exported 188.1 tonnes of honey. Most honey exported from Tasmania (77 per cent) is pre-packed or value-added (Table 6.14).

In 1994-95, Tasmanian apiarists also exported 2.5 tonnes (worth $6300) of natural honeycomb and 5.8 tonnes (worth $26 000) of beeswax.

Table 6.14: Exports of honey from Australia (1994-95)

	Bulk (tonnes)	**Pre-packed (tonnes)**	**Total exports (tonnes)**
Tasmania	42.7 (23%)	145.4 (77%)	188.1
Australia	7712.4 (80%)	1888.9 (20%)	9601.3

Source: Australian Bureau of Statistics

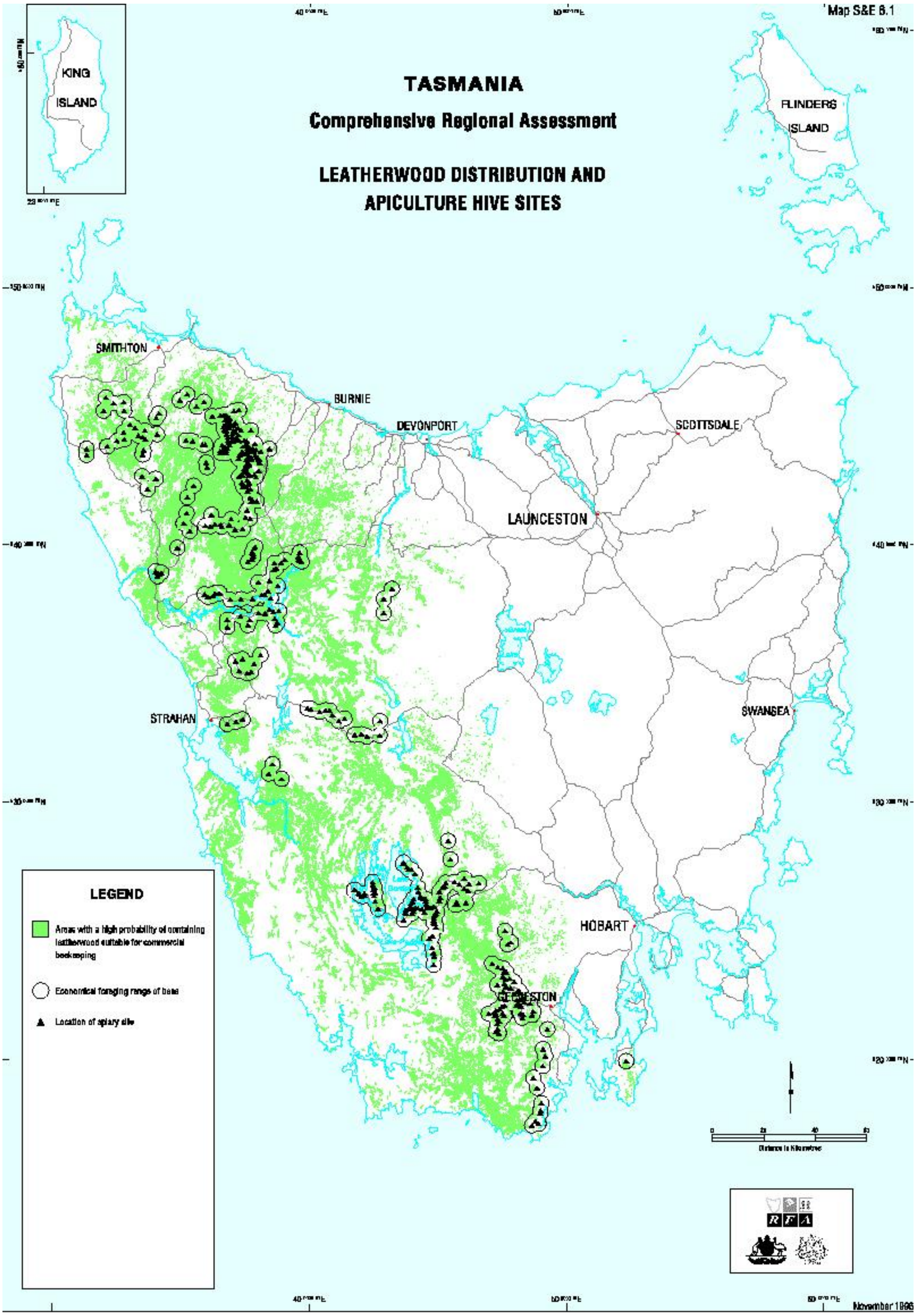
6.3.1 Characteristics of the industry

Structure

Anyone in Tasmania who keeps bees must be licensed by the department of primary industries and fisheries. In 1992 there were 732 licensed beekeepers with about 15 750 hives. About 60 per cent of hives (9600) were owned by 20 beekeepers. Currently there are 750 - 800 apiarists, the majority of them small, part-time operators. There are about 20 larger operators, with about twelve classified as full-time beekeepers. The industry is labour-intensive, mostly employing people living in country areas. Apiaries with more than 100 hives employed a total of 47 full-time and 57 part-time (Gifford 1990).

Leatherwood forest resource

(Map S&E 6.1 Leatherwood and apiculture hive sites)



The area of forest in Tasmania which contains leatherwood is estimated at 774 000 hectares. Apiarists have access to about 202 000 hectares. Access is mainly limited by the existence of roads and the economic foraging range of bees. All accessible leatherwood sites in the State are being utilised. Information on leatherwood forest used for apiculture in different land tenures is given in Table 6.15.

Management responsibilities for these land tenures and classifications lies with two State government authorities. Forestry Tasmania, under the Forestry Act manages the majority of leatherwood forest used for apiculture. The Department of Environment and Land Management manages the world heritage area under the National Parks and Wildlife Act.

Good beekeeping depends on having colonies at top production strength for the honey flow and making optimal use of consecutive flowerings of different species. Forests provide both nectar and pollen. Pollen which is vital to the health of honeybee colonies is essential for the conditioning of hives managed for crop pollination activities. Bees produce honey from nectar.

During the year, a commercial beekeeper will access two or three different floral resources. Those produced from public lands will usually be the largest. Beekeepers have traditionally obtained access to public forests through a system of apiary site rights.

Table 6.15: Leatherwood forest used for apiculture (Ziegler 1993)

Tenure	Leatherwood forest area used for apiculture (%)
Multiple use forest land	54.0
Deferred forest land	16.3
Forest reserve	0.5
Recommended areas for protection	14.3
World heritage area	10.0
Unallocated Crown land, Hydro-Electric Commission land and private land	4.5

In commercial beekeeping, choice of apiary site is influenced by the number of beekeepers already in the area and the suitability of the locality. Important factors include whether sites are:

- accessible at all times of the year, by permanent roads;
- reasonably flat, even and well-drained;
- adequately sheltered from the prevailing wind; and
- naturally warm and dry with a slope toward the north or north-east.

Specific geographical areas

Of the more settled areas of Tasmania, the northwest has extensive areas of clovers and pastures, blackberries, eucalypts and accessible leatherwood. Most of the State's commercial production is located between Longford and Smithton, with good possibilities around Scottsdale and in the northeast.

Other intensive beekeeping areas are the fruit-growing districts of the south, with an assured extended honey season beginning with early stone fruits in August, peaches in September, apples in October and berry fruits in the foothills until December.

Isolated areas of high potential for beekeeping are in the Tamar Valley in the north, and the Derwent Valley and Tasman Peninsula in the south. Most of the available leatherwood areas are in the west, northwest and southwest.

Elsewhere, consecutive flowering seasons across a number of floral resources do not occur, so honey production is patchy, dependent on short periods of eucalypt blossom, or local flora such as tea-tree and prickly box. Areas of heavy rainfall in the west and northwest and the exposed belt of elevated country in the Midlands are generally unsuitable as home sites.

Amateur beekeeping is undertaken in all parts of the State because the apiary site is usually alongside a beekeeper's home.

Honey-producing flora

Leatherwood (*Eucryphia lucida* and *E. milliganii*) grows in the rainforests of western Tasmania. It flowers annually, usually from late December to March.

Blackberry (*Rubus fruticosis*) and Clover (*Trifolium repens*) grow and flower together and yield from mid-December to late-January. Blackberry is a more reliable nectar source than clover. The timing of blackberry flowering is crucial in the flowering sequence to build hive strength for summer. Without the blackberry resource Tasmania's white honey output would be significantly reduced and apiarists would need to use sugar to build hive strength. A factor which will decrease both the blackberry and the clover resource in future is increased cropping which will reduce honey production and adversely affect colony build up. Introduction of the blackberry 'rust' fungus has already reduced the area of blackberries.

Blue gum (*Eucalyptus globulus*) usually flowers biannually during late October/early November. It is used by beekeepers in the south, and by some northern beekeepers who migrate to the east coast for the flowering season.

Prickly box (*Bursaria spinosa*) flowers annually during late November/early December. Of minor importance it is used by a few beekeepers in the south.

Tea-tree (*Leptospermum spp*) grows in the coastal heathlands. It is worked by beekeepers in conjunction with other heathland plants for spring build-up.

Yield information

Early season honey yields from apple orchards are low even in good seasons. Yields from raspberry crops of 15-20 kilograms/hive are common. Mid-season flows, such as those from clovers, and blackberries in a few localities, provide yields up to 50 kilograms/hive (averaging 30-kilograms/hive), particularly in the northwest. Late summer flows from eucalypts and leatherwood frequently yield 80-90 kilograms. Commercial apiarists have recorded yields of greater than 100 kilogram/hive on leatherwood.

Beekeeping on public land

Access to conserved lands is a central component of apiary productivity. Native forest areas are the most important source of large-scale honey flows. Non-commercial beekeepers are not major users of leased apiary sites on public lands. Most rarely move their hives over significant distances.

In 1988-89 within the Crown land region there were 150 licensed sites. The sites were licensed to 45 apiarists who placed a total of 7437 hives to produce a total of 374 tonnes of honey. This was 41 per cent of total production and 64 per cent of total leatherwood honey production. The gross value of this honey (including beeswax), was estimated at $523 045.

More than one-fifth of Tasmania, almost 1.4 million hectares, is a world heritage area. Migratory beekeeping in the Tasmanian Wilderness World Heritage Area has been established for over 60 years. The Parks and Wildlife Service recognises beekeeping as an historical land-use. There are around 45 actively used apiary sites in the area, producing about 25 per cent of the State's leatherwood honey. Given the continuation of current forestry and agricultural practices, the leatherwood resource of this area is significant to beekeepers as the only major source of nectar with long-term security. It comprises 37 per cent of the total resource but lack of roads limits access.

Stocking rates are usually set by the land managers in consultation with the beekeeping industry, varying from 20 to 100 hives per site. The rate is determined by the perceived quantity of leatherwood trees within bee range. In 1988-89 there were eleven beekeepers with an estimated 2598 hives in the area which produced 148 tonnes of honey with a gross value (including beeswax) of $207 706. Indications are that currently some apiarists are over-stocking sites because all accessible leatherwood sites are occupied.

Planned road and track closures in the world heritage area could impact significantly on apiarists access to leatherwood. The reasons for closing the roads are to protect wilderness values, minimise environmental damage and contain the spread of *Phytophthora* (DPWH Management Plan 1992).

There is some concern about the possible ecological impacts of beekeeping in natural areas. Little research on this issue has been carried out in Tasmania. Those studies that have been completed are often conflicting because of the complex and diverse nature of the honeybees' interaction with native flora and fauna. From entomological information gathered in one study the authors conclude that there is no evidence of adverse effects of current beekeeping practices on the native fauna associated with leatherwood flowers, and that managed hives do not appear to increase competition with native insects for nectar on leatherwood flowers (Ettershank and Ettershank 1993). Because of lack of conclusive evidence of the effect of introduced honeybees, the parks and wildlife service has adopted a precautionary approach to their introduction. In the Draft Management Plan for the Arthur Pieman Protected Area it is noted that: 'the introduction of honeybees (*Apis mellifera*) will be approached with caution and will only be permitted if there is confidence they will cause no significant impact on natural systems'. There is a possibility that in the future commercial beekeeping may not be permitted in world heritage areas.

State forests, particularly leatherwood forests are used by beekeepers to build up stores of honey for sale and to support the hives through the winter and early spring. In 1988-89 there were approximately 205 sites in State forest land tenure. These sites were occupied by 46 different beekeepers using approximately 4576 hives and producing an estimated 213 tonnes of honey. The gross value of this honey production was $298 607, including 2228 kilograms of beeswax.

In 1992, the Forests and Forest Industry Council assessed Tasmania's leatherwood nectar resource for apiculture and reviewed its management in order to achieve sustainability of the resource (Ziegler 1993). The study found that in multiple use forest and deferred forest areas, a forecast overall reduction of accessible mature forest with leatherwood is 5500 hectares, or 4.2 percent. The most significant reductions in leatherwood resource occur in old growth eucalypt forests, which contain a high proportion of leatherwood. However, this is in part offset because roads to log eucalypt forest types also provide access to unlogged non-eucalypt forests containing leatherwood. However, the predicted net result was a gradual loss of leatherwood.

Access to State forest sites is critically important to apiarists. If an area of State forest is of little strategic value to Forestry Tasmania, roads may become impassable due to a lack of maintenance. Apiarists may pay for access to be restored to meet the standards specified by the Forest Practices Code, however, in reality this is generally beyond their financial capacity.

In 1994, Forestry Tasmania and the Tasmanian Beekeepers Association jointly developed guidelines (Forestry Tasmania 1994) to maintain honey supplies from State forests to ensure a sustainable future for beekeeping in conjunction with other forest industries and users. Despite this document, there are concerns amongst beekeepers that the guidelines are not followed. It is of concern that in most coupes containing leatherwood, only small streamside reserves and hill tops are being conserved. The beekeepers argue that this is not sufficient to sustain their industry.

Beekeeping on private land

Beekeepers use private land primarily for winter, spring and early summer sites. The honey is mainly derived from blackberries and clover. In 1988-89 beekeepers had 15 213 hives on private land, producing an estimated 323 tonnes of honey, with a gross value of $578 427. From early January 12 013 (79 per cent) of the hives were moved to public land, leaving only 3200 hives on private land during the leatherwood season. Private forest land is generally of lower significance as a nectar resource because of the smaller areas involved and the often much lower density of relevant plant species.

North Forest Products is the only major private landholder of leatherwood forests. Apiarists have access to the leatherwood resource on payment of site rental plus a charge per hive. The minor importance of the leatherwood resource on private land does not warrant more formal arrangements.

Resource linkage

Apiarists rely on leatherwood for most of their income. The horticulture and seed industry is partly reliant on the apiarists for their income. Apiarists believe that loss of leatherwood sites would jeopardise the viability of their industry. If the industry contracted, the reduced number of hives available to pollinate crops would lead to a fall in the quality and value of produce from industries using European honeybees as pollinators. Due to quarantine restrictions bees could not be imported to meet pollination requirements.

Pollination

Commercial pollination, a fundamental component of horticultural and other crop productivity, is serviced mainly by commercial beekeepers. Twelve beekeepers own about 60 per cent of hives used in commercial pollination.

When bees are required to comprehensively pollinate a crop, more hives are required than if the crop was being used for honey production. Hives used for pollination do not produce any surplus. A fee per hive is paid for the service.

If crops requiring pollination are early, hives usually need 'building up' before being placed into the crop. This increases the beekeeper's costs which need to be recovered through a pollination fee. If pollinators require the hives when the leatherwood is flowering, the pollination fee can double (about $28 to $55) to compensate for lost leatherwood honey production.

6.3.2 Outlook

Resource change

Beekeepers have little control over honey price or yield. The usually variable and often marginal nature of apiary financial viability will be threatened with reduced access to public forested areas. A major implication of reduced access to conserved land is reduced crop pollination and consequently, an extended impact on the agricultural sector, the economy and employment.

Further access problems such as the continued logging of coupes containing leatherwood, compounded with the long time until regeneration produces nectar flow of significant quantity in leatherwoods, suggest a possible future reduction in leatherwood honey production.

It has been suggested that beekeepers displaced from one site could simply move elsewhere. The logistics and practicality of this are open to question. Over a long time, beekeepers have secured and maintained the best available apiary sites. Sites are closely maintained by their lessees as a core productive asset. When displaced from traditional sites, the prospects for

finding alternative available sites of a similar productivity may be very slight - particularly for leatherwood where all accessible sites are occupied and some even over-stocked. Larger apiarists claim that the quality of their particular sites are central to the overall productive character of their operations.

Markets

Profitability in the industry is low. Returns to honey production are always variable, often marginal, except for the larger operators, due to seasonal fluctuations. However, some optimism is warranted as yields per hive are increasing, the local market is not yet saturated and there is a growing overseas demand for specialty honey.

Previously the Australian Honey Board oversaw the marketing of Australian honey overseas, producers now do their own marketing. Honey for export sale in glass or clear plastic jars requires care and preparation because the quality of the honey and hence its value is largely assessed by the consumer on clearness, cleanness and colour. Consumers preferences mean that great care and skill must be taken in classifying, grading and blending honey. In Tasmania, a number of different types of honey with differing qualities are available. Honeys from

Tasmania are often labelled Leatherwood, Blackberry, Clover and Gum Honey (Stringy Bark).

Prospects

Currently there are no leatherwood plantations in Tasmania. Based on the production figures of commercial apiarists, the area of leatherwood forest necessary to support 100 hives would about 1000 hectares (Ziegler 1993). It is not seen as viable to establish a plantation of a slow growing tree species which is unlikely to produce a commercial nectar flow until a relatively advanced age. Another potential problem in growing leatherwood plantations is that their establishment in high rainfall agricultural areas may contaminate pure honeys such as clover honey produced in these areas.

Further research into the genetics of the honeybee and the breeding of super queen bees may result in alternative resource use or increased honey flows at existing sites. Broadening of the resource to include floral resources currently not used by apiarists may reduce the apiarist's dependence on leatherwood by establishing markets for other honey types or increasing the length of the honey season. However, research into these areas is not advanced and doesn't seem to offer apiarists any alternatives in the medium term. Tree fern plantations may be a means of creating a predictable supply independent of native forest logging. Tree ferns can be grown easily from spores and could be grown under radiata pines. Restrictions on supply from native forest could be an incentive to establish plantations.

Craftwood

The resource

Craftwood is special species timber in the form of stumps, roots, branches, burls and offcuts. The term can lead to confusion as it is often extended to encompass all the timber from special species. However, most timber from special species is used for making furniture, not for craftwork. Craftwood is also referred to as feature timber. Some timbergetters refer to the bent, discoloured wood as rubbish.

Forestry Tasmania defines craftwood as material lower in quality or smaller in size than sawlogs. In general, wood of any length that is less than 25 centimetres in diameter or of any diameter that is less than 240 centimetres long is craftwood (Forestry Commission 1987).

Craftwood can come from a range of Tasmania's minor, mostly rainforest species: *Nothofagus cunninghamii* - myrtle; *Atherosperma moschatum* - sassafras; *Eucryphia lucida* - leatherwood; *Acacia melanoxylon* - blackwood; *Phyllocladus aspleniifolius* - celery-top pine; *Dacrydium franklinii* - huon pine; and, *Athrotaxis selaginoides* - King Billy pine.
The most popular species are huon pine and black-heart sassafras. Other species used as craftwood include paperbark, native cherry, horizontal, native olive, cheesewood, musk, goldey wood and native plum.
These species occur in rainforest stands or as understorey in wet sclerophyll eucalypt forest. Tasmanian rainforests cover 565 000 hectares (Forestry Commission 1993).

Extraction

Craftwood is collected from State forests shortly before and after logging operations. Non-commercial collectors pay a small amount for a licence to collect timber for their own use as well as a royalty depending on the forestry district, the species, accessibility and the amount taken. These licence holders are limited to fallen trees, limbs and stumps and supervised by district foresters, who may also provide advice. (Forestry Tasmania 1994b).

Commercial craftwood suppliers also obtain licences to collect wood and sawmills may cut utility logs - those which do not meet the size or quality specifications of sawlogs - into large slabs or smaller blanks for wood turning.
Commercial operators tender for the extraction rights in particular areas. The tender is based on adding a value above the royalty rate. One operator, Craftwood Furniture Supplies, quotes a $53 per tonne premium on its successful tender. Forestry Tasmania (1994a) said craftwood can attract a royalty up to $1000 per cubic metre. An earlier report put the cost at $28 per cubic metre for huon pine and $7 - $14 for other species (Forestry Commission 1987). Operators also have to meet the cost of getting the timber to their sawmills.

Craftwood users obtain 85 per cent of their timber from sawmillers, the rest from timber yards or from Forestry Tasmania's yard, Esperance Craftwood and Poles, in Geeveston (Lucas et al. 1988). The yard acts as a wood bank of special species logs, poles and craftwood produced from logging in the southern forests (Forestry Tasmania 1994a).

Craftwood is probably also gathered from private forests but there are no figures on this.

Current and potential uses

Craftwood is used by full-time and part-time woodworkers and artists. They sculpt, carve and turn works of art and utilitarian articles such as bowls, wooden toys and souvenirs. Some craftspeople might incorporate a round section of craftwood into an item of furniture such as a table.

Special species timber that is highly coloured and figured makes the most popular craftwood. Many woodworkers require wood that has been cut into slabs or turning blanks.

Craftwood, often in quite small pieces, shaped or raw, is popular with visitors. There is some interest in building an export market for turning blanks and slabs (Forestry Tasmania 1994a).

Special species timber is also in demand from joiners, fine furniture makers, makers of musical instruments and boat builders. Only very small quantities are used for sculpture or free-form work.

Economic value of products

The craftwood industry is a boutique activity about which little hard statistical information has been collected.

Sustainability of production

The demand for craftwood is small. A few craftspeople turn a small amount of wood into high-value products (Commission of Inquiry 1988, p 2089).

The use of craftwood does not approach the total amount of the resource available (Forestry Tasmania 1994a). Supply greatly exceeds demand (Commission of Inquiry, 1988 p 2088). However, because of the specialised nature of the raw material, craft workers may need to place standing orders with their suppliers or collect wood well in advance of starting a project (Forestry Commission 1987).

Availability for particular species is:

- blackwood - regenerates readily and is a significant species for sawlogs, with a rotation period on 80 to 90 years. Pieces less than 30 centimetres in diameter do not satisfy sawlog specifications and are usually sold as pulpwood or occasionally as craftwood. Small sections of blackwood are not sought after as craftwood (Forestry Commission 1987);
- mytle - is a large resource wherever there is rainforest. However, there is little demand for craftwood or sawn logs. Many logs are sold for pulpwood and woodchip export (DASETT 1988, p 401);
- sassafras - is available in some quantity. Black-heart sassafras is in very strong demand from craft workers and to a limited extent by furniture makers (Forestry Commission 1987). White logs are not popular; some is used for pulping (DASETT 1988, p 400);
- leatherwood - is relatively plentiful but in little demand. An increase in cutting could generate opposition from beekeepers (Sinclair et al. 1979);
- celery-top pine - takes 300 or more years to mature. Sawlogs are still available (Forestry Commission 1987);
- King Billy pine - is a slow-maturing species too scarce to allow sustained harvest of commercial quantities. Most demand is being met by substitutes. Salvaged timber is being used only for high-value products available (Forestry Commission 1987); and

- huon pine - is also slow-maturing. Salvage from hydroelectric flooding has been stockpiled for future use. With consumption of about 500 cubic metres per year, the sawlog supply should last 70 years, craftwood much longer (Forestry Commission 1987).

The poor match between supply and demand is being counteracted to some extent by the use of Forestry Tasmania's Esperance Craftwood and Poles yard at Geeveston for storage.

The inquiry into special species timber and craftwood A1988 concluded that some of the minor species sawlog resource was not being directed to the furniture and craftwood industries, but not conclude that there was unsatisfied demand (DASETT 1988, p 401).

> 'It appears that the large quantities of minor species going to pulp or being burned would be unlikely to find buyers at prices covering the recovery costsÉIt appears that there are real problems in the long term. The rotation for minor species is typically 300 years or so. Consequently the existing virgin forests represent a finite stock (DASETT 1988, p 403).'

More up-to-date figures for the total craftwood resource outside reserves and the rate of extraction are needed.

Conservation measures

The conservation of the craftwood resource is related to the conservation of special species timbers as a whole. Large tracts of rainforest (34 per cent of the total in the State) are reserved in Tasmania's National Parks and World Heritage areas. Of the 40 recognised rainforest plant communities, three are poorly reserved and three are not known in reserves (Forestry Commission 1993).

Industry development

Future development of these high value-adding and employment-generating activities will have benefit creating a market for what was previously seen as waste.

Requirements for the development of the craftwood industry are the availability of the craftwood resource, an education and training infrastructure to provide appropriately skilled people, and extended marketing.

Tourism can help sell a number of wood products. Sinclair (1979, p 34) stated:

> 'In its tourist traffic, Tasmania possesses a communication mechanism for projecting an image. The service costs us nothing, and we must exploit it. Souvenirs, for instance, do not have to be trivial, nor do they have to be packable in an overnight bag. If we can produce an exciting range of wood articles and facilitate access to them and the craftsmen who make them, we can sell valuable products and 'export' a useful unit of promotion. Image gained in this area represents spin-off into other areas of wood manufacture.'

Effect of other forest activities

Vocal craftspeople want better access to special species timber (Forestry Tasmania 1994a). Since craftwood is a by-product of other logging operations, the rate of extraction of the craftwood resource is largely independent of demand for the product. It is driven by the demand for other forest products.

In many cases the economic potential of craftwood in the forests has been lost as the resource is depleted for less valuable uses. As noted above, some myrtle, blackwood and sassafras are pulped. And some timber that could be salvaged is burnt.

Box 7 A retiring woodturner, Hobart

A retiring woodturner - Hobart

His involvement in woodcraft began 10 years ago when he persuaded a neighbour to give him a felled blackwood tree rather than burn it. A couple of adult education courses followed and now this 65-year-old former public-servant lists wood-turning as his foremost hobby, producing bowls up to 38 centimetres in diameter, along with smaller spindle pieces such as lamp stands and vases.

A member of the Woodcraft Guild, he estimates there are hundreds of people in Tasmania for whom woodcraft is a pleasurable pastime.

He has no interest in taking his hobby into a full-time business because he doesn't fancy the prospect of standing at his lathe all day. He sympathises with professional craftspeople, who he knows have to compete for sales with large numbers of part-timers like himself.

From his home in the suburbs of Hobart he sells his work through local craft shops, as well as taking pieces with him when he makes caravan expeditions interstate. Although retired, he says that he is 'not above enjoying a bit of haggling with a gallery owner on the mainland'.

He estimates his wood consumption at less than one cubic metre a year, purchasing about half his requirements, from either Forestry Tasmania or private craftwood suppliers, and gathering the remainder from gifts of timber bestowed by friends and family. He works mainly in indigenous Tasmanian species of sassafras, blackwood and myrtle. In sassafras, he finds the bacteria-induced black heart particularly appealing, as well as the spalting effect found in some specimens due to the onset of fungal decay. In all wood he is seeking figure, or distinctive grain quality, and colour.

For the future of woodcraft timber he sees problems emerging from the predominance of clearfelling in forest management. If clearfelling keeps up, he reasons, and the plantation eucalypts are harvested at 60 years or so, the understorey will not have time to develop and craftwood species will not be available as mature trees.

He puts forward as a possible solution the reservation of at least some areas for selective logging, where the loggers would fell only what they wanted and leave the remaining trees to stand and grow, until they reached maturity.

Firewood use in Tasmania

Tasmanians are highly reliant on firewood for domestic energy, particularly heating. In the mid 1980s firewood was the main source of heating in more than half of Tasmania's homes (Todd 1986). Consequently firewood supply is an important forest use.

Firewood is cheap relative to other main domestic energy sources, such as heating oil, kerosene, liquefied petroleum gas and electricity. As a low cost energy source for household heating the continued availability of affordable firewood is an important socio-economic issue to be considered.
Although it requires more handling, the low relative cost of firewood relative assures its popularity. Residential consumption for the ten years to 1994-95, as estimated by the Australian Bureau of Agricultural and Resource Economics is given in Table 6.16

The figures are based on unpublished raw data for the report *Australian Energy Consumption and Production* (ABARE 1995). They are derived from combinations of commercial operator surveys and householder surveys. In addition to residential consumption there is approximately 10 000 tonnes of fuel wood consumed each year by the wholesale and retail trade industry in Tasmania (unpublished data for ABARE 1995).

Table 6.16: Residential firewood [1]

Year	Tonnage (kilotonnes)	Percentage increase over previous year
1985-86	433	-
1986-87	460	5.87%
1987-88	470	2.13%
1988-89	484	2.89%
1989-90	491	1.42%
1990-91	497	1.21%
1991-92	504	1.39%
1992-93	511	1.37%
1993-94	514	0.58%
1994-95	514	0.00%

[1] unpublished background data for ABARE 1995

The estimates of consumption in Table 6.16 differ significantly from estimates of demand; estimates based on surveys of firewood operators are different again. Firewood use estimates based on surveys of suppliers are consistently and substantially lower than surveys of stove retailers and firewood merchants. This is due to the substantial degree of private gathering and the unreliability of householders' estimates of firewood they collect and use. Gathering for private use is difficult to document as it occurs in the absence of licences and often on private land.

The commercial firewood industry is characterised by a few large suppliers who dominate the urban market and many small operators who operate either seasonally and/or for only short periods before moving out of the industry due to very marginal returns (Todd 1986; HEC 1988).

Low returns to small operators relate to high production costs relative to the sale price of firewood in Tasmania (HEC 1988), which is significantly lower than other States (Forestry Technical Services Pty Ltd. and University of Tasmania 1989). Firewood production costs are typically adversely affected by the seasonal nature of consumer demand, inefficient production practices, resource accessibility problems and inadequate capacity and capitalisation (Todd 1986; HEC 1988; Forestry Technical Services Pty Ltd. and University of Tasmania 1989). In contrast, the low price of firewood relative to other States is probably due to the large number of seasonal and/or part-time small scale operators competing for market share (HEC 1988; Forestry Technical Services Pty Ltd. and University of Tasmania 1989). Prices also vary throughout the State. Variations in demand between years depends on the severity of winters. Long-term planning for demand is difficult, in mild winters supply exceeds demand but more usually, demand exceeds supply, stockpiles are rapidly exhausted and delays occur between ordering and delivery.

Supply is heavily dependent upon resource accessibility which is in turn affected by such factors as wet weather conditions which periodically prevent access, and the lack of incentives for landowners to make wood available (HEC 1988). As a result firewood collectors may have to travel to gain access to their resource, which increases their overheads. The HEC estimated the profitable transport limit for fuelwood sold in Hobart in the mid 1980s as 80 km (HEC 1988).

Until the 1980s more than 80 per cent of firewood came from private land, mostly associated with land clearance and fire hazard reduction (Davies 1982, in Todd 1986). This source is unlikely to continue. However, many firewood collectors have a security of access on private land and State forest, through the purchase of 'timber runs' and firewood licences respectively, under which they harvest dead trees.

Under the timber run system, firewood collectors gain exclusive rights to cut and extract firewood from private forested or woodland blocks by paying an annual fee to the landowner. Collectors also purchase licences from Forestry Tasmania to gather firewood from State forests. Secure exclusive rights to collect firewood from private property and State forests provides a higher degree of control and management than otherwise possible. It also provides for resource and income security for the collectors. Forestry Tasmania receives approximately $130 000 per annum from the sale of firewood licences and timber gathering rights.

Environmental factors may affect future access for firewood gathering. On occasion, firewood gathering can result in the removal and destruction of vertebrate and invertebrate habitat and/or fire refugia. Firewood collection has also been identified as a source of spread of invertebrate pest species (Todd and Horwitz, 1990). Another consideration is the cost of storage of green wood until it is sufficiently dry for sale as firewood. Costs may be offset to some degree by the ease of processing and most forest harvesting occurring during the summer. Firewood collectors also need adequate time to extract the resource from forest residue prior to regeneration burn.

Box 8 Firewood - Boss in the Bush : *Mike Wilson Woodyard, Meander*

Firewood - Boss in the bush

Mike Wilson Woodyard, Meander

Mike Wilson loves the bush - the solitude, the peace - and he likes working to his own pace, being his own boss. These are the reasons he prefers to work as a woodcutter in his own firewood business, rather than in the other jobs he has held over the years with various government construction agencies.

Mike Wilson Woodyard, the business name with which the phone is answered at his home in Sandy Lane, has been going for five years, since he began taking his one-tonne utility to the Evandale Fair on Sundays with a load of wood on the back and a catchy sign: 'First in, best warmed'. As well as selling his load, he took orders, and within a few months he had enough on his books that he didn't need to make his weekend trek to Evandale any more.

Mike Wilson works the business on his own, with occasional help from his wife, Jane, cutting wood from land after it has been logged, felling it, splitting it and stacking it for drying before selling to his customers. He normally works five or six days a week. When things got busy last winter, and his working week expanded to seven days, he and his wife thought about taking someone on to help, but they decided they would rather do without the complications of an employee - superannuation, sick leave, holiday pay and so on.

Instead he resolved that he would not add to his 92-strong customer list. This leaves him processing some 500 tonnes of wood a year, taken from either private or public forest land in an operation he describes as cleaning up after the loggers have been through. Nearby customers pay $45 a tonne, while those in Launceston pay $55 a tonne.

'I take the lot,' he says of the wood that he collects - peppermint, brown-heart, black-heart, silver or black wattle, stringybark, ironbark, white-top and brown-top; everything except blue gum, which he says is like lightning-struck wood, it will not burn, it merely blackens. Most of the wood he takes back to his yard is green and must be seasoned for about six months before it can be sold. A feature of his business is the seasonal nature of the cashflow, with most of the royalties to be paid during the warmer months and most of the income generated in the cooler period.

Mike Wilson's plant, all paid for, comprises a three-tonne Isuzu tip-truck, a six-cylinder International tractor for pulling logs and also for pulling the truck out of bogs, and three chainsaws.

Once felled, the logs are cut to length - 30, 35, 40, 45 and even 60 centimetres, depending on the size of the customer's stove. After they are split, he loads them onto the truck and carts them home, on the way recording the volume he has taken so that royalties can be calculated. He pays $5 per tonne for wood taken from private land and $3.50 per cubic metre to Forestry Tasmania for the wood he extracts from State forests.

Mike Wilson holds registration as a woodcutter with both Forestry Tasmania and the private forestry industry. 'You've got to be registered with both - more rigmarole,' he says, registering a faint frustration with bureaucracy.

He has no concern about the future availability of his resource, although he thinks there is scope for Forestry Tasmania to improve its management of firewood following an incident earlier this year.

After completion of logging in a Forestry Tasmania coupe in the nearby Huntsman area, Mike Wilson expected he would have some two and a half years' clean-up work on the coupe, which he would begin as soon as he completed a current job on a section of private bush. Then he noticed smoke where it should not have been. Apparently impatient to prepare the area for replanting, the commission had instructed that the remaining timber be burned. Thus an estimated 1000 to 1500 tonnes of firewood went up in smoke. 'There was a dashed good livelihood going, and people going cold,' said Wilson, adding that the commission could have told him that it wanted speedy action taken.

Now in his early 40s, Mike Wilson says he will be looking to get out of the firewood business by the time he is 55, when he expects he'll be ready to retire. Until then, he has no worries about his prospects. 'It's a pretty sound little business,' he says.

Grazing in forest and woodland

Many of the grassy open eucalypt forest and woodland communities of Tasmania on both private and public land are subjected to grazing by domestic livestock. This 'rough grazing' or the grazing of 'native pastures' has a long history in Tasmania. Commencing with first settlement, grazing of 'native pastures' became a major agricultural activity and was one of the main motivations for the settlement and clearing of the open forests and woodlands of the Tasmanian Midlands and Central Plateau.

The term 'native pasture' typically refers to any of the native plant communities that are, in part, dominated by native grass species such as *Poa labillardieri*, *Themeda australis, Danthonia setacea*, and *D. caespitosa*, although *T . australis* disappears under grazing pressure (Kirkpatrick, 1991). Within Tasmania such grazing is predominantly by sheep. Consequently, 'native pasture' represents a spectrum of disturbed and undisturbed grassy vegetation ranging from the forest and woodland communities that fall within the dry sclerophyll vegetation classifications of Duncan and Brown (1985) and Kirkpatrick (1991) through to tussock grasslands and heathlands.

At approximately 524 000 hectares, native pastures , comprise approximately one-third of Tasmania's available grazing land and as such represent a substantial economic resource to the State. The main areas of forested or woodland native pastures are found within the Midlands region of Tasmania, the Central Plateau and within the lowland forests and woodlands of the east coast. Such areas are also important for the growing of highly valuable superfine wools.

At the farm level, availability of native pasture is often essential to the economic and agricultural sustainability of the farm enterprise. It provides late summer and autumn feed making it possible either to release improved pastures from year-round grazing pressure or to allow grazing pressure to be reduced over the late summer and autumn months. Stock kept on native pasture over the late summer and winter months is often moved back onto improved pastures during spring and early summer to make use of, and control, spring growth. Also, given that native perennial grass species are generally more drought-resistant than improved pasture species, native pastures can function as short-term drought reserves.

However, grazing of grassy forest ecosystems in Tasmania can have substantial conservation impacts. These impacts on conservation values are discussed in detail within Chapter 3 of the Environment and Heritage report (Tasmanian Public Land Use Commission, 1996).

Public land tenures with grazed native pasture include State forest and land managed by the Hydro-Electric Commission and local councils. It may also include non-National Park crown land reserves managed by the Parks and Wildlife Service The main Hydro-Electric Commission grazing lands occur on the Central Plateau. Grazing also occurs on many small areas around substations.

Within State forests most grazing occurs within the Central Plateau and Midlands regions under a system of agistement licences, grazing leases or property management leases. The return from these licences and leases to Forestry Tasmania is $24 600 per annum.

Grassy forest available for grazing within State forest has undergone a decline in recent years because of its effect upon wood production and forest regeneration.

Livestock grazing may prevent tree and shrub regeneration through trampling and browsing damage to seedlings and/or the use of very frequent, if not seasonal, low intensity fires to encourage and/or maintain grassy understories (Orr, 1991). Consequently, livestock may often need to be excluded from grassy open forest and woodland areas utilised for forest production until eucalypt seedlings are of a height at which they are not susceptible to browsing or trampling damage or to low intensity fire damage. At this height the shrub and young tree layer may in turn affect the abundance of grassy vegetation.
It is important to note that where tree and shrub regeneration fails, loss of forest will eventually occur as the remaining trees become more susceptible to death from disease, insect attack and increased exposure with increasing age (Orr 1991). This may then reduce the grazing productivity of 'native pastures' due to the lack of shelter for livestock and subsequent higher energy use, as well as the increased susceptibility of livestock to exposure-related deaths. Rural tree decline is currently a major problem in Tasmania. In many areas re-establishing eucalypts by sowing or planting is often both expensive and unreliable (Orr 1991).

The deleterious effects of livestock grazing on the conservation values of some grassy forest communities, and the conflict between forestry management requirements and grazing, represent potential threats to the availability for grazing of native pasture communities on public land.

The history of European development and land clearance on private land in Tasmania has resulted in many grassy communities and species being poorly reserved and/or restricted to forest and woodland remnants whose long-term viability is uncertain.

Overall the availability of native pastures for grazing allows many Tasmanian farm enterprises to maintain larger herds and/or flocks and to increase productivity and profitability. Although the productivity of native pasture in Tasmania is generally substantially lower than improved or cultivated pastures, it is important to note that 'native pastures' are often unable to be converted to improved pastures due to edaphic and topographic factors. However, fertilisation and tree retention on some soil types may allow the Dry Sheep Equivalent per hectare stocking rate to be increased.

Other plant products

6.7.1 Sphagnum moss and peat

The resource

In Australia and New Zealand the most common species are from the Restionaceae, aquatic or semi-aquatic species, terrestrial sedges and cushion plants. There are seven species of Sphagnum in Tasmania, of which Sphagnum cristatum, the most common, is favoured for harvesting. Sphagnum peatlands are uncommon but patches occur in cool, wet locations from sea level on islands in Bass Strait to mountain tops in south-western Tasmania. There is very little sphagnum peatland recorded on private land. In some places sphagnum covers the ground in pale-green or orange-green hummocks of moss, separated by hollows containing water. In other places shrubs (Richea or Baeckea), trees or ferns may grow above the moss. Marsupials graze the edges.
Peat accumulates when plants slowly decay in water. The plants could be sphagnum moss, sedge, reeds or other species.
Whinam and Buxton (in press) estimate the area of sphagnum peatland in Tasmania at 1330 hectares. Most of this occurs in the formerly glaciated Central Plateau or in the Mersey River valley.

Extraction

Forestry Tasmania allows commercial sphagnum moss harvesting at three locations in State forest. About one-twentieth of the resource is harvested each year.
Several means of harvesting moss have been attempted. Older methods used heavy machinery to scrape off the top layer of moss. This caused ruts which collected water and did not regenerate. The flow of water into the ruts drained moisture from other parts of the bog. A newer method uses railway tracks and flying foxes to keep machinery off the bog.
Peat is extracted by harvesting or mining. Peat mining is subject to the *Mining Act 1929.* For peat mining, an area is cleared of vegetation, large drains are dug around the edge of the peatland, the surface is levelled and the peat mined in strips. The peatland is destroyed by mining.
In the early 1980s peat production was estimated at about 5000 tonnes per year. Imports were about 8000 tonnes per year (Natureland of Tasmania Pty Ltd 1984).

Table 6.17: Annual sales of sphagnum moss from Crown land

Year	Tonnes	Royalty $
1988-89	197	1 735
1989-90	250	2 390
1990-91	478	4 954
1991-92	123	1 215
1992-93	93	1 025

Source: Forestry Commission 1993

Current and potential uses

Sphagnum moss and peat are used in the nursery industry as a component of potting mix. The moss is also used for wrapping orchids, roses and fruit trees; it holds 10 to 20 times its weight in water and keeps bare-rooted plants in good condition for transport. About 100 tonnes of sphagnum moss per year is consumed by the Tasmanian market, any excess is exported.

Some botanic gardens in Australia are using the composted husks of coconuts, of which there is an abundant supply, as an alternative potting material. Possible uses for peat are as bedding for horse stables, as an absorbent or insulator, and as a source for organic chemicals.

Regional significance of products

A number of small operators harvest moss and peat in conjunction with other business activities. The part-time nature of current operations means that the social impact of moss and peat production is likely to be small.

Sustainability of production

The industry is not sustainable at alpine altitudes. In sub-alpine bogs small amounts of moss can be harvested. Regrowth requires about 10 to 20 years.

Peat mining is not sustainable. Mining peat destroys the bog and alters the related hydrology. Peat accumulates at about 2 centimetres per century, so the prospect of regenerating a mined bog is remote.

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In the early 1980s peat production was estimated at about 5000 tonnes per year. Imports were about 8000 tonnes per year (Natureland of Tasmania Pty Ltd 1984).

Conservation measures

The conservation status of the remaining large bogs and mires in Tasmania is good. More than 90 per cent are within National Parks and World Heritage areas. Tussock grassland-sphagnum mire at Blue Tier and aquatic sphagnum bogs at Mole Creek in the north-east of the State are not well protected.

A management plan exists for one moss harvesting operation. The harvesting of two other bogs was considered (Forestry Commission 1993). The Parks and Wildlife Service checks all applications to harvest sphagnum moss from State forests.

Effect of other forestry activities

Since the survival and growth of sphagnum bogs is very sensitive to water quality and flow, upstream logging, roadworks, sewerage effluent and pasture improvement can have a detrimental effect. Fire and grazing can destroy peatlands. To maintain a harvesting regime, fire and livestock must be excluded.

Industry development options

Given the small area of available resources and the slow rate of regeneration, there appears to be little potential for expanding the industry. Planting new bogs is not feasible. Maintaining the present rate of extraction of moss will depend on careful management.

6.7.2 Tree ferns

The resource

Five species of tree ferns grow in Tasmania. *Dicksonia antarctica* is the most common. It occurs in a wide range of plant communities in moist, fertile soils at altitudes up to 1000 metres. The tree fern tolerates fire, regrowing after burning.

Extraction

Dicksonia antarctica is the only tree fern species allowed to be harvested. The ferns come from areas scheduled for logging or from areas to be permanently cleared for some other purpose such as road construction.

Harvesting is controlled by a tree fern management plan (Forestry Commission 1989); a new management plan is being prepared. The plan estimates the resource available for harvesting at 20 million ferns on Crown land and 9 million on private land. With a rotation of 85 years, this gives an annual harvesting limit on Crown land of 235 000 stems. The management plan makes available a minimum of 85 000 stems per year. Up to 265 000 stems could be available from private land.

Table 6.18: Annual sales of tree ferns from Crown land

Year	Stems	Royalty $
1988-89	1 099	13 138
1989-90	1 775	21 997
1990-91	1 181	15 654
1991-92	1 140	16 592
1992-93	3 484	31 093

Source: Forestry Commission 1993

Table 6.19: Planned harvesting of tree ferns from Crown land

Estimated Number of stems				
District	1995-96	1996-97	1997-98	Total
Bass	6 040	5 670	5 360	17 070
Circular Head	1 000	600	400	2 000
Derwent	1 130	1 200	2 300	4 630
Eastern Tiers	0	0	0	0
Huon	26 550	28 900	20 800	76 250
Mersey	0	0	0	0
Murchison	0	0	0	0
Total	34 720	36 370	28 860	99 950

Source: Three year wood production plans 1995/6 to 1997/98 Forestry Tasmania 1995

Figures for harvesting from private land are not available.
To improve monitoring the management plan created a licensing system for all cutters on Crown land. Major operations require contracts of sale disclosing sources and destinations of all tree ferns. Royalties are charged per fern, offering an incentive to maximise the use of each plant.
Harvesting will be targetted from plantation clearing as a priority (Forestry Tasmania 1995). However, tree ferns may be salvaged from logging areas, conservation areas and wildlife sanctuaries on Crown land. An adequate number of mature ferns must be left to restock the harvested area.

Current and potential uses

The top part of *Dicksonia antarctica* can develop a new root system after being harvested. Provided it is kept moist, it can also survive for considerable periods after harvesting before being replanted.
Tree ferns are used live in landscaping and gardens. A small number are carved into slabs or containers for holding other plants.
The demand for tree ferns is small compared to the size of the available resource (Neyland 1986).
The ferns grow at 3.5 to 5 centimetres per year and produce spores at the age of about 23 years. A timber harvesting rotation of 85 years should ensure that forest has regrown sufficiently to provide the right conditions for fern growth and that mature ferns will be producing spores. The management plan argues that this should yield a sustainable harvest.

Conservation measures

About one quarter of the population of *Dicksonia antarctica* are in reserves (Forestry Commission 1989). The other four species of tree fern are also in reserves. Other conservation measures are contained in the tree fern management plan.
Most tree ferns are sold in Australia but some are exported to the USA and Japan. Because *Dicksonia antarctica* is listed on Appendix 2 of the Convention on International Trade in Endangered Species of Wild Fauna and Flora, exporters must prepare a management plan and have it approved by the Federal Minister for the Environment. In 1993 there were two approved management plans in Tasmania, one in the north-east and one in the north-west.

Industry development options

Subject to horticultural fashion, there is potential for much larger trade in tree ferns (Neyland 1986).

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Focus Catchments

For each focus catchment a particular measuring location is identified and some general information is given:-

Stream Flow

Stream flow is discussed using monthly "box-and-whisker" plots. Each plot consists of a box, whiskers and outliers. A line is drawn across the box at the median. The limits of the box are the first and third quartiles indicating that 50% of all observations lie within the box. Whiskers are defined by lines extending from the box to Q1 - 1.5*(Q3 - Q1) and Q3 + 1.5*(Q3 - Q1). All measurements outside the range of the whiskers are shown as outliers using asterisks.

Water Quality

A summary of available water quality statistics is given for each catchment. Mean figures are presented for each parameter since the number of samples of each parameter is typically small. Means are easily biased by extreme figures (ie either high or low figures) which may be atypical of conditions in the rivers. Adequate assessment of water quality in any of these streams requires more detailed sampling and analysis.

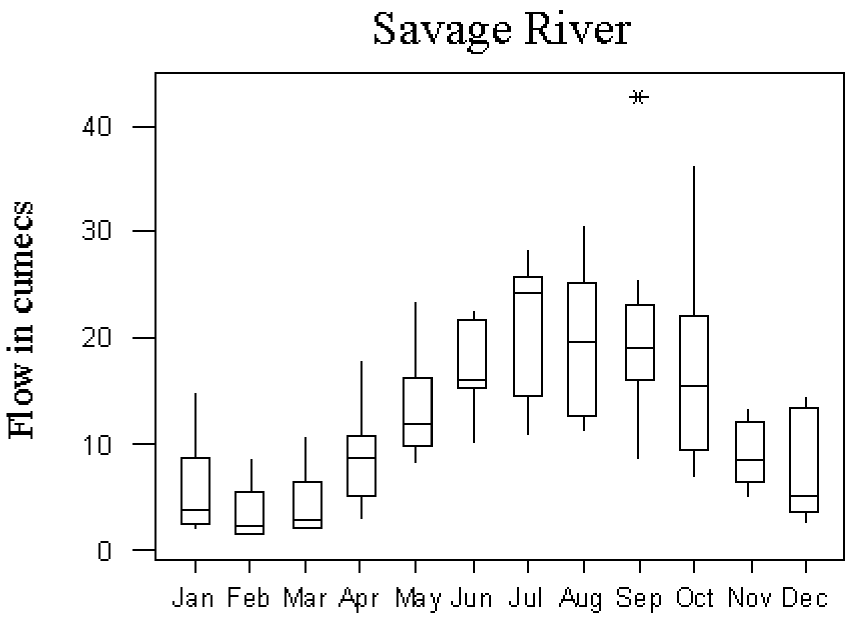
Allocation

Brief details of water allocations and management issues are presented for each focus catchment.

Savage River downstream Doodies Creek (Pieman River Basin)

Station Number:	10202		
Easting:	341500	Northing:	5390700
Period of Record:	Apr 1979 to Sept 1990		
Catchment Area (Km2):	283		

Savage River is subject to pollution inputs from mining activity and, to a limited extent, urban development. The streamflow measuring location is downstream of the mining development and exhibits a strong seasonal pattern of flows.



Maximum monthly flows tend to occur in July, but September and October appear to be the months in which major flood flows tend to occur. Summer flows are generally lowest in February and March.

The water in the Savage River is slightly acidic but well within normal ranges for a stream whose flows are governed by rain water. The salinity of the stream is slightly elevated compared with other West Coast streams, however the measured range is approximately a factor of ten below tolerable limits. The single dissolved oxygen reading is high probably as a result of the many rapids in the system. There does not appear to be any significant impact from organic loads. The single copper concentration reading is a factor of 10 above the levels recommended for the protection of aquatic ecosystems (ANZECC 1992).

Parameter	Units	N	Min	Max	Mean
Water Temperature	C	7	8.3	15	11.5
EC at 25C	uS/cm	4	137	197	177
pH		9	5.94	7.1	6.53
Apparent Colour	Hazen	2	70	175	122.5
Tot Suspended Solids	mg/l	2	1	25	13
Filt Residue (104C)	mg/l	2	100	210	155
Dissolved Oxygen	mg/l	1			11.02
Tot Copper	mg/l	1			0.051
Free Ammonia	mg/l	-			
Tot Phosphate	mg/l	-			
Tot Coliforms/100ml	ct/100ml	-			

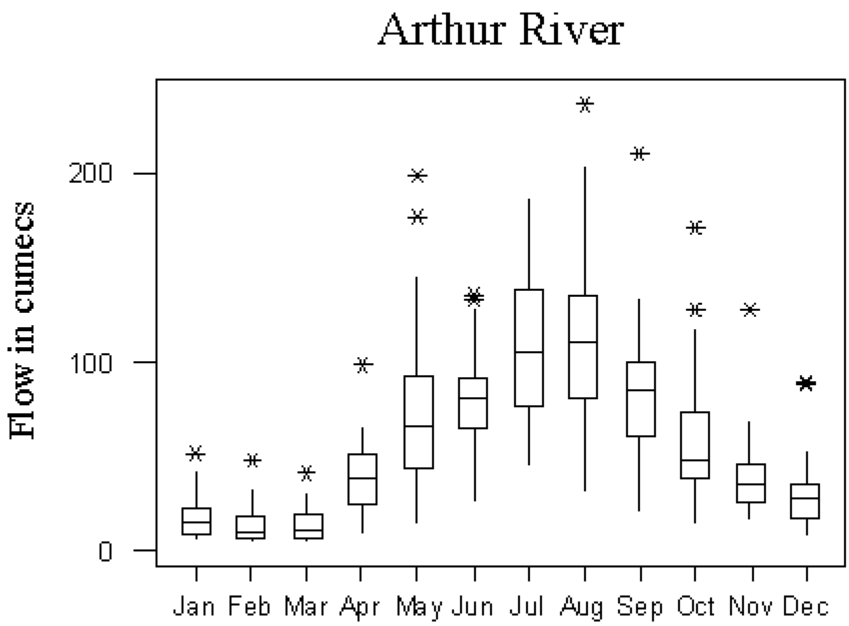
Note:- - indicates no data available

Savage River Mines is the only consumptive user of water from Savage River. The current mine is operating under a temporary licence to take 20 ML/d (0.23 cumecs).

Arthur River downstream Rapid River (Arthur River Basin)

Station Number:	159		
Easting:	338700	Northing:	5445700
Period of Record:	May 1955 to date		
Catchment Area (Km2):	1535		

The Arthur River is catchment subject to forestry and agricultural land uses. The streamflow measuring station is located downstream of the Rapid River and covers about 2/3 of the basin. Monthly flows show a strong seasonal pattern. Maximum monthly flows tend to occur in July/August, but flood flows can occur at any time of year. Summer flows are generally lowest from January through to March.



The water in the Arthur River is slightly acidic but well within normal ranges for a stream with flows governed by rain water. The salinity of the stream is low and fairly typical of West Coast streams. Suspended solids levels are very low, although closer inspection of the data is needed to infer the effects of flood flows. Copper concentrations are around the upper limit recommended by ANZECC

(1992). The single dissolved oxygen level is relatively low but may be dependent on the time of day the reading was taken and the sampling equipment. Further readings of DO are required.

Parameter	Units	N	Min	Max	Mean
Water Temperature	C	46	4.5	22	12.4
EC at 25C	uS/cm	12	64	110	35
pH		49	5.3	7.4	6.6
Apparent Colour	Hazen	-			
Tot Suspended Solids	mg/l	5	2.9	12.8	5.5
Filt Residue (104C)	mg/l	-			
Dissolved Oxygen	mg/l	1			4.6
Tot Copper	mg/l	5	0.004	0.0065	0.005
Free Ammonia	mg/l	-			
Tot Phosphate	mg/l	-			
Tot Coliforms/100ml	ct/100ml	-			

Note:- - indicates no data available

Water extraction from the Arthur River basin is mainly confined to the Wey River in the headwaters. Water from the Wey is taken into storage at Talbots Lagoon and transferred into the Emu River catchment for use by North Forest Products and Australian Paper. Under a commissional water right 5500 ML is taken into Talbots Lagoon and 15860 ML transferred from the storage and the Wey River. A further 256 ML is allocated for irrigation purposes in the lower part of the catchment.

Pet River upstream Burnie Water Supply (Smithton-Burnie Coast Basin)

Station Number: 14203

Easting: 401700 Northing: 5441200

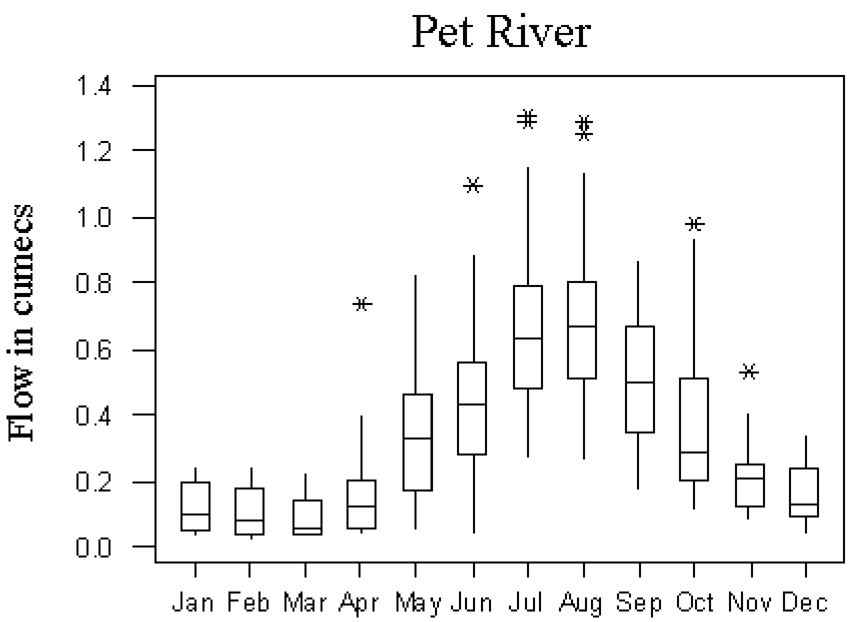
Period of Record: Nov 1963 to Dec 1994

Catchment Area (Km2): 11

The Pet River exhibits a highly seasonal and variable flow regime typical of a small catchment. Flows in the river have been augmented by diversion of Guide River waters, however, no detailed monitoring of this diversion has been undertaken.

August is typically the month of highest flow. Flood flows can dominate from April through to November.

The catchment is predominantly used for forestry and agricultural purposes.



The Pet River has very close to neutral pH although a wide range of readings have been measured. The suggestion is that alternately rainfall inflows (acidic) and groundwater inflows (alkaline) dominate the system. Salinity is quite low in the catchment. Nutrient levels are quite high in the system probably the result of enrichment from animal access and agricultural practices. Total coliform levels are also high, probably due to animal access to waterways as well as the elevated water temperatures which are possible in such a small catchment.

Parameter	**Units**	**N**	**Min**	**Max**	**Mean**
Water Temperature	C	47	6	20	11.8
Field EC at 25C	uS/cm	15	57	99	73
pH		24	5.9	8.1	6.9
Apparent Colour	Hazen	9	15	50	26
Tot Suspended Solids	mg/l	29	0.4	29	5.2

Filt Residue (104C)	mg/l	32	30.5	125	55.2
Dissolved Oxygen	mg/l	9	7.9	11	9.7
Tot Copper	mg/l	-			
Free Ammonia	mg/l	2	0.2	0.4	0.3
Tot Phosphate	mg/l	8	0.001	0.59	0.081
Tot Coliforms/100ml	ct/100ml	2	700	3200	1950

Note:- - indicates no data available

Water Takes from the Emu River System

1 Recent History
Prior to 1993 water rights assigned under the Burnie Water Act and the APPM Act utilised most of the reliable water supply in the Emu River catchment. When the APPM mill at Burnie was sold to Amcor Paper (Australian Paper), the rights under the APPM Act could not be assigned.

APPM, now North Forest Products (North Broken Hill Peko Ltd), entered into a Heads of Agreement with Australian Paper (Amcor) to supply water from Companion Dam on the Emu River and Talbots Lagoon on the Wey River. Water assigned was similar in amount to that supplied to the Burnie Mill from the dams when APPM owned and operated the Burnie Mill.

Even though the water was assigned between the two companies, neither company could legally take water from the river system under the APPM Act due to change of ownership. To enable the companies to take water, under the terms of the Heads of Agreement, they both needed to apply for Commissional Water Rights under the Water Act 1957. These rights were issued in December 1993.

There is now an embargo on the issue of new Commissional Water Rights to pump directly out of the Emu River catchment over the period 1 December to 30 April.

2. Description of river operation
The two principal diverters from the Emu and Wey River catchment are North Forest Products (NFP) at Hampshire and Australian Paper at Burnie. NFP own and control the major storage and diversion works in the catchment. These are Talbots Lagoon, a water race from Talbots Lagoon to the Emu catchment, and Companion Dam. Details of sizes and capacities of these works are set out in the following:

- Talbots Lagoon - 5000 ML;
- Race from Talbots Lagoon - 65 ML/d;
- Companion Dam - 1400 ML.

NFP releases water from Talbots Lagoon through a water race into the Emu catchment and Companion Dam to supply Australian Paper at Burnie. In addition to receiving water via Companion Dam, Australian Paper rely on significant amounts from tributary flows entering the Emu River downstream of Companion Dam.

Australian Paper divert a maximum of 90 Megalitres per day from the Emu River at Burnie. The estimated average daily diversion is in the range of 75 to 80 Megalitres per day. NFP have a diversion requirement of 5.8 Megalitres per day at Hampshire.

Based on discussions with NFP in 1993, it was determined that the existing storages and water race were fully committed in supplying existing requirements during dry periods. During 1987 it was estimated that Talbots Lagoon only had 4 days of water left before rain broke the "storage drought". During the same time, Companion Dam was effectively emptied and the Burnie Mill needed to buy water from Burnie City to supplement their water requirement.

3. Existing Rights

Burnie City Council

Under the Burnie Water Act, the City of Burnie is entitled to take all the water they may require from the Emu River, Pet River, Guide River and Romaine Creek to supply inhabitants of Burnie and contiguous districts with water for domestic and manufacturing purposes, for motive power and irrigation.

Currently Burnie do not take water out of the Emu River catchment. If extractions did commence from the catchment, care would need to be exercised with respect to flow conditions at the time of diversion. Any extractions during dry times would impact on the water supply reliability to North Forest Products' wood chip mill at Hampshire and Australian Paper's Burnie Mill.

North Forest Products

NFP take the following water under a Commissional Water Right (CWR) :

Emu River	5.8 ML/d to a maximum of 2102 ML from 1 Jan to 31 Dec.
Emu River (Companion Dam)	1400 ML into storage between 1 May and 30 Nov.
Wey River (Talbots Lagoon)	5500 ML between 1 May and 30 November
Wey River (transfer into Emu catchment)	65 ML/d to a maximum of 15860 ML from 1 Oct to 31 May

Australian Paper

Australian Paper also divert water under a CWR. Under their licence they are entitled to take 32800 Megalitres between the 1 January and 31 December at the rate of 90 Megalitres per day at the Burnie Mill.

Irrigation Rights

Rights for irrigation are given as Commissional Water Rights (CWR's) under the Water Act. Water allocated to irrigators in the Emu River catchment amounts to a daily diversion rate of 2.25 ML/d between 1 December and 30 April and storage takes into dams of 485 ML.

4. Availability of resource.

As mentioned previously, the stored resource and reliable summer flow (ie that which would occur between 80 to 100 % of time) is fully utilised by existing water requirements in the Emu River catchment. This includes the reliable flow from Loudwater Creek which is required to give resource security to the Burnie Mill.

Ettrick River upstream South Road (King Island Basin)

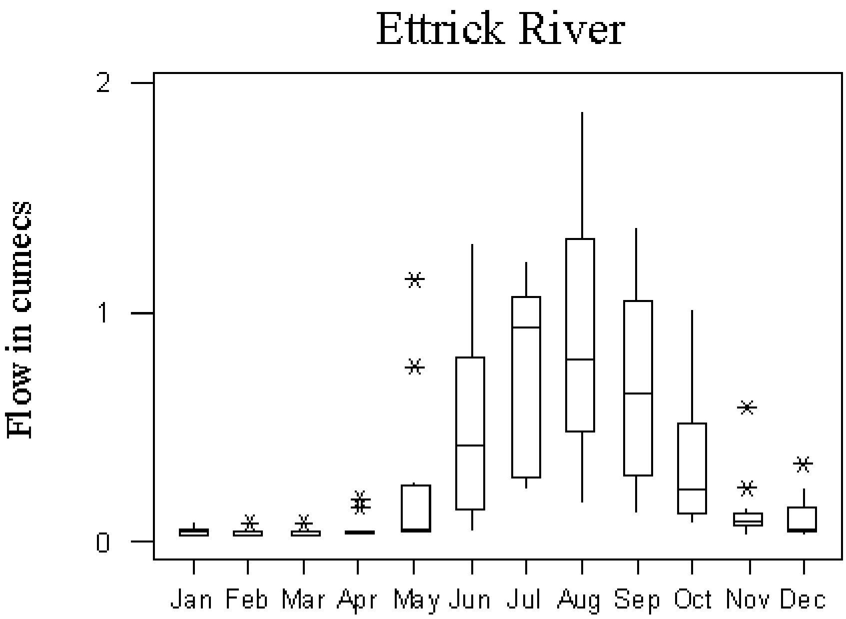
Station Number: 13200

Easting: 234900 Northing: 5568400

Period of Record: Mar 1981 to Sept 1994

Catchment Area (Km2): 44.6

Land use in the Ettrick River catchment is dominated by dairy and beef cattle grazing. Monthly flows are highly variable during winter months (June - October) and fall rapidly to very low levels between November and April. Flows in the system are clearly dominated by rainfall with very little input from groundwater storage. Flows in November and May are particularly variable.



Water quality information for the Ettrick River is sparse. The single apparent colour and filterable residue readings are high suggesting effects of land clearance and/or erosion. The stream has very nearly neutral pH.

Parameter	Units	N	Min	Max	Mean
Water Temperature	C	3	8.9	18	13.0

EC at 25C	uS/cm	-			
pH		4	6.9	7	7
Apparent Colour	Hazen	1			250
Tot Suspended Solids	mg/l	1			3
Filt Residue (104C)	mg/l	1			290
Dissolved Oxygen	mg/l	-			
Tot Copper	mg/l	-			
Free Ammonia	mg/l	-			
Tot Phosphate	mg/l	-			
Tot Coliforms/100ml	ct/100ml	-			

Note:- - indicates no data available

Ettrick River

Water allocated in the Ettrick River amounts to only .. ML. This mainly comprises diversions into farm storage of ....ML with only ....ML taken directly out of the River. Further licences to extract irrigation water are not being authorised due the low reliability of summer flows.

Forth River upstream Wilmot (Forth River Basin)

Station Number: 665

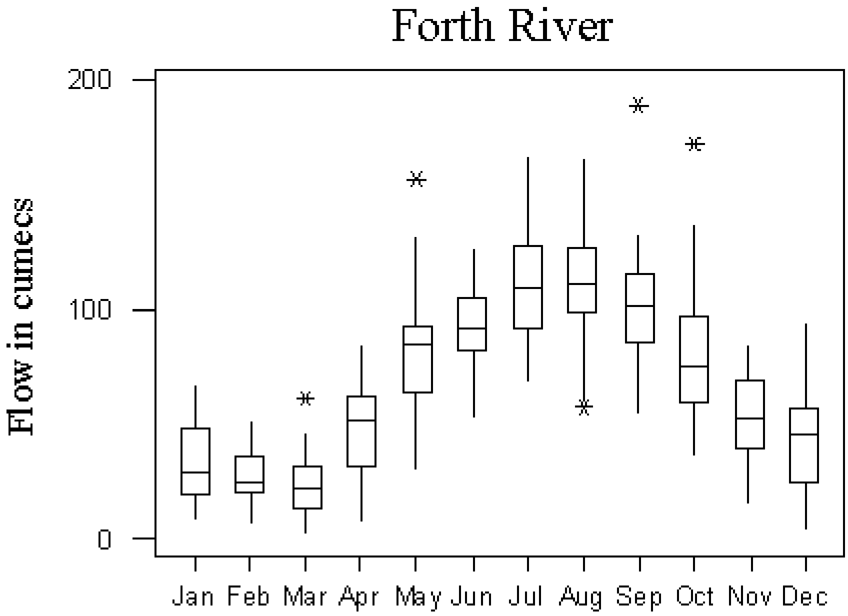
Easting: 436300 Northing: 5438200

Period of Record: Sept 1972 to date

Catchment Area (Km2): 1105

Agriculture and forestry are the predominant land uses in the Forth River catchment. The Forth River is highly regulated by HEC storages and since 1970 has been subject to diversions from the Mersey River catchment via Lake Parangana and the Lemonthyme Power Station. Downstream of this power station the Forth River essentially consists of a chain of storages (a lentic system) in contrast with its natural state as a lotic (running water) system.

Streamflows exhibit relatively uniform variation throughout the year with large ranges in the extremes. Average summer flows are high due to the regulation of Lake Barrington.



The pH of the Forth River water is generally slightly acidic indicating the dominance of rainfall on river flows. Conductivity is quite high possibly due to the effects of geology in the region. (Saltwater intrusion at the measuring site may also be a factor). Suspended solids and filterable residue concentrations are quite low suggesting little erosion or effects of land clearance. This is not surprising given the large natural buffer strips afforded by the steep country surrounding the Forth River. Dissolved oxygen levels are quite healthy and only low levels of nutrients have been identified. Maximum total coliform levels are quite high and may suggest an problem with pondage in the lower Forth River particularly during summer.

Parameter	Units	N	Min	Max	Mean
Water Temperature	C	30	4.5	18	11.7
EC at 25C	uS/cm	5	29.1	62.6	36.9
pH		32	5.4	7.8	6.9
Apparent Colour	Hazen	31	10	125	37
Tot Suspended Solids	mg/l	31	0.1	44	4.3
Filt Residue (104C)	mg/l	32	14	100	36.4
Dissolved Oxygen	mg/l	26	7.4	12.1	9.9
Tot Copper	mg/l	-			
Free Ammonia	mg/l	8	0.02	0.17	0.11
Tot Phosphate	mg/l	8	0.001	0.011	0.008
Tot Coliforms/100ml	ct/100ml	8	4	6300	865

Note:- - indicates no data available

Forth River

The flow leaving the Forth River power stations is generally more than sufficient to look after existing irrigation and water supply requirements. However, periods of low regulation can place a premium on water extraction.

North West Regional Water Authority.
The Forth River is a source of supply for the North West Regional Water Authority (NWRWA). A specific allocation from this river does not appear to have been made but rather the Authority have a right to take all the water they require from the River. In February 1995, the North West Regional Water Authority had trouble getting sufficient water to meet demand and the HEC made a special release at the time.

Irrigation Rights
Rights for irrigation water are allocated as CWR's up to a daily diversion rate of 16.5 ML/d between the 1 Dec and 30 Apr, with storage takes into dams of 880 ML. The maximum individual daily diversion rate over this period is 9 ML/d.

Environmental water requirements
Although the Forth River is highly regulated, environmental flows are an issue and would need to be considered as part of any proposal to extract further water from the Forth River or its catchment. Furthermore there is room to improve the current operation of the Mersey-Forth power system to, for example, ensure that adequate water passes over the NWRWA pump station weir to enable fish passage at critical times of the year.