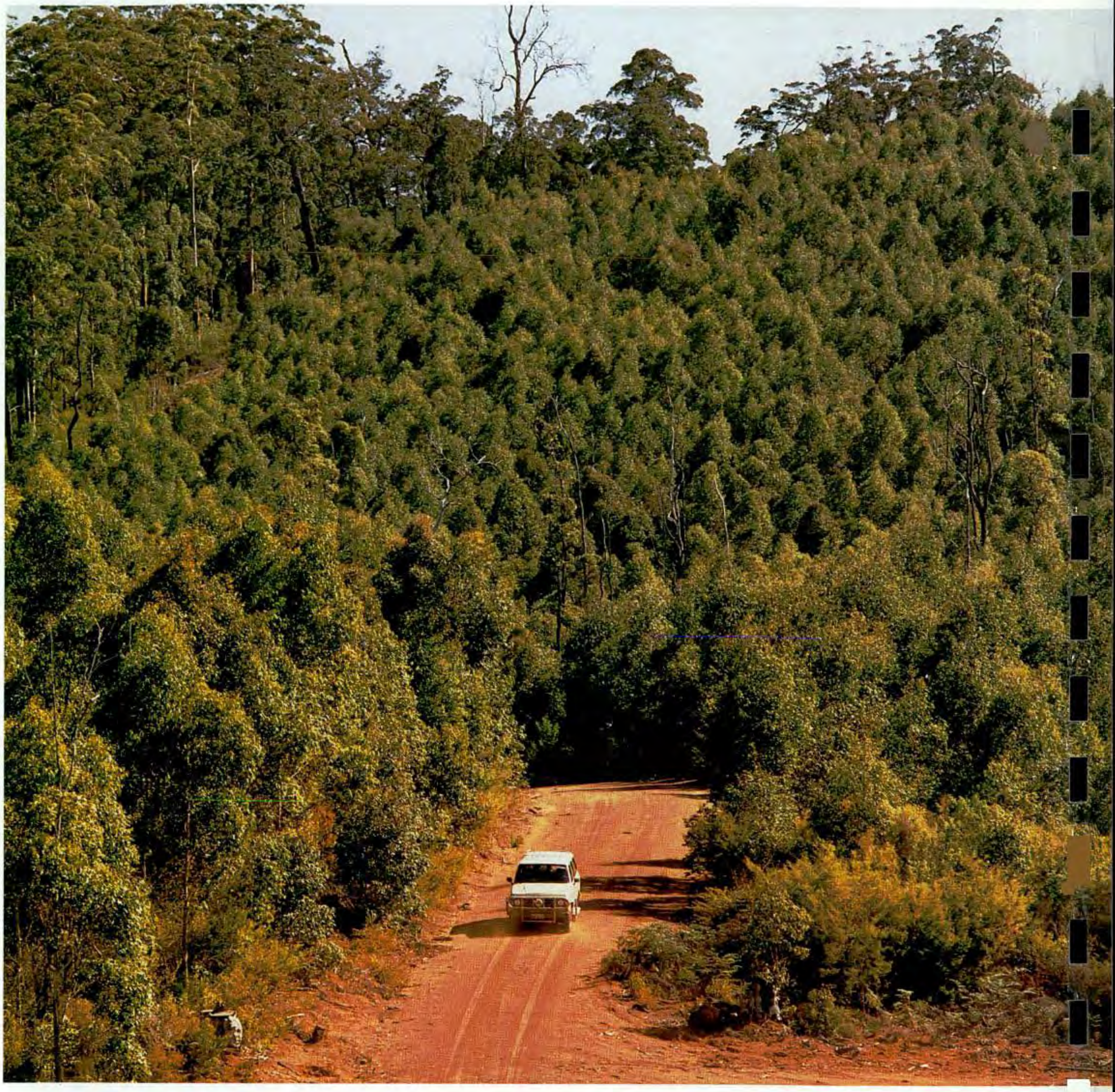
60 year old regrowth karri forest near Pemberton

WACAP

TOWARDS 2005

Environmental Review and Management Programme, Draft Environmental Impact Statement.

Dames & Moore
in association with
Margules and Partners Pty. Ltd.



7 year old karri regrowth forest near Manjimup

WACAP TOWARDS 2005

ENVIRONMENTAL REVIEW AND MANAGEMENT PROGRAMME
AND DRAFT ENVIRONMENTAL IMPACT STATEMENT FOR THE
EXTENSION OF THE LICENCE FOR
W.A. MARRI WOODCHIP EXPORT INDUSTRY

April, 1987

WACAP TOWARDS 2005

ENVIRONMENTAL REVIEW AND MANAGEMENT PROGRAMME AND DRAFT ENVIRONMENTAL IMPACT STATEMENT FOR THE EXTENSION OF THE LICENCE FOR W.A. MARRI WOODCHIP EXPORT INDUSTRY

The Environmental Protection Authority (EPA) and the Commonwealth Department of Arts, Heritage and Environment (DAHE) invites people to make a submission on this proposal.

WA Chip and Pulp Pty Ltd (WACAP) established a woodchip export project in 1976. The licences controlling the production and export of woodchips are due to expire in 1991 and the company is proposing to continue its export woodchip operations beyond that date.

In accordance with the requirements of the WA Government and provisions of the Commonwealth Environment Protection (Impact of Proposals) Act an Environmental Review and Management Programme/Draft Environmental Impact Statement, which describes current and proposed operations and their probable effects on the environment, has been prepared by the WA Chip and Pulp Pty Ltd.

WHY WRITE A SUBMISSION?

A submission is a way to provide information, express your opinion and put forward your suggested course of action — including any alternative approach. It is useful if you indicate any suggestions you have to improve the proposal.

All submissions received by the Departments of Conservation and Environment, and Arts, Heritage and Environment will be acknowledged. Submissions will be evaluated in the development of each of the reports and recommendations made to the State and Commonwealth Governments.

Submissions will be treated as public documents unless confidentiality is requested and may be quoted either in full or in part in each report.

DEVELOPING A SUBMISSION

You may agree or disagree, or comment on, the general issues discussed in the ERMP/Draft EIS, or with specific proposals. It helps if you give reasons for your conclusions, supported by relevant data.

You may make an important contribution by suggesting ways to make the proposal environmentally more acceptable.

- clearly state your point of view;
- indicate the source of your information or argument if this is applicable; and
- suggest recommendations, safeguards or alternatives.

POINTS TO KEEP IN MIND

By keeping the following points in mind, you will make it easier for your submission to be analysed:

Attempt to list points so that the issues raised are clear. A summary of your submission is helpful.

Refer each point to the appropriate sections, chapter or recommendation in the ERMP/Draft EIS.

If you discuss different sections of the ERMP/Draft EIS, keep them distinct and separate, so there is no confusion as to which section you are considering.

Attach any factual information you wish to provide and give details of the source. Make sure your information is accurate.

Submissions will be treated as public documents unless confidentiality is requested.

REMEMBER TO INCLUDE

YOUR NAME

ADDRESS

DATE

THE CLOSING DATE FOR SUBMISSION IS: July 6, 1987.
SUBMISSIONS SHOULD BE ADDRESSED TO:

The Chairman,
Environmental Protection Authority
1 Mount Street
PERTH WA 6000
Attention: Mr. C. Murray

The Secretary,
Department of Arts, Heritage and Environment
GPO Box 1252
CANBERRA CITY ACT 2601
Attention: Ms. J. Tomkins

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1.0 SUMMARY

1.1 INTRODUCTION

The W.A. Chip & Pulp Co Pty Ltd (WACAP) established a woodchip export project in 1976 utilising marri and karri wood residues from the southern forest areas of Western Australia. The original EIS for the project area was prepared in 1973 by the then Forests Department of Western Australia. The licences controlling the production and export of woodchips are due to expire in May 1991. This Environmental Review and Management Programme/draft Environmental Impact Statement (ERMP/draft EIS) has been prepared in order to satisfy State and Commonwealth requirements so that the licences controlling production and export of woodchips can be extended for a further 15 years after the current licences expire.

This document has been prepared in accordance with guidelines provided by the Environmental Protection Authority (EPA). These guidelines were submitted, in draft, to various government agencies and interested non-government parties for comment. The resultant comments were included in the final guidelines provided by EPA from which this document was prepared.

The need for continuation of the project is based on a continuing export market for the product, the benefits which are provided by the woodchipping project to the forestry industry based on the southern forests of Western Australia, and the economic and employment benefits which result from the project, particularly at the local and regional scales.

1.2 EXISTING OPERATIONS

WACAP produces woodchips from wood which has no other economic use. The sources include:

- Logs from State forest areas which are unsuitable for the production of sawn timber. These logs are predominantly from marri trees but include some from karri trees.
- Logs unsuitable for sawmilling from private land which is either cleared for agricultural purposes or for the establishment of timber plantations. Most of these logs are also from marri trees.
- Residues from timber mills representing the offcuts from sawn timber production. These residues are mainly derived from karri logs.

Most of the wood for the production of woodchips has been obtained from the integrated forestry operations carried out in State forest and managed by the Department of Conservation and Land Management (CALM) in its Southern Forest Region. Under the existing Forest Produce (Chipwood) Licence, a licence area of 884,100ha (Figure 1) has been delineated. Within this area, Crown land managed by CALM occupies 717,600ha, and of this area, 457,000ha is available to a greater or lesser extent for production forestry which produces chiplogs as a byproduct.

Under the terms of its licences, WACAP can export up to 750,000 tonnes per year of marri and karri woodchips. The licence also allows for the additional export of 150,000 tonnes of jarrah woodchips; however, there is currently no market for this product. Since its inception, the woodchip project has produced approximately 6.2 million tonnes of woodchips, of which 5.2 million tonnes have been obtained from State forest within the licence area. An additional 55,000 tonnes of woodchips have been derived from forestry activities in State forest outside the licence area. The balance of production has been from private land and sawmill residues.

WACAP pays royalties to CALM for chiplogs from State forest at the rate of $8.47 per tonne. In 1986, royalties paid to CALM amounted to $5.4 million. Different payments are made for chiplogs from private land, depending on the purpose of the clearing operations, and for sawmill residues.

CALM is responsible for the management of State forest to cater for a wide range of land uses including conservation, production forestry, catchment protection, recreation and a variety of special purpose uses. In terms of production forestry, CALM and its controlling bodies are totally responsible for formulation of policy, planning, harvesting and regeneration. The chiplogs on which the woodchipping project depends are a byproduct of this forestry.

The main forest types which are harvested within the licence area are karri-marri, karri and jarrah-marri. CALM has developed different approaches to harvesting, regeneration and environmental control in the karri type forests to those which apply to the jarrah type forests.

Forestry operations are planned well in advance. In forest containing karri, these plans involve:

- o Clear-felling of discrete areas averaging 70 to 80ha, to produce general purpose sawlogs, salvage sawlogs and chiplogs. Selected karri trees are retained in some clear-felled areas to provide a seed source for subsequent regeneration.
- o Rolling and burning of the remaining vegetation to provide ashbeds which favour re-establishment of the forest.
- o Removal of the seed trees.
- o Planting, seeding, and infill planting where necessary, to ensure re-establishment of the forest.
- o Thinning programmes in regrowth forests to promote growth of retained trees and to remove unwanted trees. Thinnings provide both sawlogs and chiplogs.
- o Burning after thinning to reduce the risk of wildfire damage to the retained trees.

In jarrah forests, the procedures are different in that harvesting operations involve either thinning or the group selection felling of small areas. There is no market for jarrah woodchips and therefore marri trees provide the only source of chiplogs from jarrah forests.

Chiplogs from State forests and private land are transported by trucks to WACAP's Diamond Chipmill, located 11km south of Manjimup. After checking to ensure that no sawlogs are present, the remaining logs are de-barked, chipped, screened and conveyed to a stockpile or bins from where they are subsequently railed to a large stockpile at the Port of Bunbury. At Bunbury, the woodchips are loaded into special ships for transport to overseas markets.

1.3 PROPOSED CONTINUATION OF THE PROJECT

1.3.1 <u>General</u>

The woodchip export project has been operating for 11 years. During this period, silvicultural operations and environmental management procedures have been developed and refined as would be expected in a well-established, mature industry. No major changes in procedures are envisaged. The changes that are proposed are more in the nature of fine tuning to produce improvements in operating efficiency or environmental management.

1.3.2 Resources

The licence area from within which most of the State forest chiplogs will be produced will remained unchanged. During the proposed licence period there will be a decline in production of chiplogs from mature (old growth) forests within the licence area. However, this production will be replaced to a large extent by thinnings from regrowth karri forest.

Additional supplies of marri chiplogs will be provided by CALM from integrated harvesting operations outside the licence area. It is anticipated that chiplogs from private property clearing operations will continue to be available, at least until the year 2000. By this time, private hardwood plantations established by WACAP will be ready for harvesting.

The Timber Strategy Paper (CALM 1987b) provides assessments of the yields of chipwood that will be available from the State forests over the proposed licence period. These, together with estimates made by WACAP of chipwood available from other sources, are sufficient to meet the export volumes proposed (up to 750,000 tonnes per year of marri and karri woodchips).

It is important to understand that CALM's forest management procedures in the Southern Forests are based on the sustained yield concept, whereby the yield of wood products harvested is not greater than the volume of wood grown by the forest within the same period. The current harvested volume is less than the total increment of the forest and the harvesting level can be sustained indefinitely.

1.3.3 Improvements in Operating Procedures

A number of improvements in harvesting equipment have been developed. Of particular interest is the continuing development and increasing use of harvesting machines which cause less soil compaction than conventional machines. This includes the use of static log loaders at the bush landings which reduces disturbance and soil compaction, and also reduces the risk of spread of dieback disease.

Mechanical harvesting equipment will be used for thinning of karri regrowth. The advantage of this equipment over conventional chainsaw-felling and skidding is that productivity is increased and worker safety is improved.

1.4 EXISTING ENVIRONMENTAL CONDITIONS

1.4.1 Climate

The woodchip licence area is located in the South West of Western Australia. The climate is mediterranean, characterised by cool, wet winters and dry mild summers. Annual rainfall decreases with distance from the coast, ranging from a minimum 600mm per year on the northeast edge of the licence area, to more than 1500mm per year in the southern coastal area.

1.4.2 Geology, Landform and Soils

The licence area comprises the southern part of the Great Plateau of Western Australia, characterised by Precambrian crystalline rocks - mainly granite, gneiss and basic volcanic rocks. These basement rocks have been extensively weathered, forming lateritic profiles up to 20m thick beneath the plateau remnants, with thinner profiles in the valleys where erosion has removed much of the weathered material.

The main soil types are:

- Lateritic soils consisting of sands, gravelly sands and lateritic caprock, which occupy the upland plateau remnants.
- Yellow duplex soils consisting of gravelly sand underlain by clay, which occupy middle and upper slope positions in dissected terrain.
- Red earths, which are deep sandy loams occurring on lower slopes in high rainfall areas.
- Brown gravelly duplex soils, consisting of deep gravelly sandy loam underlain by clay, which occur in dissected terrain in high rainfall areas in the southern part of the licence area.

1.4.3 Hydrology

The licence area is drained by the following rivers:

Blackwood River
Donnelly River
Warren River
Shannon River
Deep River
Walpole River
Frankland River

To date these surface waters have not been extensively developed for water supply purposes although small reservoirs have been developed to supply the towns of Manjimup and Pemberton. It is estimated that 720 million cubic metres per year of water is potentially available for water supply compared to the total streamflow which averages 1550 million cubic metres per year.

Under undisturbed forest conditions, streamflow from the project area ranges between zero and 25 percent of the rainfall. This low stream yield is a result of the deep soils which provide a large, subsurface storage capacity.

Clearing of forests reduces evapotranspiration losses and leads to increasing subsurface storage and increased streamflows.

Soil profiles in the intermediate (900mm to 1100mm per year average) rainfall zone and low (less than 900mm per year) rainfall zone contain salt which dissolves as groundwater levels rise following forest clearing. In the low rainfall zone groundwater rise may be insufficient to intersect the streams, however, in parts of the intermediate zone, saline groundwater contributes appreciable quantities of salt to the streams. As a result of agricultural clearing, mainly to the northeast and east of the licence area, the water quality of rivers draining these areas has deteriorated. The average salinity of the Warren River, for example, has increased from 400mg/L to more than 700mg/L over the past 40 years. By contrast, rivers and streams draining high rainfall areas contain relatively little salt. The forestry operations are concentrated mainly in higher rainfall areas and have not caused serious or long term salinity changes.

The concentration of suspended sediments in the project area is low, averaging less than 20mg/L. High sediment concentrations do occur in small streams as a result of local soil disturbance.

1.4.4 Flora and Fauna

The two vegetation types subject to wood harvesting operations are:

- High Open Forest, comprising karri or karri and marri with some jarrah and marri. Apart from these tall trees, these forests include understorey trees (karri oak and W.A. peppermint) and a variety of shrubs and creepers. These forests mainly occupy the areas of red earths and brown duplex soils where average rainfall exceeds 1016mm per year.
- Open Forest, comprising jarrah or jarrah and marri, with other less common eucalypt species. A variety of understorey species, mainly different from those of the high open forest, occur. These forests grow mainly on the lateritic soils and in drier parts of the licence area.

A variety of other vegetation types are interspersed with the forests. These include low woodlands, heaths and wetland communities.

The forests of the project area, particularly the karri forests, are relatively poor in fauna species in comparison to drier areas to the northeast. A total of 28 native mammal species have been recorded from the area, of which four are considered to be now extinct. Some 144 bird species, 32 reptile species and 15 species of frogs have also been recorded.

A review of published and unpublished information on rare or restricted flora species reveals six gazetted rare or restricted species are known to occur in the licence area. Of these, only one species is confined to the licence area.

Of the fauna species gazetted as rare or endangered, five mammal species and three bird species are known to be present within the licence area. The project is not expected to adversely affect populations of these species. An additional four mammal species and one bird species, although their ranges of distribution intersect the licence area, are believed not to be present.

1.4.5 Social Environment

Most of the woodchip project operations take place within the Shire of Manjimup which supports a population of approximately 10,000 and has a current annual average growth rate of 1.3 percent. This compares with the overall South West Region with a population of approximately 115,000 and an annual average growth rate of 2.9 percent.

The wood products industry is a major employer in the region employing 1471 people in 1983/84, with the majority of this employment in the Manjimup Shire. At least 48 percent of the total workforce in Manjimup Shire is either employed by or involved in servicing the forest industries.

WACAP provides at least direct employment for 215 people with at least 138 additional jobs indirectly attributable to its operations. Of the 353 indirect and direct jobs, 251 are based in Manjimup and all but 13 are based in the South West region. Induced employment attributable to WACAP is estimated to provide at least 121 additional jobs in the region.

Other industries in the Manjimup Shire include tourism, agriculture, horticulture and the associated food processing industry at Manjimup.

Unemployment in the Manjimup Shire fluctuates due to the seasonal employment provided by harvesting of orchards and market gardens. The official employment rate in December, 1986 at 8.4 percent was marginally below the State average.

Data on mobility and family type in the Manjimup Shire suggest a higher stability than for the region as a whole, with strong local family networks, and a less mobile population.

1.4.6 Land Use

The predominant land use in the project area is the production of timber products, mainly from State forest, of which approximately 370,000ha is used for this purpose. A similar area of State forest and other Crown Land is reserved for other purposes which include conservation and recreation. The forests also support bee-keeping activities and minor wildflower harvesting.

The private land within the project area is used for a variety of agricultural purposes - mainly the grazing of cattle, with market gardens and fruit orchards in the Manjimup area. Hardwood plantations are also being established on private land, with considerable technical and financial assistance provided by WACAP.

The project area includes various areas and sites which are listed on the Register of the National Estate, compiled by the Australian Heritage Commission. Most of these areas and sites correspond to parks or reserves which are excluded from the harvesting of wood products. However, there are several listed or suggested areas of the National Estate on State forest which are included in CALM's proposed wood harvesting plans. It is CALM's opinion that the extensive areas of parks and reserves established by CALM following comprehensive studies cater adequately for conservation, landscape and recreation needs in the South West forests and that, accordingly, there is no justification for the reservation of additional areas.

1.5 ENVIRONMENTAL IMPACTS

1.5.1 Soil Resources

A comprehensive range of procedures has been developed by CALM to minimise soil erosion from forestry activities. These have been successful in maintaining erosion within acceptable limits.

Soil compaction due to harvesting operations has the potential to impede regrowth of the forest. Again, procedures have been developed and implemented by CALM which ameliorate these effects.

The potential long term loss of nutrients from forest soils has been the subject of studies. These studies indicate that the ecosystems are resilient to loss of nutrients due to harvesting and subsequent burning operations and no serious consequences are anticipated for the regenerating forests.

1.5.2 Water Resources

Harvesting operations cause an abrupt reduction in transpiration, causing increased runoff and sediment transport, rising groundwater levels, and increased contribution of salt to surface waters. At a local scale, these impacts can be important, particularly in the intermediate rainfall zone. Retained forest vegetation adjacent to streams helps to reduce these effects. Improvements to this system of stream buffers are foreshadowed in CALM's regional plans. However, these local impacts are of short duration and, on a regional scale, the effects are minor and do not compromise existing or planned water resource developments.

The establishment of hardwood plantations on private property which is currently cleared provides the potential for amelioration of salinised soils and streams. This would represent a major improvement in land use from the viewpoint of water resources.

1.5.3 Biological Resources

Harvesting operations are widely dispersed in space and time; this helps to minimise the potential negative impacts on flora and fauna.

CALM's regeneration operations lead to development of a forest with enhanced productive potential without the loss of biological diversity or stability. Harvesting operations are confined to the common forest types and are not carried out in areas with unusual ecological attributes.

In addition, representative areas of mature forests are retained in parks and reserves which are not available for the harvesting of wood products. It is proposed by CALM that these areas will be formally given security of tenure and purpose. These non-wood production areas together with road, river and stream reserves constitute approximately 45 percent of Crown land within the licence area.

The maintenance of genetic resources is ensured by the retention of these non-wood production areas and by careful selection of seed and seed trees for regeneration of harvested areas.

The retention of buffer zones of mature forests adjacent to roads, streams and property boundaries, together with the many non-wood production areas, will ensure that viable populations of fauna are maintained. Fauna populations from these refuge areas will also serve to recolonise the harvested areas as the forest regenerates.

The progressive replacement of parts of the mature forest with regenerating forest will disadvantage some species, particularly those that require elevated holes for their nests. These species are, however, common and widespread. Proposed changes to the reserves within timber production areas will also alleviate this problem.

The proposed operations are not expected to have an effect on rare or endangered species of flora or fauna. In the case of the rare plants, their distributions are such that they do not occur in areas which will be intensively harvested. The rare mammal species occur in conservation management priority areas and are not known to enter the high forests where most of the harvesting will occur. The rare birds, although uncommon, are widespread.

1.5.4 Landscape Values

Harvesting operations result in obvious visual disturbance. However, the attractiveness of harvested areas returns within a few years. Buffers retained adjacent to roads and rivers also effectively screen the harvested areas from public view and help maintain these values.

1.5.5. National Estate Values

Most of the areas on the National Estate register will be excluded from wood harvesting operations. The remaining registered areas duplicate forest types and values which are adequately represented in other areas not subject to wood harvesting. These considerations, together with the dispersal of harvesting operations in space and time, and the retention of mature forest buffers, mean that the total impact on National Estate values will be very low.

1.5.6 Population and Employment

Continuation of the woodchip export project will assist in maintaining the stability and prosperity of those communities which depend on the forest industries.

1.5.7 Economics

The woodchip project will continue to provide substantial revenue to all levels of Government. In 1985/86, WACAP payments to Government bodies amounted to $15 million. It is expected that payments of this magnitude will be maintained in real terms for the life of the project.

The substantial contributions of this project to the nation's export income ($38 million in 1986) are also expected to be maintained.

1.6 ALTERNATIVES

Alternatives to the proposed continuation of the woodchip export project which have been considered include:

- No action (i.e. closure of the woodchip industry)
- Variations to the area of supply
- Alternative sources of chiplogs
- Alternative silvicultural management of the forest
- Varying levels of production
- Alternative uses of chipwood
- Alternative industries

Closure of the woodchip industry would have severe adverse impacts on employment and on the economy of the South West region. The reduction in revenues would be detrimental to Government departments, particularly to CALM and Westrail. In addition, without the woodchip industry, CALM's plans for the maintenance of sustainable production from the Southern Forests could not be achieved unless the State Government was prepared to subsidise the silvicultural operations required to ensure that full productivity is maintained.

The other alternatives provide no significant benefits beyond those which are realised by the existing proposals. In many cases, adoption of these alternatives would have adverse consequences. An alternative use of chipwood is the development of a local pulp processing industry which would have significant benefits in terms of employment, export income and import replacement. WACAP is currently reassessing past feasibility studies to see if the cost structure has altered enough to put such an industry in a more favourable position.

1.7 MANAGEMENT PROGRAMME

1.7.1 Policy

The CALM Act (1984) established the Department of Conservation and Land Management (CALM) and two controlling bodies - the Lands and Forests Commission (LFC) and the National Parks and Nature Conservation Authority (NPNCA). The function of these bodies is to have relevant CALM land vested in them and to develop, through the agency of CALM, policies and management plans to achieve or promote the objectives of the particular land use

CALM is responsible for all aspects of management on land designated in the CALM Act, including the definition of environmental standards, their enforcement, monitoring and review.

Policies on wood production, conservation, environmental protection, fire management, recreation and the control of weeds, pests and diseases are given in the Draft Regional Management Plans (CALM 1987a,b,c). These plans will be open to public review and comment at the same time as public review and comment are sought on this ERMP/draft EIS.

1.7.2 Environmental Protection Measures

A comprehensive range of environmental protection measures have been developed by CALM governing forestry operations in State forests. Detailed procedures are specified in the Industry Control Manual and Southern Forest Operations Manual. Supervision and inspection of operations carried out by subcontractors and by WACAP, are provided by forest officers from CALM.

The main environmental protection measures are summarised below:

o Conservation of Ecological Values

This is accomplished by the network of parks and reserves which have been excluded from wood harvesting and which will be afforded security of tenure and purpose under CALM's new policies. Within the licence area, approximately 35%

of the forested Crown Land managed by CALM is proposed to have a priority that would preclude wood harvesting. Additional road, river and stream buffer zones bring up to 45% (approximately 323,000ha), the area set aside to conserve ecological values. These areas contain representative examples of all forest types that occur in southern forests, and have been selected after detailed study of conservation needs by the EPA (DCE, 1973, CALM, 1987a).

Additional protection of ecological values will be provided by the retention of buffers amounting to approximately 20 percent of each forest block which is managed for wood production.

o <u>Protection of Water Quality</u>

A detailed range of procedures is implemented to minimise soil erosion, thereby minimising introduction of sediments to surface streams.

The range of procedures includes:

- The retention of uncut buffer zones, in surface drainage areas with significant potential for erosion.
- A commitment to ongoing cooperation with the Water Authority in catchment management.
- Implementation of special harvesting procedures in areas designated as 'special care' zones, that is having slopes in excess of 15 degrees.
- Sequencing coupes in time to avoid concentration on individual drainage systems.
- Selective placement of landings, tracks and roads to minimise erosion.
- Installation of drainage works, embankments and watercourse crossings, where necessary, to minimise erosion.

Outside the higher rainfall zone, operations are specially designed to minimise the increased propensity for salinisation.

o Protection of Forest Productivity

A wide range of silvicultural practices have been developed to optimise regrowth of forest areas. These practices relate to harvesting of wood products, burning of unusable wastes, seeding and planting of harvested areas, rehabilitation of highly disturbed areas and thinning of regrowth forests. The practices are varied depending on forest type and site conditions.

The clearing of forests from private land requires a permit from the Department of Agriculture. In some areas a clearing permit from the Water Authority is also required.

WACAP encourages afforestation of previously cleared land and reforestation of newly cleared land. In addition, WACAP proposes to increase the area of hardwood plantations on its own land. It is anticipated that the area of private hardwood plantations will increase markedly in the next few years. Once these hardwood plantations reach the appropriate state of development, thinning and harvesting operations will be based on the relevant procedures established by CALM.

o Fire Protection and Control

CALM has developed a comprehensive and detailed fire protection programme involving:

- The retention of buffer zones,
- Prescribed burning practices to control forest fuel levels and control of burning activities,
- Maintenance of a fire suppression capability,
- Continued research into fire behaviour and ecology, refining of burning guides and development of future fuel reduction programmes.

o Protection of Genetic Diversity and Integrity

The maintenance of genetic diversity and integrity is achieved in two ways:

- By inclusion in areas reserved from wood harvesting operations, of the full range of genetic variation of each species.
- By careful control of the selection and use of seed in forest renewal.

The implementation of CALM's Regional Plan proposals will ensure reserved areas receive the highest protection possible for tenure and use.

The control of selection and use of seed in forest renewal will be managed by:

- Proper recording of relevant seed collection data.
- Ensuring seed used in direct seeding and nursery work is identified and obtained from the same major river valley, and from at least 10 separate parent trees.
- Recording of the origin of seed used in regeneration works.

Maximum advantage will be taken of the seed tree system to regenerate coupes, as this system has least impact on genetic diversity and integrity.

o Maintenance of Landscape Values and Visual Amenity

The management practices summarised above, in combination, serve to minimise short term visual impacts, to protect landscape values and to enhance these values in the long term.

1.7.3 Monitoring and Research

CALM undertakes or participates in a wide range of research programmes relating to hydrology, silviculture, ecology, fire control and the spread of dieback disease.

Specific ongoing research or proposals include:

o Project 2 paired catchment study (Appendix G)
o Field assessment of groundwater and soil salt characteristics.
o Karri ecology and silviculture research programme.

Supervision and control by CALM of the forestry operation is in accordance with the standards laid down in the original EIS (Forests Department 1973) and which have been refined over time. Additional control is exercised now by the need to obtain EPA approval for modification to the buffer system, and by public scrutiny of operations.

The monitoring of operations with positive feedback to correct problems as they arise is as essential to the ongoing management of this project as it is for other projects.

WACAP provides financial support for Government research programmes and undertakes its own research relating to woodchipping technology and the management of hardwood plantations. During 1986 at least 22 different research projects were being carried out. Many of these projects will continue well into the future.

1.8 CONCLUSIONS

It is concluded that the woodchip export project should continue. This conclusion is based on the following findings of this ERMP/draft EIS:

- The woodchip industry utilises wood residues which have no other practical or feasible beneficial use.
- The industry performs a vital function in overall forestry management, particularly in the karri forest, by removing residues which if left would inhibit regeneration and would be prohibitively expensive to remove by other means.
- Substantial payments are made by WACAP to Commonwealth, State and local Governments. These payments far exceed the costs incurred by Government in relation to WACAP's operations.
- WACAP's operations directly or indirectly provide employment for at least 353 people. This employment and the salaries and wages involved are highly important in maintaining the economic well-being of Manjimup Shire and are also significant in the South West region of Western Australia.
- Continuation of the project will have no serious long term, adverse ecological impacts, and will not significantly degrade soil or water resources.
- Continuation of the project has considerable community support, particularly at the local level.
- There are no practical and economically sound alternatives which would produce the same benefits with less environmental impact.

2.0 INTRODUCTION

2.1 THE PROPONENT

The Proponent for this project is W.A. Chip & Pulp Co. Pty Ltd (WACAP), which is wholly owned by Bunnings Limited, a publicly listed company with its headquarters in Western Australia.

The Department of Conservation and Land Management (CALM) is also closely associated with the project because, through its integrated forest management activities, CALM is responsible for providing wood in the form of chiplogs for the project. Under the Conservation and Land Management Act (1984) and the Forest Act (1918) which preceeded it, CALM has the sole responsibility for formulating forest policies and for implementing forest management practices. These are explained in detail in the Timber Strategy and the Regional Management Plans (CALM 1987a,b,c).

2.2 THE PROJECT

Since 1976 WACAP has carried out an export woodchip operation in the South West of Western Australia. Woodchips are produced for export from logs made available by CALM as part of its forest management practices in State forests - located within the licence area shown on Figure 2. Chiplogs are also made available by CALM from time to time, from its activities in State forests outside the licence area. Private landowners also provide chiplogs. Additional woodchips are produced from residues from marri and karri sawmills throughout the South West.

The Diamond Chipmill, located 11km south of Manjimup is the main centre for woodchip production. At this facility, chiplogs are converted to chips which are loaded onto trains for transport to the Port of Bunbury, from where they are shipped overseas.

WACAP's operations are governed by an export licence issued annually by the Commonwealth Government and by Forest Produce (Chipwood) Licence No. 1588 issued by the Western Australian Government under the "Woodchip Industry Agreement Act, 1969". The provisions of the Forest Produce (Chipwood) Licence No. 1588 are detailed in Appendix J.

The Western Australian Licence and Act are due to expire in 1991. WACAP will make application for a renewal of the relevant licence to enable the industry to continue for a further 15 years. WACAP have written to the Minister for Primary Industry, and have received a reply stating the requirement for environmental impact assessment prior to the application for licence renewal. There had been no application for licence renewal by WACAP, before this.

2.3 OBJECTIVES OF THE PROJECT

The general objectives of the project are:

- To maintain export income and employment from responsible use of forest resources.

- To enable efficient removal of wood residues after saw-log operations so that the Department of Conservation and Land Management (CALM) can meet its timber strategy objectives which are aimed at the sustainable utilisation of forest resources. This strategy is compatible with the World Conservation Strategy (IUCN 1980) which states:

  "Thus Conservation is positive, embracing preservation, maintenance, sustainable utilisation, restoration and enhancement of the natural environment".

2.4 PURPOSE OF ERMP/DRAFT EIS

The purpose of this Environmental Review and Management Programme (ERMP)/Draft Environmental Impact Statement (draft EIS) is to meet the requirements of the Western Australian Environmental Protection Authority (EPA) in relation to extension for a further 15 years following expiry in 1991 of the Forest Produce (Chipwood) Licence, and the extension of the Woodchip Industry Agreement Act. At the same time, the ERMP/Draft EIS is produced to comply with the Commonwealth Environment Protection (Impact of Proposals) Act, 1974 in association with application for renewal of the export licence.

The environmental documentation is being produced well in advance of expiry of the licences partly in response to inquiries by WACAP customers who require assurance of continued supplies of woodchips. In particular, the desirability of long-range planning of special ship availability is a matter of concern to the principal customers, and viewed by WACAP as important to good customer relations. Additionally, it is necessary for WACAP to receive the necessary approvals well in advance of licence expiry in order that it can formulate its substantial capital and investment plans. WACAP's capital and investment plans include continuation of their plantation programme. Other potential sources of capital outlay include major repairs and upgrading of the existing Chipmill facilities.

Within the State forest of the licence area, CALM has total responsibility for establishing policy for planning, for the formulation of operating procedures and for the inspection of forestry operations. CALM's policies and procedures are presented in detail in the draft Regional Management Plans and Timber Strategy. The impact assessments and environmental management programme presented in this ERMP/Draft EIS are based on CALM's current and planned policies and procedures. However, these policies and procedures are subject to public input and are also subject to continuing re-evaluation within CALM. Accordingly, there is the potential for future changes in procedures that may affect the harvesting operations and therefore affect the supply of chiplogs to WACAP. Clearly, such changes are beyond WACAP's control, and it is not possible for WACAP to anticipate the changes that may take place or the environmental consequences of these changes.

2.5 THE ENVIRONMENTAL REVIEW PROCESS

This ERMP/draft EIS document has been prepared in accordance with Guidelines formulated jointly by the EPA and the Commonwealth Department of Arts, Heritage and the Environment; these guidelines are reproduced in Appendix A. This document is the second EIS produced for the Western Australian Woodchip Project. The first was prepared by the State in 1973 and predated the promulgation of the Commonwealth environmental legislation.

The document will be available for public review and comment following which a final EIS document will be produced which will address issues raised in the public submissions. The final EIS document will also be available to the public. Any changes or additional commitments made as a result of consideration of submissions made by the public or by Government authorities, would be included in the final EIS.

The remainder of this document presents:

- An overview of the need for the continuation of the project.
- A description of the existing and proposed woodchipping operations in the context of the overall forest management strategy.
- A summarised description of the existing environment as it pertains to the project.
- Assessment of the potential environmental impacts of the project.
- Identification of alternatives to the project as proposed, with assessments of the potential impacts that would be associated with each alternative.
- The Environmental Management Programme which presents the commitments made by the Proponent and by CALM for procedures to minimise adverse impacts and to monitor the effects of the proposed activities.
- A description and discussion of the Public Participation Programme.
- A list of references cited plus a glossary of technical terms used in the document.

3.0 NEED FOR CONTINUATION OF THE PROJECT

3.1 MARKET FOR FOREST PRODUCTS

3.1.1 Local

In Western Australia, production forest is directed primarily towards supplying the local demand for sawn timber. CALM has forecast a small increase in this demand over time (CALM, 1987b). Softwoods from pine plantations will progressively replace jarrah for local supplies of sawn timber. The production of karri sawlogs is projected to remain at close to current levels from all sources.

There are only limited markets for wood which is unsuitable for production of sawn timber. No significant local markets exist for pulpwood used for paper manufacture. A recent proposal for charcoal production is based on the use of jarrah residues. Jarrah is also used extensively for firewood, particularly from forest areas close to the major population centres. The available resources of jarrah residues far exceed the current demand, as jarrah is unsuitable for the production of export woodchips. This is due to the high cost involved in processing it to a standard suitable for fine paper manufacture. Consequently it is not a commercially economic woodchip source at the present time.

The woodchipping operations utilise only wood which is unsuitable for the production of sawn timber. Accordingly, there is no conflict between resources used for woodchipping and those used for forest products. On present trends, no competition for resources is foreseen. In order to emphasise the extent to which the Western Australian Forest is sawlog driven, a comparison with the South Coast of NSW shows that the sawlog to chipwood ratio (in tonnes) is 1:1 in Western Australia and 1:9 in New South Wales.

3.1.2 National

The Australian demand for forest products exceeds the national supply. The total value of imported timber and wood products was $1216 million in 1984-85, of which $321 million was the value of imported sawn timber. Exports of forest products for the same year were valued at $299 million of which $211 million represented the export value of woodchips (Australian Forestry Council 1986).

For the nation as a whole, there is a similar trend to that in Western Australia, for the progressive replacement of hardwood by softwood timber.

3.1.3 International

There is a rising international demand for hardwood chips due to the increasing demand for short-fibred pulp which is used for the production of high quality paper. As a result the market for hardwood woodchips is reasonably buoyant and is forecast to become increasingly so. ("The Economist" Feb 7, 1987).

Most of the woodchips produced in Australia are exported to Japan, with South Korea and Taiwan also accounting for significant sales.

There are currently nine licences for the export of woodchips from Australia for a total quantity of 5,255,000 tonnes per annum. WACAP's entitlement for 900,000 tonnes per annum represents 17 percent of this volume and the WACAP operation is the third largest in Australia.

WACAP is not seeking to increase woodchip production beyond the levels already licenced. Therefore, although WACAP will be competing for contracts from time to time with other Australian companies, it is not seeking to increase its market share.

The proposed McLean Forest Project, which is currently the subject of an ERMP/EIS may compete with WACAP to some extent. However, the McLean project is based on private forest resources whereas WACAP receives the bulk of its wood from State forests. In addition, WACAP's support for the establishment of private hardwood plantations and the geographic location of its facilities are expected to ensure that it maintains its supply of wood from private sources.

The McLean proposal will compete with this project for a limited amount of resource. At present under CALM log segregation procedures, sawlogs rejected by the main licence holder are offered to salvage sawmillers. If they refuse to take them they are deemed to be chiplogs and go to WACAP. McLean sawmills has consistently taken a lower standard salvage log than other salvage millers thus depriving WACAP of resource. In the 1985/86 calander year McLean took approximately 40,000 tonnes of logs of all species off State forest.

Approximately 20,000 tonnes of that would have gone as salvage sawlogs to any buyer hence it can be assessed McLean is potentially depriving WACAP of 20,000 tonnes/annum. At present WACAP gets a proportion of that back as McLean sells his sawmill residue chips to WACAP.

If the McLean project went ahead it is likely the loss to WACAP of resource would increase as McLean would retain his sawmill residue for his own exports and would have added incentive to lower his standard of salvage sawlog taken.

Even if the quantity doubled it would still be only approximately 5% of WACAP's potential annual resource. The competition between the projects hence is marginal.

3.2 FOREST MANAGEMENT CONSIDERATIONS

Woodchipping in Western Australia provides the means by which utilisation of forest products is maximised. It is therefore considered by CALM to be an integral and vital part of forest management.

Woodchipping is important to forest management in two ways:

(i) It utilises logs and sawmill residues which have no other beneficial use, thereby saving the considerable cost that would otherwise be involved in removing trees to promote full regrowth (technically referred to as regeneration) of the forest.

(ii) The royalties provided by woodchipping (currently $5.75 million per year) provide an important source of funds for forest management. These payments and payments made to sawmills assist in maintaining the price of sawn timber at reasonable levels.

If the Western Australia woodchipping industry was to be discontinued the results would be decreased supplies and increased prices of sawn timber and/or a marked reduction in forest productivity with further adverse impacts for the timber industry in the long term.

In economic and silvicultural terms, the woodchipping operations are important in maintaining the viability of the overall forest industry.

3.3 SOCIAL AND ECONOMIC BENEFITS

The total sales revenue for WACAP in 1985-86 was $38 million. Total payments to the Commonwealth Government from WACAP's operations alone amount to $4.2 million (1985/86). Total payments to the State Government in the same period were $11 million. WACAP currently employs 79 people mainly at the Diamond Chipmill in Manjimup and contracts out a further 142 direct jobs in timber felling and transport. Total employment generated in the South West Region by WACAP's operations has been estimated to range between 461 to 574 jobs. Household income resulting from these jobs was estimated at between $9.1 million and $11.2 million.

In Manjimup Shire WACAP is now an integral part of the community with 1320 people or 13.3 percent of the 1985 population, dependent upon the woodchipping industry.

4.0 CURRENT WOODCHIP OPERATIONS IN THE CONTEXT OF FOREST MANAGEMENT

This section is intended to describe WACAP's existing operations. However, WACAP's operations can not be considered in isolation from the overall forest management strategy and the complete range of forestry activities of which woodchipping forms an integral part. It is therefore necessary that the total forest management be described in some detail so that the woodchipping operations can be considered in context. WACAP's own operations are described in Section 4.5. Most of the balance of this section refers to strategies and activities which are the responsibility of CALM, and over which WACAP has no control.

WACAP's role, although highly significant in terms of its contribution to the maintenance of a viable forestry industry, is relatively minor in terms of the activities involved.

4.1 BACKGROUND

4.1.1 The History of Forestry in the South West Region

From the earliest days of settlement, the timber industry has been an important contributor to the economy of Western Australia. It developed rapidly from the 1890's and reached a peak of production in 1913 before declining during the First World War. This activity, however, was restricted to the readily accessible forests of the northern jarrah and the coastal karri, at Boranup on the West Coast and Denmark on the South Coast. The inaccessibility of the southern hinterland forests precluded their utilisation during this period of activity. However, the high rainfall and apparent fertility of the area made it attractive for agricultural development. By 1910, land subdivisions were well underway in Manjimup and Pemberton and, to speed up the disposal of the wood cleared from subdivisions, the railway line was extended to Jardee and new mills were established at Denmark, Pemberton and Jardee itself.

Although a Forests Branch of the Lands Department was formed in 1896 it did little more than collect revenue. In 1916, following a report from Hutchins, a South African forester, C.E. Lane-Poole was appointed as the first Conservator of Forests. His first task was to produce legislation for the Forest Act which passed through parliament in

1918. Lane-Poole's appointment however, only lasted until 1921 when, after repeated battling with a Government more interested in releasing land for agriculture than dedicating it as State forest, he resigned in protest. A Royal Commission precipitated by Lane-Poole's resignation helped turn the tide and in 1925 the first karri forest, 2,900ha at Big Brook, was dedicated as State forest. Further dedication in 1929 raised the area of karri in State forest to 61,000ha. However, it was not until 1955 that the bulk of the current State forest karri areas were finally dedicated.

The first working plan for karri forest was produced in 1927 and for jarrah forest in 1929. These plans introduced control over the forests, but for the southern forest it was control over a poorly known estate which was largely inaccessible from an economic standpoint.

Production from the forests fluctuated according to general economic conditions. Following the First World War it rose sharply, peaking in 1927 then declining into the depression with a brief rise from 1935 to 1940 then a decline during the years of the Second World War.

The post-war boom brought about a great increase in activity in the southern forest region. A reduction in jarrah production from the northern forest was offset by increased production from the south by the opening of new mills at Donnelly River, Quininup, Northcliffe and Shannon River in 1951.

Up to 1924, all karri timber was produced as a result of clearing for agriculture. However, following the dedication of Big Brook forest harvesting of areas of State forest was commenced, using the clear-felling method, whereby regrowth of new forest was achieved using seed from trees left after the harvesting. The clear-felling method was continued until the 1940's when a change to the group selection harvesting method occurred. The reasons for the change were both political and economic. There was at this time great pressure for the alienation of harvested forest land for agriculture. To reduce this farming pressure, the Forest Department introduced the practice of selection harvesting whereby groups of trees were harvested over an area rarely larger than 10ha, sometimes only two or three trees, so that the cleared areas were too small for farming. Another reason for the change from clear-felling to selection harvesting was that clear-felling produced a problem of waste. This arose because the timber industry of the day was producing quality sawn timber for export, and therefore could use only the tall, straight trees. This meant there was no economic use for "forest residue" comprised of smaller trees, defective trees, and trees of other species, such as marri which were unsuitable for sawmilling. The Forest Department recognised that this "forest residue" hindered successful regeneration of new regrowth forest, and that burning this forest residue helped promote good regeneration by creating the ash-bed in which karri seedlings germinated well and flourished.

If left standing, its shade and competition for water and nutrients hindered the growth of young karri, and if felled, it lay on the ground as a physical obstruction, and had to be physically moved in preparation for safe burning that would not endanger surrounding forest. On the other hand, selection harvesting seemed to offer the prospect of minimising these problems, because where single trees were harvested, no "forest residue" occurred, and where small groups of prime quality trees were harvested, the problem of "forest residue" was minimised. In addition there was a growing awareness that substantial quantities of old growth timber throughout the forest were deteriorating due to fire damage and ageing. By selection harvesting these individual trees, this wasting resource could be salvaged before it further deteriorated, and at the same time the harvesting roads built into their remote locations would facilitate fire protection.

In the mid 1960's the forest management system was again reviewed as disadvantages of selection cutting emerged. Among these were the difficulty in burning the small gaps in the forest for regeneration with a fire intense enough to produce good seed bed without damaging the surrounding forest. Another factor was the decline in health of the crowns of the surrounding forest due to exposure to wind, heat, hail and other stresses from which adjacent trees once protected it. Also the surrounding mature forest depressed regrowth in the selection-harvest gap, due to overshading and competition for nutrients. In addition, large areas of forest with scattered regrowth posed a problem for fire protection, as even cool fires kill young karri regrowth up to the age of 15 or 20. There was also great difficulty in carrying out the second cut without causing damage to the regrowth in the gaps by falling trees crushing the regrowth. To avoid these problems, clearfelling was reintroduced in 1967 as the optimum system for karri.

In the first years after the reintroduction of clear-felling, the mixed karri - marri stands were avoided wherever possible because there was no market for the marri, also the regeneration of such stands was difficult and expensive in that it required the marri to be removed by being ring-barked, poisoned or bulldozed, to provide the conditions known to be desirable for karri regeneration.

Trees unsuitable for sawing can often be used for reconstituted products and, as far back as 1899, a pulp industry was suggested for Western Australia. A pilot plant produced paper from karri in 1920 and, in 1922, a Royal Commission recommended that such an industry be established. Little further eventuated for more than 50 years despite a feasibility study in the 1950's. Modern improvements in pulping technology and increased world demand for high grade printing and writing papers resulted in a demand for suitable eucalypt woodchips including marri. In 1976 WACAP commenced export of marri and karri chips in response to this demand. This has enabled a more effective forest management programme to be practiced throughout the South West forests, by providing a market for formerly wasted resources.

4.1.2 Summary of Past Inquiries Relating to Woodchipping

The WACAP export woodchip operation and the overall forest management of which it forms a part, have been the subject of a series of environmental reviews, reports and enquiries starting with an EIS produced by the Forest Department at the request of the Commonwealth, prior to commencement of WACAP's operations in 1976.

This section lists these previous enquiries, studies and reports and identifies the areas of environmental concern which were raised at the time of the various reports being published.

Enquiries and reviews conducted to date include:

DATE	TITLE	BODY RESPONSIBLE FOR PREPARATION
1973	Marri Woodchip Proposal EIS	Forests Department of Western Australia
1974	Conservation through Reserves Committee	Environmental Protection Authority
1975	Kelsall Committee Report	Interdepartmental Report, WA State Government
1975	Economic and Environmental aspects of the export hardwood woodchip industry	Working group set up by the Aust. Ministers for the Environmental and Conservation and Agriculture
1976	The Mulcahy Report	Environmental Protection Authority
1977	Woodchips and the Environment	Report from the Senate Standing Committee on Science and the Environment
1978	Kelsall Committee	Department of Conservation and Environment
1980	Kelsall Committee	Department of Conservation and Environment
1981	Australia's Forestry and Forest Products Industries	The Senate Standing Committee on Trade and Commerce
1981-82	EPA Review of Karri Conservation	Environmental Protection Authority

The issues raised or addressed relative to the Western Australian industry included the following:

- The preservation of representative areas of the full range of forest types.
- The maintenance of genetic diversity.
- The potential for increased salinity of soils and surface water.
- The potential effect on fauna and flora. In particular the level of scientific knowledge was seen as inadequate at the time of the earlier inquiries.
- Social impacts such as employment opportunities, decentralisation and recreation.

- The potential effects on soils, such as nutrient depletion, compaction and erosion.
- The perceived lack of control of operations on private property.
- Woodchip operations are a useful silvicultural tool.
- Woodchip operations must be controlled to ensure the highest value end use is found.

These and other potential effects of the project are discussed in Section 7.0 of this document.

4.1.3 Details of Current Licences Relating to Woodchipping

The export licence (Licence to Export Unprocessed Wood) issued to WACAP and renewed annually by the Commonwealth Minister for Primary Industry under the Export Control Act, 1982, permits shipment of up to 900,000 green tonnes of woodchips per year. Of the 900,000 tonnes, 150,000 tonnes is for jarrah woodchips from sawmill residues only, which presently have no export market.

In assessing an application for a licence to export, the Minister considers a number of matters including:

- Price - Prices received by the various Australian exporters and prices in the international market place are closely monitored to ensure that the Australian prices are commensurate with world market levels.
- Domestic Requirements - Possible domestic needs are assessed to ensure domestic industries are not disadvantaged by export of raw material.
- Further Processing - Export licences for largely unprocessed wood are issued on the basis that the company shall prepare feasibility studies investigating further processing (pulp and/or paper) in Australia if requested to do so by the Department.
- Environmental.

Export proposals must comply with the relevant Federal legislation, in particular the Environment Protection (Impact of Proposals) Act 1974 and the Australian Heritage Commission Act 1975.

Under the Environment Protection (Impact of Proposals) Act, action is initiated when the Minister responsible for a decision on a proposal (in this case, the Minister for Primary Industry) designates a proponent (i.e. the person/company who is responsible for the proposal). On the basis of preliminary information from the proponent, the Minister for Arts, Heritage and Environment determines whether an Environmental Impact Statement (EIS) is required. An EIS may cover either the whole operation (as with the export licence renewal application) or cover significant changes to areas to be harvested or methods used. On the basis of an assessment of the EIS, the Minister for Arts, Heritage and Environment provides advice to the action Minister (Primary Industry) on the proposal, which must be taken into account in reaching a decision on the proposal.

Under the Australian Heritage Commission Act, Commonwealth Ministers must advise the Commission of any proposed action which may affect places on the Register of the National Estate, and not take any action which may affect such a place unless there are no feasible or prudent alternatives.

The Wood Chipping Industry Agreement Act No 58 of 1969 and its Amendment No 34 of 1973, provided for the establishment of a wood chipping industry in Western Australia. Under the terms of this Act, Forest Produce (Woodchip) Licence No 1588 was granted to WACAP, effective May 27, 1974. This licence is due to expire 15 years after the date of the first export of woodchips, which occurred on 10 May, 1976.

The licence defines the areas of State forest from which chiplogs are obtained and sets out the basis of royalties. The Act sets out the basis of freight and port charges payable by WACAP.

4.1.4 Woodchip Specifications

4.1.4.1 Species

Export chips are produced from

Karri *Eucalyptus diversicolor*

Marri *Eucalyptus calophylla*

Jarrah (*Eucalyptus marginata*) chips are not currently accepted for export.

4.1.4.2 Chip Specification

Chips must meet stringent size criteria to enable optimum processing during the pulping process. In addition they must be free of all foreign bodies, including; metal, stone, sand, plastic, charcoal or pieces of wood which have not been fully processed.

4.1.5 Land Tenure

The licence area is as defined in the Forest Produce (Chipwood) Licence No. 1588 and illustrated in Figure 2.

The licence area occupies a total of 884,100ha, ownership of which is as follows (December 1986):

CROWN LAND	
National Parks and Nature Reserves	41,400ha
State Forest and Executive Director (CALM) Land	563,300ha
Timber Reserves	26,500ha
Vacant Crown Land	70,900ha
Miscellaneous Reserves (water, townsite, etc.)	22,200ha
TOTAL CROWN LAND	724,300ha
PRIVATE LAND	
Cleared and Non-forest	121,600ha
Uncleared	38,200ha
TOTAL PRIVATE LAND	159,800ha

Most of the Crown land is vested in or managed by CALM. Current Land Use is described in Section 6.4 and Proposed Land Use in Section 5.1.

4.2 CURRENT OPERATIONS - STATE FOREST

Approval to proceed with the marri woodchip project was based on the original EIS (Forests Department 1973). That EIS made commitments with regard to forest management that have been included in current operations since then. Specifically those commitments were:

- Restriction of coupe size to 200ha in karri and 800ha in jarrah forest types.
- To separate major logs roads from public roads.
- To retain 20% of any one forest block reserved from cutting.
- To retain stream buffers to protect water quality.
- To instal cross drains on roads and snig tracks to prevent erosion.
- To remove temporary drainage structures constructed in the course of harvesting.
- To keep harvesting debris out of streams.
- To avoid harvesting steep slopes.
- To encourage rubber tyred machinery.
- To not cut in the LRZ until the salinity question was solved.
- To reserve from cutting, fringe of vegetation around rocky outcrops, swamps, and lakes.
- Retain 2km of reserve 100 metres either side of a river, stream or gully for each 500ha cut.
- Disperse coupes in time by 4 to 5 years.
- To reserve from the operation entirely the Perup river fauna priority area.
- To ensure a minimum of 200 metres either side of roads with amenity value.
- To reserve from cutting the best landscape and picnic sites.
- To prevent wood suitable for sawmilling being chipped.

In addition the Forest Produce (Chipwood) licence (FPL) No. 1588 contained further commitments by the company with regard to royalties, roading, cutting coupes, utilisation, crop tree damage, water catchment operation and fire control. A copy of FPL 1588 is attached in Appendix J.

4.2.1 Resources Used

- Within the Licence Area

Chiplogs extracted from State forest for woodchip production are mainly marri. Marri logs are produced from integrated operations in both karri/marri and jarrah/marri forest designed to produce karri and jarrah sawlogs respectively. Karri chiplogs are produced from the karri sawlog operations where logs fail to meet the various sawlog standards. Since 1979/80, increasing quantities of karri chiplogs have been produced from thinning operations in forest regrown after clear-felling operations in the 1930's. Jarrah chiplogs were taken on a trial basis in 1979/80 and 1980/1981, comprising a total of approximately 5,950m.

Table 1 summarises the resources used and their origin over the life of the industry to date.

TABLE 1

RESOURCES FROM STATE FOREST USED IN CHIPWOOD INDUSTRY TO DATE

YEAR	FOREST AREA CUT OVER (ha)			TONNES OF CHIPLOGS REMOVED	% OF TOTAL	
	KM	JM	Regrowth K		Karri	Regrowth
1976	1850	0	0	330,480	38	0
1977	2690	140	0	515,890	26	0
1978	3220	320	0	507,380	24	0
1979	2580	1160	0	615,760	18	0
1980	2310	2120	140	711,620	21	0.2
1981	1580	1450	250	524,750	23	5.3
1982	1330	820	260	443,230	22	6.2
1983	1520	890	270	485,750	25	6.3
1984	2500	2100	390	584,900	15	5.2
1985	1610	2640	320	622,930	13	5.3
1986	Not Available			637,240	10	8

There has been a decline in the proportion of karri in the total chiplog volume since 1982/83. This has been attributed to the strong improvement in demand for sawn timber, resulting in greater utilization of lower quality logs by the main mills and salvage operators. As a consequence these logs were unavailable to WACAP and the percentage of karri in the total to WACAP has declined.

- Outside the Licence Area

There is potentially a large volume of marri chipwood available from jarrah-marri forest in State forest outside the licence area. Since 1981 some of this resource has been supplied to WACAP in the following amounts (Table 2).

TABLE 2

CHIPWOOD INTAKE FROM STATE FOREST OUTSIDE THE LICENCE AREA

YEAR	TONNES
1981	2,708
1982	6,350
1983	6,435
1984	20,500
1985	16,700
1986	5,070

The bulk of this material has come from the clearing of jarrah/marri forest by the then Forest Department, for establishment of pine plantations in the Donnybrook Sunklands. As this project has been terminated, no further supplies will be available from that source. However, there will continue to be access to wood outside the licence area.

4.2.2 Royalty

Current operations involve extraction of chiplogs from State forest and private property for conversion to woodchips. Logs extracted from State forest attract the payment of a set royalty to the State Government whereas stumpage payments to private landholders are varied according to circumstances.

Royalties payable for chiplogs extracted from State forest are determined at set intervals of five years under the terms of the Forest Produce (Chipwood) Licence (FPL). The royalty level is determined by the Executive Director of the Department of Conservation and Land Management who consults with the Department of Industrial Development (the administrator of the Wood Chipping Industry Agreement Act) and WACAP. In setting royalty levels, factors considered are royalty payable on hardwoods cut for sawlogs and the movement in the price of woodchips since the last review.

Royalty levels and revenue paid to the State for the life of the agreement to date are detailed in Table 3.

TABLE 3

ROYALTY PAID TO THE STATE

PERIOD	1969-Dec/74	Jan/75-Dec/80	Jan/81-Dec/85	Jan/86-to date
Chiplog royalty ($/tonne)	$0.44 - 0.61	$0.61	$2.59	$8.47
Volume produced (tonne)	NIL	2,681,140	2,714,270	642,310 (1986)
TOTAL REVENUE	NIL	$1.64 million	$7.02 million	$5.4 million (1986)

The growth of royalty payments for chiplog, compared to sawlog royalities and the Consumer Price Index is shown in Figure 3.

For the period to 80/81 the staggered rises in chiplog royalty were below the CPI increase. Subsequently, chiplog royalties have increased at a rate which is now approximately four times the equivalent CPI increase rate.

As the CPI is not expected to reach the chiplog royalty level by 1990, the period from 1981 to 1991 will be one where the net financial benefit of the operation to the State will continue to increase.

Although chipwood royalties are established under the terms of the Forest Produce Licence, sawlog royalties are determined on the basis of forest growing costs. The higher the residue royalty the lower the sawlog royalty required to achieve the financial target. Thus, woodchipping serves to lower the costs of sawn timber. Royalties are structured such that the best quality logs have the highest price, to encourage the highest end use for these resources.

Current royalty levels in the licence area from State forests are:

Marri/Karri chiplogs	=	$\$10.29/m^3$ (\$8.47/tonne)
1st grade Karri sawlogs	=	$\$16.84/m^3$
2nd grade Karri sawlogs	=	$\$16.26/m^3$
Small Karri sawlogs	=	$\$18.32/m^3$
1st grade Jarrah sawlogs	=	$\$15.68/m^3$
2nd grade Jarrah sawlogs	=	$\$15.72/m^3$
Marri sawlogs	=	$\$11.69/m^3$

The significance to forest regeneration of removing the chipwood following sawlog harvesting is explained in Section 4.2.6/7/8. Under the same silvicultural system the alternative to producing woodchips is to poison or fell chiplog trees and burn the residue.

4.2.3 Forest Protection

4.2.3.1 Fire

The management objectives for fire on CALM lands are:

- o To protect community and environmental values, from damage or destruction by wildfire, and
- o To use fire as a management tool to achieve land management objectives, in accordance with designated land use priorities (CALM, 1987c).

As a result of these objectives fire is used in three ways:

- o to reduce fuel to lower wildfire intensity in some areas,
- o for silvicultural purposes in the regeneration of karri and jarrah, and
- o for specific habitat manipulation.

In practice these uses are not exclusive and any prescribed fire may be aimed at achieving any or all of these purposes.

In developing a strategy to protect the forest and neighbouring lands from unplanned fire, CALM places strong emphasis on fuel reduction measures backed up by an efficient aerial detection and fire suppression force.

Fuel reduction burning by aircraft was pioneered in Western Australia and this, coupled with an accurate fire behaviour guide (Sneeuwjagt and Peet 1985), has enabled fire management to be practiced on extensive areas at reasonable cost.

4.2.3.2 Disease

The most serious disease in Western Australian forest is jarrah dieback caused by the soil borne pathogen Phytophthora cinnamomi. There is widespread variation in the susceptibility of various plant species to the disease, as well as variation of the disease's impact within species, depending on site type. In general, plants can be categorised as highly susceptible (e.g. Banksia grandis), moderately susceptable (e.g. jarrah) and tolerant (e.g. karri and marri).

Disease management on Crown Land is based on four measures:

- o The accurate location of areas of disease infection.
- o The application and continuous updating of hygiene procedures designed to minimise the risk of artificial spread of the pathogen.
- o The management of the forest ecosystem to create conditions unfavourable for fungus development.
- o Identification of host-pathogen-environment relationships to predict disease impact.

The cornerstone of effective hygiene measures is accurate knowledge of disease presence. Because symptoms of the disease may not be recognised for up to three years after infection it is possible despite the best intentioned hygiene procedures to spread the disease unwittingly. To overcome this problem the former Forest Department found it necessary to declare large parts of the forest, mainly jarrah, as Disease Risk Areas (DRA's) under an amendment to the Forest Act (1918). This legislative power effectively quarantined forest for the time required for symptoms of the disease to emerge without the risk of introducing infection to previously uninfected areas. Large scale colour aerial photography was carried out to identify and map infected areas. Where aerial photography is not available intensive ground reconnaissance is used to locate and map dieback infections.

4.2.3.3 Salinity

Salination of streams is a problem associated with the complete clearing of native vegetation which leads to a decline in transpiration causing water tables to rise and flush salt accumulated in the soil profile into streams (see Section 6.1.4).

This can be a serious problem in low rainfall zones (average rainfall less than 760mm/yr). Accordingly, a commitment was made in the original EIS (Forests Department 1973) that in the low rainfall zone of the licence area, where jarrah/marri is the prevalent forest type, marri chiplogs would not be harvested until further research was carried out. No such harvesting has occurred, other than in small research catchments.

4.2.4 Forest Operations Planning

Planning for forest operations on Crown Land is handled by CALM at four distinct planning levels, as shown in Table 4.

TABLE 4

FOREST OPERATIONS PLANNING

PLAN TYPE	FUNCTION
CORPORATE PLAN	Coverage - All CALM Act land. Sets overall Departmental charter, primary objectives and defines broad policy statements for major aspects of land use. Public participation - none.
REGIONAL PLAN	Coverage - All CALM Act land in a particular administrative region. Identifies all CALM Act land in the region, its physical and biological resources and assigns a priority use to it. Identifies strategic issues and problems and provides guidelines and management strategies to be implemented to address these. Public participation - a statutory 2 months.
AREA MANAGEMENT PLAN	Coverage - Specific area or set of areas of common purpose. Detailed strategies for management of areas whose requirement cannot be covered by Regional Plan. Public participation - a statutory 2 months.
IMPLEMENTATION PLANS	Coverage - Specific operations on CALM Act land. Provides quantitative information on the extent and timing of an operation e.g. burning, recreation development, harvesting. Public participation - not required by legislation, but plans are available for inspection in District offices.

Prior to release of CALM's Regional Plans (CALM 1987a) the formal plan covering the operation in the woodchip licence area was the former Forest Department's General Working Plan No. 87 (1982a). This plan details the areas available for wood production, the yield that is to be produced and the broad policies and strategies appropriate to land management.

Detailed planning for the production of wood products centre around two implementation plans:

(i) 4 year harvesting plan.
(ii) Current operations harvesting plan (the one year plan).

The success of the harvesting operation relies on these plans to a large extent because harvesting must be integrated with other forest activities. The forest and its management requirements are both dynamic; hence continous planning is needed to adjust for changes in land use priorities, developments in forestry techniques, wood product markets, unseasonal weather, fire control, Government policy, and forest growth.

- Factors affecting decision on where to harvest

Areas harvested are totally dependent on the States needs for sawlogs, up to the maximum allowable annual harvest. CALM's Timber Strategy supplement to the draft Regional Management Plans details the annual quantity of first grade sawlog harvest within a sustained yield context (CALM 1987b). Areas designated to supply that proportion of sawlogs to be obtained from the Woodchip licence area dictate the amounts of residue that will be available as other products, including chiplogs. The production of chiplogs is a byproduct of sawmilling operations. No forest is harvested specifically for chiplogs alone.

Table 5 summarises the many constraints that are considered in allocating where areas are to be harvested. It also gives an indication of the relative importance of the various constraints by showing the level of discretion available in planning for them, and of the sphere of influence in which they are most important.

TABLE 5

SUMMARY OF CONSTRAINTS AFFECTING HARVESTING

LEVEL OF CONSTRAINT	PHYSICAL ENVIRONMENT (LOGGING AREAS)	FOREST MANAGEMENT (CALM)	SOCIO-ECONOMIC ENVIRONMENT (TIMBER)
POLICY (No field discretion allowed)	o Limit maximum coupe size o Log hygienically (especially DRA)	o Log according to land tenure and Land Use Management Priorities o Ensure sustained yield of sawlogs	o Log permissible intake of sawlogs
STRATEGIC (Some field discretion allowed)	o Limit soil disturbance o Maximise dispersion of seed o Avoid steep slopes o Buffer lakes o Protect streams o Regenerate using seed trees	o Log geographic areas proportional to resource o Implement Fire Protection Strategy: - avoid primary burning buffers - log secondary burning buffers o Implement Regeneration Strategy: - avoid hazard reduction burning for at least 3 years in karri - hazard reduction burn within 3 years in jarrah - balance planting with seed tree regeneration each year - complete karri coupe in time for summer regeneration burning	o Minimise road construction o Maximise log quality o Minimise average haul distance o Log karri and jarrah according to market requirements
OPERATIONAL (Much field discretion allowed)	o Define safe road alignments o Define safe log stock-piling areas o Define "special care" zones over sensitive areas such as water courses, moderate slopes, marginal and non forest areas	o Apply logging prescription according to forest type o Maximise salvage of second grade sawlogs o Allocate summer and winter logging according to terrain o Balance short and long haul distances	o Allocate summer and winter logging according to season o Provide adequate log stockpile

- Factors affecting when to harvest

Harvesting is closely integrated with associated operations such as fuel reduction and regeneration burning, disease mapping, and resource inventories. Unforeseen contingencies may be provided for in the short term by changing harvesting plans, but this may cause serious long term consequences (Table 6).

TABLE 6

TIMING CONSTRAINTS OF OPERATIONS RELATED TO HARVESTING

RELATED OPERATIONS	YEARS - BEFORE AND AFTER HARVESTING										
	-8	-7	-6	-5	-4	-3	-2	-1	0	+1	+2
Fuel Reduction Burning	* (J)			* (K)	*			* (J)			
Resource Inventory		*	*	*		*					
Quarantine for disease expression (jarrah)		*	*	*							
Disease Photography (J)					*						
Disease Interpretation (J)						*					
Karri Seed Forecasting						*					
Coupe Demarcation							*	*			
Roading					*		*	*			
Harvesting Plans Year 1								*			
Harvesting Plans Year 2-4									*		
Harvesting									*		
Regeneration Burning										*	
Removal of Seed Trees (K)										*	*
Protection for Fire											*

* Required to occur at this time. Failure to do so would most probably result in an inability to carry out planned harvesting operation

(J) Jarrah type forest

(K) Karri type forest

Source: CALM 1987 pers comm.

- Integration of harvesting with other requirements

The planning process for harvesting integrates the many forest requirements, is incremental, and carried out manually. Harvesting in old growth forests is planned to provide first grade sawlogs initially, and chiplogs finally. Maps of each area display information on the forest and many related operations and functions such as forest types, land use priorities, and past hazard reduction and regeneration burning.

The State forest is subdivided into management areas known as Forest Blocks which are usually between 3000 and 6000ha in area. The boundaries are formed by roads and natural features such as rivers. Each Forest Block is further subdivided into a series of Compartments, for planning purposes. Figure 4 shows the layout of a section of Beavis Block which contains 10 Compartments in all.

The Four Year Harvesting Plan, which is updated annually, allocates harvesting to Compartments in Forest Blocks throughout the Licence Area at a level which will supply the anticipated requirements as defined in the Regional Management Plans. As an example, Figure 4 indicates the areas to be harvested in the years from 1977 to 1980.

Each discrete harvesting area is known as a coupe. There may be several coupes in each compartment. The original EIS (Forests Department 1973) prescribed a maximum coupe size of 200ha in karri and 800ha in jarrah. In practice over the last five years, the average coupe size in karri has been 77ha and in jarrah it has been 123ha.

Each year, the forest areas scheduled for harvesting in the following year are defined as coupes in the One Year Harvesting Plan. Figure 5 shows part of the same Forest Block depicted in Figure 4, and delineates a coupe of 192ha.

Delineation of each coupe is based on the forest management constraints listed in Table 5.

4.2.5 Planning and Construction of Roads in State Forests

Following the preparation of the four year harvesting plan access road proposals are formulated by Industry in accordance with CALM requirements and submitted to CALM for approval. A conceptual roading plan is prepared for each forest block. This conceptual plan takes into account factors such as topography, drainage pattern, slopes, erosion hazard and dieback hygiene.

WA Chip and Pulp have responsibility for construction and maintenance of the primary log haul routes to access the forest available for timber production. This network of roads is largely complete. The General Purpose sawmill companies are responsible for construction and maintenance of the major access roads and in coupe roads within each forest block.

In new growth harvesting operations and some major old growth harvesting operations CALM is the principal contractor and takes responsibility for road construction and maintenance. Roading costs are recovered from each of the log customers supplied from these operations. Roads are constructed to prescribed engineering standards. Environmental controls and landscape considerations are also carefully prescribed and supervised by the Forest officer. Planning and construction of stream crossings is prescribed in detail to minimise potential siltation from road surfaces and drains. Roads are constructed two years in advance of required use, wherever possible, to allow proper consolidation of the road surface. Existing forest roads and tracks are used wherever possible to minimise new clearing. Where an existing road is realigned, the unused portion of the old road is rehabilitated and replanted.

In jarrah/marri forest a detailed dieback hygiene evaluation is prepared prior to road selection and construction.

A comprehensive prescription for selection, working and rehabilitation of pits for basic raw materials (gravel, sand, quartz) is supervised by the Forest Officer. Whilst roads are being used for log haulage the Timber Industry is responsible for proper maintenance. Grading to surfaces, clearing of drains, pipes and silt traps and slashing of verges to maintain a safe view is prescribed.

Traffic control signs are used to increase the safety of road users and to improve the traffic flow and efficiency of bush operations.

4.2.6 Forest Operations - Karri/Marri

The implementation of the one year harvesting plan encompases the harvesting operation. Preparation of the coupe for harvesting by the contractor is carried out by CALM according to a job specification manual which details the procedures and standards for controlling the harvesting operation. This document is called the "Southern Forest Region Industry Control Specifications" or ICM after its previous title "Industry Control Manual". Contents are listed in Table 7 and detailed in Appendix E.

TABLE 7

SOUTHERN FOREST REGION INDUSTRY CONTROL SPECIFICATIONS:
LIST OF CONTENTS

Item 1	Sawlog Specifications - Southern Forest Region Mills
Item 2	Specification of Chiplogs to WACAP
Item 3	Karri Peeler Log Specification and Operations Checklist
Item 4	Specification for Supply of Untreated Round Timber for Bridge Construction and Operations Checklist
Item 5	Operations Checklist for Batten Logs to Monier and Contract 85H1 (Brookes)
Item 6	Log Specification for Bush Landings in Chipwood Licence Area
Item 7	Log Segregation at WACAP Chipmill Landing
Item 8	Harvesting Plans and Contractual Arrangements
Item 9	Salvage Log Prescription for Log Parcels Outside Annual Harvesting Plan
Item 10	Jarrah Silviculture Prescription
Item 11	Karri Silviculture Prescription
Item 12	Commercial Thinning of Karri Regrowth Stands
Item 13	Coupe Planning Prescription
Item 14	Coupe Control Prescription
Item 15	Environmental Protection Prescription
Item 16	Dieback Hygiene Harvesting Prescription
Item 17	Harvesting Disturbance Control Prescription
Item 18	Erosion Control Prescription
Item 20	Forest Officers Checklist and Coupe Inspection Report
Item 21	Fallers Block Certification Sheet
Item 22	Industry Roading Prescription
Item 23	Traffic Control Signs
Item 24	Gravel Pit Working and Rehabilitation Prescription
Item 25	Summary of Demarcation Procedures and Forest Markings
Item 26	Approved Abbreviations for Blocks within Southern Region and Chipwood Licence Area

CALM has also produced the "Southern Forest Region Operations Manual" to provide procedures and standards outside the scope of the Industry Control Manual. Subjects covered in this manual are listed in Table 8 and detailed in Appendix E.

TABLE 8

SOUTHERN FOREST REGION OPERATIONS MANUAL:
LIST OF CONTENTS

TABLE 8 (continued)

4.3 Tops Disposal in Jarrah Regrowth Stands

4.4 Standards for Coupe Preparation for Karri Regeneration

4.5 Standards for Coupe Preparation for Jarrah Regeneration

4.6 Gravel Pit Rehabilitation Preparation

4.7 Landing and Snig Track Rehabilitation for Planting

4.8 Direct Seeding for Karri Regeneration

4.9 Planting Open Root Nursery Stock

4.10 Assessing Regeneration Success in Karri Forests

4.11 Assessing Regeneration Success in Jarrah Forests

4.12 Seed Forecasting Prior to Karri Harvesting

4.13 Karri Seed Collection

4.14 Pelletting Karri Seed

4.15 Planting Container Stock Eucalypts

4.16 Direct Seeding of Shrub Species on Rehabilitated Areas

5. ROADING

5.1 Strategic Roading for the Protection of Hardwood Regeneration

5.2 Maintenance of Access for Fire Control

5.3 Access Construction for Blackberry Control Work

5.4 Road Construction Specifications

6. METEOROLOGICAL INSTRUMENTS

6.1 Obtaining Meteorological Observations

6.2 Stevenson Screen Siting

6.3 Maintenance of Meteorological Instruments

7. DISEASE MANAGEMENT

7.1 Armillaria Recognition

7.2 Vehicle Wash Down Procedure

7.3 Hygiene in Road Maintenance

7.4 Procedure for Sampling Sites Possibly Infected with P. cinnamomi

8. MANAGEMENT OF AREAS WITH PARTICULAR CONSERVATION VALUES

8.1 Definition of Areas with Particular Conservation Values

8.2 Scope of Operations Allowed in these Areas

4.2.6.1 Silvicultural Techniques

Silviculture is the practice of growing and managing trees to achieve certain objectives such as wood production.

The silvicultural practices for State Forests are designed and carried out by CALM. These sections provide a summary of those practices and the role of the woodchip industry in their implementation.

Section 4.1.1 describes the historical development of silvicultural techniques in South West State Forest. The current silvicultural system employed by CALM in old growth karri forest is the clear felling system, making use of seed trees, planting and/or artificial seeding for regeneration. The clearfelling system, leading to the creation of discrete areas of even-aged forest is the optimum system for karri forest, as it is for most tall forests of the world where the objective is continuous management for production. (Jacobs 1955, Forest Service USDA 1973). This system facilitates the optimum development of the regeneration and allows subsequent cycles of harvesting to be carried out without damage to the regrowth (Bradshaw 1985a).

Harvesting for the production of sawlogs only has many serious problems for long term sustainable production. Trees left standing because they are unsuitable for use as sawlogs, continue to occupy space which could be occupied by sawlog producing trees; they suppress surrounding regrowth, they provide the major seed source which will lead to a gradual domination by the less economically useful species by progeny of the poorest quality trees. Continued removal of trees of sawlog quality only will lead in the long term to the creation of a stand occupied mainly by trees of a species or quality unsuited for sawlogs, and a forest which is well below its productive capacity. This is a particularly serious problem in mixed karri/marri stands.

Alternatively these non-sawlog ("cull") trees may be removed and burnt up or sold for a product which is less demanding of size, quality or species than in the sawmilling industry. (White 1971a,b, Forests Department 1973, Bradshaw and Lush 1981). The removal of these trees, to enhance regeneration and future production of forests being harvested for sawlogs is a major benefit of the woodchipping industry to forest management in Western Australia. The need for such an industry had been recognised since 1899 (Bradshaw and Lush 1981) as an essential part of sound long term forest management and is equally necessary regardless of whether clearfelling or selection cutting is practiced.

From 1967 to 1975, clearfelling for sawlogs was carried out without associated wood chipping. The Forests Department avoided problems of excessive waste to some extent by concentrating on pure karri stands but in some areas of mixed karri-marri forest, the non-sawlog trees were bulldozed and burnt to facilitate regeneration. Other areas were harvested for sawlogs and regeneration was delayed until the marri and non-sawlog karri could be chipped (White 1971b).

- Current Practice

There are three principle silvicultural systems used in karri and karri/marri forest containing old growth trees. These are:

(1) Clear-felling with seed trees,
(2) Clearfelling and planting with nursery seedlings, and
(3) Clearfelling and artificial seeding (Bradshaw 1983).

Application of one or other system is primarily determined by the stage of the karri seed cycle in any particular coupe. Karri generally bears seed on a 4 or 5 year cycle (Loneragan 1979). Seed sampling determines the stage of the floral cycle of the forest before harvesting takes place.

4.2.6.2 Harvesting Methods (Karri/Marri)

Coupe planning commences well before the year of harvest.

The following steps are involved in planning for harvesting for each coupe:

o The boundaries are demarcated in the field to exclude road, river and stream buffers, steeply sloping zones and other sensitive areas to be excluded from harvesting.
o A network of access routes are determined in association with the harvesting contractor taking consideration of dieback disease occurrence, erosion hazard, harvesting machine capabilities and safety aspects.

Figure 6 shows the Coupe Control Sheet for the same areas shown in Figure 5, with boundaries and access routes delineated.

Harvesting within each coupe proceeds progressively via a series of Faller's Blocks, each approximately 5ha in area. Forest Landings are established along access tracks at the required intervals.

Coupes are then harvested using a felling sequence where smaller stems are felled prior to the larger ones to avoid loss of the small log resource due to mechanical damage. Trees are felled using chainsaws. Stump heights are kept as low as possible to maximise timber recovery and minimise obstruction to future operations. Often the smaller marri component is felled ahead of the karri component. The Forest Officer checks to ensure that the maximum utilisation standards of timber has been achieved. He also checks soil disturbance, protection of reserved areas and safety standards. A faller's block must be harvested of all commercial products to the satisfaction of a senior Forest Officer before the faller is allowed to commence falling in a new block. Once the Forest Officer is satisifed, the block is formally certified as complete and the harvesting contractor may not re-enter it.

After each tree is felled, the stem and crown limbs are cut into lengths to extract the maximum amount of commercial wood.

Machinery used in transporting the logs to the landing (snigging) include rubber tyred rope and grapple skidders, low ground pressure steel-tracked skidders and crawler tractors with a trailing arch. Steel tracked and rubber tyred loaders and heel boom "static" loaders are used at the forest landing to sort the logs according to their end use, and to load them onto trucks.

Special attention during the harvesting operation is given to minimising the possibility of soil damage due to erosion on steep slopes or puddling in wet weather. Steep slopes (areas greater than 15^{o}) are covered by special prescriptions designed to minimise disturbance and the potential for water erosion. Systematic surveys are carried out to pre-empt damage due to the effect of machinery movement on excessively wet soils. When soil moisture exceeds a critical limit, the coupe or faller's block is closed by the Forest Officer until the soil dries out.

4.2.6.3 Areas Excluded from Harvesting

Areas excluded from the harvesting operation are demarcated by the Forest Officer before the commencement of harvesting.

These areas include:

- Road, river and stream reserves; 800, 400, and 200m wide respectively.
- Vegetation buffers around rock outcrops, non-forested wetlands, swamps, lakes and woodland ecotypes.
- Permanently moist gully headwaters.
- "Large tree reserves" around significant single trees or groups of trees. These reserves are a minimum of 4ha in size.
- Pure marri stands.
- Special interest areas (e.g. scientific, historical).
- Inventory and research plots.
- 50m wide vegetation buffers on recognised watercourses in the A and B zones of gazetted water catchments.

Other areas attracting consideration are steep slopes and "recognised" water courses (i.e. perennial streams or streams with defined banks of one metre or greater in width) which are demarcated as "special care zones" to be harvested on a restrictive basis. The impact of harvesting in "special care zones" is closely monitored as harvesting progresses.

4.2.6.4 Post Harvesting Operations

- Erosion Control

Following the harvesting operation within each coupe, cross drains are constructed on snig tracks to prevent soil erosion, spaced according to slope and soil type. This completes the harvesting contractor's activities in a coupe.

- Regeneration

A post harvest regeneration plan of the same areas shown in Figure 6 is shown in Figure 7.

Scrub-rolling is carried out using bulldozers to flatten the remaining vegetation ready for burning.

Coupe boundary tracks are constructed or upgraded and additional water points are then established. A detailed burning prescription is written and the harvesting slash is burnt to facilitate regeneration from seed (seed trees, hand or aerial seeding) or hand planting. Care is taken to ensure that adjacent river and stream reserves are protected from fire during the regeneration burn. Landings and major snig tracks are ripped to allow rehabilitation by hand planting (Item 4.7 Southern Forest Region Operations Manual).

- Clearfelling with seed trees

If harvesting for sawlogs and chipwood in any particular coupe is expected to be complete when ripe seed is available in sufficient quantity, then clearfelling with seed trees will generally be prescribed. In this event, seed trees will be marked by CALM officers to be retained. These are usually dominant trees with a healthy spreading crown, of good shape and free of obvious hereditary defect. These are retained at the rate of approximately four per hectare (CALM 1986a).

Following harvesting, remaining scrub and understorey is "scrub rolled" with a bulldozer to ensure that the debris will be more completely burned in the subsequent regeneration burn. The debris is then burned during the November to April period at a time when weather conditions are suitable and sufficient seed is available on the seed trees. The purpose of this "regeneration" burn is to: prepare seed bed suitable for karri regeneration; to induce seed fall from the seed trees; to dispose of harvesting residue so that fire hazard within the regenerating forest is minimised and access for future management is improved. Burns of sufficient intensity to achieve this are prescribed (Jones 1978). Karri in common with many other eucalypts requires a seed bed which is free of scrub and litter in which to germinate and survive (Jacobs 1955). Disturbed soil is markedly superior to non ashbed sites (Loneragan 1961, Loneragan and Loneragan 1964, Annels 1980). The complementary effect of burning is to induce seed fall (Christensen 1970, Loneragan 1979) onto the competition-free seed bed where it is available for germination when weather conditions are suitable.

In the spring following the regeneration burn, germination surveys are conducted to determine the success and uniformity of germination (CALM 1986b). Should areas of failed regeneration occur they are planted with nursery seedlings in the following winter. Although no marri seed trees are left during harvesting, marri will regenerate from seedlings and stumps which survive the harvesting operation (White 1971b).

Seed trees are scheduled for removal between six weeks and two years after the regeneration burn (Bradshaw 1983) which allows time for seed to be shed, but removes the seed trees before they can have a suppressive effect on the regeneration and while the regeneration is still flexible enough to withstand the impacts of harvesting.

- Planting

The cyclic nature of karri seeding means that there are periods of two to three years when there is insufficient seed for regeneration with the seed tree method. Even during the main seed cycle, there are sometimes particular areas which have insufficient seed available. The "holding over" of these areas until seed becomes available would create an excessive scrub rolling and burning programme in the seed years. To ensure that regeneration is established as soon after harvesting as possible, CALM uses the clearfelling and artificial regeneration system during intervening years and where seed supply from seed trees would be insufficient. This also assists in regulating the workload.

Harvesting, scrub rolling and burning methods are similar to these described above except that no seed trees are retained. In the winter following the slash burn, the area is planted with nursery raised seedlings (Sneeuwjagt 1982) at the rate of 1250/ha. The spacing of plants is approximately 4m between rows and 2m between trees but planters are instructed to divert from lines to place plants in the optimum microsite for development (e.g. ashbed).

- Seeding

An alternative to regeneration with nursery seedlings is regeneration by the broadcast sowing (from the ground or air) of seed which has previously been collected. The long periods between seed cycles and the low seed production of karri (Loneragan 1979) means that karri seed is both expensive and limited in supply. This and the fact that the germination rate of wild broadcast sowings is much lower than in the nursery (Annels 1980) has meant that there has been only a limited application of this technique.

Following seeding or hand planting, a regeneration survey or survival count is carried out to ensure adequate stocking has been achieved. The target rate for karri planting is 95% survival. (Marri regenerates naturally from rootstocks generally in the same proportion as in the original mixed stand). If the number of trees is insufficient, infill planting is carried out in the following planting season.

- Rehabilitation of disturbed ground

Rehabilitation of disturbed soil, resulting from harvesting, takes place in the summer following regeneration. The involves ripping of landings and major snig tracks to a depth of approximately 0.5m. This process is essential for root development of trees planted the following winter.

4.2.7 Forest Operations - Jarrah/Marri

4.2.7.1 Silvicultural Techniques

The general principles of the silvicultural system used in the jarrah forest have been described by Bradshaw in 1985(b) and in more detail for some southern jarrah forests in 1986.

In summary, because the jarrah forest is a complex mosaic of stand structure, age and quality, which has resulted from natural variation as well as past treatment, a variety of silvicultural practices are needed to suit the particular condition of the forest at a particular time. This ranges from thinning to promote the growth on the remaining trees, through partial cutting to stimulate regeneration establishment, to the complete removal of all trees in a gap (or small clearfelled area) to allow unimpeded regeneration.

The role of woodchipping in jarrah silviculture is similar to that described in the earlier section for karri silviculture, involving the removal of those trees of a species or quality which are unsuitable for sawlogs but which if left in the forest after sawlog cutting would occupy space to the exclusion of a future forest of more useful or potentially useful trees. The southern jarrah/marri forest has a substantially higher component of marri than the northern forest. In a typical virgin jarrah-marri forest, a large proportion of the trees have no commercial value as sawlogs (Stirling pers comm.). The removal of sawlogs only leaves the stand overstocked with trees which have no value as sawlogs themselves and which will inhibit or suppress regrowth and lead to a domination by the less useful species through their predominance as the seed source. Without the removal of these trees after sawlog cutting, the potential of the forest to produce a sustainable yield of sawlogs for the future is seriously diminished.

The majority of the Southern jarrah forest is virgin forest or has been subjected to a light selection cut with no follow-up removal of non-commercial trees. The emphasis in silvicultural prescriptions is towards regeneration establishment or regeneration release (Bradshaw 1985b, 1986). Removal of trees with no sawlog potential is essential if the forest is to realise its potential for future jarrah sawlog production.

Although CALM actively seeks the removal of non-sawlog material from areas being cut for sawlogs so that its silvicultural strategies can be fully implemented, WACAP has to date only been able to accept marri in any signficant amounts. The absence of a substantial market for jarrah chipwood has not allowed this component of the cull material to be utilised commercially. CALM therefore carries out some poisoning of jarrah culls as a final silvicultural operation behind the integrated sawlog/chipwood operation.

- Current Practice

The usual sequence of operations in the jarrah forest is:

- o Following selection and demarcation of the coupe to be harvested, individual trees are marked by CALM (usually by marking those which are to be retained) according to the silvicultural requirements referred to earlier.
- o Trees which are available for removal and which are acceptable as poles for power transmission, peeler logs for plywood or veneer production, sawlogs or chipwood are removed as an integrated operation.
- o Harvesting debris is burned (usually at low intensity) to facilitate fire protection or, where necessary, to prepare a seed bed and stimulate seed fall.
- o Some areas receive further silvicultural treatment by poisoning of unsaleable surplus culls to reduce competition to improve regeneration.

4.2.7.2 Harvesting Methods (Jarrah/Marri)

Harvesting methods in jarrah forest types are governed primarily by the occurrence and impact of jarrah dieback disease. As a result hygiene harvesting is implemented. This method of harvesting is aimed at minimising the introduction and spread of the disease and to maintain the long term productivity of the forest.

Detailed dieback hygiene maps are used to plan the road location and the layout and cutting sequence of faller's blocks according to dieback status and likely impacts of infection. All operations must be approved by a "7 Way Test" before proceeding. The 7 Way Test is a detailed evaluation of the likely impacts of disease introduction on vegetation and likely consequences of those impacts on Land Use.

In dieback-free forest, faller's blocks are defined according to the topography and are harvested under a two phase operation; that is, the falling and snigging are separated in space or time so as to prevent the introduction of the disease from roadside into the dieback-free forest upslope. All machinery is cleaned down before entering dieback-free forest, and when moving from one microcatchment to another.

Trees are marked by a Forest Officer for retention according to the structure and condition of the forest (Bradshaw 1985b, 1986). Unmarked stems are then felled for extraction. Care in the placement of major snig tracks, along with directional felling and clearing of debris adjacent to retained trees ensures that damage to remaining trees is minimised. Minor forest products (fenceposts, etc) are cut from jarrah trees unsuitable for sawlogs.

4.2.7.3 Areas Excluded from Harvesting

Exclusions from harvesting are as per section 4.2.6.3.

4.2.7.4 Post Harvesting Operations

After harvesting, landings and major snig tracks are ripped by bulldozers to allow rehabilitation by planting or by natural regeneration.

A burn is then carried out to remove the dry leaves and small branches from the falled tree crowns, to stimulate growth of existing small trees and to provide protection from fire to the regenerating forest for about five years.

At about the same time as the burn is carried out, groups of saplings or pole size regrowth are then thinned and gaps are enhanced by cull-felling. These gaps are regenerated with jarrah and marri regrowth from rootstocks and some seedlings. This assists the growth of the next generation of trees.

4.2.8 Forest Operations - Regrowth Karri

4.2.8.1 Silvicultural Techniques

The development of regrowth forest and the object of thinning have been described as follows:

- o A forest begins its life with a huge number of seedlings which grow and compete with one another for available nutrients, moisture, space and light. The faster growing individuals begin to dominate and suppress their neighbours which eventually stop growing and die.

- o Such competition is natural selection, which continues throughout the life cycle of the forest. With karri, competition may reduce the population from as many as 100,000 seedlings initially to only 150 mature trees on a hectare after 100 years.

- o Thinning is the removal of some of the trees during the life of the stand. It is carried out for three purposes:

  - to remove and utilize logs from those trees that would otherwise die, thereby adding to the forest yield,
  - to provide more nutrients, moisture, space and light to encourage growth of the selected remaining trees.
  - to remove trees which would not provide future sawlogs

The intensity and frequency of thinning can be varied in numerous ways to suit differing sites, promote growth of different numbers of trees, or to provide different products (Bradshaw and Lush 1981).

Thinning is an important part of CALM's silvicultural strategy to encourage the growth of karri so that it will reach sawlog size sooner, thereby helping to increase and regulate the sawlog yield from the karri forest.

During the early stages of the life cycle of karri, the trees which need to be thinned (and which will die from competition anyway) are not large enough to yield sawlogs. However, they do produce a high quality source of fibre for paper. The chipwood industry therefore has an important role to play in further assisting the future production of sawlogs by providing a commercial means of thinning the regrowth forests. Without this opportunity it is unlikely that thinning could be carried out economically. (Regrowth established in 1930 was thinned in 1980, this operation having been made possible by the existence of a chipwood industry).

As stands become older and the trees larger, the proportion of other products increases. The chipwood industry still has a role in utilising those parts of the tree which are of poor quality or are from the top sections of trees which may be too knotty for other products. Later thinnings yield a range of products including peeler logs for plywood, large and small sawlogs and chipwood.

Two distinct groups of even-aged regrowth exist; those areas regenerated prior to 1967 (mostly from 1930-40) and those regenerated after 1967. The older group is currently being thinned for the first time (at about age 50). Thinning intensity varies according to height (Bradshaw 1985a) and at this age yields a range of products. For 1986 it was: peeler logs 0.7%, conventional sawlogs 14.4%; small sawlogs 25%; chipwood 60% (Walker pers comm.).

The presnce of the chipwood industry will allow earlier thinnings to take place in the post 1967 regrowth forests, and it is expected that these stands will be thinned at an average age 15 to 20, 45 and 60 years before the option of clearfelling arises again after 100 years when the number of trees per hectare will be about the same as in the virgin forest. The actual age and intensity of thinning will vary according to site quality and the need to provide for a regulated flow of products (Bradshaw pers comm.).

Regrowth also occurs in mixture with mature trees in areas which have been selectively cut in the past or as a result of wildfire. Regrowth occurring in sufficiently large gaps in the mature forest to allow its continued development without suppression by surrounding large trees will be treated in the same way as virgin forest. Detailed descriptions of these types are given by Bradshaw (1985a). The chipwood industry also has a role to play here in the utilisation of the small logs from thinnings or from clearfelling in these stands.

4.2.8.2 Harvesting Methods (Regrowth Karri)

Coupe planning and demarcation are as described in Section 4.2.6.2. The optimum density of tree stems is decided based on the dimensions of the trees. Trees for retention are selected and marked on the basis of crown dominance, form, vigour and spacing. (Bradshaw, 1985a).

All unmarked stems are felled manually by chainsaw or by a mechanical harvester/processor. Log products are then segregated and stacked using small bunching machines and the logs are picked up and carried by machine to roadside landings for loading onto trailers or trucks.

Harvesting Contractors in regrowth forests are subcontracted and managed by CALM and a comprehensive "Code of Logging Practice" is enforced. Regular inspections are carried out by a Forest Officer to ensure that utilisation standards are being met, damage to crop trees is not excessive, and all required environmental protection measures are implemented. There is a monetary penalty for excessive stem damage to crop trees. During the harvesting operation the harvesting contractor is required to remove all harvesting debris over 50mm in diameter to at least 1m away from retained trees to protect them from fire damage. Standard erosion control measures are also carried out at the completion of the thinning operation.

4.2.8.3 Areas Excluded from Harvesting

Research plots are excluded from the thinning operation. In some cases 20m wide buffers adjacent to private property are retained to protect the thinned stand from wind damage.

Thinning is approved in designated road reserves under special conditions prescribed to maintain aesthetic values. Thinning may be approved within stream reserves under stringent conditions which minimise erosion and sedimentation.

4.2.8.4 Post Harvest Operations

Following the completion of the thinning operation the area is burnt under mild conditions to remove fuel resulting from falled crowns, and hence assist in future fire protection and fire management requirements.

4.2.9 Other Forest Uses

4.2.9.1 Recreation

The south west region of Western Australia is a major destination for tourists and recreationalists and the karri forest, although a relatively small portion of the South West, is a focus for many national and international travellers. Similarly the renowned wildflowers attract many national and international visitors to the State, and can be seen to advantage in the forest areas, including the karri belt. People with a more intimate knowledge of the area are also attracted to features such as the inlets, beaches, coastal landscapes, extensive sand dunes, rivers and specific recreation roads.

Most tourists visit the region between September and April. This is primarily due to the weather conditions. The cool wet winters are not conducive to many of the popular recreation activities while the mild dry summer conditions are an attraction to many visitors, particularly from the Perth metropolitan area. Travellers tend to visit the north of Australia in the winter months and the southern areas in the summer period.

- Access

The primary routes for recreational access within the region are the South Western, Brockman, Vasse and Muir Highways. Throughout the region there is an extensive network of Shire and CALM roads. Many minor forest roads and access tracks are only trafficable to four-wheel-drive vehicles and trail bikes.

There are five major landscape types which can be classed as recreational resources. These are summarised as follows:

- The river systems, particularly the few which flow throughout the year.
- The inlets, with a range of surrounding forests and with vantage points offering good views.
- The coastal headlands, providing spectacular views from elevated vantage points. Vegetation varies with the geology which ranges from limestone to igneous outcrops.
- The undeveloped beaches often backed by extensive inland sand dunes with peppermint woodlands and trapped swamps and lakes.
- The diverse forest types which afford a range of scenic attractions.
  - Karri - pure stands found on erosional soils from granite gneiss and basalt. Characterised by dense understory.
  - Jarrah - ranges from tall stands through to stunted mallee types on poorer soils. Banksia understory is common, with sheoak on sandier soils.
  - Marri - usually found in association with other forest, either karri-marri or jarrah-marri. Pure stands of these tall, large-boled trees are also seen occasionally.
  - Tingle, Blackbutt, Wandoo - minor occurences which offer various visual characteristics affording diversity within the main forest types.
  - Pine and blue gum - occasional stands of exotic pine and blue gum are found within the area. Both present a marked colour and textural contrast with the endemic forest.

- Recreation Activities

A wide range of recreation activities are undertaken within the region. The more popular pursuits include pleasure driving and sightseeing, picnicking, fishing (coastal and inland), marroning, camping, hiking, four-wheel driving and camping. There are many commercial tourist operations within the area which utilise both natural and man made resources. Such activities include four-wheel drive safari, canoeing, hiking, horse riding forest tours and farm accommodation.

Information collected by CALM and the local Tourist Bureau shows that there has been a marked increase in both national and international visitors during the past five years and this trend is continuing.

School groups regularly undertake conducted tours of the forest concentrating on harvesting and regeneration operations. The Forest Products Association conducts tours from Manjimup, highlighting all aspects of forest management. These tours include an inspection of a sawmill and the Diamond Chipmill.

- Forest Recreational Facilities

Whilst forest recreation is a compatible secondary use over much of State Forest, there are several areas set aside with recreation as a priority use. These recreation priority areas include:

- One Tree Bridge (670ha)
- Brockman (630ha)
- Muirillup (210ha) and
- Mt Frankland (400ha).

Recreation is an integral part of National Park Management.

To cater for the increasing demands, a range of recreational facilities has been developed by CALM. A major day use and camping area has been established at the Shannon Townsite. This facility has a multi-use centre, overnight shelters, toilet blocks, camping areas, a sheltered barbecue, walk trails, information centre, picnic facilities and a nine hole golf course. Other major recreation sites include One Tree Bridge/Glenoran Pool, Gloucester Tree, Big Brook Dam and Valley of the Giants. These areas have picnic facilities, information and toilets. There are many popular sites ranging from the major developments listed above through to small roadside picnic areas. Approximately 60 sites are listed in the Southern Region Management Plan. Many of the major sites are also listed in the tourist promotion publications.

Self-guiding tour forest drives have been established to cater for the many tourists who seek this recreation experience. The popular drives include Rainbow Trail, Tramway Trail, Donnelly Drive, Valley of the Giants, WACAP Education Drive, Hilltop Drive and Knoll Drive.

4.2.9.2 Water Catchment

The woodchip licence area lies within the Australian Water Resources Council's river basins 606 (Shannon), 607 (Warren), and 608 (Donnelly). These three basins are in an area of high rainfall and runoff and together constitute the most important surface water resources still undeveloped in the south west (Collins and Barrett 1980, Section 6.1.4.3). The quality of the resource is of particular concern. Nearly 14 percent of the area is cleared for agriculture and this has caused a growing salinity problem in some parts of the catchments. In order to protect water quality clearing controls were introduced in the Warren catchment in 1978 under the Country Areas Water Supply Act (1947-1976). Elaborate management practices and research programmes have been developed to ensure that the water resource arising from forestry operations is protected (see Section 7.1.2).

Under the multiple use management programmes the higher rainfall, non-saline parts of these catchments are allocated a wood production priority which is compatible with its use for catchment protection. In the lower rainfall, potentially saline parts of the catchments, a catchment protection priority is allocated and any wood production is conditional that it must not conflict with that priority (CALM, 1987c).

4.2.9.3 Wildflower Collection

Wildflowers provide part of the attraction for tourists to the forest, particularly during spring. Collection of wildflowers is also undertaken commercially.

The taking of wildflowers from Crown Land is controlled through the Wildlife Conservation Act 1950-1980. This act provides for the issue of four types of licences:

(i) Commercial purposes licence - allows for sale of protected flora from Crown Land.
(ii) Commercial producers licence - allows for the sale of protected flora taken on private land.

(iii) Scientific or prescribed purposes licence - allows for the taking, but not the sale of native plants.

(iv) Nurserymans' Licence - allows for the growing for sale of native plants.

The act also allows for terms and conditions to be placed on each licence. On a State wide basis the cut flower and seed business had an estimated value of approximately $2.3 million at the wholesale level in 1981 (Burgman and Hopper 1982). This estimate was based on pickers returns in 1980/81. However, subsequent returns by pickers have not been significantly consistent to allow better analysis, or to isolate activity in the chipwood licence area. The Burgman and Hopper report however found that most picking activity in 1980/81 was concentrated around Perth and Mount Barker. It is unlikely that this trend has changed, suggesting that the chipwood licence area is not a very significant source of cut flowers.

Burgman and Hopper (1982) identified the 20 most heavily exploited species. Of these, those occurring in the licence area and most likely to have been picked are:

SPECIES	GENERAL SITE OCCURRENCE
Agonis parviceps (tea tree)	non forest flats of the south western portion of the licence area
Podocarpus drouynianus (emu bush)	southern jarrah - marri forest
Beaufortia sparsa (no accepted common name)	southern and eastern non-forest flats
Adenanthos obovatus (no accepted common name)	northern and eastern jarrah forest
Boronia megastigma (brown boronia)	northern and eastern non-forest flats

Of these, local observation suggests that Agonis parviceps is the most economically significant followed perhaps by Boronia megastigma. There are of course many other species exploited at a low level of production.

It is apparent however, that the export woodchip industry to date and in the future will have very little impact on the wildflower industry because the most economically important species occur in the non-forest areas and those that do occur in the forested areas are widespread throughout State Forest.

4.2.9.4 Nature Conservation

Nature conservation is a significant use of forest in the licence area. At present 241,300ha or 33% of the Crown Land on the licence area has as its primary use native conservation, hence is reserved from cutting (see Section 6.4). An additional 82,300ha, protected from intensive harvesting is distributed throughout the areas designated for cutting, to ensure habitat for flora and fauna is maintained and to provide movement corridors and recolonisation cells (see Section 4.2).

Production forest is managed as far as possible to protect environmental values and ensure revegetation is complete, (see Section 4.2 and 7.1.4) so that the long term conservation value of the cut over areas is maintained.

In addition to managing priority areas specifically for conservation values, production areas have operational prescriptions incorporating measures to minimise short term impacts on the natural environment, and eliminate long term impacts.

4.2.10 Supervision and Control

There are several control mechanisms available to ensure the Timber Industry activities in the forest are conducted with prescriptions.

The CALM Act (1984) and Regulations specify the powers of the Executive Director and Forest officers, as well as stipulating the conditions of various Permits, Licences and Contracts of Sale for timber.

The Forest Produce (Chipwood) Licence No. 1588 which authorises harvesting activity in the forest was granted in May 1974 subject to special conditions. The conditions specify royalty payment and review as well as requirements for roading plans, coupe management, utilization standards, protection of crop trees, protection of stream reserves, fire control, dieback hygiene and disposal of logs suitable for sawmilling, or other purposes.

The activities of all harvesting contractors in State forest are subject to the comprehensive prescriptions contained in the Southern Forest Region Industry Control Manual. Specifications contained in this manual cover the range of log utilisation, silvicultural, engineering and environmental control requirements for harvesting and roadings operations. This manual is issued to all Forest officers and Timber Industry supervisors working on Timber Protection activities.

When CALM employs the harvesting Contractor directly, the Contractors activities in the forest are subject to a "Code of Logging Practice" which is an integral part of the contract. Renewal of these harvesting contracts is subject to satisfactory performance by the Contractors working under "The Code".

Currently all regrowth harvesting operations (120,000 cubic metres per annum) and several minor integrated hardwood operations (55,000 cubic metres per annum) in the Southern Forest Region are organised under Contract to CALM and are subject to a "Code of Logging Practice". As more arrangements for sales of log timber are made under Contracts of Sale instead of Permits or Licences, CALM will assume a more direct role in control of harvesting operations (ref Section 9.5).

All harvesting operations are subject to regular detailed inspections by a Forest officer. In the Southern Forest Region the equivalent of 30 full time Forest officers are involved in supervision of the Timber Industry. Forest officers carry out inspections to a detailed checklist. Illegal activities or malpractice in the forest can be dealt with as a forest offence. An individual forest workers authority to work in the forest may also be withdrawn by cancellation of their Timber Works Registration Act or regulation reference. CALM Harvesting Contractors may suffer financial penalties for malpractise (e.g. excessive damage to crop trees) or have their contracts terminated.

4.2.11 Monitoring and Research

Monitoring of timber production activities includes the following:

- o Utilisation surveys to assess volume of various log products left after harvesting is completed.
- o Progressive tallies of logs to sawmills and the chipmill to ensure permissable intakes are not exceeded.
- o Weight/Volume relationships for various log species.
- o Progress of log stockpiling during the summer stockpiling period.
- o Soil disturbance or damage caused by harvesting during winter months.

- Crop tree damage caused by felling or harvesting machinery where crop trees are being retained.
- Adherence to prescription to prevent the introduction and spread of dieback disease.
- Impact of harvesting on steep slopes and soil movement.
- Water quality monitoring in conjunction with WA Water Authority.
- Germination and survival of regeneration following harvesting.

Research is being conducted in the following areas:

Silviculture

- Research to develop a long term supply of high quality, inexpensive karri seed.
- Research to improve survival and growth of planted karri seedlings including fertiliser application at time of planting.
- Research into thinning of young (post 1967) and older (pre 1967) karri regrowth stands to improve sawlog production.

Ecology

- Effects of harvesting and fire on small mammal populations.
- Effects of forest operations on the ecology of bird communities in the karri forest.
- Effects of harvesting on hollow nesting animal species.
- Effects of fire regimes on understorey plant species composition.
- Dieback - mapping of infested areas, research into the disease and the conditions that influence its spread.

Fire

- Research to determine conditions and techniques appropriate for burning of young karri stands.
- Research to determine the stage of stand development at which prescribed burning can commence.

4.2.12 Modifications to Operations

The guidelines for operations in the forest are constantly being modified as research and monitoring results are obtained. The Industry Control Manual, Codes of Logging Practice and Operations Manual are reviewed and revised at regular intervals as new information is interpreted.

Regular feedback is provided to Industry Personnel. Training programmes are provided for CALM staff and Industry personnel when new procedures are introduced. During the first decade of integrated sawlog and woodchip harvesting operations in the Southern Forest Region, operations have changed signficantly. An example of this process is provided by the assessment of impacts of soil compaction and disturbance by harvesting equipment during winter months. When the initial problems of poor germination and growth of seedlings on soils disturbed by winter harvesting were detected in 1977, a major operations research programme was initiated. Harvesting trials, silviculture research and rehabilitation trials were implemented by the Department. Feedback was provided to Industry and new harvesting equipment and techniques were investigated and tested. A control system to limit the extent of soil disturbance and damage was devised and implemented. This control system has been refined over the years.

As a consequence of the research and harvesting trials conducted and the control system enforced, the following changes have occurred within the last decade:

- Harvesting Plans are issued with a constraint that summer stockpiling of up to 25 percent of the permissable intake will be required to operate within the Plan. Extensive log stockpiles are accumulated each summer with some mills stockpiling up to four month's intake.
- Location of log landings and snig tracks are planned in advance for each faller's block.
- New harvesting equipment such as flexible track (low ground pressure) skidders and static hydraulic loaders have been purchased by Industry.
- Log landings and snig tracks are rehabilitated by specially equipped bulldozers. WACAP co-ordinates this rehabilitation programme for all integrated harvesting contractors, and the rehabilitation is funded entirely by Industry.
- Coupes are closed for the winter if soil moisture limits are exceeded.

4.3 CURRENT FORESTRY OPERATIONS - PRIVATE PROPERTY

4.3.1 Area of Supply

The licence area set out in the Forest Produce Licence No 1588 applies solely to State Forests; it does not constrain WACAP's private property chiplog operations.

WACAP has purchased private property chiplogs from landowners up to 300km distant from the Diamond Chip Mill. The only constraints on WACAP's potential supply zone for private property chiplogs are harvesting and transport costs and the quantity of wood available from the particular operation. It is possible for WACAP to purchase chiplogs from landowners distant from the Diamond Chip Mill if they are close to major Perth/Manjimup transport routes. This is feasible because trucks delivering sawlogs to Perth saw-mills can backload chiplogs to the Diamond Chip Mill.

4.3.2 Relevant Legislation

WACAP has no authority to control private property harvesting operations. In the case of forest clearing by a farmer for agriculture, the company often receives little notice of the proposed operation and in many cases the trees have already been pushed over and possibly windrowed by the farmer before WACAP becomes aware of its availability. Plantation preparation by WACAP on its own land will be conducted in accordance with CALM codes and practice, and WACAP recommends that participants in WACAP's various Tree Farming Incentive Schemes (Section 4.3.4) also adopt CALM's practices.

These controlled operations are planned up to 12 months ahead of operations.

The three government Acts that have an effect on WACAP's operations on private property are described below.

4.3.2.1 Country Area Water Supply Act, 1947-78.

The West Australian Water Authority requires and issues licences to clear indigenous vegetation in areas sensitive to salinization and erosion. Whether or not a licence is issued depends upon where the property is situated in relation to four zones of diminishing stream salinity hazard, labelled progressively A to D, within specified water catchments. Regardless of the stream salinity hazard zone, the Act decrees that no licence will be issued for clearing indigenous vegetation beyond 90 percent of the area of the property in question.

The guidelines issued by the Water Authority in December 1985 clearly state the type and intensity of clearing operation allowed in each zone and the special conditions imposed upon forestry operations. In general, clearing for agricultural purposes will not be permitted in Zone A, or in Zones B/C for areas greater than 20ha. Licences are usually granted in Zone D, subject to the statutory requirement which applies to all four zones, that 10 percent of the land is left uncleared.

Where the clearing is taking place to establish trees, requirements are more flexible. The issue of a licence to clear within the Warren and Kent Water Reserves will only be granted to a private landholder on condition that the applicant first submits to the Water Authority a management plan and proof of an agreement with a commercial company for establishment of a tree plantation.

In Zones A and B, the Water Authority will only grant a licence if it considers that the proposed development of the tree plantation will result in a reduction in salinity hazard. A special provision is that for every hectare of forest cleared and replanted an additional two hectares of pasture land must be planted.

Licences for up to 20ha of plantation re-forestation will normally be granted in Zones C and D provided that 10% of the total holding remains uncleared.

The Water Authority has issued 25 licences to establish plantations in the Warren River Water Reserve, the details of which are given in Table 9.

TABLE 9

PLANTATIONS IN THE WARREN RIVER WATER RESERVE

LANDHOLDER	ZONES	NO. OF LICENCES ISSUED	AREA OF FOREST CLEARED AND REPLACED WITH PLANTATION (ha)	EXTRA AREA PLANTED ON EXPASTURE SITES (ha)	TOTAL (ha)
CALM	B - D	21	577 Forest 490 Shade trees	2134	3201.0
BUNNINGS & WACAP	A - C - D	5	253 Forest 20 Regrowth	57	330.0
TOTAL			1340	2191	3531.0

The Water Authority is currently preparing guidelines for the thinning of regrowth forests in protected catchments (Water Authority, pers comm.). Under these guidelines licences will normally be subject to the following conditions:

- Thinning will only be permitted down to a residual Basal Area of $10m^2$/ha.
- The block must remain a forest block with no pasture underneath. Fencing will be required in the jarrah/marri forest but not in the karri and karri/marri forest.
- Thinning will be permitted, subject to detailed assessment by CALM officers in the C and D zones of the Warren and Kent catchments.
- In the Warren B and Denmark C zones, buffer strips 50m on primary streams and 100m wide on secondary streams will be required.
- Licences shall not normally be granted for thinning operations in Zone A.

4.3.2.2 Soil and Land Conservation Act, 1945-82

The WA Department of Agriculture also has regulatory powers over private property forest harvesting through its administration of the the Soil and Land Conservation Act 1945-1982 which requires that approval be obtained for any forest clearing operation covering an area greater than 1ha. Clearing may be restricted by the Act in the following situations.

- Deep sandy soils where clearing results in a high wind erosion hazard.
- Areas designated for wind breaks on soils where wind erosion is likely.
- Land identified as a specific groundwater recharge area where clearing is likely to cause a significant rise of the watertable in waterlogged or saline hazard areas.
- Areas of severe salinity hazard.
- Steep slopes where a severe water erosion hazard is likely.
- Areas of shallow soil over-lying rock or laterite.
- Areas required for waterways.
- Areas adjacent to rivers and creeks.

(Robertson 1986)

The regulations are not intended to limit the clearing of land with agricultural potential, but are designed to prevent clearing which may cause land degradation.

There are some unclear areas in relation to the regulations because the legislation states that a Notice of Intention to Clear Land need only be submitted where a change of land use is being considered. In the case of bonafide private forest management where the area cleared is being naturally regenerated or converted to plantation it could be argued that no such change in land use is occurring. However, the Department is recommending that landholders notify the Commissioner of Soil Conservation in order to avoid the possibility of prosecution if the post-harvest land use is deemed a change in land use, which could occur if the natural regeneration is unsuccessful, if stock are allowed into the regenerating area or if the plantation is located on a non-productive site.

4.3.2.3 Bush Fires Act, 1954-79

Local Government in its administering of the Bush Fires Act, 1954-79 has some influence over the activities of WACAP and its plantation treefarmers. Shire appointed Fire Control officers have the authority to issue permits to burn harvesting residues during the period of restricted burning.

Within the Shires of Manjimup and Bridgetown-Greenbushes, plantation landowners are required to construct fire breaks at least 5m in width around external plantation boundaries. In addition, plantations are required to be subdivided by internal 6m wide fire breaks into compartments no greater than 28ha in area.

4.3.3 Resource Estimates

WACAP categorises its private chiplog resource into two subdivisions; "WACAP Forest" and "Other Private Property". The former category includes chiplogs coming from WACAP's own holdings, private property regrowth thinning and participants in one of WACAP's five Forestry Incentive Schemes. The latter two resources are included in this subdivision because WACAP retains a continuing interest in the resources and their productivity. Over the past seven years (1980-87) WACAP forests have supplied an average of 12646 tonnes of chiplogs per annum or 1.7% of the 644,078 average annual tonnage of Woodchips produced by WACAP over the same period.

WACAP Forests are concentrated in the Northcliffe area which is approximately 60km southwest of Manjimup.

The "Other Private Property" category is for chiplogs received primarily from agricultural clearing and pine re-forestation operations. WACAP does not seek out these resources but will accept them subject to the landholders having obtained the necessary licences (see Section 4.3.2). Over the past 11 years (1976-86) these private property forests have supplied an average annual yield of 39,033 tonnes of chiplogs or 6.0% of the tonnage of woodchips shipped by WACAP over the same period (Table 10). Marri chiplogs account for the bulk of the private wood utilised by WACAP making up approximately 80% or 31,226 tonnes of the average annual intake, the balance being Karri.

4.3.4 Payments to Landowners and Reforestation Incentives

WACAP's payment to private property landholders for chiplogs from native forest is based around the end use of the land. To encourage as little permanent clearing of native vegetation as possible and to promote revegetation with high yielding species, they have structured payments as detailed in Table 11.

[redacted]

TABLE 10

WACAP PRIVATE PROPERTY WOOD SUPPLY

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	TOTAL (tonnes)
EX WACAP FOREST												
Chiplogs (tonnes)	-	-	-	-	1316	2948	7956	15800	24644	17696	18164	88524
* Woodchips (tonnes)	-	-	-	-	1158	2594	7001	13904	21687	15572	15984	77900
EX OTHER PRIVATE PROPERTY												
Chiplogs (tonnes)	218	6691	4327	46326	85810	27176	11616	19248	71001	87518	69432	429363
* Woodchips (tonnes)	192	5888	3808	40767	75513	23915	10222	16938	62480	77016	61100	377839
TOTAL WOODCHIPS EXPORTED. ALL SOURCES. (Crown & Private) (tonnes)	254703	397441	429848	658931	818072	525758	491359	618044	718479	679845	656993	6249473

* Assumes 12% Loss Chiplogs to Woodchips
10% in Bark
2% in Fines (sawdust, undersize chips)

AVERAGE ANNUAL TONNAGES

SOURCE	PERIOD	PRODUCT	QUANTITY (tonnes/yr)
EX WACAP FOREST	80 - 86	CHIPLOGS	12646
EX OTHER PRIVATE PROPERTY	76 - 86	CHIPLOGS	39033
		WOODCHIPS	34349
	80 - 86	CHIPLOGS	53114
		WOODCHIPS	46741
ALL PRIVATE PROPERTY SOURCES	80 - 86	CHIPLOGS	65760
		WOODCHIPS	57870
AVERAGE ANNUAL EXPORT	76 - 86	WOODCHIPS	568134
ALL SOURCES (Crown and Private)	80 - 86	WOODCHIPS	644078

Source: (WACAP, 1987)

TABLE 11

WACAP PAYMENT TO PRIVATE PROPERTY LANDHOLDERS

END USE OF LAND FOLLOWING CHIPLOG HARVEST	PAYMENT	COMMENT
Cleared for pasture	$1.23/tonne	Direct stumpage payment
Reforested	$1.23/tonne $2.80/tonne	At initial clearing. On reforestation. Often made "in kind" with seedlings
Native forest. Woodchip operation is a thinning of either JM or K regrowth forest	$8.47/tonne	Direct stumpage payment
WACAP landholder (Tree Farmer) Schemes	$8.47/tonne	Direct stumpage payment

Whilst WACAP are opposed to clearing of native forest for pasture development it is not sensible to refuse to take logs completely, for in most cases they would be burnt.

The rate of payment is not affected by distance from the Diamond Chipmill. However, WACAP may decline to accept wood from more distant sources.

The State Forest royalty rates are determined every five years when the Forest Produce Licence is reviewed. WACAP reviews its private property rates at the same time. Increases in WACAP private property payment rates over the current licence period are detailed in Table 12.

TABLE 12

INCREASES IN WACAP PRIVATE PROPERTY RATES

PERIOD	1969 - 12/74	1/75 - 12/80	1/81 - 12/85	1/86 - 12/90
Basic Payment for Agricultural Clearing ($/tonne)	$0.44 - 0.61	$0.61	$1.23	$1.23
Tree Farmer Payment $/tonne	-	-	$2.59	$8.47

Source: WACAP

4.3.4.1 Landholder Agreements

In addition to the stumpage structure WACAP encourages reforestation and afforestation through implementation of four landholder agreement schemes.

Type 1, Amenity Plantings: WACAP provide a small number of trees to service organisations, local councils and farmers for amenity planting. There are no conditions placed upon these donations.

Type 2, Treefarmer Scheme for Farmers wishing to Afforest Pasture Land: In this instance WACAP signs an agreement with the farmer to supply eucalpyt seedlings, fertlizer, planting equipment and advice. The farmer is obliged to do the planting and further tending of the plantation or to finance this work.

The only condition placed by WACAP on this type of agreement is that the company is guaranteed first right of refusal for any timber produced by the plantation. If the Tree Farmer wishes to withdraw from the scheme he must repay to WACAP the value of the assistance given plus interest.

Type 3, Tree Farmer Schemes for Landholders who wish to Reforest their Land with more Productive Eucalypt Plantations: Under the conditions of this scheme WACAP obtains the first right of refusal of any timber produced by the plantation in return for providing the following:

- o A preminium stumpage of $8.27 per tonne for any chiplogs salvaged in the clearing operation.
- o Sufficient eucalypt seedlings to establish a productive plantation with an initial stocking of 1250 trees per hectare.
- o Advice to the landholder on planting and tending techniques.
- o Planting equipment.

The farmer is responsible for actually planting the trees or financing the work as well as the follow up maintenance of the plantation.

Type 4, Lease Agreements: In this instance both WACAP and the landholder contribute to the initial plantation establishment costs.

WACAP agrees to pay current market price for any timber harvested from the plantation during the lease period.

Returns from the sale of timber are split between the landholder and WACAP according to the compounded value of each party's original contribution.

Negotiations for tree farmer schemes are all entered into and finalised before any harvesting takes place.

The current number of landholders (incl. 1987) in each scheme and the areas involved are summarised below:

	SCHEME	NO. OF LANDHOLDERS	TOTAL AREA ALL LANDHOLDERS (ha)
1	Amenity Planting	15	60
2	Treefarmers Afforestation	2	15
3	Treefarmers Reforestation	34	255
4	Lease agreements	1	10
	TOTALS	52	340

Source: WACAP

WACAP expects a considerable expansion in the number of landholders who become involved in these schemes as they become more publicised and the earlier plantations begin to produce merchantable timber.

The Western Australian Government also operates a landowner joint venture scheme for softwood share farming. Under the conditions of this scheme, the landowner provides suitable land (greater than 40ha) and CALM provides the resources for all softwood operations as well as carrying all the risk of the venture.

Participants receive a predetermined annuity, indexed for inflation and a predetermined percentage of clearfell revenue (CALM, 1987b).

Currently the scheme only applies to softwood plantations. However, there is a possibility that it may be widened to include eucalypt plantations as part of a catchment redemption program in specific saline affected catchments (CALM, pers comm.).

4.3.4.2 Disincentives to Clear

WACAP's stumpage structure for private property chiplogs is a major disincentive to clear native forest for agricultural purposes.

Two Government authorities also administer legislation which can act as a disincentive to farmers to clear forest. These are: the Water Authority of WA Licence to Clear Indigenous Vegetation and; the WA Department of Agriculture Notice of Intention to Clear Land. These have both been discussed in Section 4.3.2.

4.3.4.3 Post Harvest Land Use Decisions

The post harvest land use decisions of landholders have not been fully documented by WACAP. It is difficult for WACAP to ascertain the areas involved because it purchases chiplogs by volume and much of the salvage harvesting from agricultural clearing has taken place in scattered timber. However, it is possible to estimate areas from which trees were harvested using an average yield figure of 60tonnes/ha for private property (Table 13).

Agriculture is expected to remain the major post-harvest land use despite the incentives to reforest and disincentives to clear forest listed in Section 4.3.6.2. As stated in those sections WACAP does not actively seek out or encourage private property clearing, rather it utilizes timber from clearing operations which would be otherwise burnt. The lack of incentive to clear native forest provided by a log salvage operation can be illustrated by the comparing average costs and returns associated with clearing a forest and replacing it with pasture (Table 14).

TABLE 13

POST HARVEST LAND USE - PRIVATE PROPERTY

	AREA INVOLVED OVER PERIOD 1976-86 (ha)	%
Eucalypt Plantation	880	11.1
Pine Plantations	400	5.1
Agriculture	6600	83.4
Natural Regeneration	-	
Timber Production on Thinned Native Forest	30	0.4
TOTAL	7910	100

Source: WACAP

TABLE 14

COSTS AND RETURNS INVOLVED IN ESTABLISHING
ONE HECTARE OF IMPROVED PASTURE ON EX FOREST SITES

OPERATION	COSTS \$/ha	RETURNS \$/ha
Clearing and burning	350	
Salvage Harvesting for $50m^3$/ha of Chiplog @ \$1.50/m^3		75
Ploughing	50	
Seeding and Fertilizer Improved Pasture	135	
Fencing	40	
TOTAL	575	75

Net Balance: \$-500/ha

Source: (WACAP and CALM, pers comm.)

4.3.5 Operation Types

4.3.5.1 Mature Forest - Eucalypt Plantation

Much of the mature private property forest has been heavily cut over for sawlog in the past. Removal of the preferred sawlog trees has left forests consisting of over-mature stems, unsuitable sawlog species such as marri and little productive regrowth. From a timber production perspective, forests in this condition are of little value.

In such instances WACAP prefers to clearfell and reforest with more productive eucalypt plantation rather than rely on natural regeneration and supplementary planting of indigenous species. WACAP predicts an average Mean Annual Increment (MAI) of $20m^3$/ha/yr from their *E. globulus* plantations (refer to Appendix F) which compares more than favourably with an average MAI of $5m^3$/ha/yr for karri regrowth managed on a 100 year rotation (CALM 1987b).

To date WACAP has reforested nearly 1000ha of its own land and around 76ha of Tree Farmers forest in this manner. Prior to commencing a plantation conversion programme, WACAP ensure that all the necessary clearing permits are obtained.

4.3.5.2 Mature Forest - Natural Regeneration

WACAP does not carry out any private property harvesting which relies on natural regeneration for reforestation. This is partly because of the previously described (4.3.5.1) depauperate nature of many private property forests and the consequent lack of suitable seed trees. It is also in the landholders best financial interest to have the most productive forest possible, which is plantation eucalpyts.

WACAP seeks to ensure that private property landholders are serious about turning their existing forest into a productive forestry or agricultural unit and not merely interested in clearfelling the forest to generate a short term cash flow. WACAP will not undertake harvesting on private property where the timber has not been pushed over prior to the commencement of harvesting. The reason is that if the landowner is prepared to pay to have the timber pushed, it demonstrates, prior to WACAP's involvement, a clear intention not to leave the land idle. WACAP also offers incentives in its stumpage rates for landholders who are prepared to reforest with eucalypt plantations (ref 4.3.4).

4.3.5.3 Mature Forest - Agriculture/Pine Conversion

Recovery of logs from forest cleared for agriculture and pine growing is the most common type of operation undertaken by WACAP on private property. Over the past 11 years, WACAP has salvage harvested around 9900ha of private property forest destined for agricultural production and around 400ha has been converted to pine plantation (ref 4.3.4.3).

WACAP offers a disincentive to this type of operation through its low stumpage ($1.23/tonne) paid for logs coming from private property (ref 4.3.4). However, despite the low stumpage rate the same area of private property forest is still being cleared annually for this purpose. WACAP is therefore utilizing timber which would otherwise be cleared and burnt, a situation which is still occurring in many instances where land holders fail to contact WACAP prior to burning timber they have cleared.

Landowners opting to reforest their native forest to pine plantation may qualify for WACAP's tree encouragement stumpage (ref 4.3.4). P. radiata is the predominant species of pine planted in the southern region.

4.3.5.4 Agricultural Land - Eucalypt Plantation

This type of conversion is the preferred method of plantation establishment practised by WACAP. Site preparation and establishment costs are much lower on expasture sites than exforest sites. However, land purchase price is generally much higher for pasture than bush blocks.

Another impetus towards the establishment of plantations on ex-pasture sites is the WA Water Authority's requirement under the provisions of the "Licence to Clear Indigenous Vegetation" that for every one hectare cleared and reforested, an extra two hectares must be afforested on expasture land in Zones A and B of the Warren and Kent River Water Reserves and the Denmark River Catchment Area.

WACAP has planted around 200ha of their own ex-pasture land to plantation and around 50ha of Tree Farmers pastured land. It is expected that more pastured land will be planted to eucalypt plantations as the value of trees for water catchment redemption and total farm production becomes more widely appreciated.

4.3.5.5 Regrowth Thinning Operation

Where good stands of karri regrowth exist on private property, WACAP is suggesting to the landholders that a commerical thinning operation should be undertaken. This operation is aimed at removing a proportion of the trees to bring forward the production of more valuable sawlogs.

WACAP undertakes an integrated harvesting operation when thinning, removing small sawlogs (down to 200mm) as well as chiplogs (down to 150mm). This is of more benefit silviculturally than the sawlog-only operations that occurred in the past.

Previously, operations generally removed the better quality trees which was not the most appropriate silvicultural technique. In contrast, WACAP officers treemark for retention using the silvicultural guidelines for thinning in Technical Report No. 1 (Bradshaw 1985a) prepared by CALM. WACAP officers have the opportunity to persuade the farmer to retain his forest and to advise him on the best silvicultural practice. Such information is not readily available from CALM or the Department of Agriculture.

WACAP has carried out approximately 30ha of karri regrowth thinning to date, yielding an average volume of 95t/ha chiplog and 43tonnes/ha sawlog.

4.3.5.6 Eucalypt Plantation Establishment

Tasmanian blue gum (Eucalyptus globulus) is the preferred plantation species for WACAP and tree farmer plantations. This species has shown superior growth rates in trials when compared to native species such as karri (E. diversicolor) and other introduced species trialled by WACAP, including E. nitens, E. regnans, E. saligna, E. grandis, E, muellerana and E. maidenii and E. viminalis.

WACAP plantations establishes sites which are capable of carrying reasonable quality forest as indicated by soil type and in areas with an average annual rainfall in excess of 800mm and which are within a 100km radius of either Manjimup or Bunbury. This policy is followed because eucalypt plantations are a considerable capital investment and the aim is to produce the maximum volume close to consumption centres in the shortest possible time, thereby giving the forest owner the highest possible internal rate of return. At present WACAP expects the rotation period to be around 10 to 15 years with an average plantation yielding approximately 360t/ha over a 15 year rotation period.

Plantation establishment techniques have been refined by WACAP over the last three years as experience dictates. Two separate systems have been developed for ex-forest and ex-pasture sites, they are:

Ex-forest Sites

- o Salvage harvesting of sawlogs and residue chiplogs.
- o Scrub rolling to knock down dead trees and scrub.
- o Broadcast burning usually in autumn when a permit to burn can be obtained.
- o Stick-raking, stacking of debris and reburning.
- o Ploughing, if necessary, depending on the soil types.
- o Planting of eucalypt seedlings in May - July at a stocking rate of 1,250 trees per hectare.
- o Fertilizing with a nitrogenous fertilizer, (100 grams per tree at the time of planting)
- o Survival assessment at one year after planting. If seedling survival is less than 80%, WACAP will consider replanting.

Ex-Pasture Sites

- o Planting lines are cultivated or ripped to a depth of 60cm.
- o Planting lines are sprayed with weedicide one month prior to planting to eliminate grass competition.
- o Planting, fertilizing and survival assessment as per ex forest sites.

After planting, it is necessary to exclude stock from the plantation for a period of at least 18 months. Firebreaks and access tracks also need to be maintained periodically during the rotation to facilitate fire protection and to meet local government requirements.

4.3.6 Planning and Construction of Roads on Private Property

Most roads on private property are of low standard. Extraction tracks are located in agreement with the land owner and are for the most part unformed. Where tree farms are to be established, the extraction tracks are located around the boundaries of the block to enable subsequent use as firebreaks for protecting the plantation.

Once harvesting is complete, extraction tracks may be crossdrained if there is the possibility of erosion. More usually they are left untouched, either to be ploughed in or retained for the farmers' use, according to the farmers' wishes.

Private property timber is predominantly carried on Shire roads and State highways to the Diamond chipmill, but where possible, private haulage roads are utilised. The only load limits enforced for the trucks are their registered payload and the special load limits by local Shires sometimes placed on roads and bridges.

4.3.7 Supervision, Environmental Monitoring and Controls

WACAP employs two full-time officers responsible for private property forests; a Private Forest Development Officer and a Private Property Wood Procurement Officer. The private Forest Development Officer is a graduate forester whose main duty is to co-ordinate the tree farming schemes and to supervise the activities of the private property Wood Procurement Officer.

The private property Wood Procurement Officer is an experienced foreman who is responsible for wood procurement and supervision of harvesting operations on private property being cleared for agricultural purposes, tree farming or regrowth thinning.

These officers visit the site of any harvesting operations at least once per week to monitor production and environmental effects. In addition, the WACAP operations manager oversees the activities of the private property officers as part of his overall responsibility for all private and crown forest harvesting operations.

WACAP harvesting contractors typically salvage chiplogs and sawlogs from timber pushed over by landholders as part of clearing operation. Hence, most environmental damage has already occurred prior to the timber salvage operation because the trees are already on the ground.

WACAP accepts that it is in the company's best interests to conduct its operations safely and with responsible environmental control. WACAP is not empowered to enforce any direct penalties for environmentally unsound harvesting practices on private land. However, the company considers that the system is self-regulating. It is in the harvesting contractor's interest to observe good harvesting practice because he depends upon the company for his continued livelihood. If the contractor does not carry out a harvesting operation in an acceptable manner then he risks having his operating quota reduced by WACAP.

Safety rules and regulations covering harvesting operations and harvesting road rules are enforced rigorously by WACAP officers.

4.4 SAWMILL RESIDUES

Sawmill residues consist of waste solid wood (slabs, off cuts, boxed hearts, dockings) left after the sawn timber has been cut from the sawlogs. It has been estimated that as much as 40 percent of the timber which goes into the sawmills of Western Australia ends up as sawmill residues (McLean 1986).

Prior to the commencement of WACAP's operations, these residues were burnt as waste at the sawmills. Today, mills cutting karri and marri either have chippers and screens installed at the mill, or they transport their residues to a nearby mill or to the Diamond Chip Mill where the residues are converted into export quality woodchips. These woodchips are then either transported to the Diamond mill in Manjimup or are delivered directly to the shiploading facilities at Bunbury.

WACAP accepts sawmill residues in two forms. Large pieces of solid wood (boxed hearts) are delivered to their Diamond Mill. Additional residues are woodchipped by sawmills and either transported to Diamond Mill or direct to the port facilities at Bunbury.

The average annual quantities of sawmill residues delivered to the mill and the port over the six years 81-86 are 71,371 tonnes and 18,525 tonnes respectively. In total, sawmill residues contribute 89,896 tonnes or 14.6 percent of the average annual shipment of woodchips by WACAP.

Not only does the chipping of sawmill residues increase the overall yield of products from each log; it also allows sawmills to accept a lower grade of sawlog. This practice increases the amount of sawn timber produced from each area of forest harvested. This increased productivity improves the financial viability of each sawmill and plays an important role in keeping the cost of sawn timber at an acceptable price to the public.

Employment is also increased, as personnel are required for production and maintenance of chipping operations at the sawmill and for transporting the woodchips by road from the sawmill to either of the WACAP installations.

The following sawmills are at present supplying residues to WACAP (Table 15).

TABLE 15

SAWMILLS SUPPLYING SAWMILL RESIDUES TO WACAP

WOODCHIPS	SOLID WOOD (Boxed Hearts)
Bunnings - Jardee	Amalgamated Timber Products - Yornup
- Northcliffe	Rijavec & Co. - Manjimup
- Pemberton	Worsley Timber Co. - Palgarup
McLean Sawmills - Denmark	A.F. & M. Drake - Jardee
Gandy Timbers P/L - Jardee	T. Waugh - Manjimup
Monier - Busselton	A.C. Rudd - Northcliffe
Whittakers - Greenbushes	South West Timbers - Pemberton

4.5 EXISTING WOODCHIPPING OPERATIONS

4.5.1 Description of WACAP Operations

4.5.1.1 Sources of Wood For Production of Woodchips

Logs for the production of woodchips are obtained:

- o From areas of State Forest within the boundaries shown on Figure 2, as selected and designated by CALM.
- o From areas of State Forest outside the boundaries in which CALM's forest management activities produce logs unsuitable for sawing but suitable for woodchipping.
- o From private properties within the South West region where the landowners, following receipt of the necessary clearing permits, have offered the fallen trees for sale to WACAP. In the future chiplogs will also be obtained from private hardwood plantation.

In addition, woodchips are produced from the residues of saw-milling operations in the South West.

Chiplogs from both State and private forests have been predominantly marri with some low quality karri. Sawmill residues have been mainly karri.

A breakdown of the sources of chips over the past seven years is given in Table 16.

TABLE 16

SOURCES OF WOODCHIPS 1980-1986

SOURCE	QUANTITY (tonnes)						
	1980	1981	1982	1983	1984	1985	1986
Chip-logs from Crown Land	711,620	527,458	449,580	492,185	605,400	639,630	642,310
Chip-logs from Private Property (including WACAP forest)	87,126	30,124	19,572	35,048	95,645	105,214	87,596
Saw-mill residues	-	105,970	88,390	81,440	100,040	91,640	103,460

Over the past six years most of the chip-logs from both State Forests and private land have been obtained from mature forests. Marri has provided more than 80% percent of these logs. CALM's regrowth forest thinning programme currently provides about 6 percent of chip-logs which are predominantly karri. The proportion of karri chip-logs will increase as more thinnings become available. By 1988 it is anticipated that the annual production of thinnings will amount to 110,000t. Saw-mill residues comprise mainly karri.

Jarrah chips have also been produced from sawmill residues and several trial shipments have been exported. However, there is currently no significant market for jarrah chips.

4.5.2 Selection of Chiplogs

Selection of logs from State forest for woodchipping is carried out under the strict supervision of officers from CALM as described in detail in the preceeding sections.

Harvesting contractors carry out the harvesting operations in areas designated in advance by CALM. At the forest landings, general purpose logs suitable for timber production are selected and branded for subsequent delivery to the timber mill. A salvage saw harvesting operator then appraises the remaining logs and selects additional logs suitable for salvage milling. The remaining logs (chiplogs) are then hauled to the woodchip milling facility near Manjimup.

Officers from CALM regularly carry out spot checks at the forest landings and at the Diamond Chipmill plant to ensure that the only logs used for woodchipping are those not suitable for timber production. Any sawlog quality logs identified at the Chipmill, are set aside for subsequent sale.

There are a number of safeguards against using valuable timber for woodchip production.

These include:

- o Commercial - the price for saw logs substantially exceeds the price for chip logs (see Section 4.3.3). It is in the interests of all parties - CALM, the harvesting contractors, mill operators and WACAP to maximise recovery of millable timber.
- o Inspection - the selection of logs is subject to inspection both in the field and at the woodchip mill.

Selection procedures on private forests are similar with saw logs being sold to timber mills and only logs unsuitable for timber production are set aside for woodchipping. Again, the much higher value of sawlogs ensures that the property owner will seek to maximise saw logs and minimise chip logs. Again there is a substantial price differential in favour of sawlogs over chiplogs.

4.5.3 Haulage of Chiplogs

From the forest landings the chip logs are loaded onto road trucks for delivery to the chip mill. Where possible, these trucks follow forest roads and Shire roads to reach one of three main arterial roads which lead to the woodchip mill.

These arterial roads, Bannister Road to the south, Palings Road to the north and Gloucester Road to the west, were constructed and are maintained by WACAP, which in conjunction with other members of the forest industry, provides year round maintenance of the other forest roads. In some cases, Shire roads are used to connect with the private dedicated road system.

Public main roads are also used for haulage of chiplogs, where necessary, for haulage from private forests and from some State Forest areas. Public roads are also used for delivery of residue-derived woodchips from sawmills to both the WACAP mill and to the WACAP port facility at Bunbury. It should be emphasised that no more than 20 percent of raw material is transported via the public road system. Detail of traffic volumes on public roads is presented in Section 6.6.5.

4.5.4 Woodchipping Operations

The woodchip mill occupies a cleared area of 12ha located within the 61ha Forest Lease No 1179/40, 11km south of Manjimup.

The chipping facilities and operations are depicted schematically on Figure 8 and summarised below.

Chiplogs are off-loaded from the haulage trucks and may either be directed for immediate processing or stockpiled at the mill landing for subsequent processing. Upon arrival, logs are checked for charcoal and also where necessary, reduced in length using a chainsaw.

Marri and karri logs are fed to a ring de-barker where the bark is removed. Logs too large to enter the chipper are directed to twin circular saws where the log's cross-section is reduced. The logs are then fed into the disc-type chipper. The chips are then fed to the screening plant from which oversize chips are directed to a smaller chipper and undersize chips (less than 4.76mm in length) are directed to a waste bin.

The woodchips are then conveyed and stacked in an overhead train-loading bin which has a capacity of about 1000 green tonnes. Excess woodchips are stockpiled in an adjacent area.

The bark and fines are kept separate - the bark goes to an overhead hopper and all fines to a ground level bin.

Production at the woodchip mill is continuous over two, 8 hours shifts for 5 days per week.

Three liquid effluents are produced from the Diamond Chipmill, namely process water, sewerage and run-off;

(i) The process waters include water used for lubricating slow moving steel to steel equipment plus some stormwater drainage. This process water is mostly contained within a closed system comprising two dams, concrete storage facilities and collection drains. In periods of peak rainfall the addition of drainage water to the process water sometimes exceeds the holding capacity of the dams and the excess is then released into a drainage line which flows into a final dam on Nelson location 9937 before it is released into a tributary to the Lefroy Brook. The release of the water from this final dam is controlled by the Western Australian Water Authority through a Waste/Effluent Disposal Licence No. 194 under the Rights in Water and Irrigation Act. Because release of this water occurs at peak rainfall times, the dilution with rainwater is maximised.

(ii) Sewerage from both the office and the works amenities are treated by septic disposal systems.

(iii) Run-off, not included in the process waters, is collected and released at several locations around the mill. This run-off water may become coloured due to the inclusion of natural water soluble extracts plus some fine, non-colloidal material (mainly bark) from the log storage area. Where appropriate, sumps have been installed to collect the non-colloidal material from these run-off waters.

The bark is disposed of by burning to waste at a residue disposal site on WACAP owned private property near the Diamond Chipmill (Nelson Location 9937) Some screen rejects are sold to the Perth nursery market as a media for growing containerised plants and the balance of the screen rejects is also burnt to waste at the residue disposal site. The burning of these two residues produces a considerable quantity of smoke into the atmosphere. Because the residue disposal site is distant from neighbours and townships it is dispersed into the atmosphere without causing complaint or concern.

WACAP has expended considerable effort without success in trying to establish an economical use for these waste products. However, discussions are presently underway with two parties for future use of these materials.

4.5.5 Transportation to Port

From the overhead bins the woodchips are loaded into wagons and railed to Bunbury. Small quantities of woodchips from sawmill residues are trucked directly to the port from timber mills.

Typically, there are 15 trains to and from Bunbury each week, each with an average of 21 wagons containing a total of 1000 tonnes of chips. Without the woodchip traffic, this railway line would be likely to close.

At Bunbury the wagons unload into below ground hoppers from which the chips are fed onto a conveyor leading to an elevated boom conveyor which discharges to a stockpile.

4.5.6 Port Operations

The WACAP Port Facilities are depicted schematically in Figure 9. The operations at Bunbury Port can be summarised as follows:

- receipt of woodchips by rail and road from Manjimup
- stockpiling of woodchips
- loading of woodchips onto ships for transport to overseas markets

The facilities at Bunbury port (inner harbour) consist of purpose-built loading and unloading infrastructure, stockpile area, suitable docking facilities and relevant administrative buildings. The lease area for the port operations comprises lots 561 and 562 which cover 9.255ha and leasing is controlled by the Bunbury Port Authority.

Stockpiling operations utilise a jet-slinger to distribute the woodchips onto the stockpile; the basic stockpile is constructed in a horseshoe shape. Currently there are approximately 38,000m^3 of jarrah woodchips and 91,000m^3 of marri-karri woodchips stockpiled. Under emergency conditions, the stockpile has reached a total volume of 191,000m^3.

Loading rates from train to stockpile, and from stockpile to ship can progress at up to $521m^3$/hour and $868m^3$/hour respectively. The frequency of loading of ships is determined by export buyers. The quantity of woodchips exported since 1976 is presented in Table 17. Loading of ships is undertaken by the Waterside Workers Federation. WACAP provides administrative and maintenance staff, and the facilities are under 24 hours security guard.

The stockpiling operations do result in some drift of fines during the spray of the woodchips. As the prevailing local winds are westerly, the majority of the drift is back onto the lease area, away from the town. There is some drift across the inner harbour towards Alcoa of Australia operations, but no complaints have ever been received.

The only concern informally expressed by the public has been related to the visual impact of the woodchip stockpile.

TABLE 17

QUANTITY OF WOODCHIPS EXPORTED

YEAR	QUANTITY (tonnes/year)
1976	254,703
1977	397,441
1978	429,848
1979 *	658,931
1980 *	818,072
1981 *	525,758
1982	491,359
1983	618,044
1984	718,479
1985 *	679,845
1986	656,993

* Includes jarrah woodchips.

4.6 OPERATION TRAINING/WORKER SAFETY

The Timber Industry Regulation Act (1926-69) and its regulations provide for the safety and welfare of Timber Industry employees from bush operations to mill operations including workshops.

Two inspectors are currently employed whose job it is to inspect operations. Where, in their opinion, unsafe machinery is being used or unsafe practices are being carried out, the inspectors are responsible for prescribing appropriate remedies.

All timber industry workers in the forests are required to be registered with CALM (CALM Act Regulations) although no standard credentials are required to obtain registration. Registration can be removed and the worker excluded from the State Forest by CALM, if in the opinion of the inspector, his conduct endangers himself or his workmates.

- Training

The TIR Act does not provide for the training of bush operators to ensure that safe work practices are implemented, merely that inspection of work is undertaken. The responsibility for training lies within the managers of the various operations.
In the project area there are two separate management organisations which supervise facets of the project. They are:

- CALM - principle harvesting contractor for all regrowth operations.
- WACAP - supervision of harvesting contractors and all chipmill activities.

CALM subcontracts its harvesting and relies on subcontractors to provide any training necessary. CALM's training programmes are directed at their own direct employees. Chainsaw operation and faller safety training is provided.

Bunnings Forest Products, the main harvesting contractor for WACAP, employs a full time training officer who is responsibile for co-ordinating and organising training of bush crews and other employees. Through this training programme courses in chainsaw, falling, machine operation and other operations are periodically offered. WACAP employs a safety officer and conducts training for plant operators and general safety training.

The approach to training for bush operations in the project area is not comprehensive or well integrated at present and this is a weakness in comparison to an area such as Eden where a co-ordinated training scheme is run by a interdisciplinary team known as the "Eden Logging Industry Training Team" (ELITT). This weakness has been recognised by the Industry. The WA Timber Industry Training Committee, has commissioned a study into the training needs of the hardwood and softwood harvesting sectors of the Timber Industry. That report, produced in December 1986, highlighted the need to improve the accident prevention record of the industry and the need for a more integrated and comprehensive approach to training and worker safety (Clarke 1986).

The report proposed a system whereby all bush operators would be licenced and would require training and accreditation to work in the different sectors.

The report has been distributed to individual companies and to CALM for comment, following which the WA Timber Industry Training Committee will review the comment and propose an implementation plan.

Scientific research monitors and protects water quality in rivers and streams

5.0 PROPOSED CONTINUATION OF OPERATIONS

5.1 AREA OF OPERATION

It is proposed that there be no change to the boundary of the woodchip licence area as defined in FPL No. 1588 and illustrated in Figure 2. Also WACAP is not proposing to increase licence volumes, to change rail transport or port operations.

From time to time residue material will be available from outside the chipwood licence area due to jarrah sawlog operations and the thinning of jarrah regrowth stands. This material will be made available to WACAP as it occurs. There is potentially approximately 150,000m^3/annum available (see Section 5.2).

There have been no discussions between CALM and WACAP with regard to renewal of the Woodchipping Industry Agreement Act.

5.1.1 Wood and Non Wood Values Within the Project Area

The full range of forest values are recognised by CALM in the project area. Apart from the production of wood products, these include water resource values and the production of minor products such as honey and wildflowers. CALM was established to practice the conservation of living resources, specifically plants, animals and micro-organisms and those non-living elements of the environment on which they depend (CALM 1987c). To achieve these objectives, CALM has instituted a multiple use policy based on the zoning of land into priority uses. The priority use for an area is based on the value most favoured by specific attributes of the ecosystem, the location of the area, public demand for various uses and the purpose for which the area was vested. (CALM 1987c). Priority uses recognised by CALM are Nature Conservation, Recreation, Protection, Production, Mining and Public Utility.

Although mining and public utility are non biological uses of CALM land, they are required by the State and constitute essential parts of multiple use planning.

Uses that can be carried out which do not significantly conflict with the priority use are called compatible uses. Uses that can be compatible with the priority use if practiced under certain constraints are referred to as conditional uses and those which could never be practiced if the priority use is to be satisfied are non-compatible uses (CALM 1987c).

5.1.2 Proposed Land Use Within the Project Area

The Southern and Central Forest Regional Plans detail the proposed Crown land use within the project area. These uses are shown by priority for the licence area in Table 18. Those areas that will continue to be available for wood production and those not available are shown on Figure 10.

TABLE 18

PROPOSED CROWN LAND USE WITHIN THE LICENCE AREA

USE CATEGORY	TENURE	AREA (ha)	%
Nature Conservation	National Park	190,300	26.3
	Nature Reserve	4,950	0.7
	State Parks	-	-
	Forest Parks	53,000	7.3
Protection	State forest (mainly*)	227,300	31.4
Production	State forest (mainly*)	240,450	33.2
Miscellaneous	Crown Land not Controlled by CALM	8,300	1
TOTAL		724,300	100

* Includes Timber Reserves and Executive Director Land

Recreation has at present no area priority on State forest although it is considered a compatible use over most areas. However, National Parks and State Parks have recreation as a key land use, even though there is at present no specific zoning designation.

Of the total of Crown forest in the licence area, 34% will be totally reserved from cutting. An additional 10% comprising prescribed buffers will be of limited availability. Of the 56% remaining, the production priority comprises 33% with the balance being conditionally available for wood production.

5.2 FUTURE RESOURCES

The following sub-section identifies sources of chiplogs which will become available for the project during the next licence period and beyond.

The availability of these resources over the proposed licence period is set out in Table 19.

TABLE 19

POTENTIAL YIELDS OF MARRI/KARRI CHIPLOGS AT FIVE YEAR INTERVALS

(Figures in 000's tonnes Chiplogs per annum)

SOURCE	1987 - 1990	1991 - 1995	1996 - 2000	2001 - 2005
CROWN RESOURCES				
• Licence Area				
old growth KM	194	188	158	170
old growth JM	316	286	190	190
regrowth K	109	109	207	231
• Ex Licence Area				
old growth JM	137	137	129	129
regrowth thinning JM	61	61	61	61
TOTAL CROWN	817	781	745	781
PRIVATE PROPERTY				
• Agricultural Clearing	69	30	30	0
• Eucalypt plantation	0	0	0	219
• Regrowth thinning	7	10	10	0
TOTAL POTENTIALLY AVAILABLE CHIPLOG FROM ALL SOURCES	893	821	785	1,000

The above volume when converted to green chip tonnes for export and added to anticipated sawmill residue provides the total potential export chip tonnage.

1 tonnes log = 0.88 tonnes green chips

THESE FIGURES IN EXPORT CHIP TONNES

Total Potentially Available Chiplogs	786	722	691	880
Sawmill Residues	96	89	86	62
TONNES CHIPS POTENTIALLY AVAILABLE FOR EXPORT	882	811	777	942

5.2.1 Sustainable Yield

CALM's management for non-wood values has been described in the previous subsection. This subsection will describe management of the timber production forests to firstly upgrade and then maintain their timber production capacity in perpetuity.

- Sustained Yield

The volume of wood taken from the forest each year is referred to as the 'yield' from the forest. Sustained yield forestry seeks to balance the yield removed each year with the volume of wood which is grown by the forest over the same period. This volume of wood is referred to as the 'annual increment'.

Sustained yield forestry is the strategy in which each year sufficient forest is harvested (and regrown) to supply a volume of wood equal to the annual increment. Although a simple concept in theory its practice is much more complex. To establish a sustained yield it is necessary to have:

- a positive annual increment,
- a fixed resource base,
- readily available and stable markets for the products, and
- knowledge of the resource and its growth rates.

Underwood (1983) provided a good analysis of the problems associated with implementation of sustainable yield forestry in the karri forests.

The situation in the karri forest serves to illustrate one of the major difficulties in the development of a sustained yield forest. The problem is that in a virgin forest there is no net growth of timber (positive annual increment). The virgin forest is in a state of natural equilibrium where the death and decay of old trees is balanced by the regrowth of younger ones. In other words, the sustained yield figure for a virgin forest is zero. Therefore as soon as harvest begins, yield (products removed) exceeds growth. If a forest is being properly managed, harvest must be accompanied by regeneration (replanting or reseeding) of the areas cut over. Many years then elapse before the regrowth forests are old enough to yield the desired product. Therefore for every virgin forest, there must be a 'conversion period', which is the time during which the forest is converted to a condition when sustained yield management is possible.

This problem was also recognised by the US Public Law 86th Conference whose definition of sustained yield recognised that the sustainable yields must firstly be achieved before they can be maintained.

> "sustained yield of the several products and services means an achievement and maintenance in perpetuity of a high level or regular periodic output of the various renewable resources of National Forests without impairment of the productivity of the land".

The sustained yield system is difficult to manage in the real world where market preferences, natural disasters such as fires, or land use changes may dictate a less than optimum cutting schedule (either more or less) for a period of time. For this reason Ferguson's use of the term "sustainable yield" is preferred, that is a yield which is sustainable, not necessarily one which is sustained (Ferguson, 1985).

CALM is required in management plans for State Forest "to ensure the multiple use and sustained yield of that resource for the satisfaction of long term social and economic needs" CALM Act (1984) Sect. 56(a).

How they plan to achieve that in this project area may be illustrated by example of the karri forest.

- Sustainable yield in the karri forest

The CALM Timber Strategy Paper details the cutting and regeneration rate of the old growth karri forest up to the year 2080. Simultaneously there will be a decrease in the area and standing volume of old growth forest in timber production areas and a corresponding increase in the area and volume of regrowth forest.

The basis of the karri cutting rate is the sawlog supply predictions as outlined in CALM's Timber Strategy Paper. In this context sustainable yield is determined in terms of sawlogs, hence chiplog yields follow as a result. For this reason the sustainable yield is discussed in terms of sawlog supply.

Figure 11 illustrates the anticipated sawlog yields from now until the year 2080. Whilst old growth cutting can be accurately determined because it is use of a measured resource, regrowth is based on predicted growth rates and is more conceptual. The figure illustrates three key features relevant to the sustainable yield programme for karri.

- o The old growth is an existing resource available at any rate desired. The current yield strategy has as its objective to extend that resource until the regrowth is of sufficient age to substitute for it completely.
- o Sawlog supply from old growth and regrowth has been balanced to obtain an approximately constant yield of sawlogs.
- o The regrowth with management will yield a much greater volume than the old growth has thus allowing the sawlog cut to rise substantially in the mid 2070's.

It has been possible to maintain the existing sawlog cut from the karri forest because of improvements in utilisation of old growth logs and development in sawing and seasoning technology which has permitted the use of regrowth thinnings for sawlog material which would previously have not met the required standard.

It is quite likely that the sawlog yields shown in Figure 11 will be conservative as CALM has stated the intention to seek to manage regrowth stands more intensively by thinning and fertilisation (CALM 1987b). The chip yield up to the year 2040 as a result of these sawlog strategies is also shown in Figure 11. It is of interest that in the period after the year 2030, chip yields will fall below sawlog yields. This is a reflection of the efficiency of earlier thinning in removing the bulk of the waste material such that the second and subsequent thinnings will have a markedly reduced residue component.

By the late 2050's when the old growth production forest will be completely regenerated there will be approximately 90,000ha of regrowth. At a conservative average increment of $5m^3$/ha/yr of karri trees the long term annual sustainable yield should be in excess of $450,00m^3$/yr of all karri products.

It should be emphasised that these yield predictions apply only to karri within State Forest in the Licence Area that has timber production as a designated use. That is it excludes National Parks, and other Conservation Management Priority Areas.

5.2.2 State Forest Resource

- Within the licence area

At present, the only suitable species for chiplogs are marri and karri. The total inventory of chipwood resource of these species in the licence area is approximately 18.2 million tonnes (CALM 1987b). This figure represents existing marri and karri logs in old growth karri/marri and jarrah/marri stands. In addition to this, chiplogs are being produced by growth in the young regenerated stands. At the current intake level of approximately 600,000t per year this gives the existing chipwood resources a life of 30 years. Such a calculation is misleading, however, as CALM have stated that chipwood will only be available to WACAP at a rate and quantity determined by integrated harvesting planned to produce the level of sawlog supply detailed in CALM's Timber Strategy Paper, using the silviculture detailed in Sections 4.2.6.7 and 8.

Chipwood resource will then, in terms of quantity and level of supply, be dependent on three separate operations:

- o Harvesting of old growth karri/marri forest.
- o Harvesting of old growth jarrah/marri forest.
- o Thinning operation in various aged karri regrowth stands.

Table 19 details the anticipated yield of chipwood for the next 15 years of the project based on CALM's sawlog yield strategy in the Timber Strategy Paper (CALM 1987b).

Chiplog resource from old growth harvesting in both karri-marri and jarrah-marri will decline as reductions on the sawlog cut of karri and jarrah from those forest types are made. In all reductions in the first grade sawlog cut will result in a reduction of 160,000t of chipwood by 1996 or 30% of the 1987 intake level.

This would result in a serious undersupply to WACAP from the licence area were it not for the rapid build up of the chipwood yields from the thinning of regrowth stands. Recent let tenders by CALM will generate 110,000t building up to 207,000t as greater areas reach thinnable ages.

The volume of material becoming available, however, will not be able to completely balance the loss from old growth cutting hence there will be a decline in yields from within the licence area. In addition to the planned reduction in old growth cutting, there has been a loss of chipwood resource due to improvement in utilization standards and the development of new markets for small diameter sawlogs. CALM estimates the small karri sawlog sales, karri salvage sawlog sales and additional marri sawlog sales have and will continue to divert approximately 70,000t from chiplog to sawlog outlets.

- Outside the licence on State forest

Jarrah-marri forests to the north of the project area which are harvested for sawlogs will continue to be silviculturally treated as described in Section 4.2.7. Chiplog salvage is planned to continue for this type of operation in the CALM districts of Nannup and Kirup. The same harvesting and silvicultural practices will be employed by CALM in their management of these operations when providing chiplogs to WACAP, as have been described for similar forest types within the licence area (see Section 4.2).

Table 19 shows the potential volumes of chiplogs from this source which will be made available to WACAP.

5.2.3 Future Resource - Private Property

5.2.3.1 Old Growth Forests

Estimates of the remaining private property forest resource within the WACAP licence area have been made by CALM (Table 20). The most up to date statistics were compiled from a December 1983 aerial survey.

TABLE 20

PRIVATE PROPERTY FOREST TYPE WITHIN WACAP LICENCE AREA

FOREST TYPE	AREA (ha)	AREA AS A PERCENTAGE OF PRIVATE LAND AREA
Karri, karri/marri	10,000	6.3
Jarrah, jarrah/marri	22,700	14.2
Pine	4,900	3.0
Other	100	0.1
Pasture and non-forested	121,600	76.0
Unclassified	500	0.4
TOTAL	159,800	100.0

Source: CALM, 1987

Therefore of the 159,800ha of private property within the licence area, 32,700ha is covered with potentially commercial forest.

The average rate of private property clearing in the southern forest districts is around 2.3% per year (McLean 1986). At that rate the remaining 32,700ha of productive private forests in the licence area would be cleared within the next 43 years. However, it needs to be remembered that a proportion of the remaining uncleared area is in the protected catchment of the Warren River Water Reserve and is therefore precluded from clearing.

The amount of old growth timber available in the future from private property outside the licence area is difficult to estimate. This is partly because of the lack of reliable statistics (The WA Department of Agriculture is currently compiling a inventory of forested private property) and partly because of the nature of the resource. Private property forests vary in yield from 180t/ha (old growth karri/marri) to 12t/ha scattered shade tree clearing.

Therefore a reliable estimate of future chiplog resource availability outside of the current licence area cannot be made without a comprehensive resource assessment study. Over the last five years private property woodchips have averaged 9% of total woodchip exports. WACAP expect this to decline over the next decade to approximately 5% then rise significantly to as much as 20% of all export, as WACAP forest resource comes on stream.

WACAP will continue to purchase old growth private property chiplogs on a backload basis from landholders up to 300km distant from the Diamond Chipmill provided that they are close to major Manjimup/Perth transport routes. However, these supplies are erratic and WACAP estimate that quantities will not provide more than an additional 2,000t per annum during the proposed licence period.

5.2.3.2 Thinnings

WACAP plans to expand its karri regrowth thinning operation in the future. At present they have only thinned around 30ha of private property regrowth for a yield of around $80m^3$/ha of chiplogs and $35m^3$/ha of small sawlogs (see Section 4.3.5).

There are no reliable estimates of the extent of private property regrowth forest. The pure karri - regrowth stands favoured for a thinning operation are mainly scattered around the private property resource in small isolated patches of three or four hectares. WACAP anticipate thinning 70-80ha annually during the next licence period.

5.2.3.3 Eucalypt Plantations

WACAP has an existing plantation establishment programme for its own properties and for other private property through its tree farmer schemes with local landholders (see Section 4.3.5).

This programme will be accelerated significantly commencing in 1987 when 460ha will be planted. WACAP intend increasing this to 600ha in 1988 and maintaining this level for around 14-15 years. At the end of this period 10,000ha of plantation will have been established. WACAP have tested many species, however the favoured, because of growth rate, pulp yield and pulp quality, is E. globulus. This has been and will continue to be the favoured planting species.

Plantations are at present concentrated around Northcliffe. Tree farmer schemes which are expected to pick up in the next five years are limited only by the 800mm rainfall isohyet. That is, they have to have rainfall in excess of 800mm per year.

On average each hectare will produce 365t at the end of a rotation of 15 years. On this basis each planting of 600ha will produce 219,000t at the time of harvest.

The first yields from WACAP plantations are expected in 1996 when 51,000t will be available for harvest. This level of yield will increase dramatically in 2002 when the first of the larger annual plantings will be ready for harvest. Following their initial harvest the plantations are expected to coppice, that is new shoots will grow from cut stumps. Coppice can be managed to produce useful trees which can be harvested again at shorter time than the original plantation, possibly 10 years.

5.2.4 Future Resources - Sawmill Residues

The present level of supply of sawmill residues of around 74,000m^3 (see Section 4.4) is expected to be maintained during the proposed licence period (1991-2006).

There is the possibility that the quantity of sawmill resides utilised could increase if WACAP proceeds with its plan to install a small woodchipper at the Diamond Mill. This chipper with an expected output of 400-600 tonnes/shift would be capable of handling the shorts and offcuts being burnt by the small sawmills who currently only supply boxed-out hearts to WACAP.

5.3 IMPROVED UTILISATION

Condition 12 of the Forest Produce (Chipwood) Licence signed by WACAP in June 1969 requires WACAP to utilise timber down to a minimum length of 2.1 metres and a minimum diameter of 230 millimetres. WACAP, however, has not been able to achieve this level of utilisation for marri chiplogs because of the design limitations of their ring debarker at the Diamond Chipmill. On the other hand, WACAP has been able to improve its utilisation of karri thinnings by accepting logs of less than 230 millimetres diameter.

In the early 1980's WACAP installed a second in feed deck in their mill to handle large, old growth karri and marri logs. Introducing this second line has also allowed a greater utilisation of forked stems, which previously would not pass through the chipper. In addition, it has enabled use of karri regrowth thinnings. This smaller material is fed into the chipper alongside the larger logs, using the bulk of the larger logs to force the regrowth logs through the chipper. In order to more fully utilise the regrowth resources WACAP has relaxed its specification for karri regrowth to 100mm crown end diameter or smaller if the length is 5m.

WACAP has carried out a number of utilisation trials to determine maximum possible chiplog yields and to help in the development of appropriate technology to process small timber. Feasibility studies are presently being carried out on the installation of speciality debarking and chipping equipment to convert small regrowth timber to chips.

WACAP has not yet been able to identify the need for now the availability of in-field chippers capable of producing export quality eucalyptus woodchips.

5.4 EQUIPMENT DEVELOPMENT

In an effort to reduce costs and environmental effects, harvesting machinery is constantly being modified and refined.

Important issues concerning logging machinery that have been addressed are:

- Soil compaction - Caused by the repeated movement of heavy equipment around the coupe especially when it is wet.
- Dieback Disease spread - Machinery moving between infected and non-infected forest as well as machinery moving from the bush to landings and roads, can spread dieback disease.
- Log Production - Machinery is expensive to purchase, operate and maintain. It must therefore be producing as much timber as possible per machine hour.

The impact of harvesting machinery on soil is detailed in Section 7.1.1. Discussion on machinery development for environmental management is in Section 9.0. Developments for productivity are discussed here because they influence resource availability and WACAP's harvesting viability.

5.4.1 Log Production

Mechanical harvesters of the type normally found in exotic Pine plantations are now being used for thinning karri regrowth. The typical system consists of two machines. A feller/buncher which falls the tree, removes the crown and bunches a number of stems together in a stack. The second machine, is a forwarder and its function is to pick up the stacks of timber and carry them out to the landing where it either forms a stockpile for later loading, or loads directly onto an empty trailer for haulage to the chipmill.

The advantage of the mechanical harvesting system over the traditional motor/manual system of chainsaw felling and skidding, is that production costs are reduced and soil disturbance is also reduced. It has been estimated that a basic machine harvesting system can produce around 120 tonnes/day of chiplogs compared to 80 tonnes/day for the manual harvesting system in regrowth forest (WACAP pers comm.). There are a number of variations on the basic mechanical harvesting system using a combination of machine types, including feller/bunchers, forwarders, track and rubber tyred loaders with felling shears, static log loaders and rubber-tyred loaders.

In large regrowth areas timber needs to be hand felled because the larger timber is beyond the capacity of the feller buncher. Although hand felling in regrowth is hazardous, it is a safer environment than highly stocked small diameter regrowth forest.

Another machine which is soon to be introduced into the Southern Forest Region harvesting programme is a transportable, static boom loader. This machine will be used for loading stockpiled regrowth logs onto trucks. Because the static loader will be mounted on the chassis of a large road-going truck, it will be able to move quickly from one stockpile to another throughout the forest. The need for large flat landings normally associated with rubber tyred loaders and the consequent soil compaction, will be reduced as a result.

6.0 DESCRIPTION OF THE EXISTING ENVIRONMENT

6.1 PHYSICAL ENVIRONMENT

6.1.1 Climate

Climatic data were obtained from Pemberton, Manjimup, Bridgetown and Collie and are considered to be representative of the licence area.

The close proximity to both the Indian and Southern oceans causes temperate climatic conditions with predominantly winter rainfall, generated by frontal systems from the oceans.

6.1.1.1 Prevailing Winds

Summer winds at Bridgetown are predominantly east to south-easterlies, while at Manjimup and Pemberton winds are predominantly south to south-easterlies, with south-west winds in the afternoon.

In winter, winds are predominantly north-westerlies at Bridgetown, with north-west to south-westerlies at Manjimup and Pemberton.

6.1.1.2 Temperature

The temperature regime of the area is moderate, with average annual temperatures ranging from $15.1^{o}C$ at Manjimup to $15.9^{o}C$ at Collie.

6.1.1.3 Rainfall/Evaporation

Rainfall, being the major factor influencing environmental and hydrologic conditions across the forest, has been chosen to fit convenient boundaries for zones with similar properties and requiring similar management.

These zones are:

- o high rainfall zone (HRZ) : greater than 1100mm/yr
- o intermediate rainfall zone (IRZ) : 900-1100mm/yr
- o low rainfall zone (LRZ) : less than 900mm/yr

Note: In the Clearing Licence regulations of the Country Areas Water Supply Act (1847 - 1984) an alternative designation has been used as follows:

HRZ is equivalent to the D Zone
IRZ is equivalent to the C and B Zones
LRZ is equivalent to the A Zone

Figure 12 shows the rainfall distribution for the licence area. The average annual rainfall for the area ranges from 844mm at Bridgetown to 1311mm at Pemberton with Manjimup and Collie recording 1044mm and 989mm, respectively. Pemberton, therefore, falls within the HRZ and Bridgetown in the LRZ. Manjimup and Collie fall within the intermediate rainfall zone.

Average monthly rainfall for Pemberton ranges from 16mm in February to 235mm in July. Average monthly rainfall for Bridgetown ranges from 14mm in February to 152mm in June.

Evaporation is relatively low, ranging from approximately 50mm in July to 200mm in January (Bureau of Meteorology, per comm.).

Intensity of rainfall data is available for Manjimup and Pemberton with the highest daily recordings being 83mm for June and 79mm for May, respectively.

6.1.2 Geology and Physiography

The Woodchip Licence Area (WLA), as part of the Great Plateau of Western Australia, has a basement of Precambrian crystalline rocks with sporadic overlay of shallow unconsolidated sediments. The Precambrian is divided into Archaean, mainly north of a line approximately through Lake Muir, and the Proterozoic to the south. However, the lithologies of these two divisions are similar and include granites, gneisses, migmatites, high grade metamorphics, and basic volcanics; the basement is often intruded by dolerite dykes.

This ancient plateau has been subjected to a long and complex history of events and processes which are expressed as variations in topography, soils and hydrology. Over most of the licence area the basement rocks are deeply weathered, in situ, often to a depth of more than 20m, and it is this mantle of weathered material which is of prime importance in consideration of the soil pattern. There has been differential stripping of the mantle and so various weathered and unweathered sub-strata have been exposed to become soil parent materials. The degree of stripping is related to stream activity with almost complete removal of weathered materials in the major valleys and mainly remnants of the ancient lateritised plateau surface, forming the interfluves. In addition, areas of unconsolidated, shallow grey sands with quartz pebbles and the coastal dune sytems produce contrasting environments. Thus there is a wide range of soil parent materials and this is reflected in the soil properties discussed below.

6.1.3 Soils

The objective in this report is to define the soil pattern in sufficient detail to relate to forest type and quality and to examine the impact of logging operations on the soil physical attributes and the nutrient balance. It has been shown that the licence area contains a wide range in soil conditions but, for forestry purposes, these data can be generalised to form broad-scale groups; these are shown on the accompanying map as mapping units no's I to VIII (see Figure 13). Within these broad map units there are **four main soils groups** which recur commonly and, allowing for some internal variation, these groups account for most of the production forest areas of the licence area; these are:

(i) The Lateritic Soils
(ii) The Yellow Duplex Soils
(iii) The Red Earths
(iv) The Brown Gravelly Duplex Soils.

(i) The Lateritic Soils occur in upland positions, often as divides, and are dominated by ferruginous gravels, gravelly sands, and duricrust. They occur throughout the licence area with the greatest extent along the northern margin and becoming less frequent with distance south as stream dissection becomes more general. These soils support good quality jarrah forest in which marri is a sub-dominant species. Associated with the lateritic uplands are broad, shallow, swampy valleys with non-forest plant communities (including shrublands and sedgelands).

The lateritic soils may vary in colour, texture, depth to clay stubstrate, and amount of ferruginous gravel; an example of these soils is given in Appendix C (Profile 1).

Other analyses (e.g. Hingston et al. 1980/81) show that, although total soil phosphorus is quite high most is held in unavailable forms in the gravel fraction and the amount readily available is quite low (see Section 7.1.1).

(ii) The Yellow Duplex Soils are characterised by sandy loam or loam surface horizons, often with some ferruginous gravel, and a sharp break to the yellow, brown, and grey mottled clay sub-soil. These profiles occur in the middle and upper slope positions in dissected terrain and have, as parent material, weathered mottled or pallid zone. This soil occurs in map units I, II, and VI. The vegetation is often dominated by marri with some karri under high rainfall and jarrah in drier areas. A typical profile of these soils is presented in Appendix C (Profile 2).

(iii) The Red Earths, locally referred to as 'karri loams', have a brown to red-brown sandy loam surface changing gradually to a red clay sub-soil; red duplex soils may be associated. These soils are extremely permeable when moist and, because of high iron content, have high aggregate stability. The profile described in Appendix C is representative (Profile 3).

The phosphorus content of the surface (0-10cm) horizon of red earths ranges from about 70ppm to 300ppm with most samples in the 100-150ppm class (Unpublished Analyses; CALM). These soils occur mainly in Unit VI on lower slopes of dissections in the Pemberton area where they support prime karri forest; marri is a sub-dominant species.

(iv) The Brown Gravelly Duplex Soils occur in moderately dissected terrain between Pemberton and Walpole and occupy a significant proportion of map units VII and VIII. They are characterised by deep (50-80cm) surface layers of brown gravelly sandy loam over brown and red-brown mottled clay. These soils support karri-marri and karri-tingle forests and appear to replace the red earths as the high quality sites east of Pemberton. The profile presented in Appendix C is representative (Profile 4); other examples may vary in colour, depth to clay, and amount of gravel. Gravelly yellow duplex soils, with jarrah-marri forest, may be associated.

6.1.4 Water

6.1.4.1 Hydrology

The hydrology of the south west of Western Australia has been subject to intensive study in the last 15 years. It is the process most intimately involved in the major land use problems of salinity and dieback and variously afflicts agriculture, water supply, timber production, mining and conservation. From the results of this work a detailed picture of regional hydrology has been developed. This has been expounded in several reviews by Peck (1978), Loh *et al.* (1983), Peck (1987), Borg *et al.* (1987) and Schofield (in prep). This overview of the hydrology of the project area is based on these reviews.

Water enters the area as rainfall (R) and leaves by direct evaporation (E), transpiration by vegetation (T), and stream flow (Q). Stream flow may consist of surface runoff, shallow subsurface flow and groundwater flow. Within any drainage basin, minor losses of water may occur due to deep vertical leakage of groundwater into basement rocks, or from deep lateral flow of groundwater that does not enter the stream, but in the overall water balance these losses are trivial.

The water balance can be expressed in the form of an equation as follows:

$$\Delta WS = R - E - T - Q$$

The factor ΔWS indicates change in water storage within the system. The factors E and T are difficult to measure separately and are often bulked and called evapotranspiration (Et).

Under undisturbed forest cover long term Et ranges from 75 to 100% of rainfall, Q ranges from zero to 25% of rainfall and ΔWS is zero. However, these components show considerable variation within the year, reflecting the annual climate cycle, and between years, due to climate fluctuations. They also vary systematically across the study area reflecting the climatic and physiographic gradients referred to in Sections 6.1.1 and 6.1.2.

Rainfall is one of the major factors influencing the environmental hydrologic conditions across the forest. It has been grouped into three zones (High, Intermediate and Low Rainfall zones) which have been defined in Section 6.1.1.3.

The low level of stream flow as a proportion of rainfall (i.e. the stream yield) is a striking feature of the forest water balance. Low yield is attributed to the deep weathered profile with permeable upper horizons and considerable subsoil water storage capacity, the moderate topography, and the efficiency of the deep rooted native vegetation in exploiting the stored water during the hot dry summer (Dell et al. 1983).

The prevailing winds and storms from the adjacent southern ocean deliver a trace of oceanic salt, mostly as a contaminant of rain. The dominance of the water balance by Et results in poorly leached profiles which accumulate these oceanic salts. Just as the size of the water balance components are systematically related to the climatic and geomorphological gradients across the forest, so also is the size of the salt accumulation.

The higher rainfall (up to 1400mm/yr), south-western portion of the area, which is also more deeply incised, has more efficient drainage. Stream yield ranges up to 20%, stream salinity is low (100-200mg/L of total soluble salts), salt storage is low (less than $0.5kg/m^3$), salt concentration in soil and groundwater is low (less than 1000mg/L), groundwater is extensive at shallow depth and contributes up to 5% of stream flow volume giving rise to perennial streams in the area above 1,200mm rainfall.

In contrast the lower rainfall (less than 760mm/yr) north-eastern area has more subdued topography and inefficient drainage. Stream yield is less than 5% and may be zero in years of below average rainfall. Salt storage may reach 6kg/m^3 with soil water salt concentrations up to 20,000mg/L. Groundwater is not extensive, occurring mainly low in the landscape and at too great a depth to make any contribution to stream flow. Stream flow is intermittent mainly arising from shallow subsurface flow during the wetter periods in winter. This flow path bypasses the bulk of the salt storage, and stream salinity is quite low ranging from 100 to 200mg/L.

Between these two extremes exists an intermediate hydrologic regime which is characterised by moderate stream yield and soil salt storage, and groundwater systems which may or may not contribute salts to stream-flow, depending on local physiographic and hydrogeologic conditions. Average stream salinities tend to be higher than either of the extremes and are highly variable. They average 250mg/L but range from 100 to 400mg/L and are strongly dependent on whether or not groundwater contributes to streamflow.

The equilibrium of the water and salt balances is very sensitive to change in the major water balance component, Et. Even a relatively small reduction in Et redistributes a relatively large amount of water to the storage and stream flow components of the water balance. An increase in water storage (especially groundwater) and stream flow enhances the leaching of soil profiles and the export of stored salt. As noted by Stoneman (1986), this sensitivity to a reduction in Et may not be readily apparent. Its obvious expression in stream flow and salinity can be delayed, or if the Et is reduced temporarily, the effects can be masked by the large soil water storage capacity. This will be especially so in the LRZ where available storage is greater in the absence of extensive groundwater.

Historically, two major types of reduction in Et have occurred in the project area. Temporary or intermittent reduction in the forest canopy due to clearfelling, selective logging or fire, over many decades has not had any obvious, enduring impact on streams. Permanent removal of native forest for agriculture has had substantial impact. In the HRZ this takes the form of increased stream flow but with no increase in average stream salinity. In the LRZ the effect on stream salinity can be dramatic, but the effect is not immediate. For several years after clearing the surplus water not dissipated as Et accumulates as groundwater. Groundwater levels increase, mobilising large amounts of stored salt and eventually intersecting stream beds, contributing a highly saline base flow. Although such flow may constitute less than 5% of total stream flow volume, its salt load is sufficient to turn local streams quite saline and damage the water resource value of whole river basins.

In order to protect water resources controls on agricultural clearing were established in 1978 over the major vulnerable river basins under the Country Areas Water Supply Act (1947-1976). In the licence area these controls only apply to the Warren River catchment.

6.1.4.2 Water Quality

An overview of the local scale processes involved in hydrology and water quality is presented in the previous section. On the river basin scale, local effects in the various rainfall zones and vegetation types are integrated. This integration is apparent in Table 21 which presents yield and quality data for various branches of the Warren system. Figure 2 shows the layout of the system. Modest yields of highly saline water from the partly cleared Tone and Perup River catchments in the LRZ are progressively diluted by better yielding, less saline streams from forested catchments, culminating in the input of large yielding, high quality streams similar to the Dombakup, to give an overall salinity of 716mg/l. This is in the middle of the marginal quality range (500-1000mg/L) for drinking water standards.

Little pattern is apparent in the sediment data in Table 21 perhaps because all the streams are partly cleared. Abawi and Stokes (1982) and Loh et al. (1983) have reported increases in stream sediment arising from agricultural clearing in the northern jarrah forest, though little evidence is available to support this conclusion in the southern forests. Short periods of high sediment concentration were, on a few occasions, observed after logging operations (Department of Conservation and Environment 1980). Overall sediment loads are very low by world standards and pose no threats to water supply.

The variation in water quality over time has been analysed by Collins and Barrett (1980). In Figure 14 the annual and 5-year moving average water quality for the Warren and Shannon Rivers are presented. This indicates that Warren River salinity has deteriorated from less than 400mg/L in the 1940s, well within the fresh drinking water standard (i.e. less 500mg/L), to more than 700mg/L today. Clearing histories presented in Figure 15 indicate two major periods of agricultural clearing in the Warren in 1910-1925 and 1960-1975. It appears that the full impact of the second period of clearing has yet to be expressed. In contrast, the Shannon catchment which lies mostly in the HRZ, has only a few percent of clearing and has a stable salinity of less than 200mg/L.

6.1.4.3 Water Resources and Use

The southern forest region generates an annual average stream flow of 1550 million cubic metres of which 720 million cubic metres are considered potentially exploitable for water supply (Collins and Barrett 1980). This represents some 39 percent of all surface water resources in the southwest. The yield and quality characteristics for major gauged catchments are shown in Table 22. To date these resources have only been developed to provide the limited needs of local towns or for stock and irrigation water on single farms and are less than one percent utilized. However, they are considered to be of major long term importance and their protection is given high priority.

The current town water supply at Pemberton is provided by the Pemberton Weir which has a useable storage of 66,000 cubic metres. A new dam at Big Brook was completed in October 1986, which supplies 2,000 to 2500m^3/day to the Pemberton Weir and the Pemberton Trout Hatchery. Big Brook Dam has a gross storage capacity of about 625,000m^3.

Manjimup is supplied by two reservoirs situated within the Lefroy Brook Dam catchment area. The original supply is located on Phillips Creek and a second reservoir (Manjimup Dam), was built on Scabby Gully in 1967. Both catchments are State forest. The present supply has an estimated total yield of 700,000m^3/annum.

TABLE 21

YIELD AND QUALITY DATA FOR THE WARREN BASIN

RIVER OR STREAM	STATION NO.	AREA km^2	AVERAGE RAINFALL mm	VOLUME $m^3 \times 10^6$	YIELD %	CLEARING %	TOTAL SALTS mg/L	SEDIMENT <63 micron mg/L
Dombakup	155	115	1425	42	26	16	148	10
Warren	220	4035	865	359	10	33	716	8
Warren	003	2910	735	109	5	36	2104	14
Wilgarup	144	450	915	30	7	32	861	9
Perup	004	645	765	19	4	19	3120	7
Tone	007	1035	630	24	4	66	3956	17

Adapted from Collins and Barrett (1980)

TABLE 22

YIELD AND QUALITY DATA FOR MAJOR GAUGED CATCHMENTS

RIVER OR STREAM	AREA km^2	AVERAGE RAINFALL mm/yr	VOLUME $m^3 \times 10^6$	YIELD %	CLEARING %	TOTAL SALTS mg/L	SEDIMENT <63 micron mg/L
Deep	457	990	75	17	0	177	4
Weld	240	1250	57	19	0	163	11
Shannon	350	1195	87	21	3	159	4
Gardner	420	1390	124	21	17	159	7
Warren	4035	865	359	10	33	716	8
Dombakup	115	1425	42	26	16	148	10
Donnelly	817	1110	140	15	22	206	6
Barlee	165	1170	33	17	0	151	5

Adapted from Collins and Barrett (1980)

6.2 FLORA AND FAUNA

6.2.1 Terrestrial Flora

6.2.1.1 Forest Communities

The hardwood forests of the licence area have been broadly described on the basis of vegetation structure (Smith, 1972). He defined vegetation formations on the basis of the physiognomy of the dominant stratum, subdivided the formations into associations on the basis of floristics and density, and grouped them according to repeating sequences related to topographic and edaphic features. Beard (1981) extended this mapping to the whole South West Botanical Province. McArthur and Clifton (1975) undertook the first detailed survey of vegetation in relation to soils.

More recently, Christensen et al. (1985) have given a brief description of vegetation structural types with colour illustrations and a comprehensive enumeration of species in terms of collection locations and vegetation types. They record some 750 species from 75 families within the licence area. A summary of plant species collected in the area since 1968 is presented in Appendix H.

The two vegetation types directly affected by harvesting operations are described by Christensen et al. (1985) as follows:

- High Open Forest - High open forest are typically karri, yarri or karri and marri forests, less frequently mixed with jarrah and yarri. Near Walpole, yellow tingle (E. guilfoylei), red tingle (E. jacksonii) or Rates' tingle (E. brevistylis) many be present. The main understorey tree species are karri oak (Allocasuarina decussata) and WA peppermint (Agonis flexuosa). Common shrub species are Acacia urophylla, Trymalium floribundum, Paraserianthes lophantha, Pimelea clavata, Thomasia quercifolia, Chorilaena quercifolia and Agonis parviceps. In the south-easterly sections of the survey area, Acacia pentadenia, Lepidosperma tetraquetrum and Lepidosperma effusum are the dominant species, while in the northerly sections of the survey area in the Donnelly River valley, Bossiaea laidlawiana is more common.

High open forests have developed on the better soils (mainly red earths and brown gravelly duplex soils) within the licence area in regions where annual rainfall is greater than 1016mm.

o Open Forest - The open forest is generally composed of jarrah or jarrah/marri mixtures, with yarri, flooded gum and yate occasionally occurring in small patches by themselves. Common understorey species that many also be present throughout the survey area include Banksia grandis, Allocasuarina fraseriana, Persoonia longfolia and P. elliptica. On grey sands, Banksia attenuata and Xylomelum occidentale may occur, and on damper sites Agonis flexuosa may be present. Common shrub species are Bossiaea linophylla, B. ornata, Macrozamia riedlei, Hakea amplexicaulis, Xanthorrhoea preissii and X. gracilis, Acacia pulchella and Agonis parviceps. On the drier sections, Hakea lissocarpha and Trymalium ledifolium are common species.

Open forests grow on lateritic and podzolic soils, and in drier regions.

The main forest types are interspersed with low woodlands, heaths, waterways and wetlands. On the dryer inland margins the jarrah open forest grades into wandoo woodlands.

In the forests of the southwest of Western Australia the patterns of continuous variation or gradients in site characteristics (climate, physiography) and the segregation of vegetation along these gradients has long been recognised as a striking feature (Havel, 1975a). Using principle component analysis, Havel (1975a,b) divided the vegetation continuum in the northern jarrah forest into a number of major site-vegetation types. The value of this type of classification is that it has a real ecological basis which relates to real productivity and management characteristics on the local scale. Using landform mapping by Churchwood and McArthur (1980), Heddle et al. (1980) used the Havel classification to create more extensive, easily mappable vegetation complexes which extend into the northwest corner of the licence area.

The desirability of further extending such site-vegetation classification and mapping throughout the southern forest region has been recognised. The first stage in this work has just been completed by Strelein (in press) for the south jarrah forest. He has defined 17 site-vegetation types and discusses them in relation to dieback impact, regeneration and productivity. The basis for applying extensive mapping based on Strelein's site-vegetation types will be available given the impending publication of detailed landform and soil classification and mapping work by Churchwood et al. (in press).

Site variation also occurs in the karri forest. Variations in terms of productivity and major understorey types are well known and have formed the basis of forest management programmes. Further research is still required to provide discrete site-type information.

6.2.1.2 Rare and Endangered Flora

A summary of information on rare and restricted species is presented in Appendix B. This summary was prepared with the objective of specifying the geographic and ecological setting of any rare or restricted species previously recorded in forest types likely to be affected by harvesting operations. The major sources of information were:

- A guide to the gazetted rare flora of Western Australia by Rye and Hopper (1981), and a supplement to it by Patrick and Hopper (1982), which define the gazetted rare species and provide basic information on their distribution.
- An unpublished report by the Department of Fisheries and Wildlife (now CALM) prepared by officers at the Wildlife Research Centre at Woodvale, enumerating a number of species from the jarrah and karri forests considered to be rare or geographically restricted, though mostly not gazetted as such.
- A report on a number of biological surveys carried out in the southern forests by Christensen et al (1985) which contains a full enumeration by survey localities and forest types of all plant species observed in the course of the surveys.

These were supplemented by a search in the WA Herbarium for more recent collections of species enumerated in documents 1 and 2 above. Additional information was also obtained in discussion with Mr A. Annels (pers comm.), who has been associated with most of the recent ecological studies in southern forests especially those of Christensen et al (1985), Strelein (in press) and G. Inions (unpublished data). Discussions were also held with Dr S. Hopper and Mr G. Keighery.

6.2.1.3 Introduced Flora

Few introduced species have been able to establish a niche in the forest communities in the study area. The main weed of concern is Blackberry (Rubus fruticosus) which is a formally declared noxious weed for which CALM has a statutory responsibility for control (CALM 1987a). Other important declared weeds are Apple of Sodom (Solanum hermanii) and St John's Wort (Hypericum perforatum). The occurrence of these weeds is quite localised and they are controlled by spraying at a cost of about $50,000 a year (CALM 1987a).

Many agricultural weed species, especially annuals, occur in the vicinity of agricultural land but do not successfully colonise intact forest. They may persist at a low level by annual re-introduction of wind borne-seed along the forest margin or briefly colonise the forest in the wake of fire (see Section 7.1.4.1.) or other disturbances.

Some exotic trees show potential for colonisation; these include Acacia melanoxylon, Acacia dealbata and Eucalyptus saligna. Present occurrences are very minor and under control.

6.2.1.4 Eucalypt Diseases and Pests

The only major eucalypt disease presently recognized in the southern forest is jarrah dieback, caused by the introduced soil borne fungus, Phytophthora cinnamomi (Podger 1972). The disease can cause sudden death or slow decline in jarrah and many other species, and can dramatically alter the floristic composition and vigour of susceptible sites. Present infection is widely dispersed within an area of 52,000ha or 9 percent of the southern forest (CALM 1987a).

It is well established that the fungus is most active in warm, wet soil conditions. This is clearly reflected in the southern forest where Strelein's (in press) site-vegetation types P and S, characterised by higher rainfall and poor drainage, are most damaged. In the northern jarrah forest Shea et al. (1983) and Kinal (1986) have associated high disease impact in apparently well-drained upslope locations, with poor internal drainage. It also appears that the fungus is sensitive to the water status of the host. The capacity to predict disease impact is still being developed. Numerous other site and host factors, in addition to water status, may affect fungal activity. Any one factor may inhibit expression of disease even where water status is highly conducive to its occurrence.

It could be expected that site-vegetation types, which are an expression of the integrated effect of site factors on vegetation, would have predictive value.

In the northern jarrah the site-vegetation types of Havel (1975a,b) proved too general to give a satisfactory prediction of disease impact. Shearer (pers comm.) has developed a new classification system for this purpose, although it still requires field validation. The new Strelein (in press) southern jarrah site-vegetation types require field assessment to reveal how well they can predict disease impact.

In general the long term impact of the fungus in southern forests is expected to be less serious than in the northern jarrah forest (Christensen 1975, Dept Conservation and Environment, 1980). This is due to the large proportion of obviously resistant sites and species (e.g. well drained, fertile valley soils carrying karri and marri) and to the generally lower soil temperatures.

Disease control has concentrated on the prevention of spread of the fungus by transport of infected soil. This has given rise to an elaborate set of hygiene and access control procedures which are now comprehensively incorporated into all forest management (Forests Dept 1982; Underwood and Murch, 1984). Upgrading disease control is a continuing process with current advances focussing on the development of impact prediction techniques and the manipulation of site and host conditions to disfavour fungal activity.

Two native insects are pests of increasing concern in the licence area. A full account of them is given by Abbott (1985). The jarrah leafminer (Perthida glyphopa) larvae develops within the blade of the leaf from June to October, drops to the ground to over-summer below ground and pupate in February/March. The adults lay eggs in April/May. The larvae are confined to the leaf on which they hatch. The mature leaf canopy can be totally destroyed by October but is replaced by new foliage in the summer leaf flush. Repeated annual defoliation reduces growth rate and there is concern that it may eventually cause death in jarrah. Although this insect has long been recognised as a problem, the area severely affected has expanded in recent years.

In 1983, extensive areas of canopy damage caused by the gum leaf skeletoniser (Uraba lugens) occurred between Manjimup and Walpole. This damage has recurred annually over an expanding area. A summer (January hatching) and winter (June/August) generation occur. Larvae are gregarious when young but solitary and mobile when older. The dual feeding season could prevent refoliation and the pest therefore has the potential to do serious damage.

6.2.2 Fauna

Within the areas affected by woodchipping the two main vegetation communities, the karri and jarrah, support contrasting faunal compositions.

The tall, wet sclerophyll karri forest might be expected to have a distinctive fauna, parallel to similar forests in eastern Australia. However, the fauna is relatively poor in species, with a predominance of short - lived, quick colonising species similar to those which occur in the adjacent dry sclerophyll jarrah forest. Christensen et al. (1985) found this suggestive of a similar susceptibility to fire in the karri as in the jarrah, which has favoured species suited to a more variable environment.

The jarrah forest is better endowed with species, particularly in its dryer northeastern sector where it is interspersed with wandoo (E. wandoo) woodland and extensive thickets of heartleaf poison (Gastrolobium bilobum) occur. The Perup/Tone River area is of particular interest, as it contains five rare mammal species, namely the woylie (Bettongia penicillata), the tammar wallaby (Macropus eugenii), the numbat (Myrmecobius fasciatus), the chuditch (Dasyurus geoffroii) and the common ringtail possum (Pseudocheirus peregrinus). A total of 40,000ha has been allocated as a fauna protection management priority area. This area has been intensively studied, and the biology of its rare fauna is sufficiently well understood to prescribe particular management practices, especially fire, for their protection (Christensen 1980, Christensen 1982, Burrows, 1985).

Christensen et al. (1985) report the results of 19 surveys carried out between 1970 and 1982. They summarise vertebrate species distribution, abundance and habitat preference and provide comprehensive species lists. Their results, and others where available, are used here to provide an overview of fauna for the southern forest region as a whole.

6.2.2.1 Mammals

A total of 28 native mammal species have been recorded (five macropods, four possums, four dasyurids, the southern brown bandicoot (Isoodon obesulus), the numbat, the echidna (Tachyglossus aculeatus), the dingo (Canis familiaris dingo), two rodents and nine bats).

Some species are widespread, namely the western grey kangaroo (Macropus fuliginosus) and two bats (Pipistrellus tasmaniensis and Eptesicus regulus). Many others are widely distributed but are locally confined to particular habitats. Several species previously observed in the region are now thought to be extinct within the licence area, including Bettongia lesueur, Macrotis lagotis, Phascogale calura and Potorous tridactylus.

6.2.2.2 Birds

Some 144 species of birds have been recorded in the southern forest region although this includes some coastal species. The karri is generally less well-endowed with species than the jarrah forest and the marginal woodlands.

Wardell-Johnson (1985) observed that the distinct two-tiered structure of the karri forest supports separate bird communities in each tier. The understorey has large populations of a few mainly insectivorus species, of high site fidelity. In response to the variable nature of karri flowering, the overstorey supports variable populations of stable species composition but considerable mobility.

Agricultural development has opened a niche for some species from outside the region and expanded the range of habitat types for many local species. Some are recognised as orchard pests including the Port Lincoln ringneck (Barnardius zonarius), red capped parrot (Purpureicephalus spurius), western rosella (Platycercus icterotis) and Baudins cockatoo (Calyptorhynchus baudinii). These birds cause damage to fruit crops which can be severe in some years.

Several species are considered to be rare (see Section 6.2.2.6) although only one, the ground parrot (Pezoporus wallicus), has not been sighted in recent time.

6.2.2.3 Reptiles

Christensen et al (1985) recorded 32 reptiles species in their surveys although at least several more species have previously been recorded or may extend into the area from adjacent areas. This is quite a small number for a large diverse area and is attributed to the cool moist climate. The greatest diversity of species is observed on the margins of the main forest belt. Sandy soils and areas of bare ground are the favoured habitats.

Geckoes, legless lizards and dragons are poorly represented in the area. One turtle, the oblong turtle (Chelodina oblonga) is common throughout the region. Snakes are poorly represented (9 species) and skinks well represented (19 species).

6.2.2.4 Amphibians

Some 15 species of frogs were recorded by Christensen et al. (1985) although several more are thought to occur in the region. Many of the species appear very tolerant of change in their environment as evidenced by their common occurrence in farmland.

6.2.2.5 Invertebrates

Invertebrates are enormously diverse and abundant in comparison to the higher animals. They are intimately part of forest ecology being involved in major processes (nutrient cycling, soil forming processes, food chains) in every conceivable role including herbivore, decomposer, predator and parasite. Probably more than half of the species remain uncollected and unnamed, and few have been subject to any detailed research. Those researched are mostly insect pests or soil and litter dwelling species, important in fire/nutrient cycling and rehabilitation of degraded soils (Abbott 1985; Abbott et al. 1986).

At this stage research in this area has not progressed to the stage where a synthesis is really possible. Two areas showing promise of providing guidance for management are fire/nutrient cycling studies and rehabilitation.

Majer (1985) briefly reviewed the often conflicting research results relating to fire effects on invertebrates. He identifies two pertinent themes in fire management in south west forests. On the basis of very limited data, he postulated that soil and litter invertebrates are less resilent under a hot spring burning regime than a hot autumn burn, since the latter meshes better with the natural cycles of food availability and invertebrate activity. Secondly, he considered the resilience of invertebrates to fire to be greater in the wetter forest types.

On the rehabilitation question, Majer (1983) expounds the thesis that ants, because of their abundance, size, species richness and occupation of higher often specialised niches, makes them very suitable as indicators of recovery after disturbance.

6.2.2.6 Rare and Endangered Fauna

The latest listing of rare species was published in the Government Gazette in November 1985. Any of these whose known or likely range extends into the forested zone of the licence area are listed in Table 23 with a brief comment on status according to Christensen et al. (1985).

TABLE 23

RARE AND ENDANGERED FAUNA IN LICENCE AREA

SCIENTIFIC NAME	COMMON NAME	STATUS
Mammals		
Bettongia penicillata	woylie	present - variable
Myrmecobius fasciatus	numbat	present - rare
Bettongia lesueur	boodie	not present
Macrotis lagotis	dalgyte	not present
Phascogale calura	red tailed wambenger	not present
Potorous tridactylus	long-nosed potoroo	not present
Macropus eugenii	tammar wallaby	present - stable
Pseudocherius peregrinus	common ringtail possum	present - rare
Dasyurus geoffroii	chuditch	present - rare
Birds		
Falcunculus frontatus	crested shrike - tit	present - stable
Emblema oculata	red eared firetale	present - stable
Pezoporus wallicus	ground parrot	not present
Falco peregrinus	peregrine falcon	present - rare

A widespread decline in native mammal numbers followed European settlement here and around Australia in general. This phenomenon is mainly attributed to introduced predators especially the cat (Felis catus) (Christensen et al. 1985).

6.2.2.7 Introduced Fauna

The major introduced species in the licence area are mammals. Their distribution and abundance is documented by Christensen et al. (1985). Table 24 lists species, with comments on their distribution.

TABLE 24

INTRODUCED MAMMALS

SCIENTIFIC NAME	COMMON NAME	STATUS
Rattus rattus	black rat	near water, human habitation
Mus musculus	mouse	widely dispersed
Oryctolagus cuniculus	rabbit	near farmland
Felis catus	cat	widely dispersed
Vulpes vulpes	fox	widespread
Mustela putoris	ferret	rare
Capra hircus	feral goat	in pockets
Sus scrofa	feral pig	spreading
Equus caballus	horse	in pockets

6.2.3 Aquatic Life

Twelve native species and five introduced species of freshwater fish have been collected in the area (Christensen et al. 1985). With the exception of the mullett (Mugil cephalus) and the pouched lamprey (Geotria australis) all the native species are endemic to the south west region. Several species occur in forest streams only, and have a very restricted range. Others which extend into the brackish estuaries appear more widespread.

The marron (Cherax tenuimanus) a large native freshwater crustacean and a few smaller crustacea, occur in the region. The marron is the major target of a small recreational fishing activity.

With the exception of the marron, the distribution, abundance and life histories of the native plants and animals of the forest streams are poorly known.

6.3 ROLE OF FIRE IN THE SOUTHERN FORESTS

The hot dry summer, the inflammability of the litter and vegetation, and the potential for lightning strikes, prescribe that the southwest of Western Australia, like much of the rest of the continent, will experience bushfire from time to time. Aboriginal man added to the ignition potential in the southern forests some several thousand years ago. Convincing evidence of active, planned use of fire by the Aboriginals is provided by Hallam (1975, 1985). As a consequence of the occurrence of fire, a flora and fauna evolved to tolerate or even need fire (Gill 1975, Gill 1981, Recher and Christensen 1981).

Christensen and Annels (1985) analysed the attributes of the flora and fauna which indicate the role of fire in southern forest ecosystems. The frequency of fire in jarrah types, with its shorter period to seeding and relative richness in understorey sprouting species, appears likely to have been as little as once every three years. In contrast, the karri has longer periods to seeding and fewer sprouters in its understorey, and a frequency longer than once in five years is indicated. This relatively high frequency in karri, a 'wet' sclerophyll forest, is supported by the preponderance of short-lived, early-maturing species in the mammal fauna. Season of burning is likely to have been earlier in jarrah, another factor favouring sprouting species in the understorey over seeding species, possibly early summer compared to late summer in karri. The evidence suggests considerable variability in fire intensity especially so in karri. The fire regime (i.e. the general pattern of frequency, season and intensity to emerge from the large variation in time and space) is a useful concept. In the jarrah forest the regime prior to European man, seems to have been one of frequent summer fire which, less frequently and usually only by late summer, extended into the wetter karri, irregularly coinciding with extreme weather conditions to cause hot, even extreme fires. The great variability inherent in the natural fire regimes of the southern forests suggest 'fire resilient' ecosystems which should prove amenable to progressive development of managed fire regimes which control hazard but also meet the basic needs of the ecosystem. Fire is used extensively as a management tool by CALM in the licence area. The pattern of fire is aligned to primary land use although fuel reduction for control of wildfires to protect human life and neighbouring values is of over-riding concern.

On production priority land, fire is used:

- To reduce fuels to a level at which wildfires can more readily be contained under average fire weather. This is 8t/ha for jarrah and 19t/ha for karri. This equates to a rotation length of between 7 to 9 years for karri and 5 to 7 years for jarrah.
- For silvicultural purposes to regenerate cut over karri and jarrah forest.
- For manipulation of vegetation for specific annual habitat purposes.

Large conservation reserves such as Natural Parks have special fire management plans drawn up for them. In the absence of any specific need, these plans attempt to balance the protection requirements with the objective of having each major vegetation association represented by a range of fuel age.

On average there is about 80,000ha of fuel reduction burning and 4,500ha of silvicultural burns each year in the CALM Southern Forest Region.

6.4 LAND USE

Within the 884,100ha licence area, 724,300ha is Crown Land and the remaining 159,800ha is privately owned.

The EPA has conducted a number of reviews of land use priorities for crown land within the project area, which, in particular have examined the needs for conservation reserves (see Section 4.1.2). The ultimate objective of this review process was to develop a sound basis for a system of reservation of a range of karri forest ecotypes for conservation and recreation.

The findings of these independent, scientifically-based reviews have effectively established the extent and location of the existing regional reserve system in the karri forest.

Most of the Crown Land is vested in or managed by CALM for a variety of purposes including conservation, catchment protection and wood production. It is classified by CALM into priority land uses. The areas of each classification are shown on Table 25.

TABLE 25

LAND USE PRIORITY OF CROWN LAND IN LICENCE AREA (Dec 1986) *

LAND USE CLASSIFICATION	AREA (ha)
National Parks (existing and proposed)	115,900
Nature Reserves	2,400
Flora fauna landscape conservation	123,000
River and stream reserves	35,500
Roadside amenity	46,800
Recreation	3,000
Scientific study	9,700
Catchment protection	80,300
Protection of forest values	41,700
Wood production	252,700
Unclassified	6,600
	599,300
Other Crown Land (vested in other authorities)	6,700
TOTAL	724,300

* Substantial changes to Land Use Plans are proposed in the Draft Management Plan for the Southern Forest Region.

Significant land uses within State forests of the licence area include:

- Nature conservation
- Timber production to produce a range of wood products.
- Catchment protection to minimise deterioration of surface water quality.
- Tourism and recreation (see Section 4.2.9).
- Beekeeping
- Collecting of wildflowers (see Section 4.2.9.3).
- Extraction of earthfill for road construction.

Harvesting of timber is permitted within the following classifications:

- o Wood Production.
- o Protection of Forest Values.
- o Catchment Protection.

It is also permitted in certain areas classified as Scientific Study, where the purpose of the study is to evaluate the effects of harvesting. Harvesting is prohibited in National Parks, Nature Reserves and the remaining classifications of State forest.

Of the private land within the Licence Area, 38,400ha is uncleared and 121,400ha is cleared, mainly for pasture. Pasture areas are used for grazing by livestock, mainly beef cattle. Fruit orchards and market gardens are established around Manjimup to provide both fresh and processed products.

6.5 HISTORICAL, ETHNOGRAPHIC AND ARCHAEOLOGICAL SITES

CALM (1987a) contains a list of historical sites in the southern forest. These include relics of the early timber industry, early mining remains and some historic structures and buildings.

Discussions were held with personnel from the Aboriginal Sites Department of the Western Australian Museum to ascertain the strategy to be undertaken in relation to ethnohistorical and archaeological aspects of the project.

Given the size of the area involved and time constraints imposed on both parties, it was mutually agreed that a strategy would be devised which would entail on-going liaison between WACAP and the Western Australian Museum. The Proponent has initiated steps to ascertain whether any previous Aboriginal archaeological or ethnohistorical surveys have been carried out in the licence area, either by Museum staff or independent consultants, and whether the Museum anticipates carrying out work in the area in the near future.

6.6 SOCIO-ECONOMIC ENVIRONMENT

6.6.1 Socioeconomics

6.6.1.1 Regional and Local Population Trends

The focus of current woodchipping operations is the Shire of Manjimup (Figure 1). The main population centres are Manjimup, Pemberton, Northcliffe and Walpole. Trends in population growth in relation to surrounding Shires, the South West region and the State are shown in Table 26.

TABLE 26

REGIONAL AND LOCAL POPULATION TRENDS

LOCAL GOVERNMENT AREA	1971 CENSUS	1976 CENSUS	1981 CENSUS	1985 ESTIMATE	1981/85 A.A.G.R
Manjimup	8748	8322	9400	9910	1.3
Bridgetown Greenbushes	3152	2744	3290	3570	2.1
Nannup	1072	972	1060	1090	0.7
Boyup Brook	1968	1826	2000	2060	0.7
South West Region	77347	81666	101880	114000	2.9
Western Australia	703199	1144857	1300060	1408220	2.0

A.A.G.R. Annual Average Growth Rate
Source: A.B.S

6.6.1.2 Terminology

- Economic Base

A region's economic base consists of those economic activities which involve sales to individuals or firms located outside the region, thus giving rise to inflow of money from non-local sources. An industry which is part of this economic base activity is considered a "basic" or "export" industry. All other industries make up the "service" or "local" activity since their output is included within the **input-output approach** to regional analysis which uses a three-way division of individual industries. These comprise the direct, indirect (production induced) and induced components (consumption-induced) of an industry. An input table has been prepared for the study region and has been used in conjunction with the economic base analysis.

- Type I and II Multipliers

A Type I multiplier is used in input-output analysis and is defined as

$$\frac{\text{Direct Effect} + \text{Indirect Effect}}{\text{Direct Effect}}$$

A Type II multiplier is

$$\frac{\text{Direct} + \text{Indirect} + \text{Induced Effect}}{\text{Direct Effect}}$$

Effects can be either output, income or employment.

- Concentration Index or "Location Quotient"

For this study an industry was classified as "basic" if its relative share of employment in the local context exceeded the share of that industry at the regional level. This relationship is called a concentration index or a "location quotient".

6.6.1.3 National Significance of WACAP's Operations

The value of WACAP's woodchip exports in 1986 amounted to $38 million. Total exports from 1982 to 1986 amounted to $151 million. The industry is therefore a significant contributor in terms of national exports and its cessation would have a significant adverse impact on the balance of payments.

6.6.1.4 Regional Significance of the Wood Products Industry

This section presents a discussion of the economic significance of the wood products industry for the South West Region of Western Australia; firstly, by examining the relative significance of the industry in terms of employment and output, and then, by describing a preliminary version of a set of Western Australian Government regional Input/Output Tables, released by the WA Department of Regional Development and the North West, (DRDNW) which quantifies the effect of a change in the level of activity (increase or decrease) in this industry on the region.

The wood products industry is a major employer in the South West Region. In 1983/84, the total number of people employed by the manufacturing sector in the region was 6139, of which 1471 were employed in the wood products industry, spread over 57 separate establishments. In comparison, the basic metal products industry employed 1953 people in only four establishments, and 1289 people in 50 establishments were employed in the food, beverage and tobacco products industry.

Employment in the wood products industry in the region has fluctuated, reflecting the derived demand nature of the product. From 1753 people in 1974/75, it peaked at 1885 people in 1977/78, declined to 1559 in the recession of 1982/83 and then to 1471 in 1983/84. Employment has recovered since then in line with the recovery in the housing market. In percentage terms, the share of employment in the manufacturing sector accounted for by the wood products industry declined from 38.5 percent in 1974/75 to 24 percent in 1983/84, due in part to the decline in employment in the wood products industry and also to employment growth in other manufacturing activities within the region. Manjimup is the centre of the wood products industry, employing 853 people in the total manufacturing sector in 1983/84, only marginally fewer than Bunbury.

The input/output analysis prepared by the WA Government suggests that the industry has significant linkages to the rest of the region. In particular, it is estimated to have an output multiplier of 2.2, an income multiplier of 2.0 and an employment multiplier of 2.6. That is, for every $10000 change in the value of output produced in the wood products industry, a change equal to $12000 occurs elsewhere in the region. For each $10,000 increase in income in the wood products sector, regional income is increased by $10,000 and for each job in the industry, 1.6 are jobs produced elsewhere.

The analysis shows that the wood products industry has a considerable economic impact as an industry group. However, the exact results documented for this industry grouping may not be applicable to a particular segment. For any specific segment (eg. resawn, dressed timber, veneers and boards, chipwood exports), the multiplier results will better represent the industry the more closely its structure in terms of its pattern of input and labour usage, relates to that of the wood products group as a whole.

In applying the results of the study to chipwood exports, this assumption was tested using specific job estimates from all significant sectors servicing the woodchip industry. The development of specific impact estimates for this activity would normally require a reconstruction of the published input/output table, separating it from the wood products group. This, in turn, requires access to detailed information which both the Australian Bureau of Statistics and WACAP regard as highly confidential. In order to overcome this problem, this study has concentrated on employment generated in the woodchip industry and its most significant sources of inputs. Employment and income estimates were calculated and are discussed in Section 7.2. A separation of the effects of woodchipping only was also achieved in a Tasmanian study of chipwood exports which used the ORANI model of the Tasmanian economy. This study estimated that a 10% reduction in the volume of chipwood exports would reduce employment in the industry by 28.5% (113 jobs), and there was an employment multiplier reported of 3.8. The estimated output multiplier was 2.45. Estimates of the significance of forest industries in other regions are shown in Table 27.

TABLE 27

ESTIMATED MULTIPLIERS FOR THE WOOD PRODUCTS INDUSTRY

REGION/INDUSTRY	OUTPUT MULTIPLIER Type I	OUTPUT MULTIPLIER Type II	INCOME MULTIPLIER Type I	INCOME MULTIPLIER Type II	EMPLOYMENT MULTIPLIER Type I	EMPLOYMENT MULTIPLIER Type II
Moreton region*:						
All wood/paper products	1.4	1.9	1.4	1.9	1.4	1.9
Wide Bay region*:						
All wood/paper products	1.6	2.1	1.6	2.2	1.6	2.0
Queensland*:						
Sawmills, plyboards	1.8	2.5	1.8	2.6	1.7	2.4
Joinery, furniture	1.9	2.6	1.9	2.7	1.8	2.4
Victoria**:						
Sawmills	++	++	1.2	++	1.1	++
Joinery	++	++	1.5	++	1.6	++
Furniture	++	++	1.5	++	1.6	++
South-West region of Western Australia***:						
All wood products	1.7	2.2	1.7	2.2	1.8	2.6
Western Australia***:						
All wood products	1.6	2.2	1.6	2.4	1.5	2.2
Tasmania+:						
Pulp wood exports	-	++	-	++	-	3.8

Source: * Morison et al. (1982)
** Burke (1984)
*** Western Australian Department of Regional Development (1986)
\+ Centre for Regional Economic Analysis (1985)
++ Not published

6.6.1.5 Local Significance of the Forest Industry

The economic structure of the local economy has been dominated by the forest industries. In the most recent census year for which data are presently available (1981), the forest industries which include forestry, harvesting, wood products and furniture, accounted for 1108 jobs out of a total workforce of 4079, or 27% of the workforce. This figure does not include the transport and storage, or the community services sectors which have a significant proportion of each sector directly or indirectly employed in the forest industries (e.g. timber haulage and CALM personnel). Trends in the economic structure of the local economy in the period 1971 - 1981 are shown in Table 28. Of particular importance is the increase in forestry and harvesting in the period 1976 to 1981 and the decline in relative importance of both agriculture and manufacturing sectors. This level of increase is strongly related to the introduction of woodchipping as the harvesting of chiplogs did not start until late 1975. The relative share of employment in the community services sector has increased substantially. No other substantial shifts in the relative importance of other industries occurred in this period.

Using a regional concentration index (sometimes called a location quotient) the local economy was divided into its basic or export-oriented industries and its service industries. These data were analysed using economic base analysis (Weiss and Gooding, 1966). The result of this analysis suggests that the total employment multiplier in the period 1971-1981 for the local economy was 2.01. That is, for each basic job created in the local economy 1.01 service jobs were required. It should be emphasised that this multiplier is applicable to all basic industries and is not sector specific as would be the case for an input - output analysis.

This analysis suggests that a minimum of 48.3 percent of the total workforce of Manjimup Shire in 1981 was involved directly or indirectly in servicing the forest industries. Since 1981 the main stimulus for growth has been forest-based industry and consequently this dependence would not have declined below this figure. Because of the importance of the forest industries to the economy it should be emphasised that the above figure is a minimum estimate.

TABLE 28

ECONOMIC STRUCTURE BASED ON EMPLOYMENT SECTORS - MANJIMUP SHIRE
1971-1981

	1971		1976		1981	
	No.	%	No.	%	No.	%
Agriculture	806	23.3	770	20.8	742	18.2
Forestry & Harvesting	127	3.7	159	4.3	347	8.5
Sub Total Agroforesty	933	26.9	929	25.1	1089	26.7
Mining	14	0.4	2	0.05	12	0.3
Food Beverage Tobacco			101	2.7	106	2.6
Wood Prods Furn.			820	22.1	761	18.6
Other Manufacturing			72	1.9	118	2.99
Sub Total Manufacturing	987	28.5	993	24.0	985	24.2
Utilities and Services	2	0.05	24	0.7	30	0.7
Construction	200	5.8	195	5.3	144	3.5
Wholesale and Retail	492	14.2	535	14.4	542	13.3
Transport and Storage	130	3.7	94	2.5	152	3.7
Communication	48	1.4	58	1.6	38	0.9
Finance - Real Estate	85	2.4	79	2.1	94	2.3
Public Administration	64	1.8	50	1.3	71	1.7
Community Services	275	7.9	402	10.8	465	11.4
Entertainment/Restaurants Hotel etc	128	3.7	102	2.7	139	3.4
Other N/C	105	2.9	243	6.5	318	7.8
TOTAL EMPLOYED WORKFORCE	3463	100.0	3706	100.0	4079	100.0

Source: ABS Census

6.6.1.6 Distribution of Employment in the Woodchip Industry

Employment data were collected for every sector of the local and regional economy considered to have significant involvement in the woodchipping industry. The results are shown in Table 29 which allocates employment in both direct and indirect jobs and is also allocated by locality. The overwhelming importance of Manjimup and its environs as the centre of industry is demonstrated in this table with 71.1 percent of the direct and indirect jobs.

6.6.1.7 Other Industries

- Agriculture

Agriculture is the other main basic industry in the Shire. During the decade to 1976 there was an aggregation of adjoining rural holdings resulting in a 23 percent decrease in the number of holdings in the Blackwood Statistical sub-division. This was accompanied by a general decline in rural employment and a shift from sheep into beef cattle and fat lamb production. From 1976 to 1983, this trend continued with a 14.1 percent decline in the number of rural holdings in the Manjimup Shire and a consequent decline in agricultural employment. As shown in Table 28 the share of total agricultural employment has been slowly decreasing.

Agriculture has some propects of growth due to the recent purchase of the co-operative cannery by Edgells. It is anticipated that the cannery will service an expanding market for potatoes in South East Asia. The resulting demand is predicted to double over the next two seasons. There are also good prospects for increased production of cauliflowers to service the existing export industry. The employment generated by the cannery will be seasonal with a requirement for approximately 180 casual workers if the potato production went to a two-shift operation (CES communication, Manjimup) by 1988.

TABLE 29

DISTRIBUTION OF EMPLOYMENT BY JOB CATEGORY - DIRECT AND INDIRECT MAJOR JOB CATEGORIES* IN THE WOODCHIP INDUSTRY

JOB CATEGORY	WACAP[1]	FELLING[1]	HAULING[1] & DELIVERY	ROAD CONSTRUCTION[2] & MAINTENANCE	MANAGEMENT[2] & CLERICAL	OTHER[2]	OTHER[3] SAWMILL CHIPS	SHIPPING AGENTS & WATERSIDE WORKERS	CALM[2]	WESTRAIL[2]	TOTAL
Manjimup	58	28	94	14	18	13			24	2	251
Northcliffe	1	1									2
Pemberton	7	3	10	2	2	2					26
Bridgetown							5				5
Denmark							5				5
Busselton							5				5
Bunbury	11					2		6		27	46
Perth	2				2	7			1	1	13
TOTAL	79	32	104	16	22	24	15	6	25	30	353

Source: WACAP

Classification

1 Direct Jobs

2 Indirect Jobs

3 Direct and Indirect

* Does not include all indirect employment

- Tourism

Tourism is the other industry in the Shire which is considered to have growth potential. The main market for tourism has been visitors from the Perth Metropolitan area who are interested in camping, hiking and sight-seeing. The interstate and overseas visitor tended not to use the area as a destination and, in the past, have been directed to coastal attractions between Margaret River and Bunbury. The area was summarised as "a place where you stop to look at the big trees on the way to somewhere else". The industry is aiming to increase the length of the stay of this type of tourist, in order to maximise tourist revenue and increase employment potential.

However, local tourist representatives also recognise that too much growth of conventional tourism may actually degrade the quality of the experience for the industry's main clientele.

The main tourist market comprises families and hikers, with most tourists visiting the area during the school holidays in December and January. Their ability to spend money is more limited than the 'conventional tourist'. Most of these visitors stay in the caravan parks or in non-designated areas and at the youth hostel located some distance from Pemberton.

Quarterly occupancy rates and total visitor arrivals for hotels and caravan parks for the period September 1981 to June 1986 were analysed and are shown as Figure 16. These figures show that, although the numbers of visitors have increased in caravan parks, the occupancy rates in both hotels, motels and caravan parks are below capacity, with the highest occupancy rate being in the March quarter for 1986 which was less than 50%. Such occupancy rates suggests that for much of the year, many of the hotels conduct marginal operations and are heavily dependent on family run operations.* Comparison with the South West figures demonstrates the contrast between the significant tourist growth at the regional level and the slight increase in Manjimup.

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* Hotels and motels in the Shire show no increases in arrivals for the period 1981-86 whereas at the regional level there is an increasing trend.

Local tourist representatives agree that there is ample accommodation to cope with an increase in visitors who use conventional accommodation even in the peak period over the school holidays. Even though these figures may mask the local demand for forest-based tourism (many visitors choose not to camp in designated areas) overall employment generation prospects are limited.

One sector of the industry with better prospects is a small, local craft industry which specialises in wood products which are then sold to the conventional tourist. However, in terms of significant employment potential, this craft sector is also limited.

Pemberton is the centre of the local tourist industry where there are three parks within reasonable proximity: namely Warren National Park, Beedelup National Park and Northcliffe Forest Park.

Attractions in the Pemberton area include:

- Gloucester Tree
- Marron Farm
- 100 year old Forest,
- Fonty's Pool,
- Rainbow, Tramway and Treen Brook Trails,
- The Bibbulmun Track
- Cascades
- Trout Hatchery
- Big Brook Dam

The town of Manjimup is not a recognized tourist centre although it is only 26km from Pemberton. In October, 1986 the tourist bureau in Manjimup was relocated to a Timber Park, a short walk from the main shopping area. Timber Park is being developed as a tourist attraction with an area of forest, a large craft shop, a timber museum and a 'timber town' of old buildings that have been re-erected on this site.

Although tourism in the southwest of Western Australia has undoubtedly increased in the past five years, there has been only slight growth of conventional tourism in the Manjimup Shire, an indication that people are spending their holidays at the coastal resorts rather than in the hinterland. The significant growth rate in total visits to the

Pemberton Tourist Bureau suggests that the market in the future will continue to be family groups from Perth who travel to Pemberton to enjoy the forest experience. Even though this type of visitor will increase local income, it's mid-term employment potential in the industry is limited, due to considerable excess capacity.

6.6.1.8 Unemployment

Unemployment has not been a social problem in Manjimiup since the recession in the timber industry in 1981-83. The official unemployment rate in Dec '86 was 8.4 percent which was marginally below the State average. Employment is very cyclical with employment in March always 25 percent to 30 percent higher than in December. The official estimate of unemployed was given as 300 for Dec '86 which is expected to be down to 230 by March 1987 because of the apple and pear picking season.

The seasonal nature of employment has meant that under-employment has been a much more signficant issue than unemployment. Horticulture can presently offer very little in the wet-winter season. The actual level of registrations at the CES office in Manjimup, compared to Collie and Bunbury, is shown in Figure 17.

6.6.2 Social Indicators

As shown in Table 30 the Manjimup Shire had similar socio-economic characteristics to its surrounding shires in 1981. Since that time, population growth has been relatively slow and a similar community structure in 1986 may be anticipated. There was a high percentage of school age children compared to the region and an unusually low percentage of people over 65 years of age for a rural area. Manjimup Shire residents had slightly less tertiary level education and a significantly lower level of home ownership. There was also a significantly higher proportion of employed married women than at the regional level. These three indicators suggest that the local community has a lower standard of living than at the regional level. Local Shire officials also suggested that living standard is lower than for the broader region. However, observation of income characteristics showed Manjimup Shire to have a household income distribution

TABLE 30

SOCIAL INDICATORS - 1981

	MANJIMUP SHIRE	NANNUP SHIRE	BRIDGETOWN GREENBUSHES SHIRE	SOUTH WEST REGION
POPULATION				
Male	4679	553	1659	50166
Female	4273	480	1516	47668
TOTAL	8952	1033	3175	97834
HOUSEHOLD SIZE				
in persons/household	3.26	3.44	3.16	3.15
% Children 0 - 14	29.0	29.2	28.5	27.5
% 65 and over	7.3	7.1	9.8	10.5
% Tertiary Education	18.5	21.0	21.7	21.3
% Home Ownership	55.7	60.0	65.7	67.1
% Employed Married Women	45.4	44.9	45.3	38.9
Household Income Mode	Bi - Modal over $26000 and $12000-15000	Bi - Modal over $26,000 and $12000-15000	Bi - Modal over $26000 and $12000-15000	Bi - Modal over $26000 and $12000-15000

Source: Derived from ABS Census

at least comparable to the region and the individual income distribution had a modal value higher than the region. This could be explained by the higher employment participation rate amongst married women. In other words more of the women may work to increase living standards. As the surrounding Shires of Nannup and Bridgetown show very similar characteristics, the above may be more a reflection of the rural community in general.

The data on mobility and family type (Tables 31 and 32) showed Manjimup Shire to be more stable despite the lower home ownership rates and have a higher proportion of conventional families with dependants than at the regional level. The results of the attitudinal survey discussed in Section 10.0 also suggested a community which has strong local family networks based on a considerable length of residence in the area.

TABLE 31

MOBILITY OF POPULATION -
1976 USUAL RESIDENCE OF 1981 USUAL RESIDENTS

	MANJIMUP SHIRE %	NANNUP SHIRE %	BRIDGETOWN GREENBUSHES SHIRE %	SOUTH WEST REGION %
Same Residence	49.4	48.1	48.0	45.6
Other Residence -				
Same LGA	16.6	8.6	12.2	14.4
Other LGA				
NSW	0.3	1.0	1.1	0.8
VIC	0.7	1.1	1.0	0.8
QLD	0.4	0.5	0.1	0.5
SA	0.2	0.4	0.4	0.5
WA	18.7	25.3	24.8	24.9
TAS	0.1	0.2	0.4	0.1
NT	0.1	6.0	0.4	0.2
ACT	0.1	0.0	0.0	0.1
Overseas	1.9	0.6	0.6	1.0
Not stated	0.9	0.6	0.6	1.0
N/A Age under 5 yrs	10.3	12.2	8.8	8.7

Source: ABS
L.G.A. Local Government Area

TABLE 32

FAMILY TYPE - 1981

	MANJIMUP SHIRE %	NANNUP SHIRE %	BRIDGETOWN GREENBUSHES SHIRE %	SOUTH WEST REGION %
Head Only	19.7	17.8	20.1	19.6
Head & Dependants Only	4.0	6.4	2.8	4.7
Head & Spouse Only	21.0	17.8	24.2	25.7
Head, Spouse & Dependants	34.6	35.3	33.1	31.5
Head & Other Adults Only	3.2	4.8	4.1	3.3
Head, Other Adults & Depend's	1.1	1.0	0.7	1.0
Head, Spouse & Other Adults	8.1	7.6	8.3	7.4
Head, Spouse, Other Adults	8.4	9.2	6.7	6.9
TOTAL	100.0	100.0	100.0	100.0

Source: ABS Census

6.6.3 National Estate Areas

The Australian Heritage Commission, a body set up under Commonwealth legislation Australian Heritage Commission Act, 1975 has the responsibility of compiling the Register of the National Estate. An entry on the register can be any part of the built or natural environment which, on nomination, is considered by the Australian Heritage Commission to be of national heritage significance.

Registration is meant to put heritage items into a National context thus alerting planners to the existence of a significant feature or values and allowing planners to consider these attributes when planning an action. The Act does not constrain the actions of State government, Local government or private individuals. It does however, impose constraints on the action of Commonwealth Ministers and authorities. It stipulates that they must not take any action which would adversely affect any place on the register, unless there is no feasible or prudent alternative, unless all action is taken to minimise damage where there is no such alternative, and unless the Commission is informed and given time to comment.

As the Commonwealth Minister for Primary Industry must issue an export licence to WACAP under provisions of the Commonwealth Export Control Act (1982), it is incumbent on him to consider the likely impact of the proposal on the National Estate values of places within the project area.

The process of registration involves the following steps:

- An area is suggested to the Australian Heritage Commission (AHC) by its own officers or any other person, for consideration. Any person may suggest any area but suggested areas have no statutory basis under the Act.
- The AHC appoints a panel of experts to evaluate each suggestion. Concurrently suggestions, with some exceptions, are referred to the relevant State Government Departments by the AHC State Committee prior to AHC's consideration of the expert panel's report.
- In assessing suggestions, the Commission examines only the significance of the place in National Estate terms. It does not consider current or proposed ownership, management or use of the place.
- If the AHC on consideration of the panel's evaluation decides to register the place it must, under Section 26 of the Act, give public notice of Intention to Register, thus providing 3 months opportunity for the public to object. Places in this stage of the process are referred to as the "Interim List". Places on the Interim List have the full protection of the Act.
- If objections are received, the AHC must "give due consideration to that objection" then decide "whether by reason of its consideration of objections, or otherwise, that the place should be recorded as part of the National Estate".

If no objections are received the place automatically proceeds to registration.

Under Section 25 of the Act the Commonwealth Minister may direct a place be either registered or not registered or instigate proceedings to have a place removed from the register. Also, the AHC can elect to remove a place from the Register and it must give the public three months to object to the removal from the Register. Places within the project area and registered on the interim list, or suggested for inclusion in the National Estate are detailed in Appendix D and illustrated on Figure 18. None of the many "built environment" entries on the register have been listed, as these will not be affected by continuation of the project.

It is important to distinguish between the status of registered and interim listed places and suggested areas. These additional suggestions for inclusion on the register have been mentioned in Appendix D for completeness. The AHC receives many suggestions for additional areas which are assessed using previously described procedures. Some are rejected by the AHC as being unsuitable or inappropriate. An example of this is the nomination of the entire southwest karri forest. Other areas make it through to the next stage of the process - the Interim List. It is not until this stage that some status is afforded under legislation.

6.6.4 Landscape Values

Landscape types in the region vary markedly from tall forests through to the inland sand dunes, also included agricultural pasture land, and the inselbergs found east of Shannon, and in the lower portions of the Deep and Frankland River Valleys. Such inselbergs include Mt Frankland, Mt Chudalup and Mt Burnside. Within the forest itself, views at ground level are commonly restricted by the density of the vegetation. The texture of the forest varies according to species composition, maturity, fire history and viewing angle.

The cumulative attributes of these landscape characteristics are typical of a region with a high level of diversity and a generally high scenic quality. The major valleys in particular provide attractive scenery with large trees fully displayed across still or flowing rivers.

Each individual has thoughts, impressions, values and definitions regarding visual quality. The response to familiarity and the power of emotional responses appears to have a significant bearing on the perception of the visual landscape. However, there are basic aspects which combine to form an impression. These include harmony, order, form, line, colour and texture. Recognising the importance of these aspects, CALM has developed and implemented a number of safeguards to minimise the visual impacts which harvesting and other forest operations may have on landscape values (see Section 7.1.6).

Only the major forest types (karri, karri-marri and jarrah-marri) are affected by woodchip harvesting operations.

6.6.5 Transport Issues

6.6.5.1 Existing Transport of Logs and Woodchips to and from WACAP

Transport of logs from the forest to WACAP is undertaken by purpose-built log trucks. The majority of the log trucks (80 to 90 percent) travel through the forest on private roads, which are designed and constructed for that purpose (Figure 19). See Section 4.5 for detail on private roads on State forest leases.

There are cases, however, where haulage roads do not connect directly to WACAP's private forest roads to the Diamond Chipmill. In these cases log trucks travel on public roads. The trucks travelling on public roads must conform to the relevant regulations and licensing requirements set by the WA Police Department. The maximum gross load on a public road is 38 tonnes. An extra mass permit can be obtained for a designated route which allows 16.5 tonnes per additional bogie to a maximum length of 17 metres. These permits must be renewed annually. Operations are restricted to daylight hours and normally operate only five day per week. Figure 19 shows the substantial percentage of heavy transport movements on public roads in close proximity to the Diamond Chipmill. The percentage of heavy vehicles declines substantially with increasing distance from the mill.

During February, 1987 log trucks with sawlogs were travelling on public roads through Pemberton because of karri regrowth harvesting operations on the Vasse Highway north east of the township. The other main use of public roads, during this period was due to chipwood transported from private property in the Nyamup area.

Other truck traffic associated with WACAP and using public roads, includes sawmill residue trucks transporting sawmill residue from other mills to the Diamond Chipmill for chipping, and service vehicles such as fuel tankers.

The woodchips produced by WACAP are transported to Bunbury Port facilities by rail. Special rail trucks are provided by WACAP for this purpose. The rail link from Manjimup to Bunbury was upgraded as part of the development of WACAP's operations. As the rail system is already geared to the transport of woodchips from WACAP, the renewal of the woodchip licence will have minimal impact on the existing rail network. Trains of 1,000 tonne capacity, consisting of 21 wagons, run 5 times per week with three each weekday. In times of peak or reduced production these figures may vary to suit the level required.

6.6.5.2 Existing Road Characteristics and Traffic Volumes

The major roads linking Manjimup to other areas are:

- o South Western Highway
- o Muirs Highway
- o Vasse Highway

All are major sealed roads with two or more lanes, except for the Vasse Highway which reduces to a single lane for part of its length between Nannup and Pemberton. Other relevant roads are: the Nannup to Manjimup Road, which is single-lane, both sealed and unsealed; and Eastbourne Road, which was upgraded to a sealed, two-lane road to cater for the WACAP operations.

Traffic counts are only available for the major regional roads. The most recent counts are shown on Figure 19. The heavy vehicle component is only available for some of the roads and is defined as vehicles with dual wheels, other than light commercial vehicles.

The most noticeable feature of the traffic counts is the high heavy-vehicle component south of Manjimup. This high proportion of heavy vehicles is confined to an area south from Manjimup, for approximately 40km along the South Western Highway and 5km along the Vasse Highway. As discussed above some of these movements are due to log trucks, transporting logs to the various sawmills in that area, and sawmill residue trucks bringing residue from other mills to the Diamond Chipmill. The remainder of these heavy vehicle movements represent the normal background level of truck traffic on the public road system, which is estimated at between 8 and 11 percent as indicated in Figure 19. The existing log and residue trucks using the public road system are estimated to involve 20 to 40 truckloads carrying a total of approximately 500 to 600 tonnes per day of logs.

Traffic volumes on the South Western Highway in the Manjimup area were calculated by the MRD to be increasing at 3.7 percent per year. As the licence volume of woodchips will not increase, no significant increases in heavy transport are anticipated as a result of continuing WACAP operations.

7.0 IMPACT OF PROJECT

7.1 PHYSICAL AND BIOLOGICAL ENVIRONMENT

The impact of the project on the physical environment is discussed in terms of the total integrated harvesting operation. An evaluation of the incremental effect of chipwood extraction compared to harvesting of sawlogs only is also given.

7.1.1 Impacts on Soils

Soils provide the fundamental basis for the continued productivity of the forest.

Some forest management practices, for example, road construction, harvesting and fire control can affect forest soils. Undesirable impacts can be prevented by the application of sound management and operational practices.

Soil factors likely to be affected include: nutrient status, physical structure, and its continued stability.

7.1.1.1 Soil Stability

Forests, especially with full canopy closure are very effective in protecting soils from erosion. Protection is provided by the forest canopy which reduces the initial momentum of the raindrops; by the shrub and litter layer which further dissipate the energy of the rain, reduces run-off and minimise compaction and puddling; and by the roots which assist in binding the soil. Tree felling operations remove the canopy and some of the understorey, and disturb the litter layer, thus increasing the risk of erosion (Senate Standing Committee on Science and the Environment 1977) until regeneration re-establishes cover.

The Senate Committee identified nine main factors influencing the extent and rate of erosion, namely:

- climate
- slope
- extent of area cleared

- o severity of clearing
- o rate of revegetation
- o degree of soil disturbance
- o soil properties
- o application of erosion control measures
- o fire

These are discussed below.

- Climate

Rainfall in the project area mainly occurs during winter in long, low intensity events often associated with frontal activity. Under these circumstances infiltration is maximised, resulting in comparatively low levels of runoff. This reduces the potential for erosion; however it does mean that care must be exercised to protect wet soils from physical damage. Infrequent relatively high intensity rainfall events do occur (see Section 6.1.1.3) and the design of all protection measures takes this into account.

- Slope

Few areas of forest designated for timber production in the project area have slopes in excess of 15 degrees. Typically slopes are less than five degrees. With these gentle gradients the majority of the forest is not greatly predisposed to erosion. However, steeper slopes occur alongside rivers and streams and these have the potential to erode if not managed properly. Erosional impact is managed by identifying all areas with slopes in excess of 15 degrees before harvesting, and marking them for special management. Slopes in excess of 20 percent are demarcated as special care zones in the field and slopes considered too risky are excluded from harvesting.

Measures used to prevent soil erosion during the harvesting process are minimum scrub rolling, direction of tree crowns away from watercourses during felling, no crossing of watercourses with snig tracks, snigging on the contour as much as possible, working from the back of the block and installing cross drains on tracks as the area is completed, harvesting under moist soil conditions when the soil is most stable, leaving of logs on slopes if their recovery will create excessive disturbance, regeneration burning early in summer to allow maximum time for rootstock regeneration and planting along the contour.

- Extent of Area Cleared, Severity of Clearing and Rate of Revegetation

Karri clearfell harvesting coupes vary in size from 20ha to the maximum of 200ha with the annnual average ranging from 70-80ha (Stirling pers. comm.). Little cover is retained within a coupe immediately following harvesting, and the subsequent regeneration burn. The litter layer is also removed exposing soil.

The potential for erosion is greatest at this time. However, this period of maximum exposure is short-lived, as revegetation takes place rapidly providing increasing protection from the erosive elements (wind and rain). Studies into the revegetation of harvested coupes indicate a rapid return of vegetation cover. Species regenerating from rootstocks and rhizomes emerge soon after the burn. Seed germination occurs through the winter. Within one year, 60 percent cover of the soil is attained (see Section 7.1.4.1).

Harvesting in jarrah forest uses a range of silvicultural methods which vary in the amount of canopy removed (jarrah forest silviculture is reviewed in Section 4.0). Group selection felling (2 to 10ha) removes most, while individual tree selection cutting retains no less than approximately 40 percent crown cover. Jarrah forest grows mainly on gravelly lateritic soils which are highly resistant to erosion.

Group selection cut areas are chosen by the presence of established small trees (ground coppice) with the capacity to respond very quickly to removal of the overstorey. With this extra component of rootstock regeneration the period of maximum exposure to erosive elements is even less than that for the karri forest (see Section 7.1.4.1).

- Degree of Soil Disturbance

The extent and degree of soil disturbance in harvesting coupes elsewhere in Australia has been reviewed by several authors: Bridges 1983, Scott 1981, Heyligers 1975. In Table 33 their data are compared with the maximum levels of disturbance permitted on State forest harvesting coupes in Western Australia.

TABLE 33

SOIL DISTURBANCE FOLLOWING HARVESTING

DISTURBANCE TYPE	PERCENT OF TOTAL AREA BRIDGES (1) 1983	SCOTT (2)(3) 1981		HEYLIGERS (4) 1975	CALM INDUSTRY CONTROL MANUAL (5)
undisturbed	36	35.1	45.5	-	
light disturbance	49	46.8	33.2	-	
snig tracks	12	11.1	17.9	25-30	15
log dumps (landings) and minor roads	3	7.0	3.4	2-8	5

1. Based on assessment of disturbance in the Eden region. Bridges (1983)

2. Based on assessment of disturbance at the Reedy Creek pulpwood demonstration area by Forest's Commission of Victoria. Reported in Scott (1981)

3 Based on Maramingo pulpwood demonstration area as for (2) above

4 Statement by Heyligers (1975) regarding general levels of disturbance from harvesting operations over Australian forests

5. Maximum acceptable levels of soil damage from CALM Industry Control Manual (1986a)

The litter layer in the 80 percent of the coupe which remains undisturbed is largely intact. Lightly disturbed areas retain significant litter cover while snig tracks and log dumps have no litter cover.

- Effects on Soil Properties

Repeated passage of machinery and dragging of logs has the capacity to cause substantial changes to soils within harvested areas. Such changes include soil compaction which can occur over a range of soil moisture contents, rutting and scouring caused by wheels passing through wet or soft soil, and puddling where machine movement and high soil moisture can convert soil to a semi-fluid state (Cameron and Henderson 1979).

The degree and type of change is affected by many variables. They include topography, soil type, soil depth, soil moisture, amount and distribution of forest litter and slash, volume of timber extracted, type of harvesting system and the pattern of extraction.

Landings, minor roads and snig tracks before rehabilitation generate overland flow of water which can lead to erosion. This can be prevented by appropriate control measures (see Section 7.1.1.). The major impact of change in soil physical structure is on plant growth. Compacted soils if not rehabilitated have increased soil strength and reduced total porosity through a reduction in large voids and reduced aeration and water infiltration. The consequences of soil compaction without rehabilitation were examined by Greacen and Sands (1980) in their review of available literature. They found inconsistencies in the results from field experiments to test the effects of compaction on plant growth. Some studies indicated increased growth, others a reduction in growth and some no change.

It appears that the relative availability of nutrients and water to the plant is an important factor in determining if compaction will affect root (and subsequently) shoot growth. Root growth through compacted soil is likely to be reduced in areas of significantly increased bulk density unless zones of weakness remain within the compacted soil. These zones if they exist, are preferentially exploited by plant roots (Sands et al. 1979).

Stoneman et al (in prep) observed slower establishment of cover adjacent to snig tracks in the southern forests though this is only apparent for several years (see Section 7.1.4.2).

A range of preventative and remedial measures are applied to reduce soil compaction. These include:

(i) Soils with high organic matter levels or with organic matter incorporated are less vulnerable to compaction. The shedding of bark from logs on landings is a fortuitous occurrence in this respect.

(ii) Traffic control during harvest is used to minimise the extent of soil disturbance. CALM controls aim to limit total area of disturbed soil to 20 percent within any coupe with landings forming no more than 5 percent. Since compaction increases with soil wetness, rainfall and conditions are monitored during wet periods. The monitoring aims to anticipate likely disturbance. If this is expected to exceed a tolerable threshold operations are discontinued. Stockpiling of logs during dry soil conditions permits harvesting operations to be stopped if soil conditions are unfavourable.

(iii) Soil compaction can be reduced by the use of low ground-pressure machinery for skidding logs from the bush to the landing. Flexitrack skidders are such a machine, they generally exert ground pressures in the order of 40-55kPa compared with 55-80kPa for rubber tyred machines (Harris-Daishowa (Australia) Pty Ltd 1986). There are currently four Flexitrack machines operating in the Southern Region.

The use of static log loaders has also decreased soil compaction on the log landing. This is because the static loader as the name implies remains stationary whilst loading. It has an extendable hydraulic arm for picking up and manouvering logs from the dump to the truck. In comparison, rubber tyred loaders need to move around the landing when loading, consequently compacting the site. Landing size can also be smaller and of more uneven terrain with static loaders, therefore the impact is confined to a smaller area. At present there are two static log loaders working in the Southern Forest Region and numerous wheeled loaders (WACAP pers comm.). It is expected that the number of static loaders will increase. Another innovation has been the use of wide rubber tyres on the non-stationary equipment.

(iv) Rehabilitation of landings and snig track entries onto the landings is carried out by the industry by contour deep ripping. Drainage is provided as required.

- Application of Erosion Control Measures

CALM has drawn up comprehensive specifications for erosion control during and after harvesting operations. A summary of the specifications is provided in Section 9.0.

- Fire

Prescribed fire has the potential to cause impacts on forest soils by changing soil physical structure through heating and by temporarily exposing the soil by removing vegetation and litter layers. However, these are natural processes to which the soil has long been exposed.

Prescribed fire is used to create a suitable seedbed, to reduce post-harvesting debris and to reduce fuel levels in mature forest.

7.1.1.2 Nutrients

Harvesting and regeneration can affect forest nutrition through removal of nutrients in logs, through volatilisation and mobilisation during post-harvesting burns, through the regeneration of nitrogen fixing species and through fertiliser application. These impacts must be examined in relation to the total nutrient 'capital' of the system to determine whether there might be any adverse effect on forest composition or productivity.

An ecosystem can be viewed as a series of compartments (trees, understorey, litter, soil) each containing a pool of nutrients which is added to or drawn from according to the dynamic nutrient cycling processes of that system. The sizes of the nutrient pools, the rates of transfer between pools, the inputs into the system and losses from the system are important parameters in nutrient cycling. The processes involved have been grouped by Switzer and Nelson (1972) into three interconnected cycles:

- geochemical cycle involving import or export from the soil (this includes atmospheric accessions which enter the nutrient pool via the soil),
- bio-geochemical cycle involving transfers between plants and soil, and
- biochemical cycle involving internal redistributions in plants.

This grouping provides insight into the functioning of the ecosystem and reflects its physical environment, biological character and impacts of management and disturbance.

Another useful concept describes the stage of development of a forest following a disturbance (Attiwill 1979) as follows:

- o Uptake stage, involves regeneration of the biomass based on geochemical cycling of nutrients via the soil into the biomass.
- o Redistribution stage, involves continuing soil uptake but biochemical cycling becomes prominent as heartwood formation releases mobile nutrients for re-use.
- o Maintenance stage, where nutrient returns to the soil pool by litter fall, and mortality comes into balance with uptake from the soil pool by way of the biogeochemical cycle.

A final concept necessary in considering nutrition, particularly in forests, concerns availability. Available soil nutrients are those which exist in a form which can be utilised by plants and occur within the depth of soil exploited by plant roots. Both available and total nutrients in the soil pool are listed in Table 34. The criteria used to assess availability have been largely developed for agricultural applications where ready availability for short term growing seasons is equally important. In fact, most forms not in the available category are slowly available (Crane 1978, Turner 1981) in amounts which are significant over the period of a forest rotation. Another feature of forests, especially in the southwest of Western Australia is the depth of root penetration. Though the bulk of available nutrients occur in the top one metre or so where biological activity is greatest, trees exploit soils to great depth. Dell et al. (1983) discuss this issue in relation to jarrah. It appears that jarrah can fully exploit the weathered profile to depths of 40m. This is considered to be a factor in the salt accumulating capacity of jarrah forest profiles. This capacity for retention of salts also suggests great efficiency at retention of soluble nutrients.

In this section the nutrition of the southern forests is analysed. This is done by assembling the best available estimates of total nutrient inputs and losses (i.e. the nutrient balance) in relation to nutrient pools over a whole rotation for two representative forest types. The two forest types are karri in a red-earth soil and jarrah in a lateritic soil (see Appendix K) both in the HRZ (high rainfall zone). The rotation length is 100 years for karri and 120 years for jarrah. Pools and balances for the six major nutrients (i.e. nitrogen (N), phosphorus (P), potassium (K), sulphur (S), calcium (Ca), and mangesium (Mg)) is presented in Table 34. It must be emphasised that many of these estimates are quite crude and, especially when extrapolated over a full rotation, have large error. Their value lies in helping anticipate possible problems as a guide to future research and management.

TABLE 34

CRUDE PROJECTED NUTRIENT BALANCE (kg) OVER A ROTATION OF 100 YEARS FOR KARRI AND 120 YEARS FOR JARRAH

COMPONENT		NITROGEN JARRAH	NITROGEN KARRI	PHOSPHORUS JARRAH	PHOSPHORUS KARRI	POTASSIUM JARRAH	POTASSIUM KARRI	SULPHUR JARRAH	SULPHUR KARRI	CALCIUM JARRAH	CALCIUM KARRI	MAGNESIUM JARRAH	MAGNESIUM KARRI	COMMENTS
Pools	soil	1536[1]	7439[2]	14[1]	54[2]	110[1]	471[2]	118[1]	260[2]	1186[1]	3827[2]	240[1]	1027[2]	Available to 100cm jarrah and 90cm karri.
				(725)	(1718)	(5861)	(6214)	(1296)	(2906)	(5508)	(10224)	(2200)	(5346)	Total of less available forms.
	biomass	327[1]	249[2]	14[1]	20[2]	311[1]	264[2]	60[1]	24[2]	353[1]	737[2]	182[1]	151[2]	Excluding roots
	litter	48[1]	224[3]	2[1]	7[2]	8[1]	32[2]	8[1]	28[2]	90[1]	396[2]	20[1]	60[2]	Litter age 6 yrs in jarrah 9 yrs in karri
	TOTAL	1911	7912	30	81	429	767	186	312	1629	4960	442	1238	
Inputs	atmospheric	60[5]	50[7]	36[1]	30[1]	600[4]	500[4]	840[4]	700[4]	1080[4]	900[4]	840[4]	700[4]	Jarrah rotation 120 years, karri rotation 100 years
	weathering	-	-	8[9]	8[9]	1080[9]	900[9]	-	-	720[9]	600[9]	240[9]	200[9]	Assumes weathering of 0.01mm rock thickness per yr
	fixation	1080[6]	1500[1]	-	-	-	-	-	-	-	-	-	-	Symbiotic plus asymbiotic.
	TOTAL	1140	1550	44	38	1680	1400	840	700	1800	1500	1080	900	
Losses	fire	840[1,3]	1947[7]	?	?	-	-	420[7]	330[7]	-	-	-	-	Burning rotation 6 yrs in jarrah, 9 yrs in karri
	drainage	nil[5]	nil[1]	nil[1]	nil[1]	233[8]	194[8]	516[8]	430[8]	648[8]	540[8]	1440[8]	1200[8]	75% N loss in litter plus 50% loss from understorey
	harvest	101[3]	108[2]	4[3]	10[2]	90[3]	147[2]	19[3]	8[2]	62[3]	550[2]	34[3]	102[2]	120 tonnes/ha for jarrah 204 tonnes/ha for karri
	TOTAL	941	2055	4	10	323	341	955	768	710	1098	1474	1302	
	BALANCE (excluding pool)	+ 199	- 505	+ 40	+ 28	+ 1357	+ 1059	- 115	- 68	+ 1090	+ 402	- 394	- 402	

SOURCES:
1. Hingston et al (unpublished ms) jarrah means of 13 sites in northern forest
2. Hingston et al 1979 single 36 yr old karri red earth site
3. Hingston et al 1980/81
4. Hingston and Gailites 1976
5. Bell and Barry 1980
6. Hingston 1985
7. O'Connell 1987
8. Loh et al 1983
9. Hingston 1977

- Harvesting Effects

The budgets indicate that harvest negligible are modest in relation to other losses occurring during the rotation and in relation to the available soil and residual biomass pools. They also assume total bark removal at harvest which especially in karri does not occur in practice. Since bark is a nutrient rich fraction of the bole, containing some 50 percent of total bole nutrients (Hingston et al. 1979) actual losses are much less. Any loss would have only minor effect on the uptake phase of the regenerating forest, being similar to the situation that would prevail in a natural forest anyway given that much of the nutrients in bole biomass would only slowly become available, as fallen trees decay.

The data presented in Table 34 are for a yield per hectare of 120 tonnes of jarrah/marri and 204 tonnes of karri. The latter figure is a little less than the current average yield (285 tonnes/ha) but is the bole wood present in the 36 year old stand analysed by Hingston et al. (1979).

- The Uptake Stage

Stoneman et al (in prep) have documented regeneration in terms of canopy density and cover and this is discussed in Section 7.1.4.2.

Grove and Malajczuk (1985a,b) have documented regeneration in karri in terms of biomass production and nutrient accumulation in the major overstorey species (karri) and the predominant understorey species Bossiaea laidlawiana and Trymalium spathulatum. Their results for N, P and K are summarised in Table 35.

These data indicate rapid early production of biomass and uptake of nutrients. The surge in karri biomass accumulation to 31.3 tonnes/ha by age 4, indicates substantial draw on the most readily available fraction of nutrients in the soil (O'Connell, 1987), including those mobilised in the regeneration burn (Grove et al, 1986). Subsequent draw on soil nutrients tapers off probably due to biochemical cycling commencing with the laying down of heartwood and the establishment of biogeochemical cycling with the litter fall which exceeds 2 tonnes/ha/yr by age 4 and is increasingly protected in a microclimate suitable for decomposition (O'Connell 1987). The large N pool accumulated in B. laidlawiana biomass following regeneration, probably largely derived from fixation, highlights the important role of this species in karri forest nutrition. This importance is accentuated by the negative nitrogen balance suggested in Table 34. This is further discussed in the following section.

Nutrient uptake in regeneration of jarrah has not been documented in nearly so much detail. Being a dryer and less fertile system, its rate of biomass production is less than karri.

- Nitrogen

Nitrogen is a key nutrient involved in complex cycling processes. Considerable management influence on the N balance is possible, directly by choice of fire regime and indirectly, by regulation of the legume understorey using fire and P fertilisation. Furthermore, significant productivity increases may be possible with improved N and P nutrition (Hingston et al. 1982, Grove in press).

If the assumptions on which the data summarised in Table 34 are correct it could be concluded that the karri system may be in negative nitrogen balance. Even if this were true the magnitude of the deficit (5kg/ha/year) is insignificant given that the nitrogen soil pool is 20 times greater than the hypothesized deficit.

The principal factors affecting the N balance in the karri forest are fire (loss) and fixation (input). Loss of N as a consequence of harvesting is relatively small.

A reduction in the frequency of prescribed fire could theoretically reduce N loss. These potential gains in N would be lost by one or more wildfires during the 100-year rotation.

The history of wildfire incidence in the karri forest indicates that the probability of wildfire occurring is increased markedly if fuel reduction burning is not carried out.

There is also potential to increase fixation. Grove and Malajczuk (1980) report increasing fixing capacity with age in *B. laidlawiana* but the opposite occurs with *Macrozamia reidlei* (Grove et al 1980) and with some jarrah forest *Acacia* species (Hansen 1986). Enhanced fixation may be achieved by applying P fertilizer (Hingston et al 1982, Hansen 1986, Grove in press), or by increasing soil water availability through forest thinning (Hansen 1986).

TABLE 35

BIOMASS AND NUTRIENTS IN REGENERATING KARRI

	B. laidlawiana				T. spathulatum				karri				
AGE	BIOMASS	N	P	K	BIOMASS	N	P	K	BIOMASS	N	P	K	TOTAL BIOMASS
4	2.1	14	0.21	6	1.3	4	0.14	4	31.3	96	5.32	131	34.7
8	17.5	103	1.65	44	12.7	30	1.19	39	35.0	106	5.91	140	65.2
11	23.7	129	2.08	57	12.3	24	1.03	36	43.5	132	7.35	176	79.5
36	12.9	73	1.16	32	12.7	28	1.14	38	223	189	18.00	225	249

NOTE: Biomass in tonnes/ha, nutrients in kg/ha, at age 36 understorey species were 9 years old. Adapted from Grove and Malajczuk (1985a,b)

Yet another complication in N nutrition was explored by Hansen (1986). He found the N fixing activity of three prominent jarrah forest acacias to be suppressed by naturally occurring levels of nitrate in the soil solution. Similarly, Grove (in press) found fertiliser N suppressed growth of B. laidlawiana relative to its non-legume competitors. Both observations suggest an equilibrium between legumes and the soil N pool i.e. any depletion in N is likely to be compensated for by an increase in legume vigor and fixation, and vice versa.

It is concluded that harvesting has no significant effect on N balances in the southern forests. Although there are major losses and additions of N to the karri forest over a rotation, there is no evidence that the system of forest management practice is different from that which would have occurred naturally.

- Phosphorus

Although well endowed with considerable reserves of relatively inaccessible forms of P in the soil pool, the active P cycle functions adequately and in positive balance, turning over relatively small amounts of more available forms. The once per rotation harvest loss of P is small, being about the same amount as might be applied in a single annual dressing for farmland i.e. 50-100kg/ha superphospate. Losses may also occur in fire (O'Connell et al 1981) but the results of Grove et al (1986) from intense jarrah forest fires, indicate that this loss is small. In any event, losses are well covered by inputs to the system from the atmosphere and possibly also from rock weathering which, over a 100 year rotation period, are significant. Also the modest fertiliser application made to planted seedlings provides about as much phosphorus as is removed at harvest.

Responses in legume growth and N fixation following applications of P have been reported by Hingston et al (1982), Hansen (1986) and Grove (in press). It appears likely that applied P could result in improved N inputs and enhanced production.

- Potassium, sulphur, calcium and magnesium

The remaining nutrients in Table 34 have similarities and so can be considered together.

For each nutrient, large atmospheric and weathering inputs and large drainage losses occur. With the exception of Ca in karri, harvest losses are small in relation to the other components of the balance. In the case of both S and Mg, negative balances are inferred, and for both these are only barely covered by the available soil pool to one metre depth.

Before considering harvesting impacts it is necessary to qualify the assumptions in Table 34. The atmospheric inputs, from Hingston and Gailitis (1976), are reliable estimates and stable over time. The weathering estimates from Hingston (1977) are crude, being based on a weathering rate of 0.01mm thickness of granite per year. At the weathering depths encountered in jarrah and karri profiles, much of this yield is likely to remain within the geochemical cycle, entering groundwater and eventually being lost in drainage. The drainage losses from Loh et al (1983) are good current estimates but cannot be projected in time, since they may partly reflect temporary depletion of storages, and may therefore eventually decline. This latter point is well illustrated by sodium and chloride balances which, after agricultural clearing, can go into large negative balances (see Section 7.1.2) (Peck and Hurle 1973).

The most pertinent aspects of the balances are therefore the atmospheric inputs, and the harvest and fire losses in relation to the available pools. In all cases the ongoing atmospheric inputs exceed the intermittent harvest and fire losses over the length of the rotation and adequate available pools cover the short term peak demands following fire and harvest.

7.1.2 Impacts on Water

The initial ERMP (Forest Department 1973) upon which the current woodchipping operations are based, identified potential water quality problems, most notably salinity in the dryer jarrah-marri forest type portion of the proposed licence area. The concern was that the more intensive disturbance inherent in an integrated sawlog plus chiplog harvesting operation may cause water quality impacts greater than those associated with selection harvesting only practised in jarrah-marri forests. Long experience had indicated that the water quality impacts of selection harvesting only were quite tolerable, but this could not be assumed for integrated harvesting operations.

In October 1973, the then Minister for Environmental Protection arranged for the formation of a Research Steering Committee under the chairmanship of the Deputy Director of Engineering, Public Works Department (Mr K.J. Kelsall). The Steering Committee recognised the need not only to identify short term effects of proposed new harvesting regimes, but to assess long term changes through the complete regeneration cycle. Four projects were established to:

- o Identify areas vulnerable to salinity increases (Project 1). This project was completed and reviewed by DCE (1980).
- o Study the changes in surface and groundwater hydrology through the complete regeneration cycle (Project 2).
- o Monitor the major rivers of the region to identify any large scale changes in water quality (Project 3). This project was virtually complete when reviewed by DCE (1980).
- o Monitor the groundwater and streamflow response in operational coupes to provide an early warning of any major environmental problems in the early years of the new cutting regimes (Project 4).

Answers to three specific questions were required as follows:

(i) Will there be an increase in stream salinity, and if so, will its magnitude and duration be acceptable?

(ii) Will there be an increase in stream sediment concentration, and if so, will its magnitude and duration be acceptable?

(iii) What will the future water yield be?

Previous reports on the progress of this research have been published (DCE 1978, 1980). Another major review of this work was commenced during 1986. Several reports have been published or will be published shortly. These include Borg and Loh (1987) reporting on Project 2, Borg et al. (1987) reporting on Project 4, Stoneman et al. (in prep), reporting on the hydrological effects of regeneration and Martin (in prep), reporting on hydrogeological studies. In addition, an overview of all of this work and related work in the central and northern jarrah forest areas will shortly be available from the Research Steering Committee for Land Use and Water Supply, the group which has taken over from the Kelsall Committee. These publications and manuscripts were reviewed in the preparation of this section.

- Research Results

Stoneman et al. (in prep) examined cover, density and basal area on some 35 sites chosen to represent the range of forest type, rainfall zone and regrowth age. Their major objective was to gain a quantitative understanding of forest density changes following harvesting. Since density is a major determinant of evapotranspiration, which dominates the water balance, it is a strong indicator of long term hydrologic effects. They found rapid vegetation recovery, supporting earlier, more local results, presented by Carbon et al. (1979) and Grove and Malajczuk (1985a,b). Pre-harvesting levels of cover and density are achieved after about 10 years in karri, about 15 years in HRZ jarrah and a little longer in LRZ and IRZ jarrah (Figure 20). The Stoneman et al. data, and observations from further afield, indicate that total cover and density of a regrowth stand can, in the medium term, exceed that of a mature forest.

The transient (10 to 15 year) period of reduced cover results in diminished evapotranspiration and a surplus of water to be passed through other hydrological pathways. The impacts of this were the subject of research in projects 2 and 4 reported on by Borg and Loh (1987) and Borg et al. (1987).

In all rainfall zones, groundwater levels rose for two to four years following harvest then started to decline as vegetation regenerated. A return to pre-harvesting levels has not yet been observed after eight years, but levels are still declining (Figure 21). In the LRZ, groundwater did not rise enough to influence streamflow. In the IRZ and HRZ groundwater contributed to streamflow prior to harvesting and the rise in level increased the contribution of groundwater to stream flow, increasing stream salinity by 50-150mg/L at peak groundwater levels. Subsequent declining groundwater level was reflected in a decline in stream salinity. At all times in all rainfall zones, the mean annual stream salinity remained in the 'fresh' water quality category (ie. less the 500mg/L) (Table 36). However, in the IRZ March Road Catchment, during the late spring and autumn low flow periods when groundwater forms a relatively larger proportion of stream flow, salinity increased from 700mg/L prior to harvesting to a maximum of 2000mg/L post harvesting. These increases in salinity have no impact on the regional water quality because they are confined to small areas of the catchment and to periods of low stream flow. The annual average stream salinity still remained fresh.

Annual mean stream sediment concentrations were uniformly low (less than 5mg/L) at all research sites. They peaked from one to two years after harvesting, at 35mg/L for a winter harvested site and 20mg/L for summer harvested sites. Figure 22 suggests a return to pre-harvesting levels within four to five years. Stream buffers eliminated sediment yield from summer harvesting, although their value in winter harvesting was not tested.

Daily peak sediment concentrations can be much larger than annual means. Results from earlier work were reviewed in a previous report (DCE 1980) and modifications to harvesting practices undertaken to reduce peak loads.

Stream flow volumes peaked at two to three years after harvesting. Figure 23 indicates a likely return to pre-harvesting levels after 10 to 12 years. At peak levels annual runoff increases by more than 100mm in the HRZ and 40mm in the LRZ, more than doubling pre-treatment catchment yields. Most of this increase arises from shallow subsurface flow.

The study period, 1975-1985, was unusually dry. The annual average rainfall for the period was 10 percent below the long term mean. This factor probably influenced the magnitude of responses observed but not the general trends.

- Salinity Effects

In those areas where there is shallow saline groundwater, there will be a small increase in stream salinity. The increase will be temporary, peaking a few years after harvesting and diminishing to pre-harvesting levels in 10 to 15 years which is the time taken for the vegetation cover to return to levels comparable with undisturbed forest. The increase will be small (less than 150mg/L) and annual mean salinity will not exceed the 'fresh' category limit of 500mg/L. The largest increase will occur in the IRZ, where moderate salt storage and moderately extensive groundwater occur together, not as previously presumed in the LRZ. On a river basin scale these salinity effects are minor.

TABLE 36

MEAN ANNUAL STREAM SALINITY OF TREATED CATCHMENTS

(flow weighted in mg/L TSS)

CATCHMENT	MEAN ANNUAL RAINFALL (mm)	YEAR OF LOGGING	MEAN TSS (mg/L) BEFORE LOGGING	MAX. TSS (mg/L) AFTER LOGGING	TSS (mg/L) IN 1985
Crowea	1380	1977	142	192 (1979)	153
Poole	1290	1977	102	196 (1979)	163
Iffley	1220	1977	352	432 (1979)	307
Mooralup	900	1977	no data	142 (1980)	no flow
Lewin South	1220	1982	99	182 (1985)	182
March Road	1070	1982	153	314 (1985)	314
April Road North	1070	1982	101	140 (1985)	111
Yerraminnup South	850	1982	133	114 (1985)	114

In some micro catchments brackish base flows may occur in the IRZ after harvesting during periods of low stream flow. This could be minimised by more widespread use of stream buffers (see Section 6.1.4).

- Sediment Loads

Without the use of buffers along streams, small and temporary increases to sediment loads will occur, for two to three years after harvesting, particularly if activity takes place during winter. The effect is minor on the regional scale, although it could be significant in a local catchment feeding a small water supply system. No such system exists however in the area of operation.

Sediment loads are reduced by stream buffers.

- Long Term Water Yield

As a larger proportion of the project area is converted to vigorous regrowth forest stream yields will decline. This will be of little consequence to water supply until these resources are due to be developed in about 30 years time. It is possible to design forest thinning operations to optimize both water and timber yields.

7.1.3 Impact on Fire Behaviour and Control

The south west of Western Australia has a mediterranean climate which means that the conditions are favourable for high intensity fires to occur in every summer. Such destructive fires occurred in the past (Dwellingup in 1961, Boorara in 1969) prior to implementation of the Forest Department's fuel reduction policy over all forest areas. Since 1969 however, no such fires have occurred in State forest although the potential for them has been present on many occasions and serious fires have occurred in National Parks in the region. Fuel reduction burning has enabled many potentially disastrous fires to be controlled before serious damage occurred (Underwood et al. 1985).

A harvesting operation of the nature described in Sections 4.2.6, 7 and 8 has the potential to change fire behaviour and control through modification of fuels and fuel reduction practice, though increased risk of ignition, and through provision of fire suppression facilities such as greater access and more manpower and equipment.

- Fuels and Fuel Reduction

Harvesting of wood products is followed by regeneration which, in order to preserve its commercial potential, must be protected from fire for 15 to 20 years in karri and approximately 10 years in jarrah. Although burning after harvesting reduces fine fuels, developing regeneration reaches a readily flammable stage at approximately five years in jarrah and between 5 and 10 years in karri, depending on initial stocking rate and understorey species and density. Fuels in excess of 29t/ha have been measured in 15 year old regeneration (McCaw 1986). This means that as density and cover increase a greater proportion of the forest could exceed the desired maximum of 8t/ha jarrah and 19t/ha karri. The increased risk associated with this growth will be compensated somewhat by fuel reduction burning in the older regeneration. However, this will not be sufficient to prevent an overall increase in the incidence of high fuels.

The Department of Conservation and Land Management recognises this and has adopted a sequence of harvesting operations to ensure broad and narrow buffers are retained within which fuel reduction burning will continue. The presence of these buffers will tend to reduce the intensity of wildfires adjacent to private property. Accordingly, the buffers serve to control the spread of wildfires and minimise the damage that they cause.

Maintenance of these burning buffers is critical to the fire protection of the project area. Despite the constraints they place on logging, they are necessary for additional fire protection as a supplement to suppression capability alone.

Rate of fire spread and fire intensity is directly proportional to fuel loads (Peet 1965). Experience through-out the world has shown that under extreme fire risk conditions when a fire starts, no suppression organisation is capable of containing it in heavy fuels. Low fuel buffers are required to reduce fire intensity and spread, and thus to enable effective suppressive actions.

- Ignition Risk

The risk of a fire starting is proportional to the number of potential ignition sources present.

CALM uses fire to achieve a range of silvicultural and management objectives.

Examples of CALM's use of fire include:

- advance burning of mature jarrah forest to reduce undergrowth for faller safety during harvesting and to lessen fuel loads for post-harvesting regeneration burns,
- mild intensity post-harvesting regeneration burn in jarrah to stimulate lignotubers and remove fine fuel from harvesting debris,
- high intensity slash burn for regeneration of karri following harvesting,
- mild tops burn of karri thinnings to reduce fine fuel loads at ages 20+ years,
- low intensity burning for fuel reduction in both mature forest and regeneration over 10 years age jarrah and 15 years old for karri.

Within the licence area in 1985/86, there were 40 high intensity slash burns covering 1866ha, 290ha of advance burns, 2450ha of jarrah regeneration burns and 86,431ha of fuel reduction burning.

Table 37 presents statistics compiled by CALM on the causes of wildfires over a five year period. As shown on this table, 14 percent of wildfires were attributed to escapes from prescribed burning operations, but since burning is carried out under mild conditions such fires are small and do not represent a control problem.

These include:

- Prior control of fuel levels on the perimeter of burn areas,
- Redefining suitable conditions for burning.

TABLE 37

DEPARTMENT OF CONSERVATION AND LAND MANAGEMENT
WILDFIRE STATISTICS

FIRE CAUSE	AVERAGE FOR FIVE YEARS TO JUNE 1984 ALL CALM FOREST REGIONS
Deliberately lit	29
Escapes from other burning off	21
Escapes from CALM burning	14
Accidental by timber industry	3
Accidental by other industries	6
Accidental by recreationists	6
Lightning	6
Unknown	11
Other	4

- Resource Availability for Suppression

The development of combined harvesting operations for chipwood and sawlogs has increased the availability of contractor based manpower and machinery operating in the forest. In the past, harvesting machinery and manpower has been used for fire fighting by CALM. CALM (1987b) proposes to upgrade training of harvesting and sawmill crews for control of large wildfires.

In addition CALM has increased staff numbers to manage the integrated timber operations and these staff are available for the planning and implementation of fire protection operations.

In summary harvesting will decrease opportunities for control burning in some areas for a short period. This risk is offset to a large extent by the protection strategy employed by CALM and the additional suppression capability from harvesting contractors. This will continue to protect neighbouring assets, and reduce forest damage to an acceptable level.

7.1.4 Terrestrial Flora

7.1.4.1 Return of Vegetation Following Harvesting

The intensive nature of the combined sawlog and chipwood harvesting operations leads to removal of a high proportion of the standing trees, particularly in karri-dominated forest where both the dominant (karri) and the co-dominant (marri) species are utilisable down to small size. This is accentuated by subsequent regeneration treatment, which is designed to remove the debris, converting it by intense fire into an ash-bed which provides optimum conditions for the germination and subsequent competition - free growth of the karri seedlings. The fire kills off all above-ground parts of the original vegetation, stimulates germination of dormant seeds stored in the soil and releases nutrients locked in the litter and the debris. The capacity of the regenerating vegetation to return to a new equilibrium is a key consideration in examining the impact of the operation.

There have been several studies of the recovery of the vegetation following the perturbations caused by intensive harvesting and regeneration. The first of these, carried out by Kimber and Penthony in the 1970's, aimed at investigating the vegetation succession by the study of stands of varying ages since regeneration. It indicated that with increasing age the regenerated stands approached the pre-harvesting situation more closely in both structure and composition. However, definite conclusions could not be drawn from this study because of insufficient information on the pre-harvesting situation, and uncertainty about the initial comparability of the observation sites.

The next major study was part of the hydrological studies coordinated by the Research Steering Committee (the Kelsall Committee) and reviewed by DCE in 1980. In this study, the vegetation was described prior to harvesting and regeneration, and its subsequent recovery was monitored. The main sampling methods used were randomly located quadrats to describe cover and composition, and Levy-point rod sampling on a grid pattern to describe structural changes (Whiteley, unpublished data). The return of the vegetation was rapid even on the clearcut karri coupes (Crowea and Poole). Within one year 60 percent of the surface was covered by herbs, shrubs and vines, with a high proportion of leguminous species such as Acacia, Bossiaea and Kennedia.

Analysis of the floristic data indicates that a high proportion of the species originally present (83 out of 96 in Crowea Block and 70 out of 85 in Poole Block) were already present within one year after regeneration. In addition, a considerable number of new species (29 in Crowea, 21 in Poole), not observed prior to harvest, were also recorded. The new species in numbers and cover belonged chiefly to the families Orchidaceae, Poaceae, Apiaceae, Asteraceae, Goodeniaceae, Haloragaceae and Lobeliaceae. Some of these were exotic weeds, but many were indigeneous species responding to the changed environment, or stimulated by the regeneration burn. The species present before but not after the perturbance included a number of orchids, perennial shrubs and herbs. Although a high proportion of the original species returned early, their relative importance changed, the understorey of the regenerated forest being dominated by tall leguminous shrubs, in particular Bossiaea laidlawiana and Acacia pentadenia.
The above observations can be supplemented by the most recent studies of Inions (pers. comm.) aimed at the ecological classification of 203 regenerated karri stands, up to 100 years old (Appendix H). The initial analysis supports the earlier observations, in that the most common species present prior to, and after the harvesting and regeneration treatment, are widespread in occurrence and persistence, asserting their dominance with time. Some of the species not observed on the closely monitored coupes in the early stages of regeneration, such as Gahnia trifida, Thysanotus patersonii, Bossiaea linophylla and Orthrosanthus laxus, were observed in older regeneration. The study has not yet yielded additional information on the more ephemeral orchid species.

On the less heavily harvested and less heavily wooded jarrah-marri coupes, an even more rapid return toward the pre-disturbance situation was observed, presumably due to a higher persistence of perennial shrubs and herbs. The proportion of species present both before and after the perturbance exceeded 90% of total (147 out of 158 at one site, 99 out of 103 at the other). The strong initial floristic differences between the coupes persisted through the perturbance, reflecting major variation in soils and climate. A considerable number of new species appeared after the perturbance (32 at one site, 44 at the other), including a number of exotic weeds. Observation indicated that the persistence of exotic weeds on the relatively infertile jarrah sites is poor. The return of the indigineous plant cover is influenced by the intensity of the disturbance, being slowest on snig tracks and loading ramps, an observation also reported by Stoneman et al. (in prep).

The information on species regeneration is summarised in Appendix H.

The third main thrust of research has been in the field of stand dynamics and nutrient cycling (Hingston et al. 1979, O'Connell 1980, O'Connell and Menage 1982, O'Connell 1984). These indicate that the build-up of biomass is quite rapid, reflecting the mobilisation of nutrients by the regeneration burn and the prominent role played in the recovery by leguminous nitrogen-fixing shrubs and vines. Although these are less prominent in jarrah-marri than in the karri-marri stands, their role in the nutrition of the forest is highly significant.

7.1.4.2 Eucalypt Regeneration

Stoneman et al. (in prep) examine the silvicultural attributes of some 35 sites chosen to represent the range of forest type, rainfall zone and regrowth age. For regrowth ages older than 12 years (i.e. before present integrated harvesting commenced), they used a selection of the best examples of even-aged regeneration available. Their results indicate that eucalypt canopy density approaches pre-harvesting levels after about 10 years in karri, 15 years in HRZ jarrah-marri and 20 years in IRZ to LRZ jarrah-marri (Figure 20). They detected variation in growth rate, stocking and structure which they attributed to natural site variation, prior management effects on advance growth population, and soil disturbance. Effects of soil disturbance, noticed in early operations (pre-1976) is now minimised by better planning (avoiding vulnerable soil types, ceasing operations in wet conditions) and by rehabilitation of landings (refer to Section 7.1.1.1 and Wronski 1984).

The results also suggest that, in the medium term, even-aged regenerating stands will exceed the canopy density of mature forests. This is a feature of a youthful, actively developing stand where competition within the stand is intense. The practice of thinning is a well established silvicultural technique to enhance timber production in such stands. This practice is currently being developed.

7.1.4.3 Rare Plants

There are six species currently gazetted as rare within the region. These are: Grevillea ripicola, Grevillea drummondii, Kennedia glabrata Lambertia orbifolia, Prasophyllum triangulare and Pultanaea skinneri (Appendix B). Only Kennedia glabrata is confined to the licence area where it occurs in one place on a granite outcrop now located within the Shannon-D'Entrecasteaux National Park. Grevillea drummondii occurs mainly on or near granitic rocks, also mainly within the same Park. As with many other legumes, Kennedia regenerates profusely from seed following fire. The remaining four gazetted species have only been collected further north and north-west on the periphery of the area rather than centrally within it.

A further species that occurs centrally within the licence area, Pentapeltis silvatica, was deleted from the Schedule when it was found to be widespread and relatively common in southern forests.

Other species indicated in previous studies to be relatively uncommon, but not warranting gazettal as rare, fall into the following categories:

- o Species mostly restricted to the southeastern portion of the licence area near Walpole, where they are relatively common and well represented in National Parks and Flora/Fauna Management Priority Areas - Aotus passerinoides, Bossiaea webbii, Eucalyptus brevistylis, Eucalyptus ficifolia, Eucalyptus guilfoylei, Eucalyptus jacksonii and Hydrocotyle hirta.
- o Species occurring only on the periphery of the licence area, and therefore unlikely to be severely affected - Acacia semitrullata, Acacia tayloriana, Dasypogon hookerii and Tetratheca parviflora.
- o Species of edaphically or topographically extreme sites, unlikely to be directly affected by the operations - Burchardia monantha, Centrolepis fascicularis, Erymosyne pectinata, Gastrolobium brownii, Hemigenia microphylla, Lomandra ordii, Restio ustulus and Schoenoplectus pungens [=Scirpus pungens].
- o Species recorded from normal forest sites within the licence area - Choretrum laterifolium, Danthonia pilsoa, Hemigenia podalyrina. Of these, the Choretrum and Danthonia have broad distributions but are infrequently collected. Both have been reported from regenerated areas. Although CALM records documented only one collection of Hemigenia podalyrina from Shannon, there are six other collections in WA Herbarium from as far afield as Wagin and Wickepin. Clarification of the status of these species by further studies and surveys is needed.
- o Species that thave been eliminated due to current taxonomic revisions - Hibbertia gilgiana.

7.1.4.4 Eucalypt Diseases and Pests

The integrated harvesting operation causes localised soil disturbance and temporary reduction in forest cover and evapotranspiration. Any forest operation which disturbs the soil has the potential to spread dieback fungus and create conditions favourable for its activity. However, the risk of spread of the fungus is minimised by hygiene procedures around which the whole harvesting operation is planned (see Sections 4.2.7.2 and 6.2.1.4. The hygiene is comprehensive and has deliberately built-in overlapping precautions. Further improvements in dieback management are expected as a consequence of improved site vegetation classification (Strelein in press) which will provide better indication of likely variations in disease susceptibility.

The temporary reduction in evapotranspiration is reflected in temporary hydrological change such as elevated groundwater levels and enhanced stream flow (see Section 7.1.2). It would also increase soil water storage which may favour fungal activity (see Section 6.2.1.4). However, numerous other factors in addition to soil water contribute to fungal activity and may prevent disease expression even given favourable soil water conditions. The fungus has been present in the southern forests for a long period of time. Although disease has resulted in mortality of some species, severe disease expression is relatively uncommon.

No insect problems appear to be of concern in relation to karri harvesting operations. In jarrah, leafminer damage has been associated with edges and clearings in the forest and with the new foliage growth this can create (Abbott 1985). However, this is considered to arise from the preference of the adult moth to lay eggs in a sunny position rather than to some increase in vulnerability of the tree itself. In a recent study by Abbott (pers comm.) where leaf damage was analysed in relation to 12 environmental and stand variables no significant association was found with recent harvesting.

7.1.4.5 Genetic Diversity/Integrity of Harvested Species

Forest management has the potential to impact on the genetic diversity and integrity of the forest tree species through the method selected to regenerate the forest. No manipulation of non-tree species takes place and hence no significant changes to the gene pool of these species is likely to occur (see Section 7.1.4).

Harvesting operations, the regeneration techniques used and their potential impacts on the forest gene pool are summarised in Table 38.

TABLE 38

FOREST TYPE, REGENERATION METHOD AND POTENTIAL GENETIC IMPACT

FOREST TYPE	REGENERATION METHOD	POTENTIAL GENETIC IMPACT
Jarrah-marri	From existing lignotuberous advance growth	None. Genetic makeup of regeneration established prior to cutting
Jarrah-marri	Where advance growth is inadequate light cutting to create gaps and encourage germination and establishment of seedlings	Slight - diversity influenced by trees retained as seed source
Karri-marri	Clear felled and hand planted with seedlings raised in a nursery	Karri diversity and Integrity will vary according to the seed source and collection pattern
Karri-marri	Clearfelled and seeded with previously collected seed	As above
Karri-marri	By seed from trees retained during harvesting for that purpose	Slight - karri diversity affected by seed tree selection process

Hand planting and artificial seeding have over the last decade been applied to an average of 1,450ha out of a annual programme of 2,260ha provided seed used for these operations is collected and used appropriately the long term reduction in genetic diversity or integrity is not considered significant. Measures used by CALM to ameliorate the potential impacts are discussed in Section 9.2.7.

The introduction of exotic species to regenerated areas is a means by which genetic integrity may be affected. CALM has a programme to establish a 100ha/year of Eucalyptus muellerana (yellow stringy bark) interplanted with karri. It is intended that the stringybark will be thinned out for poles and posts early in the rotation leaving a pure stand of karri to grow to maturity.

If E. muellerana becomes self-regenerating, it is possible that it would gradually establish itself as part of the karri ecosystem. Attiwill (1982), has stated that he regards the proliferation of exotics as the greatest threat to conservation of the karri. He qualifies that by stating that it is acceptable if practiced on a limited scale for a specific purpose. CALM will monitor this programme and undertake the necessary remedial actions if this exotic species is found to regenerate. In addition, the policy of planting E. muellerana is under review and may be discontinued.

CALM varies its approach to the use of 'exotic' (non-WA) tree species depending on the land use designation of the area concerned. CALM has a policy which requires that native species are used to regenerate disturbed sites (e.g. old gravel pit roads, etc.) in conservation priority areas, and most timber production areas.

7.1.5 Terrestrial Fauna

The integrated harvesting operation and the subsequent regeneration burn produce a major disturbance to fauna within each coupe and may also cause impacts beyond the coupe. However, in many respects this intensive disturbance is little different from that which occurs due to wildfires. Wildfire is an impact to which the southern forests have been intermittently exposed since long before the arrival of European man (Hallam 1985, Christensen and Annels 1985). Hence the existing knowledge of fire impact on fauna is useful in anticipating many of the impacts of the operation.

Although many forest species may have similar abilities to accommodate fire, as those observed by Christensen (1980) in some of the adjacent woodland species, the intensity and completeness of a regeneration burn is such that few individuals amongst the higher animals are likely to survive within the burn area. Displacement into adjoining areas may also be hazardous. For strongly territorial species, attempts to establish in already occupied adjoining forest may lead to high mortality (Christensen 1980). In contrast less territorial or nomadic species such as nectivorous overstorey birds would have less difficulty in re-locating.

Thus the pertinent questions relating to the impact of the operation concern the rate and completeness of recolonisation, which depend on two factors - the availability of coloniser stock in adjoining areas, and the attractiveness of the regenerating coupe to the colonisers.

The value of the adjoining forest as a source area for colonising fauna depends on its distribution, management regime and habitat types. In extensive wood production areas the full potential range of species could not be maintained where the period of habitat regeneration exceeds the management rotation length. For example, rotation lengths, at least in karri, of less than 100 years, would be inadequate for regeneration of trees bearing hollows (Mackowski 1984, Inions 1985) which are important for many mammal and bird species. In the karri forest Wardell-Johnson (1985) recorded that 14 out of 44 bird species observed in spring, 1982 used hollows as nest sites.

Various practices have been adopted to preserve mature habitat dispersed with regeneration forest. Firstly, harvesting coupes are widely dispersed and, early in the first rotation this ensures good mixing of young regenerated areas with mature forest.

Secondly, some 35 percent of forest within the licence area is reserved for conservation, including National Park, flora/fauna/landscape protection and recreation (see Section 4.2.9). In these areas, mature trees can be retained in perpetuity and they serve the purpose of habitat and species protection on a regional scale. As such they must be large discrete areas, which reduces their effectiveness for local scale recolonisation of regenerating areas.

Thirdly, in recognition of the need for retention of mature forest at a local scale, the original EIS (Forests Department 1973) proposed that some 20 percent of each forest block allocated to wood production remain uncut. Retained areas were distributed in a network of road, river and stream corridors within the wood production areas. To ensure their efficacy for fauna protection and aesthetics the corridor width chosen for this network was relatively large (800m for roads, 400m for rivers, 100m for streams). Given a priority for roads and rivers, few first and second order streams are currently protected (for a definition of first and second order streams see Gregory and Welling 1973). Hence reserved areas can often be some distance from regenerating coupes.

There is a case for redistribution of the existing area committed to reserves. The two important factors in this case are the relative excess of area allocated to road reserves and the relative deficiency of areas allocated to the more diverse, species-rich and widely dispersed streams (Loyn 1980, Recher et al. 1980, Recher et al. in press, Christensen and Kimber 1975). A preliminary review by CALM indicates that contraction of road reserves to an aesthetically acceptable minimum should generate sufficient area to provide reserve up to 100m in width on all streams down to the first order.

The attractiveness of the regenerating coupe to colonising fauna is linked to the vigour, composition and structure of the developing plant community. These attributes pass through a succession of stages and this is reflected in faunal changes as well. A generalised picture emerges from the work of Christensen and Kimber (1975), Christensen (1980) and Underwood and Christensen (1981). The mammals first return is represented by the large, mobile grazing macropods - the western grey kangaroo (Maropus fuliginosus) and the western brush wallaby (Macropus irma) exploiting the new crop of shrubs. The opportunist introduced house mouse (Mus musculus) can reach plague proportions by year two. As vegetation density becomes substantial in years 3 to 5, breeding populations of small mammals become established, most commonly the bush rat (Rattus fuscipes). In the long term (greater than 10 years) the mardo (Antechinus flavipes), a recognised slow coloniser, will appear.

Birds resident in the overstorey suffer radical long term change in the structure of their habitat. This is reflected in greater alteration to overstorey than understorey bird species and populations. Wardell-Johnson (1985) has established base-line data to quantify these changes.

During 1984 there was severe damage in orchards due to the recognised bird pests the Port Lincoln ringneck (Barnardius zonarius), red-capped parrot (Purpureicephalus spurius), western rosella (Platycercus icterotis) and Baudin's cockatoo (Calyptorhynchus baudinii). Degree of such damage has popularly been linked to the availability of the major diet components, marri nectar and seed. There was concern that the natural fluctuation in the marri flower crop might have been exacerbated by marri removal for woodchipping. However, Halse (1986) concluded that the evidence relating orchard damage to poor marri flowering was weak. Furthermore, marri regenerates strongly in harvested areas and flowers at an early age.

For species known to be rare or restricted it is necessary to do more than rely on the success of regeneration and recolonisation. All five species of mammals listed as rare and known to occur in the southern forest (see Table 23), occur in the Perup fauna management priority area and do not enter the high forest formation on which the woodchip project is centered. Burrows (1985) details the elaborate fire management practices which have been developed for their protection. Only one species, the common ringtail possum (Pseudocheirus peregrinus) is likely to occur in areas subject to sawlog and chiplog harvesting. Its preference for riverine habitats give it adequate protection over its wider range. Recent research indicates excellent responses in population of all of the species to control of the fox populations, providing another means of protection of these species.

Two of the listed bird species - the crested shrike-tit (Falcunculus frontatus) and the red-eared firetail (Emblema oculata) - although uncommon, appear to have widespread stable populations.

The impacts on frogs and reptiles are limited by their preference for habitats not directly impacted by harvesting i.e. stream zones and rock outcrops/open areas respectively.

The autumn burning carried out for regeneration is the favoured period for minimum adverse impact on the soil and litter invertebrates (Majer, 1985). As an indicator of the regeneration of normal decomposer activity, O'Connell (1987) found that once vegetative cover was re-established, leaf litter breakdown rates returned to similar levels observed in older stands.

The benefits of extension of stream reserves or buffers both for fauna protection and recolonisation potential (this section) and for water quality protection (see Section 7.1.2) also has potential benefits for aquatic life. The extent of suggested buffers (50m either side of the stream) appear extremely effective at reducing potential sediment flows and this should minimise impact on stream biota (Harris-Daishowa (Australia) Pty Ltd).

7.1.6 Impact on Landscape Values

The perceived impact of harvesting on the overall visual quality of the area will vary according to personal preference. There are however, some basic characteristics of timber production operations whose potential impact landscape can be generalised. The following table (Table 39), adapted from Davey et al (1984) describes the potential impacts of timber harvesting on forest landscapes.

TABLE 39

POTENTIAL IMPACTS OF TIMBER PRODUCTION ON FOREST LANDSCAPE

TIMBER PRODUCTION OPERATION	GENERAL CHARACTER	RELEVANT VARIABLES	IMPACT ON LANDSCAPE
Harvesting			
Falling[1]	Coupe harvesting average area 77ha karri and 123ha in jarrah	Coupe size and configuration; coupe alternation; vegetation retention within coupe; screening from: forest roads, vantage points recreation sites	Potential for extremely obvious visual changes. Most significant changes at close quarters with potential for highly disturbed appearance. Severe change in forest canopy and texture at a distance
Snigging	Haulage by skidder to central landing for loading; saw-logs and chiplogs separated and loaded	Location with respect to roads; size	Major visual change in small area. Usually screened from distance
Regeneration/Tree Planting			
Slash/ regeneration burning	Eucalypt	Intensity of burn-timing of burn; amount and distrib-ution of slash; coupe size etc.for as coupe harvesting	Initially increases highly disturbed appearance, then (within 2 years) leads to dramatic change because of dense even-aged regeneration
Fire Protection			
Hazard reduction burning		Intensity of burn. Season of burn	Substantial understorey changes; extensive subtle changes in landscape character of forest vegetation; major and very widespread visual pollution from smoke
Haulage Roads	Major and minor graded and surfaced roads	Design, and construction standard; terrain	Potentially very obvious linear modification, some-times with major local and distant impacts - break in canopy and exposure of disturbed ground

TABLE 39 (cont'd)

TIMBER PRODUCTION OPERATION	GENERAL CHARACTER	RELEVANT VARIABLES	IMPACT ON LANDSCAPE
Borrow Pits	For road making	Siting, rehabilitation standards	Major small scale change, usually screened from distance
Snig Tracks	Extensive network of short ground disturbances	Screening from forest roads and recreation sites	Relatively short lived moderate scale disturbance
Landings	Small clearing of major disturbance	Screening from forest roads and recreation sites	Major small scale changes usually screened from distance
Minor Access	Vehicular access usually dry weather only		Local impacts in most cases

Many of the forest management operations can alter the appearance of the landscape. It is widely accepted that some of these operations do have, at least in the short term, a detrimental impact on the visual quality. The planning and safeguards outlined in Section 9.2.7 ensure that long term degradation of the forest as a scenic resource is avoided.

Many of the coupes are not within the view of major or minor tourist routes, but where views are possible the most severe impact occurs within the first three to four years after harvesting. After this period the regeneration begins to blend with the surrounding forest. The even-aged young regrowth does not have the diversity in size of the mature forest but once the trees are 40-50 years old, the area once again takes on the visual characteristics of a forest. This can be seen in such areas as Big Brook and Treen Brook near Pemberton.

As outlined in Section 5.1.2 approximately 45 percent of the Licence Area is to be excluded from clearfelling harvesting operations. Some of this reservation is primarily to preserve visual quality. Such areas include Fauna, Flora and Landscape Management Priority Areas. Many of the major tourist routes are visually buffered from the harvesting operations through the reservation of roadside reserves. These are up to 400 metres wide on each side of the road.

Buffering has also been used around National Parks, Nature Reserves, specific recreation sites, significant rock outcrops, scarps, lakes and swamps to protect visual quality and other values. Stream reserves which are up to 200m wide also help to maintain visual quality.

Other safeguards include dispersion of coupes within forest blocks. Coupe outlines and boundaries are considered along with the network of access tracks, particularly in the elevated areas north of Walpole. Specific high visitation viewpoints such as Gloucester Tree are considered when harvesting is planned. The view from the Gloucester Tree outlook platform was evaluated to ensure that the quality of the outlook was retained.

Remedial works are undertaken to rectify specific visually discordant elements which were not predicted. Such operations include modifications to adjacent forest profiles and coupe boundaries. Rehabilitation of snig tracks and log landings etc. are also undertaken which minimises visual impact.

7.1.7 Impact on National Estate Values

7.1.7.1 Introduction

The Australian Heritage Commission's role in compiling a register of places of National Estate significance has been described in Section 6.0.

Places either on the register or being considered for inclusion are listed in Appendix D and are shown by Figure 18.

This section discusses the need for additional reserves, the possible impacts of proposed CALM management on the National Estate values within the project area, and impacts on the project resulting from increasing the extent of current listings.

7.1.7.2 Need for Additional Listings

Current National Estate registrations within the project area are largely confined to existing reserves within CALM lands (see Appendix D, Figure 18). This is appropriate and reflects the considerable depth of investigation and the detailed planning that has been used by CALM in formulating the reservation system. Attiwill (1982) in his independent review of the recommended EPA reserves concluded that the system is adequate in terms of the biology of karri and would provide a sound basis for conservation of the karri forest. The EPA's objectives in setting up the reserve system were to develop an adequate representative system of areas for conservation of flora, fauna and landscape, and for recreation.

The AHC has registered all of the EPA's recommended reserve systems with the exception of the more recently reserved sections of the Shannon Basin. When these remaining areas are registered it is reasonable to conclude that the National Estate Register will include places which collectively constitute an adequate representative system for the karri forest and that the significant landscape and recreational needs will also have been met.

The assurance of security of tenure and purpose for the reserve system spelt out in CALM's Southern Forest Regional Plan (CALM 1987a) should ensure that the reserve system continues to fulfil the objectives defined above.

On this basis there is no need for registration of substantial additional areas within the karri forest. However the AHC is in the process of assessing additional places for inclusion in the register. These areas include substantial areas where production forestry is CALM's priority land use.

It is difficult to assess the need for these additional areas in the absence of detailed descriptions of their possible National Estate values. This problem is further complicated because the AHC has combined existing registered reserves with unregistered forest production areas and is proceeding to assess the combined area as a single unit. The statements of significance provide no clear indication of those values which relate to the registered reserve area alone; those which are common to the whole area; those which rely on the whole area remaining undisturbed, and those values which are unique to the forest production areas.

While it is not possible to discuss particular values of individual areas it is possible to examine the types of values which have been ascribed to the additional areas. From this examination the likely impact of CALM's proposed management on these types of values can be assessed.

National Estate values are assessed by the AHC using an established set of criteria. National Estate values either relate to specific sites or they relate to attributes shared by the whole or most of a place. Values can either be unique to a place, or nearly so, such as sites supporting rare or endangered flora or they can be attributes which satisfy several criteria that relate more to a lack of development, than to any inherent unique feature of the site. Examples of this type would include scientific benchmark or reference areas. Given the comprehensive nature of the EPA's work in planning the existing reserve system it is doubtful that a case exists for additional large scale registrations for such non-unique values which are equally or better represented in existing conservation areas.

The case for additional registrations to recognise places with unique values remains valid, if such unique values are in fact present.

On this basis the case for registration of the Deep River Valley could not be considered compelling in view of the existence of the Shannon River Basin Reserve immediately adjacent to it.

Similarly the case for registering the Beavis Block simply because it forms 'part of an ecological and management unit', is dubious.

However, there may be parts of these blocks - for example locations of rare or endangered flora and fauna - which do justify National Estate status.

7.1.7.3 Impacts of CALM Management on National Estate Values

Appendix D lists National Estate areas within the project area. The table identifies planned harvesting activities within each place during the currency of the proposed licence period.

The vast majority of National Estate areas will remain unaffected by harvesting operations. Places that are harvested would lose National Estate values that depend on large undisturbed areas of forest. However, values related to specific sites such as rare or endangered flora or fauna can be, and are, readily accommodated by reservation from harvesting.

Values relating to rivers (e.g. the Deep River) which depend on maintenance of river values are accommodated through CALM's existing reservation system.

On this basis it is reasonable to conclude that CALM's proposed management of the karri forest will not prejudice the National Estate values of the forest as a whole.

7.1.7.4 Impact of the Timber Industry on National Estate Registrations

The Commonwealth's responsibilities towards National Estate places were described in Section 6.6.3.

Table 40 sets out those areas potentially affected and the significance of these areas to projected future sawlog and chiplog supplies from the project area.

The Commonwealth clearly has an obligation under its legislation to closely examine sources of chiplogs and could possibly prevent export of chip removed from National Estate areas, if National Estate values were likely to be prejudiced. However, the State Government is under no such obligation.

CALM has indicated its intention to harvest sawlogs from all areas of forest nominated for wood production. This intention underpins the Timber Industry Strategy and the sustained yield strategy for the karri and jarrah forests.

A decision by the Commonwealth to quarantine the chiplog component of these resources would entail the loss of 2.1 million tonnes of chiplogs in the licence area or approximately 140,320tonnes/annum if taken over 15 years. Approximately 10 to 11 percent of the annual export volume would be excluded. Resources are not included from within the Beavis-Giblett Block. This forest is not programmed for harvest during the proposed licence period.

The impacts attributable to a loss of chiplog resources from within the areas discussed above are addressed under the alternatives section (see Section 8.0).

TABLE 40

SAWLOG AND CHIPLOG RESOURCE WITHIN NATIONAL ESTATE CATEGORIES

NATIONAL ESTATE STATUS	LOCALITY	CUT TO DATE %	AVAILABLE FOREST (ha) NOT CUT & REGEN. K	J	RESOURCE Karri S/L m^3	Jarrah S/L m^3	K & M CHIP tonnes
Registered Sites	Lindsay	9[1]	500	500	24,000	17,000	109,000
Not to be harvested during proposed licence period	Beavis/ Giblett	27[2]	2,150	1,295	376,000	31,000	458,000
	SUB TOTAL	-	2,650	1,795	400,000	48,000	567,000
Interim Listing	Beavis	67	450	510	57,000	23,800	113,800
	Hawke	6	940	1,620	229,000	59,000	425,000
	SUB TOTAL	-	1,390	2,130	286,000	82,800	538,800
Site Awaiting Assessment	Deep River	14[3]	4,600	8,050	753,000	360,500	999,000
	TOTAL		8640	11,975	1,439,000	491,300	2,140,800

1 All selection cut in the past - 9 percent classified as even-aged regrowth. All is being thinned at the moment.
2 Percentage of area available for harvesting excludes road, river and stream reserves.
3 In the absence of a clear area definition from the AHC the Deep River area is assumed to include all of Wye, Deep, Dawson, Burnett and Keystone Blocks.

Source: CALM (pers comm.)

7.1.8 Silviculture

7.1.8.1 Choice of Silvicultural Systems

In those areas of State forest with a land use priority for wood production, CALM's silvicultural system will be aimed at continuous production of sawlogs with other wood products being produced in lesser quantities or produced in the process of enhancing sawlog production. Silvicultural practices aimed at long term health of the forest must also consider factors other than wood production even where this is the primary use. Silvicultural system, rotation length, sequence and dispersal of harvesting operations, and distribution of reserves are all relevant factors. Modifications of these practices to satisfy fauna and water resource requirements in particular are discussed in other sections.

Silvicultural systems involve a series of cyclic events which include harvesting; regeneration establishment; protection and tending of the regeneration and the developing second growth forest. (Bradshaw 1986). They should be capable of repeated cycles of such events without a deterioration in productive capacity of the forests.

The reasons for the adoption of the clearfelling system and even aged management system for the karri forest have been described in Section 4.2.7.1. In summary, the clearfelling system provides the clearing necessary not only for regeneration establishment, but to allow for its maximum development without the suppressive influence of older trees. Furthermore, subsequent cycles of harvesting can take place without causing excessive damage to the regrowth. Whilst the alternative approach of selective harvesting in karri forest often does provide the opportunity for regeneration establishment, this is only the first phase of development. Future development is seriously impaired by suppression by older trees and damage during subsequent harvesting cycles is severe.

Similar principles apply to the jarrah forest but the smaller size of the trees and the absence of the need for a hot fire to prepare a seed bed for regeneration, means that the clearings can be smaller, such that it is often described as a group selection system.

It appears to be a popular misconception that selective harvesting in the form of "commercial selection" of good quality sawlog trees can go on ad infinitum without causing long term deterioration of the forests capacity to reproduce those products. Selective harvesting of this kind is merely an exploitation of the best products of the forest for as long as they will last and cannot be considered a proper silvicultural system. Far from ensuring a continuing supply of sawlogs into the future this system inexorably reduces the forests capacity to produce sawlogs.

Any system of harvesting which repeatedly removes only the best quality trees or only one particular species will eventually lead to the creation of a forest which is dominated by lesser quality trees or the less favoured species. It will have been exploited for its present high value products, without the opportunity to regrow those products. This is the consequence of a system which removes only sawlogs and does not remove other less commercially useful species.

The proper application of any silvicultural system, whether it be based on even-aged or uneven-aged principle (ie. from clearfelling or selection systems) requires the removal of undesirable trees which would otherwise occupy space to the exclusion of more useful trees, or would inhibit their development. The extent to which this is a problem depends on the species composition, age and health of the forest. In virgin forest where many of the trees are old and contain faults which preclude their use for sawlogs, the problem is often considerable.

Deliberate removal of these trees in silvicultural tending operations is expensive and for that reason has often not been carried out following sawlog operations, even though the need for it is well recognised. Notable exceptions occurred in the jarrah forest during the Depression period and in the karri forest during the 1930's and from 1967 to 1975. In order to achieve this silvicultural objective (removal of trees unsuitable for sawlogs) the Forest Department actively sought to establish residue using industries. This was finally achieved with the establishment of the chipwood industry in 1975.

7.1.8.2 Impact of the Woodchip Industry on the Silviculture of the Forest

The role of the woodchip industry in forest operations is:

- o In areas of forest requiring regeneration following sawlog harvesting, to remove trees which would occupy space to the exclusion of potentially more useful trees, inhibit regrowth or lead to a domination by less useful trees.
- o To facilitate the thinning of regrowth forests and increase the growth rate of selected trees, by removing less thrifty trees of a size or quality unsuited for use as other, more demanding products such as sawlogs and poles.
- o To utilise those sections of trees which are felled for sawlogs, but which also contain sections of a size or quality unsuitable for sawlogs.

To the extent that the project removes this material, the silvicultural impact of the project is one of positive benefit. Specifically the benefits are:

- o The project assists silvicultural objectives by removing material which would otherwise remain as an impediment to long term continuous production of sawlogs by inhibiting regeneration establishment and development.
- o It obviates the necessity for the State to spend money to remove this material.
- o It provides an income to the State by utilising an otherwise waste material.
- o It utilises an otherwise waste raw material to produce a product for which there is a demand.
- o It assists long term production of sawlogs by providing an economic opportunity to thin the forest, thereby enhancing future sawlog production.

These benefits apply regardless of the silvicultural system employed by CALM.

Additional impacts which might result from increased areas of harvesting to supply chipwood only do not arise since WACAP is not seeking resources from the forest beyond those which are available to facilitate the silvicultural strategies of CALM.

7.1.9 Impact of Chipmill Operations

7.1.9.1 Air Emissions

Dust is not a problem at the Diamond Chipmill. Smoke is produced from burning of bark and fine residues. However, the location of the Chipmill is such that this smoke does not constitute a nuisance. The woodchipping operations, by removing non-sawlog wood from the forest and residues from the timber mills, actually reduce the amount of wood requiring disposal by burning.

Minor odours associated with the timber industry are produced at the Chipmill. These include the odour of freshly sawn eucalypt timber which many people regard as pleasant, and the odour associated with smoke. Again, the lack of habitation close to the Chipmill means that the effect of these odours is confined to the workforce.

7.1.9.2 Water Emissions

Wastes from washroom facilities are disposed of by means of a conventional septic tank system which infiltrates wastewater into the subsurface soils.

Discharge of excess water from the retention ponds occurs infrequently in accordance with the conditions of an Effluent Disposal Licence granted by the Water Authority which ensure that there are no adverse impacts on surface water quality.

7.1.10 Impact of Port Operations

7.1.10.1 Leachates from Woodchip Stockpile

Rainfall impinging on the stockpile soaks into the sandy soil beneath the stockpile. Temporary minor puddling occurs after prolonged heavy rain but the water is not discoloured and does not require external discharge.

7.1.10.2 Disposal of Ballast Water and Refuse by Ships

Ships using Bunbury Harbour for loading of woodchips are prohibited by law from disposing of ballast water, sullage or other refuse while in the harbour or its vicinity.

There have been no known instances of non-compliance with these laws.

7.2 SOCIO-ECONOMIC ENVIRONMENT

7.2.1 Introduction

As the proposal is to continue an existing operation, the socio-economic impact of the proposal is not significant. However, in order to address the issue of alternative courses of action, this section discusses the significance of the industry to the local regional and State economies in terms of both employment and income. It also addresses the tourist industry, other sectors of the timber industry and the social significance of the industry.

7.2.2 Output

The total value of production of WACAP operations in the State for the financial year 1985/86 was $38 million with total assets invested throughout the State of $18.1 million (1985 values). Using the output multipliers from the published input-ouput table, the indirect and induced output effects of the project mean a total output effect of $83.6 million for the State of Western Australia.

For the South West Region, total output of the WACAP operation was estimated at $15.8m. When multiplier effects are included, the total output effect on the region was estimated at $34.8m.

7.2.3 Employment Impact of the Chipwood Industry

In order to consider the employment and income effects of the industry, the employment data from Table 29 were summarised into local, regional and state wide levels and are shown in Table 41. As the coverage of the woodchip industry and its significant input industries was considered to have a high level of accuracy, it was then possible to estimate a Type I employment multiplier for the local economy and both Type I and II multipliers for the South West region. These multipliers are defined in Section 6.6.1.2. Use of the conventional Australian Standard Industrial Classifications (ASIC) system in this table results in Type I multipliers in excess of 4.0. Two Type I multipliers are therefore given in Table 41. One multiplier used the ASIC system and the other allocated timber felling and transport jobs as direct jobs. The data in Table 42 confirms that when allowance is made for the sectors that were not contained in Table 27, Type I regional multipliers from the published input - ouput table for the South West are at least as high for the woodchipping segment as for the entire forest products industry. The ASIC Type I multiplier shows that it may be considerably higher.

It is important to stress that it is by reallocating jobs to direct and indirect categories, that results in substantial increases in the size of the multiplier. The other aspect to emphasise and what is of most importance to the analysis, is the number of full-time equivalent jobs attributable to the industry, rather than the size of the multiplier.

7.2.4 Employment Estimates

The estimate of total full time equivalent jobs resulting directly and indirectly from the woodchipping industry in the Manjimup area was estimated to be a minimum of 287. As the above data has confirmed the reliability of the published input-output table multipliers, application of the regional multiplier to the number of direct jobs was considered to give a reliable minimum regional estimate. The results of the calculation are shown in Table 42.

TABLE 41

FULL-TIME EQUIVALENT JOBS AND DERIVED MULTIPLIERS
LOCAL, REGION AND STATE

JOBS	MANJIMUP & ENVIRONS	SOUTH WEST REGION	STATE
Direct	202	221	223
Indirect	85	119	130
Total	287	340	353
Type I Multiplier	1.42*	1.54*	1.58*
ASIC Type I Multiplier	3.63	4.3	4.46

* These multipliers were calculated directly from original data assuming that felling operations and transport were direct jobs. If ASIC codes were used, the multipliers would increase substantially. These figures do not take account of indirect jobs in sectors not shown in Table 29, so are considered to be minimum estimates.

TABLE 42

EMPLOYMENT MULTIPLIERS
AND TOTAL EMPLOYMENT ESTIMATES

	MANJIMUP AND ENVIRONS	SOUTH WEST REGION	
Type I	minimum estimate 1.4	1.8	
Type II	minimum estimate 2.01*	2.6	
		Low	High
Direct	202	221	221
Indirect	85	119	176
Induced	121	121	177
Total Jobs	406	461	574

* Estimated from previous economic base analysis in Section 6.6.1.2.

The estimated number of jobs including induced effects dependent upon the woodchipping industry, was estimated to be 406 for Manjimup and environs. For the South West region, the figure was estimated to be in the range 461-574 with the higher end of this range considered to be more likely. The lower estimate was derived by assuming that the regional induced effect must be at least as high as at the local level.

7.2.5 Comparison with Other Studies

Other studies have attempted to estimate the number of full time equivalent jobs resulting from the chipwood industry. These other studies have used total output figures to estimate resulting employment. Comparison of these results with the equivalent result from the present study is shown in Table 43.

TABLE 43

COMPARISON OF EMPLOYMENT ESTIMATES* WITH OTHER STUDIES

STUDY	NO. OF JOBS/ 100,000 TONNES OF PRODUCT	DATE & SOURCE	COMMENT
Harris Daishowa 1975	26	WD Scott (1981)	No region specified Excludes Forestry & Supervising Personnel
WD Scott (1981)	29-32	Kennedy and Dymowski	No region specified includes harvesting & transport
Eden EIS 1986 Harris Daishowa	69.3	Harris-Daishowa (Australia) Pty Ltd	South Coast Region. N.S.W. All direct and indirect.
Present Study	45.3		South West Region All significant sectors included

* Do not include induced effects

The present results are considered to be reliable as they are based on data from actual operation of the industry, and include employment from all significant sectors. Because not all indirect sectors have been included, the estimates may be considered to be minimum levels.

7.2.6 Income Estimates

Using income data supplied by WACAP and employment information from the previous sections, the total minimum household income estimates resulting from the Woodchip Industry are as shown in Table 44.

TABLE 44

ESTIMATED INCOME IMPACT, TOTAL HOUSEHOLD INCOME PER ANNUM

	MANJIMUP & ENVIRONS	SOUTH WEST REGION
Resulting from Direct and Indirect Jobs	\$6.2 million	\$7.3 - \$8.5 million
Resulting from Direct, Indirect & Induced Jobs	\$8.1 million	\$9.1 - \$11.2 million

These figures are considered to be minimum estimates for the Manjimup economy as they are based on the employment data from the previous section. These figures do not include any corporate income that may be distributed within the regional economy.

7.2.7 Productivity and Employment Changes

As presently envisaged, the industry will sustain the current level of employment over the term of the licence. To date, changes in employment due to more efficient forest procedures have been compensated for by employment in other segments of the direct or indirect workforce. Although more efficient machines have been introduced in the forest since the industry started, employment has not decreased because more employment has been required to handle the greater proportion of smaller, crooked and shorter logs now being consumed. It is expected that this trend will continue. In the immediate future, it is anticipated that employment may further increase with the expansion of WACAP plantations (see Section 5.2.3.3).

7.2.8 Tourism

Information on the exact position of the Tourist Industry in Manjimup Shire and its environs is extremely limited. Information supplied by the Pemberton Tourist Bureau indicated a growth rate in visitation of 17 percent in the last year which is a signficantly higher growth rate than could reasonably be anticipated by inspection of growth trends in the overall economy. This figure may also have been affected by the America's Cup.

The long term growth rate for the years 1971 - 1981 for the overall workforce was 1.64 percent. For the entertainment and recreation sector during the same period it was 0.8 percent. This sector would be the one which employs the majority of what could be considered the tourist industry.

In the more recent period 1976 - 1981 the growth in the workforce of the tourism sector was much higher rising to 6.4 percent. However, the important issue is how much of this sector's growth can be explained by growth in tourism rather than general growth in the workforce servicing the local population. The projections of various growth rates for employment in the entertainment and recreation sector are shown in Table 45.

TABLE 45

EMPLOYMENT GROWTH RATES IN ENTERTAINMENT AND RECREATION

GROWTH RATE		1981	1986	1991	1996	2001	2006
Long Term Growth Rate Entertainment & Recreation Sector 1971-81	0.8%	139	145	151	157	163	170
Total Workforce 1971-81	1.6%	139	150	163	176	191	207
Intermediate Rate for Sector	3.2%	139	163	190	223	261	305
Short Term Growth Rate Entertainment & Recreation Sector 1976-81	6.4%	139	190	258	352	481	655

Source: ABS Census, Pemberton Tourist Bureau.

If the major component of growth in the sector is local workforce growth such projections would be heavily affected if the forest industries were scaled down. In order to estimate the percentage of growth due to tourist activity, each hotel, motel or clearly dedicated tourist activity was assigned a share of employment, based on industry standards for servicing accommodation needs. The results of this assignment are shown in Table 46.

It should be emphasised that the employment assignment is based on full time equivalent jobs, not actual employment. A ratio of tourist to non-tourist employment was assumed to be 50:50. Actual employment can be considered to be significantly lower due to family - run motels and low occupancy rates.

The total of 91 full time equivalent jobs is therefore considered to be a high estimate of tourist industry employment in the Shire. It should also be remembered that a large percentage of business going to the hotel/motel sector would be generated by the timber industries, especially in Manjimup.

Assuming the intermediate growth rate of 3.2 percent from Table 45 the tourist industry employment in the entainment and recreation sector in 1986 would be 56 percent. At the highest possible growth rate of 6.4 percent per year for 25 years the increase in employment due to the tourist industry in the Shire would be 261 jobs. At the more realistic growth rates of 1.6% or 3.2% the result would be proportionally lower (see Table 47) i.e. 31 and 80 jobs respectively.

Local multiplier effects of the tourist industry are considered to be minimal as the majority of indirect purchases to the industry would be sourced outside the local economy. (Land Conservation Council 1986, Martin 1977).

Another important issue is the extent to which the tourist industry can create employment. Even though tourism may increase local income, there is evidence from the data on occupancy rates (i.e. presently below 50%) that there is considerable excess capacity in the industry. The majority of operations are staffed by family members. Consequently it may be argued that even if total visits are growing at high growth rates, the potential for employment growth in the industry would be limited.

As discussed in a previous section the main type of tourist presently visiting Manjimup Shire is the family group who is more interested in the aesthetic forest experience than 'conventional' tourism. However, again this type of visitor does not significantly affect employment because of the present level of excess capacity in the industry and the dependence on small, locally managed business. In some cases, this type of visitor does not use any designated facilities and their contribution to local employment is limited.

TABLE 46
ESTIMATE OF FULL-TIME EQUIVALENT JOBS,
TOURIST INDUSTRY,
MANJIMUP SHIRE 1986

	ROOMS	EQUIVALENT JOBS**	
		Non-Tourist	Tourist
Manjimup			
Bonne Beth Motel	16	4	4
Kingsley Motel	30	8	8
Manjimup Auto	56	15	15
Manjimup Hotel	38	10	10
Overlander Hotel	15	4	4
Sub total	155	41	41
Pemberton*			
Avalon Travelodge	6	2	2
Forest Lodge	9	2	2
Gloucester Motel	52	14	14
Karriholm Lodge	27	7	7
Pemberton Hotel	6	2	2
Sub total	100	27	27
Northcliffe			
Northcliffe Hotel	11	3	3
Sub total	11	3	3
Walpole			
Seagull Motel	13	3	3
Tinglewood Homestead	8	2	2
Walpole Hotel/Motel	30	8	8
Sub total	51	13	13
Ballingup			
Old Baley Tavern	7	2	2
Sub total	7	2	2
Pemberton Tourist Bureau	na	3	
Manjimup Tourist Bureau	na	2	
TOTAL	324	86	91

Source: Dawson's Hotel Guide - Domestic Travel Consultants Edition Oct, 1986 & Local Tourist Guide.

* Does not include caravan parks, Warren Guest House, Farmhouse B & B, Rose & Rainbow Cottages and two farm chalets.

** Not actual employment.

TABLE 47

PROJECTED INCREASE IN TOURIST INDUSTRY EMPLOYMENT

BY YEAR 2006 - MANJIMUP SHIRE

GROWTH RATE (see text)	JOB ESTIMATE
0.8%	14
1.6%	31
3.2%	80
6.4%	261

The increase in the growth rate of the entertainment and recreation sector of Manjimup in the period 1976-81 may also be considered to be evidence that the continuation of the woodchipping industry has not signficantly retarded the growth of this sector. In other words, the development of the two industries appear to be compatible, confirming the viability of the multiple land use policy.

7.2.9 Sawlog Production

Another important aspect of the impact of the woodchip industry is the effect on the production of sawlogs. Because of the integrated harvesting management strategy, significant economies are generated by higher utilisation of wood products. The integrated harvesting approach not only maximises returns to the forest industries and to CALM, but also maximises the use of the timber resource.

If woodchipping operations were discontinued, the viability of salvage harvesting and harvesting of more dispersed and less accessible stands of karri for sawlog production would be significantly reduced and total production of sawlogs would then most likely decline. Price rises for timber would inevitably result. There would be corresponding adverse impacts on employment and income for the local economy and the region. These effects have not been quantified but should be considered when alternatives are evaluated.

7.2.10 Impact on Apiarists

Forest Management practices undertaken by CALM which impact apiarists are:

- o Jarrah dieback control through Disease Risk Areas
- o Prescribed burning
- o Harvesting of mature trees.

In addition, recent land use decisions to reserve more forest areas for conservation priority, with a perceived threat that commercial feral bee sites would be excluded on environmental grounds or restricted through access control, is of concern to apiarists.

The restriction of access in disease risk areas has already impacted on the industry and it is unlikely that this impact will diminish.

Prescribed burning to reduce fuel build up in the forest is accepted by apiarists to protect the forest and its users including themselves. Burning however, can prevent bud set if tree canopies are scorched, resulting in a lack of honey flow. The switch to a greater emphasis on autumn burning and an increase in rotation length would alleviate this problem. CALM however, states that it already burns as much as practical in autumn and is constrained from increasing autumn burning by the short period of suitable weather available. To achieve the prescribed programme, a heavy reliance must still be placed on spring and summer burning. Extending the rotation length is not favoured in production areas as this would raise the level of fuel above that considered a maximum for suppression action to achieve success. CALM has however an extensive fire research section and it has undertaken to minimise the amount of burning and investigate the possibility of longer rotation lengths as far as safely possible. It also maintains a commitment to vary burning schedules according to the status of the flowering cycle.

Harvesting will impact on apiarists. Over the 15 years of the proposal an additional 20,000ha of karri type will be clearfelled and regenerated and possibly 60,000ha of jarrah-marri forest will be cut over. This will lead to a productive loss for apiarists, however, it will be compensated somewhat by the development to flowering age, of regeneration established as a result of previous cutting. The relative value of regeneration compared to mature forest is not known although in karri in particular it is likely to be well into the rotation before significant flowering occurs in regrowth areas.

The impact described above is as a result of harvesting per se. The additional impact of extracting chiplogs following a sawlog harvest is believed to be slight as these trees would be removed to waste to facilitate regeneration, and hence would be lost to apiarists in any case.

Whilst harvesting is accepted by Government as a land use in the project area apiarists, will, in the long term, be increasingly dependent on reserved mature vegetation and regrowth forests.

7.2.11 Social Impacts

7.2.11.1 Population

Using the household size factor for Manjimup Shire and the region from Section 6.6.2 and subsequent employment estimates the total population involved in the local woodchipping industry was estimated to be approximately 1,320 people. At the regional level the figure was estimated to be between 1,500 and 1810 people. For Manjimup Shire this figure represents 13.2 percent of the 1985 population.

7.2.11.2 Family Structure

Indicators of family type from Section 6.6.2 suggest that of the total population attributable to woodchipping, 35.7 percent would have dependents which equals approximately 470. At the regional level the proportion is slightly lower at 32.5% which would equal between 487 and 570 dependents.

As the Shire age structure also indicates a relatively young population, the above data suggest that in the population attributable to woodchipping there is a considerable involvement of families with dependents. The data on mobility also indicates a high percentage of the population to be longer term residents which again suggests considerable family involvement in the industry. This tendency was verified from the results of the local attitudinal survey in which 56 percent of those interviewed had lived in the area for more than 20 years and 70 percent for more than 10 years.

7.2.11.3 Community Infrastructure

With an estimated 470 dependents among the population attributable to woodchipping, local community infrastructure is also significantly affected by the operation. The most sensitive component of community infrastructure to industry changes would be primary school education. Approximately 376 of dependents in Manjimup could be expected to be of school age of which 210 would be primary school students.

7.2.12 Fiscal Impacts

WACAP has a considerable impact on State and Federal Government revenues. Table 48 lists payments to Government bodies in 1985-86, and shows that total revenue received by Government agencies in that year amounted to $15 million, 72 percent of which was paid to the State Government.

7.2.13 Historical, Archaeological and Ethnographic Sites

- Impacts

The historic sites are protected under CALM's Regional Management Plans and will not be impacted by forestry activities.

Potential impacts that may arise from continuation of woodchipping operations by WACAP on archaeological or ethnographic aspects, include disturbance to Aboriginal burial sites, artefacts, marked trees, stone arrangements or habitation structures. A management programme is outlined in Section 9.7.

7.2.1.4 Noise Impacts

Noise is not an important issue in this project as most of the operations are carried out in locations which are remote from human habitation. No significant changes are anticipated in the levels of noise generation, from those which been experienced from the operations to date. WACAP has not received any complaints relating to noise from its operations.

Occupational noise aspects of operations at the Diamond Chipmill were the subject of a study commissioned by WACAP in 1985 (Brindle 1985). As a result, a number of noise reduction and hearing protection measures were implemented to protect the workforce from noise induced hearing loss.

The residence closest to the Diamond Chipmill is located at a distance of 1.5km, of which 1.0km is densely forested. In this situation, no noise impact is evident. Accordingly, there should be no annoyance to residents from noise generated at the Chipmill.

Noise from trucks hauling chiplogs to the Diamond Chipmill represents another potential source of annoyance. Most of the haulage is through sparsely - populated State forest. Of the 20 to 25 trucks per day on public roads which deliver to the Chipmill, only a small proportion travel through Pemberton or Manjimup. The deliveries are made during daylight hours and travel through the towns is via the highway. As the operation will continue at its present production level, noise associated with truck transport is unlikely to cause significant annoyance.

TABLE 48

WACAP PAYMENTS TO GOVERNMENT BODIES IN 1985/86

		1985/86
FEDERAL GOVERNMENT		
Income Tax, Group Tax, Sales Tax and Bank Accounts Debit Tax		$4,059,000
STATE GOVERNMENT		
Payroll Tax, Financial Institution Duty and Stamp Duty		$106,000
Royalties, State Energy Commission, Motor Vehicle Licence Fees, Rail Freight, Wharfage Fees, IEHC House Rentals, Water Rates, Annual Rental Port Lease Area, Mill Registration		$10,817,000
LOCAL GOVERNMENT		
Rates		10,000
OTHER GOVERNMENT BODIES		
Telecom, OTC, Corporate Affairs, CSIRO		$133,000
TOTAL	approximately	$15 million

Source: WACAP

W.A. paper-wood is used to make high quality white paper.
This paper is used for writing pads, copy paper, books, magazines, and is basic to our cultural way of life.

8.0 ALTERNATIVES TO THE PROPOSAL

Alternatives must meet the test of being both **prudent** and **feasible.** That is they must represent an improvement over the proposal in meeting the objectives spelt out in Section 2.3 and at the same time they must remain viable. This section examines a range of possible alternatives. The impacts arising from adoption of each alternative are related to those expected to occur if the present industry continues as proposed.

8.1 ALTERNATIVES CONSIDERED

Consideration of alternatives has been limited to the 'do nothing' alternative and those which would compete with the proposal for resources and/or are incompatible with it. The many other alternative industries which could be undertaken in the region and would be unconstrained by the proposal were considered to be beyond the scope of this document.

The following alternatives are considered in this section.

- Do nothing
- Variations to the area of supply
- Alternative sources of chiplogs
- Alternative silvicultural management of the forest
- Varying levels of production
- Alternative uses of chipwood
- Alternative industries.

8.2 BASIS FOR THE ASSESSMENT OF ALTERNATIVES

This subsection outlines the assumptions made in the assessment of alternatives.
An overview of the changes to impacts anticipated for each alternative is presented in Figure 24.

8.2.1 Assumptions

- State Forest Management

Continuation of the export woodchip operation will take place in the context of CALM's proposed management of the State's forest resources (CALM 1987a,b,c). These documents form the basis for the State's sustainable yield strategy (see Section 5.0) which is dependent on maintaining predicted volumes of sawlogs. Implicit in this strategy is the intention to harvest sawlogs from those areas classified for timber production in the Regional Management Plans. Under most circumstances sawlog harvesting is facilitated by chipwood salvage. Chipwood salvage reduces the amount of work necessary to ensure adequate regeneration following harvesting operations, thereby reducing CALM's costs for regenerating the forest.

If the industry does not continue, or if particular areas were excluded from chiplog production, the intention would remain to harvest these areas to obtain sawlogs.

Management would involve thinning to waste or poisoning unmerchantable trees (trees with no value as sawlogs) to obtain suitable conditions for regrowth development. The necessary conditions for each type of forest are discussed in Sections 4.2.6, 7 and 8.

However, the need for post-harvesting silvicultural treatments and the attendant cost of those treatments may preclude harvesting in some forest types. CALM would seek funds to undertake these additional silvicultural works to ensure that all harvested areas can be adequately regenerated even though it is questionable that such funding would be made available (Appendix H). Hence possible impacts of alternatives which seek to reduce or eliminate chipwood salvage, were assessed on the basis that sawlog-only operations would continue over most of the wood production area. A decision to exclude chipwood salvage from an area would only reduce the marginal impacts on the physical environment above those attributable to sawlog-only operations.

The magnitude of these marginal impacts can be predicted and an assessment of their significance can be made. A similar analysis was undertaken by Ferguson (1985), who examined the additional impacts likely to occur as a result of expanding current sawlog-only operations to include chiplog salvage [integrated harvesting] in Victoria. Ferguson's analysis looked at the **additional** impacts likely to occur from an **increase** in the intensity of harvesting. It is reasonable to conclude that **decreases** of the same order of magnitude would occur if the intensity of harvesting was reduced. The changes in impacts discussed below form the basis for subsequent assessment of the alternatives.

Ferguson concluded: (chapter 14, page 238)

> "The additional environmental effects of integrated harvesting over sawlog-only harvesting seem small.
>
> The additional economic effects of integrated harvesting over sawlog-only harvesting represent substantial gains in net social benefit, sufficient to outweigh any possible social costs incurred in terms of environmental effects.
>
> However, rampant clear felling must not be permitted and forest practices must give due concern to environmental services. In addition, any pulpwood harvesting operation must be tied to sawlog harvesting".

In summary Ferguson's major findings included:

Nutrient Losses - nutrient losses are undoubtedly greater for integrated and joint harvesting operations, simply because more wood is removed from the site. The question to be addressed is how serious are these additional losses.

> "Provided an adequate programme of research, monitoring and assessment of growth rates is instituted, additional losses of nutrients from integrated and joint harvesting operations should not pose a major problem. Remedial fertilisation, which should be carried out at whatever levels are indicated to be necessary by the results of the detailed research, would be relatively inexpensive and infrequent. Comparison with experience in agriculture suggests that these practices are feasible and can be implemented at a low enough cost".

Water - Integrated or joint harvesting operations do not affect the road network or stream crossings and hence have no additional effect on water quantity or quality, relative to sawlog - only harvesting.

Recreation - Beyond those associated with sawlog-only harvesting, the effects of pulpwood harvesting on recreation and related services are minimal. The main adverse impact is the greater usage of particular roads by log trucks.

Flora and Fauna - Research into flora and fauna composition some 20 years after integrated sawlog and pulpwood harvesting in Gippsland [Victoria] supports the thesis that including pulpwood harvesting does not adversely affect flora and fauna conservation.

(Source: Ferguson 1985)

- Infrastructure Constraints

The capacity of the Diamond Chipmill represents a constraint on maximum production.

8.2.2 Overview of the Impacts of Alternatives

Figure 24 shows the direction (positive or negative) and magnitude of changes to impacts caused by adopting alternative actions in comparison with those resulting from the proposal.

8.3 DO NOTHING

The do nothing alternative would involve closure of the export woodchip industry. Sawlog only operations would continue in those areas where silvicultural treatments remain financially viable. This alternative would provide insignificant reductions to impacts on the non-wood values of areas subjected to sawlog-only harvesting. Areas assessed as not being viable for sawlog-only operations would retain more non-wood values as a result of a total exclusion of harvesting. The alternative would represent a significant change in the provision of non-wood values for those areas of State forests in this category and those small areas of private property harvested rather than salvaged following clearing.

The area that would be excluded from harvesting through adoption of this alternative has not been determined. However, it is reasonable to conclude that the lower quality karri-marri forest type would be excluded by virtue of the higher silvicultural costs and lower sawlog yields associated with this forest type. In effect this would represent a defacto land use decision to conserve areas of one forest type and to concentrate the remaining industry onto other forest types. Clearly this would not represent a rational allocation of scarce resources.

Adoption of this alternative would cause major negative impacts associated with CALM's planning and operations, including:

- o Effect on sustained yield strategy.
- o Continued funding.
- o Silvicultural management.
- o Fire control and suppression capabilities and socio-economic effects.

Sustained yield strategy for sawlogs would be disrupted for two reasons. Firstly, the volume of sawlogs available for harvest would be reduced. Secondly, as the chipwood industry provides the major market for regrowth thinnings and represents the most effective means by which regrowth stands can be thinned and the production of sawlogs accelerated, removal of this industry would reduce the overall yield of wood products. Additional funding to CALM would be required to cover the cost of the additional silvicultural practices needed to adequately regenerate harvested forest.

The region's fire control and suppression organisation would be reduced. Cessation of chipwood harvesting would cause a significant reduction in the availability of men and equipment available to fight fires. In addition the large volume of non sawlog quality wood normally taken as chipwood would represent a significant impediment to access through sawlog only coupes.

If the chipwood industry was discontinued, there would be an immediate reduction in employment of between 445-574 people at the regional level including 329 for Manjimup and its environs. Regional household income would decline by between \$8.9 - \$11.2 million and local household income by \$6.8 million. Likely social impacts on the township of Manjimup would include stress associated with the loss of employment, leading in some instances to family breakdown. There would be further loss of jobs as the declining population affected small businesses in Manjimup and Pemberton.

In the longer term there would be further reductions in total employment and income as total sawlog production would decrease. No other sections of the local economy have been identified which have the potential to compensate for the loss of jobs that would occur if the woodchip project was discontinued. This alternative is therefore considered not to be a viable or prudent alternative.

In addition to these local effects, closure of the woodchip export industry in Western Australia would have a significant adverse effect on the nation's balance of payments. Currently, WACAP's operations contribute $38 million per year in export income.

8.4 VARIATIONS TO THE AREA OF SUPPLY

The area of supply could be increased or decreased. Possible changes to the area would be limited by logistical/economic factors. The maximum size of the area would be defined by a radius of 180km (by road) extending from the Diamond Chipmill, based on WACAP's estimate of the maximum economic haulage distance for chiplogs.

A limited volume of private property resource is transported from a distance up to 300km (see Section 5.2.3); however, this is dependent on economically favourable backloading arrangements based on trucks returning from Perth.

The minimum size for the area of supply would encompass sufficient resources to enable WACAP to maintain operations at the minimum viable level. This level has not been defined; however, it is reasonable to presume it would be close to the 1 shift level.

8.4.1 Extended Area of Supply

Chipwood salvage is not practised in all forest areas currently harvested in the State, the northern and parts of the central forest regions having been excluded in spite of silvicultural reasons for undertaking this work (see Section 4.2.7).

Data from CALM indicate that the central region contains an **additional** 17 million tonnes of potential chipwood within WACAP's 180km economic limit, based on existing sawlog-only harvesting plans. This volume is in addition to resources described in Section 5. The Timber Industry Strategy calls for these sawlog only operations to take place over approximately 50 years. Hence an additional volume of 300,000t per annum could be available from this source.

Extending the area of supply would result in small to insignificant increases in the impacts on the physical environment of existing sawlog harvesting sites (see Section 7.1). As discussed by Ferguson (1985) these additional impacts would be outweighed by the social benefits likely to accrue from utilisation of this additional material. Extensions to the area of supply would necessitate longer haulage distances to the chipmill resulting in additional impacts on the regional road network and higher transport costs for logs. The extent of additional impacts on the regional road network would depend on the source of the additional chiplogs and the volumes hauled.

It is reasonable to conclude that the regional highway network would carry most of the additional traffic generated if this alternative was adopted. Impacts on the system under present circumstances are discussed in Section 6.6.5. Similar impacts could be expected in any extension to the chipwood salvage area.

A satellite chipping facility has the potential to reduce the impact of this alternative on the regional road network, particularly if the satellite facility was serviced by rail.

The timber industry currently has small scale satellite chipping facilities at the larger sawmills to produce chips from sawmill residues.

WACAP has no current plans to develop satellite chipping facilities capable of handling old growth size logs. WACAP would need to establish a facility similar in size to the Diamond Chipmill to be able to handle the old growth logs. The investment required to establish such a facility could not be justified in the present circumstances. This position could be reviewed should circumstances change and if sufficient volumes of chipwood salvage were offered from outside the Diamond Woodchip mill operating radius.

An extension of chipwood salvage into the northern and parts of the central region would have some significant benefits for the silvicultural management of these forests. Under the current management prescriptions it costs CALM approximately $100/ha to undertake silvicultural operations in the non-karri forest types. If chipwood harvesting was extended into these areas this cost would be replaced by a benefit in the form of additional royalty payments for wood which is burnt under current prescriptions.

8.4.2 Reduced Area of Supply

CALM's proposed land use allocation within the project area has been described in Section 5.1.2. This allocation has been developed following an extensive series of land use reviews focussed primarily at the conservation and reservation needs of the karri forest type. The recommendations from these reviews have now been implemented. No further significant changes to land use classifications within the region are likely to occur, at least in the forseeable future.

The Australian Heritage Commission is currently investigating the need to list parts of the project area on its register of the National Estate, in addition to those areas already on the register (see Section 6.6.3). The implications of listing and possible impacts of harvesting on National Estate values are discussed in Section 7.1.7.

As discussed in these sections, listing or registration of a place may constrain, but not necessarily preclude, harvesting of chiplogs for export. National Estate listing may be considered the most likely reason for a reduction in the area of supply.

Section 6.6.3 lists and describes areas currently on the National Estate register or being considered for entry (interim listing or awaiting assessment). Figure 24 discusses the implications of a withdrawal of these areas both in terms of the impacts (positive) on National Estate value and the impacts (negative) on the proposal in terms of chipwood volumes foregone. It should be noted that many areas registered or listed on the National Estate have security of tenure and purpose as conservation areas and as such would not be harvested. The remaining four areas, mainly on the interim list or awaiting assessment, contain 2 million tonnes or approximately 10 percent of assessed chipwood volumes.

A decision to cease chipwood salvage following sawlog harvesting operations undertaken in National Estate areas would do little to protect or enhance National Estate values. As discussed in Section 5.0 the Timber Industry Strategy and CALM's sustained yield predictions are based on harvesting sawlogs from all areas zoned for Timber Production, including the four areas referred to above. There would be no value in precluding chipwood harvesting, given that sawlog harvesting will take place in these areas.

Negative impacts associated with this alternative would include the loss of resources for industry and the consequent permanent reduction in sustainable yield from the karri forest. This would have implications for CALM in terms of royalities foregone and additional costs to undertake silvicultural works. Calculated on an annual basis these would amount to $720,000 and $55,000 respectively per year. Flexibility in the availability of sawlog resources would also be lost. Hence while the alternative would have no major positive benefits it would result in significant long term negative impacts on CALM's operations. For this reason the alternative is not considered to be prudent.

8.5 ALTERNATIVE SOURCES OF CHIPLOGS

In this subsection additional sources of chiplogs are examined. The only additional source of chiplogs which could be available within the term of the proposed licence period are from State forests outside the project area. This alternative has been discussed in Section 8.4.1.

Plantations represent another option for developing alternative chiplog sources. The potential benefits of plantation grown trees in meeting some of the future needs of the Forest Industry have been recognised by WACAP (see Section 4.3). The company intends establishing 10,000ha of plantations over the next 15 years at an annual rate of around 600ha/yr which would provide approximately one quarter of WACAP's export chip volume towards the end of the proposed extended licence period.

An alternative to the proposal would be to establish plantations to meet a larger proportion of the export requirements.

WACAP recognises the importance of developing alternative sources and is planning on the basis that farmers and other landowners will increase plantings to reach a minimum of 10% of existing agricultural land planted to trees.

WACAP plantations are to be managed on 15 year rotations (see Section 4.3). Hence if a decision was made immediately to initiate a major increase in the plantation programme no additional resources would be available until near the end of the proposed extension of the export licence. However some secondary benefits would occur during the currency of the proposed licence period. Plantation establishment, in particular along creek lines in salt-affected medium rainfall areas would have some major positive impacts on water quality and soil condition. This occurs because evapotranspiration of the deep-rooted trees lowers the salt-laden groundwater table.

In the higher rainfall areas, which are not prone to salt degradation, the same process of lowering water tables can result in a minor negative impact in that stream base flows may be reduced if sufficiently large areas of pasture within individual catchments were forested.

Development of WACAP's tree farming schemes would provide local landholders with alternative land use options. These would assist in offsetting their dependence on other sources of farm income.

Other impacts likely to occur as a result of establishing large areas of plantations would include improved water quality leading to a significant improvement in conditions for aquatic life. Minor positive impacts could be expected for fauna in the sense that plantations would offer a more complex and stable ecosystem for fauna within predominantly agricultural areas. Small increases in fire risk could be expected during the establishment phase of the plantations due to increased levels of fire fuels in the form of rank grass etc. Other impacts would occur in the subsequent licence period. These impacts could be positive or negative, depending on how the additional chipwood was used.

If the export quantity stayed the same and plantation grown wood was used to substitute for wood from other sources (most likely old growth logs or regrowth thinnings), then CALM would lose royalties and would incur additional costs for silvicultural works. This would equal approximately $1 million per 100,000 tonnes of resource substituted.

If the plantation resources were added to existing resources thereby increasing export levels, additional significant positive benefits could be expected. These benefits would be in the form of additional economic activity and would be reflected in increased employment, higher export earnings and increased Government revenues.

WACAP's existing plantation programme and the ready availability of resources from CALM's silvicultural works mean that additional plantations could only be contemplated if WACAP was considering a significant increase in its export levels after 2005. For this reason this alternative was not considered to be feasible at present.

8.6 ALTERNATIVE SILVICULTURAL SYSTEMS

The silvicultural systems developed for use in the karri and karri-marri forests as part of this proposal are described in Section 4.2 with their implications discussed in Section 7.1.8. Alternative silvicultural systems have been suggested for some of these forests, in particular the karri stands. Two different approaches can be identified. The first, selection harvesting, has been proposed as a means of lowering the impacts on non-wood values, typically associated with clearfelling. The second is to manage the forests on a shorter rotation to maximise production.

- Selection Harvesting

Use of selection harvesting techniques as an alternative to clear cutting would have some limited benefits mainly in relation to reductions in the scale of individual operations. These additional benefits are shown by Figure 24. The most significant benefit would be an improvement in the visual or landscape values. Use of small gaps of several hectares in size have less visual impact than the larger coupes typically used in Western Australia (average size 70-80ha). Obviously many more coupes would be required to maintain production levels, and although local impacts would be lower, the incidence of impacts would be more frequent.

Small positive impacts on fauna may occur, assuming that spatial and temporal distribution of harvested areas takes place. This process of greater distribution of harvesting in space and time could provide some short term marginal benefits in water quality. The short lived "peak" of salt which can occur in susceptible catchments following harvesting may be avoided using this technique. The disadvantages resulting from using this system are numerous and have been clearly identified from previous operations where selection silviculture had been used.

A significant disadvantage would be a measurable decrease in the subsequent production of wood from the site due to suppression of regrowth by surrounding mature trees (see Section 7.1.8), Rotheram (1983). Because of the small gaps there would be an increased risk of damage to the regenerated forest during subsequent falling operations in surrounding coupes. Damage could be caused by both mechanical means (crushing under falling trees) and from escaped fire during regeneration burns.

Subsequent hazard reduction burning operations would be severely constrained because of the need to burn an area with a mosaic of small patches of different age classes many of which would be vulnerable to fire damage. Without adequate fire fuel control (achieved by prescribed burning) CALM's ability to control bushfires in the region would be significantly reduced.

In addition to the above, selection harvesting would impose significant cost disadvantages on both CALM and WACAP. Selection harvesting would require far more frequent shifts of men and equipment. A typical harvesting crew would harvest an area of this size within several days. Each move would result in lost productivity. Supervision costs could increase significantly because of the need to mark out, supervise and inspect many more individual areas.

In summary the alternative provides few minor benefits and these are greatly outweighed by significant negative impacts. Hence the alternative is not considered prudent.

- Shortening the Rotation Period

The proposed 100 year rotation period for karri is aimed at producing high quality sawlogs. A shorter rotation alternative would seek to maximise wood production from a given area of forest. Productivity from a forest would be maximised when the Mean Annual Increment (MAI) of the forest reaches its highest level (MAI is a measure of the rate of wood increment for a forest). Productivity would be maximised if the forest was harvested and replanted when this point was reached before productivity began to decline. This regime would represent a shift in emphasis away from sawlog production towards chipwood production. A chipwood-oriented rotation would be approximately 40 years or less in duration (e.g. Opie, 1968).

Shortening the rotation length represents the least desirable means of obtaining additional resource.

A chipwood oriented silvicultural regime would not be consistent with CALM's objectives of management for the karri forest which requires recognition of, and provision for the non-wood values of the forest as well as the timber values. Maintenance of much of the forest in a comparatively early successional stage would mean that certain non-wood values which depend on mature forest such as some fauna values and aesthetic values would never be provided for in production areas.

Additional losses of nutrients could be expected under the more intensive regime although the magnitude of these losses would remain comparatively small. In addition, provision of sawlogs from these forests would be severely constrained under a shortened rotation. Limited quantities of sawlogs in small size classes could be expected. This would undoubtedly lead to a significant long term reduction in the hardwood sawmilling industry.

Hence while overall productivity from the forest would increase under the more intensive management, it would be accomplished at the cost of a reduction in the availability of higher value sawlogs. For the above reasons this alternative, while feasible in a technical sense, would not be considered prudent.

8.7 ALTERNATIVES WHICH MAY VARY THE QUANTITY EXPORTED

The volume of woodchip exports is a function of a number of factors and constraints, including:

- o Capacity of existing infrastructure,
- o The availability of suitable resources,
- o Markets,
- o Permits to export, and
- o Production costs in relation to market price.

In this subsection the options for varying the export volumes of woodchips are explored with an emphasis on resource availability and infrastructural constraints.

8.7.1 Maximising Production

The previous sections identified alternative sources of chipwood and alternative management of the forests which could provide additional volumes of chipwood. Hence an alternative exists which would increase the export volumes to take advantage of total available resource.

- Capacity of Existing Infrastructure

The chipmill is, theoretically, capable of producing 1.04 million tonnes/annum of woodchips. This production if coupled with sawmill residues would provide a total maximum export level of 1.05 million tonnes/annum. The railway facility and the port facility at Bunbury would not represent significant constraints to the export of additional volumes.

- Availability of Suitable Resources

Three main options for obtaining additional chipwood exists, namely:

- o Management on shorter, pulpwood oriented, rotations. (Not considered appropriate)
- o Additional resources from plantation grown wood. (Possible source towards the end of the proposed licence period)
- o Extending the area of supply. (Possible source)

- Markets

WACAP has long term marketing arrangements for chip sales. Similar long term arrangements would need to be developed for any additional export volumes to avoid problems associated with fluctuations in the market when selling through the spot market (short term contracts).

- Permits to Export

Permits for additional quantities would need to be sought from the Commonwealth Department of Primary Industry.

An expansion in export levels could provide significant net social benefits in terms of jobs, economic activity and through assistance to CALM's management of the forest estate. On the basis of data presented in Section 7.2 of this report each additional 100,000 tonnes of chips could provide 45.3 additional direct and indirect jobs. In addition for every $10,000 change in the value of total output of the wood products industry in the South West Region a further change equal to $12,000 occurs elsewhere in the region (see Section 6.3.1.2). These benefits could be achieved with low levels of negative impacts on the physical environment, mainly through the additional impacts caused by chipwood salvage above those caused by sawlog only operations. Additional minor negative impacts on recreation would be caused by an increase in the volume of heavy vehicles using the regional road network.

WACAP has elected at this time not to pursue the alternative of expanding the export volumes of woodchips. This represents a commercial decision on behalf of the company.

8.7.2 Reducing Export Volumes

Any reduction in export volumes would presumably be undertaken in response to a change in one of the factors identified in the previous subsection.

Of these factors, markets are the most likely factors to limit the quantity exported during the proposed licence period. Future export markets cannot be predicted except to say that WACAP has a reputation as a competitive, reliable supplier of chips.

Assuming that export levels were reduced for whatever reason, the following impacts could be expected. The range of minor positive benefits for the physical environment resulting from a lack of chipwood harvesting following either sawlog-only or private property land clearing operations (see Section 7.1) would be realised. Against these minor positive impacts, reduction in export volumes would cause a decline in employment and economic output of an equal and opposite magnitude to that described under 7.2. Clearly at some point, the WACAP operation would cease to be viable and the export woodchip operation would cease (see Do Nothing).

In view of the minor positive benefits to be gained and major negative impacts to be incurred this would not be considered a prudent alternative.

8.8 ALTERNATIVE USES OF CHIPWOOD

8.8.1 Pulp Processing

WACAP is required to complete feasibility studies into alternative pulp and pulp/paper developments as a condition of both the export licence and the Wood Chipping Industry Agreement (1969-73).

To date the company has commissioned and completed two such studies to date by independent consultants, with a possible review of the study findings in 1987. A study completed in 1978 found that production of pulp was "technically possible in terms of the suitability of available hardwood species and the existence of suitable sites and supporting facilities, but would not be economically feasible, even under the most favourable market conditions that can be foreseen at this time".

Except for short periods of time, prices for pulp on the international market where a pulp plant in Western Australia would have to compete, have not improved relative to costs.

A subsequent report was prepared in 1981 which re-examined the possibilities of developing a pulp plant. The study concentrated on the prospects for using jarrah chips as these were readily available with little prospect for an export market. This study also concluded that market conditions precluded such a development for the foreseeable future.

In 1987 WACAP plans to study the prime factors in a pulpwood study, such as the present international price for hardwood pulp, the costs of materials and equipment and financing costs to ascertain if these factors are now more favourable than they were at the time of the last study. If it is apparent that these factors have favourably changed and that pulpmill feasibility may also have changed then WACAP will commission another study to determine the feasibility of a pulpmill in Western Australia.

8.8.2 Sawing Chipwood Grade Material

CALM has implemented a comprehensive sawlog/chiplog segregation procedure in the forest. This aims at maximising the volume of sawlog produced from the operations.

Subsequently, logs reaching the WACAP yard are inspected again and where possible sound wood suitable for sawing is separated from chipwood quality logs and is stockpiled (Section 4.5.2). WACAP currently splits off any timber considered to be of sawlog quality, which is then sold by CALM to sawmills.

Efforts are being made to improve the segregation process, these include the possible addition of a small salvage sawmill to operate in close proximity to the chipmill to reduce handling costs. CALM has called for expressions of interest in establishing such a mill.

Irrespective of the extent to which the segregation process improves, the most optimistic estimates are that volume changes will be very small (less than 10,000t/annum). When compared with the annual through-put of the WACAP mill this amounts to approximately 1 to 1.5 percent of the wood processed.

8.8.3 Panel/Board Products

Potential hardwood based panel and board products include hardboard, particle board and medium density fibreboard. Production of these higher value products would potentially maximise the economic benefits to be derived from harvested wood.

Hardwoods have some inherent disadvantages compared with softwoods as raw materials for these purposes. Reconstitution of the wood fibres means that the additional strength of the eucalypt fibres is of no advantage while the extra weight represents a significant disadvantage. Use of hardwoods in the wood panel industry in Australia is limited. Hardwoods are primarily used for hardboards with smaller amounts used for plywood and particleboard (Macmillan 1984).

The prospects for creation of a new industry based on hardwood panel products do not appear to be particularly good. The Bureau of Agricultural Economics (BAE) stated at the 1984 National Agricultural Outlook Conference that annual consumption of wood-based panels would increase to around the 1 million cubic metre level by 1990 and then it would maintain a level of about 0.9 million cubic metres towards the end of the century. The BAE predicted that medium density fibreboard will tend to replace other panel products over time.

The market place will decide if any of the above options are viable. It is of interest that other major uncommitted hardwood pulpwood resources exist within Australia. These include the Southern Forests Jarrah Residues and the East Gippsland Resources. Neither resource has been developed to date indicating that no viable alternatives to woodchips exist for this type of resource.

- Scrimber

The scrimber process developed by the CSIRO utilises wood fibre from small diameter young trees to create high value structural building materials. The licence to the process is held by the South Australian Department of Woods and Forests. Scrimber would not be competing for old growth pulpwood as this is totally unsuited for the purpose. At present one experimental plant is in operation and is based on softwood thinnings.

Regrowth eucalpyts could potentially be used for this process assuming the economics of harvesting, processing and marketing are satisfactory. The minimum economic scale of operation is in the vicinity of 40,000 to 50,000 tonnes of output which would require an annual input of around 60,000 tonnes of logs.

Development of a eucalypt scrimber plant is some years off. No decision has been made on likely sites for a processing plant.

(Source: Bob Cowan, South Australian Department of Woods and Forests, pers. comm).

8.9 ALTERNATIVE INDUSTRIES

- Tourism

Tourism has often been quoted as a viable alternative to forest industries. Current evidence suggests that this is not so because:

o At present there is the equivalent of 91 full time equivalent jobs in the tourist industry in the Manjimup Shire (see Section 7.2.8). The woodchip industry is estimated to support a minimum of 287 full time equivalent jobs (see Section 7.2.4). If woodchipping were to cease immediately 186 full time job equivalents would have to taken over by tourism. This represents a 200 percent increase. A reasonable projection of a growth rate of 3.2 percent would only see a further 80 jobs added to the tourism industry by the year 2006.

It is apparent that a spectacular growth in tourism would be required to rapidly assimilate 287 jobs.

- o The tourism industry has maintained a positive growth rate during the life of the project indicating that the two industries are compatible. No surge in tourism increase could therefore be expected from a cessation of the project.

- o Local multiplier effects of the tourism industry are considered minimal hence a greater level of employment in tourism than in the woodchip project would be required to generate the same community benefits.

- o The level of excess capacity (50 percent, see Section 7.2.8) in the tourism industry suggests that the potential for employment growth concurrent with visitor growth is limited.

- o The main type of tourist presently visiting Manjimup Shire is the family group whose contribution to local employment is limited.

- o The 37 percent of the licence area completely reserved from cutting covers the full range of revegetation types and will supply tourists with an opportunity to experience virgin forest.

  In addition, areas of high amenity value are protected by retained buffer strips.

As tourism is considered compatible with woodchipping it is not included on Figure 24.

9.0 ENVIRONMENTAL MANAGEMENT PROGRAMME

9.1 POLICY AND PLANNING

The CALM Act (1984) established the Department of Conservation and Land Management (CALM) and two controlling bodies, the Lands and Forests Commission (LFC) and the National Parks and Nature Conservation Authority (NPNCA). The function of these bodies is to have relevant CALM land vested in them and to develop, through the agency of the Department, policies and management plans to achieve or promote the objectives of the particular land use.

CALM is responsible for all aspects of management on CALM Act land. As a consequence the responsibility for the definition of environmental standards, their enforcement, monitoring and review is also CALM's.

CALM has formulated Draft Regional Management Plans for the LFC and NPNCA to outline its land management policies (CALM 1987a,b). Of relevance to the environmental management of this project are the policies on:-

- Flora, Fauna and Landscape Conservation
- Cultural Areas
- Environmental Protection
- Fire Management
- Disease
- Weeds and Pests
- Recreation
- Water
- Hardwood Timber Production

Under terms of the CALM Act (1984) the Regional Plans are subject to public input. A draft of the Regional Plans has been issued in April, 1987. Public review will be concurrent with review of this ERMP/Draft EIS. Specific policies and procedures relating to hardwood timber production are detailed in the Timber Strategy which forms part of the Regional Plans and is therefore subject to the same public input.

The administration of CALM policy is delegated in the project area to the Regional Manager of the Southern Forest Region and through him to the District Managers and Field Officers.

Policy in CALM is formalised by endorsement of the Policy Directorate, a group consisting of the Directors and senior staff. Proposals for policy change can originate in any section and at any level of the Department but require endorsement by the Policy Directorate before implementation. Policy affecting other Departments (e.g. Water Authority in relation to water resources) is referred to them prior to formalisation.

Detailed forward planning is essential to efficient management of the forests. The lead time required to enable harvesting and regeneration activities to be carried out is summarised in Section 4.2.4. The various levels of planning and the scope of each, are shown on Figure 25.

The woodchip industry has already been operational for 11 years. Procedures to protect the environment were outlined in the original EIS (Forests Dept. 1973) (see Section 4.2) and have been further developed and modified as a result of experience and in the light of evaluation of the results of monitoring and research programmes.

Current environmental management measures are prescribed in the Industry Control Manual and Southern Forest Region Operations Manual. They are summarised in the following sub-sections, and are followed by proposed additions to the environmental management programme. WACAP undertakes to comply with the requirements of these documents.

9.2 ENVIRONMENTAL PROTECTION MEASURES

9.2.1 Conservation of Ecological Values

Within the licence area, approximately 248,000ha or 35% of the forested Crown Land managed by CALM is proposed to have a priority that would preclude wood harvesting. These areas include National Parks, Nature Reserves and State Parks. In addition, a further 75,000ha is in prescribed road, river and stream buffer zones bringing to 45% the area set aside to conserve ecological values.

These areas contain representative examples of all forest types that occur in the Southern Forests and have been selected after detailed study of conservation needs by the EPA (DCE 1983, CALM 1987a). As well as conserving representative areas of each forest type, the parks and reserves will ensure that the overall floristic diversity of the Southern Forests is maintained, together with the genetic diversity of individual species.

Ecological values are also taken into account within areas where timber production is the priority land use. A buffer of vegetation of minimum width one tree height will be left around rock outcrops greater than 0.25ha. Similar buffers will be left around treeless swamps and lakes where they occur. Permanently moist gully headwaters will not be cut or disturbed by machine activity (see Section 4.2.6.3).

9.2.2 Protection of Water Quality

The major concerns with regard to water quality are salinity and turbidity (see Section 7.1.2). The retention of uncut buffer zones is the best environmental management procedure to control both these. CALM currently implements the following guidelines with regard to buffers and will continue to do so until approval to change is obtained from the EPA (see Section 9.3.):

- 200 metres either side of rivers
- 100 metres either side of recognised streams
- 20 metres "special care" zone around watercourses which have a permanent flow or have defined banks of 1 metre or greater
- 50 metres on all recognised watercourses in the A and B zones of gazetted catchments gazetted by the W.A. Water Authority
- No cutting in permanently moist gully headwaters
- Minimum buffer equal in width to one tree height around treeless swamps and lakes.

(see Section 4.2.6.3).

CALM is committed to co-operating with the Water Authority in catchment management. In the A zone of gazetted catchments, a minimum of $10m^2$/ha basal area of the forest will be left after harvesting is completed.

To prevent overloading of the buffer system, proper management in the harvesting and road construction phases must be carried out. CALM is implementing and will continue to implement management of harvesting and road construction to avoid excessive movement of soil. The procedures include:

- o Identifying all slopes in excess of 15 degrees and demarcating those above 20 degrees as "special care" zones. Restriction of scrub-rolling and felling to a minimum in these zones, only harvesting when soil moisture conditions are most stable.
- o The sequencing of coupes in time so that they do not concentrate on one drainage system.
- o No landing to be located within 50m of a recognised watercourse unless approved by a forest officer.
- o Tracks to be parallel to watercourses where possible.
- o No snig tracks to cross a watercourse unless there is no alternative. If crossings do occur, a properly constructed culvert, ford or corduroy crossing is to be installed.
- o At the completion of harvesting, cross drains to be installed to divert water onto undisturbed ground, or to a silt trap.
- o Road construction to be planned and approved on the basis of:
    - Table drains to divert water at regular intervals, and silt traps at all stream crossings.
    - Cut off drain closest to a stream will not discharge water closer than 10m from the stream.
    - Embankments to be rough-surfaced or terraced and revegetated. Stabilisation may be prescribed if necessary.
    - In erodible soils, table drains will be designed to minimise erosion. This could include track barriers, sumps, bitumen bank, etc.

(see Section 4.2.5).

The control of wildfires also reduces the possibility of erosion and sediment transport.

In addition to the procedures aimed at protecting water quality, CALM co-operates with the Water Authority in catchment management. Recently CALM undertook a forest-thinning operation to increase the water yield to the Manjimup water supply reservoir. As the Southern Forest water resources are further developed, the requirement for forest thinning to manage water yield is likely to become more common.

Liquid effluents from the Diamond Chipmill are contained in storage dams and recycled through the Chipmill. Occasionally, it becomes necessary to discharge excess water. This is carried out in accordance with the provisions of an Effluent Disposal Licence granted by the Water Authority.

9.2.3 Protection of Forest Productivity

A prime objective of CALM's Timber Strategy is the maintenance of a sustained yield of forest products that will enable the forest industries to exist as long as there is a demand for forest products.

In order to protect forest productivity, environmental management must protect the soils, the health of the forest, retained crop trees, and employ a productive silvicultural (tree growing) system.

9.2.3.1 Soils

Forest soils are protected from erosion by the measures outlined in Section 9.2.2. Disturbance can occur due to compaction or puddling during the harvesting process. CALM will control this by monitoring the level of soil disturbance of landings and snig tracks as a proportion of the total area in fallers blocks. When disturbance approaches 15 percent, a survey will be undertaken. When total disturbance reaches 20 percent, the fallers block will be closed and other blocks less likely to incur disturbance will be established.

WACAP presently co-ordinates the rehabilitation of damaged soil on behalf of the timber industry (see Section 4.2.6.4). WACAP will continue to co-ordinate this programme by arranging the bulldozer and driver, servicing the machine, programming the sequence of operation and organising payment.

9.2.3.2 Disease Management

Disease management is essential for long term forest productivity. Dieback disease caused by Phytophthora cinnamomi is potentially the most serious disease and one for which strict environmental management is carried out. Apart from monitoring, control of insect or other fungal diseases is effected by a buffer zone of 10m around areas of obvious infection.

Dieback disease will continue to be managed through controls on harvesting where appropriate (see Section 4.2.7.2). These include:

- o Identification and marking of boundaries of diseased and non-diseased forest
- o Use of 7 way tests to determine impact (see Section 4.2.7.2)
- o Season of harvesting to minimise soil movement
- o Sequence harvesting from non-infected first to most-infected last to minimise the opportunity for transfer of disease to non-infected areas
- o Not crossing disease boundaries without washdown of equipment to remove infected soil
- o Split phase harvesting in dieback free forest
- o Static loading of logs to prevent contamination of the landing in the forest from the road

9.2.3.3 Protection of Retained Trees

Retained trees are at most risk during the snigging (log removal) phase of the harvesting and in post-harvest fire control. CALM will continue to safeguard these stems by:

- o Regularly carrying out damage assessments and enforcing penalty clauses on the harvesting contractors for tree damage
- o Ensuring crowns from harvested trees are removed, leaving at least one clear metre around the base of the standing crop trees.

(see Section 4.2.8.2)

9.2.3.4 Silviculture

Overall forest productivity is promoted by use of the appropriate silvicultural systems. The main features of the silvicultural management programme which will be implemented are listed below:

Karri and Karri-Marri Forest (see Section 4.2.6.1)

- o The practice of clear-felling and integrated harvesting of a variety of wood products is adopted to maximise the use of resources and to enable efficient regeneration to be achieved.

- o A variety of techniques are used to promote regeneration of clear-felled areas - the use of seed trees, nursery seedlings and artificial seeding - depending on circumstances. In addition, regenerating areas are surveyed and infill planting is carried out if sufficient trees per hectare have not established themselves.
- o Thinning of regeneration forest is carried out to increase yields of wood products and to increase the growth rates of retained trees. Following thinning, debris is moved to protect the remaining trees from fire damage.
- o Harvesting and log removal operations are discontinued when, due to wet weather, soil conditions are such that harvesting equipment would cause excessive soil compaction which would impede the re-establishment of forest vegetation.

Jarrah-Marri Forest (see Section 4.2.7.1)

- o A variety of harvesting approaches is adopted depending on the structure, age and quality of the forest. These include thinning to promote the growth of remaining trees, partial cutting to stimulate regeneration and clear-felling of small areas to allow unimpeded regeneration.
- o Clearing of debris and burning are carried out to minimise the potential for damage to the remaining trees by fire and to stimulate the regeneration.

9.2.4 Private Forests

CALM's responsibilities are confined to Crown Land. WACAP is the recipient of chiplogs from private forest harvesting operations, and can impose management controls over the harvesting or subsequent operations if it is involved in the harvesting. Often WACAP is not involved until the trees have been felled or pushed over by a bulldozer.

The safeguards that apply to the clearing of forests on private property are:

- o The requirement under the Country Areas Water Supply Act (1947-78) for landholders to obtain a permit from the Water Authority before commencing clearing operations within specified catchments,
- o The requirement under the Soil and Land Conservation Act (1945-82), for landholders to obtain a permit from the Department of Agriculture before clearing any forested area exceeding one hectare.

WACAP will not accept chiplogs from private land unless the landholder can demonstrate that these permits have been granted.

WACAP has a policy that supports afforestation of previously cleared land and reforestation of newly cleared land, and makes incentive payments and provides technical assistance to landholders who are prepared to reforest (see Section 4.3.4).

WACAP is becoming involved in the thinning of native forest and the establishment of eucalypt plantations on private property. In future, WACAP undertakes to adopt similar standard CALM environmental management procedures as detailed in the ICM for private property operations where they are the harvesting contractor (see Section 9.3.5) and where the subsequent land use is for tree farming.

9.2.5 Fire Protection and Control

Fire, although a natural part of forest ecology and an essential ingredient of forest management, also represents one of the major threats to all forest attributes. Reduction of the potential for the occurrence of uncontrolled wildfires and provision of the means of fighting fires are important elements of CALM's forest management strategy (see Section 7.1.3).

The adverse impacts of wildfire will be minimised by:

- The retention of unharvested buffer zones within the State forest and adjacent to private property.
- Prescribed burning practices which are designed to maintain forest fuel levels in buffer zones below 8t/ha in jarrah forest and 19t/ha in karri forest.
- Control of burning activities according to legislative requirements and Departmental guidelines.
- Maintenance of a trained, well-equipped fire suppression force.
- The use of personnel and equipment involved in the forest industry to combat unplanned outbreaks of fire.
- Continuing research aimed at understanding fire behaviour in prescribed and uncontrolled wildfires and techniques of fire suppression.

- Continued research and field testing to develop and refine burning guides for regrowth karri forest. Burning under conditions prescribed in these guides will permit controlled fuel reduction to take place in younger, fire sensitive regrowth stands. These guides will form the basis of future fire hazard reduction programmes in the regrowth forest.

Some details of CALM's fuel reduction strategy are given in Figure 25.

The impact of prescribed burning operations on the forest ecosystem is of concern to some people. CALM has conducted research on this matter which indicates that prescribed burning does not cause significant long term deleterious effects on the ecosystems. Nevertheless, CALM intends to maintain its long term research projects on fire ecology. Fire management procedures will be modified if the results of this research indicate that modifications are required.

9.2.6 Recolonisation by Flora and Fauna

Recolonisation of harvested areas by flora and fauna is facilitated by a number of measures incorporated into CALM's management plans.

These include:

- Conservation and protection of parks and reserves which provide the repositories within which survival of individual species is assured, and from which dispersal can occur (see Section 9.2.1).
- Retention of mature forest in a network of strips within each forest block, corresponding to road, river and stream reserves and buffers surrounding some private property and environmentally sensitive areas (see Section 7.1.5 and 9.2.2).

These areas provide refuges for some fauna displaced during harvesting and initial regeneration operations, and the sources of subsequent recolonisation.

9.2.7 Protection of Genetic Diversity/Integrity in Harvested Species

The maintenance of genetic diversity and integrity is a particular responsibility in the practice of living resource conservation. CALM is a Department set up to practice the conservation of living resources, hence must in their management, ensure this objective is achieved.

At present, this is achieved in two ways:

- o The reservation of the full range of ecotypes
- o Controls on the use of seed in regeneration.

The reservation system throughout the project area is the result of a number of investigations by independent authoritive bodies and subject to public participation (see Section 4.1.2). These studies have ensured that the full range of ecotypes is contained within reserves and that if CALM's Regional Plan proposals are implemented, these reserves will receive the highest protection possible for tenure and use.

The regeneration processes that could impact on genetic diversity and integrity are the hand planting of karri and artificial seeding of karri (see Section 7.1.4). Both methods are reliant on the use of seed collected at some previous date, hence the control of the impact must be at both the collection and use phases of the operation.

This will be managed by:

- o Proper recording of the relevant collection data for each seed lot (see Section 7.1.4). This will include the number of trees collected from, the location collected from, the tree characteristics and the site characteristics.
- o Ensuring seed used in direct seeding and nursery work is
  - identified by provenance and is obtained from the same major river valley in which the harvesting occurred,

    and

  - from at least 10 separate parent trees.
- o Recording on regeneration plans the origin of the seed used to regenerate the coupe.

In addition, maximum advantage will be taken of the seed tree system to regenerate coupes, as this regeneration system has least impact on genetic diversity and integrity.

9.2.8 Maintenance of Landscape Values and Visual Amenity

Harvesting of wood products inevitably results in temporary adverse visual impacts and temporary reduction of landscape values (see Section 7.1.6). However, the forestry management programme includes many measures to minimise or mitigate these impacts (see Section 7.1.6). CALM management will minimise visual impact by:

- Regenerating forests immediately after harvesting operations.
- The retention of uncleared forests adjacent to significant tourist roads, rivers, streams and some private land.
- Controls on the size of clear-felled areas and the dispersion of clear-felling activities in space and time.
- Remedial treatments to rectify specific visually discordant elements.
- Exclusion of harvesting in areas proximal to sites of major landscape value.

9.3 PROPOSED CHANGES TO ENVIRONMENTAL MANAGEMENT PRACTICES

9.3.1 Conservation Reserve System

Conservation reserves form a major part of the environmental protection system in the licence area. CALM has proposed in its Draft Southern Forest Regional Management Plans to give security of purpose as well as tenure to the conservation reserve system (see Section 5.1.2.)

9.3.2 Buffers for Water Quality and Fauna Conservation

The results of hydrological research are not yet definitive but do strongly indicate the main factors to be considered. The main conclusions to date which relate to management include:

- From the overall water resources perspective, impacts of clearfelling operations are minor.
- The possibility of noticeable salinity for a small part of the year in some local streams for several years after harvesting in the Intermediate Rainfall Zone, and the likely benefit of stream buffers in moderating this effect. The risk is related to groundwater depth and soil salinity in the likely groundwater discharge zone (see Section 7.1.2).

- o The resilence of the Low Rainfall Zone to salinity effects. This resilience arises from the generally great depth to groundwater and small recharge levels likely in this zone (see Section 7.1.2).
- o Buffers provide a valuable means of sediment control.

Work underway in Manjimup has made it clear that better conservation value can be gained from the existing area committed to road, river and stream reserves. The present distribution may be improved by placing more emphasis on the conservation value of smaller streams (Wardle-Johnston pers comm.).

A change in emphasis would recognise:

- o The conservation value of mature forest widely dispersed within young regenerating forest, especially with respect to fauna that use tree hollows.
- o The habitat diversity and species richness of stream areas.
- o The viability and effectiveness of relatively narrow corridors, especially when located low in the landscape.

The potential changes would be directed at enhancement of water quality and facilitation of recolonisation by fauna in accordance with the ideas outlined below:

- • Water Quality

- o An increased role for retained stream buffers. The need for permanent buffers might be reduced by the development of 'phased' operations. Phased operations would involve harvesting buffer zones several years out of phase with adjacent slopes and uplands.
- o Lifting the embargo on combined sawlog and chiplog harvesting operations in the Low Rainfall Zone, subject to appropriate buffer retention.
- o The development of a practical method of assessment of groundwater depth and soil salinity in the groundwater discharge zone in the Low and Intermediate Rainfall Zones. This would enable buffer zone demarcation and phased harvesting to be better tuned to specific localities. This may be achieved by drilling and sampling, by refinement of Strelein (in press) site-vegetation types to serve as predictors, or by geophysical techniques.

* Fauna

- o Reduce road reserves to the minimum acceptable width, consistent with maintenance of visual amenity.
- o Use the area equivalent to that excised from the road reserves to provide buffers on first, second and third order streams.
- o Explore the practicability, structure and frequency of fauna movement corridors across geographical saddles to link stream headwaters. These may need only consist of habitat trees and so could be thinned for sawlogs.
- o Remove the original EIS constraint of 20 percent of each forest block reserved so that blocks that do not need 20 percent can be reduced and those that need more can be increased.
- o The existing practice of selective thinning of reserves, consistent with their protection role, can be continued.

Clearly, further research and evaluation will be required before all the above proposals can be incorporated by CALM into detailed forest management plans. However, CALM considers some changes may be warranted on the basis of the results of studies carried out to date.

CALM has stated in its Regional Management Plans (CALM 1987a) that approval will be sought from the EPA before any redistribution of the area currently allocated to road, river and stream reserves is made. The objective of this redistribution will be to improve the overall protective, conservation and amenity value. It is not possible for WACAP to rigidly specify how the proposed changes will be incorporated into prescriptions for operations. A period of operational development will be required by CALM to ensure that this is done efficiently.

CALM has elected to undertake the following (CALM 1987c):

- o A review of the road, river and stream reserve area distribution with a view to designing the most efficient layout to achieve maximum protection of water, amenity and conservation values.
- o On the question of salinity, it is considered appropriate to establish a maximum base flow salinity limit of 1,500mg/L. It will be possible to operate below this limit through the peak of the disturbance by use of a combination of stream

buffers, phased operations and field demarcation of groundwater/soil salt sensitive areas. It is not considered necessary to base planning and evaluate success on detailed coupe by coupe assessment involving expensive drilling and monitoring. Rather, it is envisaged by CALM that practical field assessment and simple predictive methods will be sufficient to meet the salinity standards for general areas.

- o The total buffer area will be maintained at an average of 20 percent of forest block area.
- o No clear-felling of buffers will be undertaken, however, selective thinning will be carried out where appropriate as is current practice.
- o Methods and prescriptions for monitoring the above will be developed in conjunction with the Western Australian Water Authority.

9.3.3 Contract Harvesting

CALM is already the principle contractor for eucalypt regrowth and pine harvesting. CALM believes that there would be significant advantages in being the principle harvesting contractor for harvesting, as this would:

- o Provide a more direct link between the setting of environmental standards and their implementation and enforcement,
- o Eliminate the potential conflict of a harvesting company working for a sawmill company, having to extract a full range of products for a number of different customers,
- o Provide greater flexibility in the transfer of harvesting operations between coupes and areas of operation, and
- o Increase control of the lower quality log standard brought to the forest landing.

Accordingly, CALM will negotiate with the principle harvesting contractor to assume responsibility for all harvesting operations on State forest.

9.3.4 Utilisation Efficiency

The extraction of chipwood logs increases the quantity of sawlogs obtained from a coupe by providing an economic incentive for marginal quality trees to be felled and brought to the forest landing. Once at the forest landing they are segregated and offered to sawmillers. If sawmillers reject them, they are taken to the chipmill.

A small number of logs arriving at the chipmill will still have sawmill quality wood in them but not a sufficient proportion to justify a sawmiller paying the higher sawlog royalty. This has long been a concern to small sawmillers who have argued for concessional royalties on marginal sawlogs (Drake pers. comm.).

CALM has called for expression of interest to establish a sawmill adjacent to the WACAP chipmill. Logs considered to have sawmill portions will be segregated at the chip mill landing, taken to a treatment area where the sawmill pieces would be cut out and the residue returned to the chipmill.

The specifications for a tender are currently being prepared.

9.3.5 Proposed Changes to Private Property Harvesting

The level of utilisation and recovery being attained in the private property harvesting operation is impressive. However, there is room for improvement in some areas of private property salvage harvesting. Improvements which will be undertaken include:

- A code of harvesting practice to be introduced for harvesting contractors working on private property where the subsequent land use is tree farming. The code will cover such issues as road and snig track construction and drainage, log landing placement and rehabilitation, filter strips along watercourses and utilisation standards. The code will be based on CALM environmental standards as described in the ICM (CALM 1986a).

  The code will also state penalities which could be imposed for infringements of these environmental controls. These penalties should take the form of suspension from the forest or loss of contract quota.

  WACAP supervisors will be responsible for administering the code and enforcing penalties.

- The same worker safety regulations will operate in private property harvesting as in State forest harvesting. The wearing of hard hats, safety boots, and hearing protection will be compulsory for all harvesting crew members, regardless of whether they are operating a machine or not.

There will be penalties for infringements along the lines of initial warnings, suspension and finally life time bans for serious infringement. The WACAP supervisors will administer the safety regulations and impose any penalties WACAP is empowered to enforce.

Timber Industry Regulation inspectors also have responsibility to the extent that the regulations apply.

WACAP has structured its payments to landholders to encourage maintenance of vegetation on properties. This will be maintained. WACAP recognises that in spite of the incentives, there is still some likelihood of landholders clearing forests in order to establish pasture. The tree farming programme should, however, offset this. To ensure that it does, WACAP undertakes to establish a minimum of 5ha of forest for every 1000 tonnes of chiplogs taken from private property.

9.4 MONITORING OF ENVIRONMENTAL SAFEGUARDS

9.4.1 Research

9.4.1.1 Hydrology Research

Much of the hydrology research commenced under the Kelsall Committee in 1973 is now complete and the results have been presented to guide the management of operations. Only on-going projects or proposals for new research are included in this list.

- Project 2 Paired Catchment Study

This study is designed to provide accurate long term information on changes in groundwater systems, sediment loads, streamflow volume and salinity arising from integrated harvesting operations. Seven catchments in three groups representing the range of forest types in the Intermediate and Low Rainfall Zones have been calibrated before one in each group was harvested and regenerated. Results from these catchments will provide the information for on-going review of harvesting and regeneration practices over the next several years. They will also provide information on the long term water quantity and quality effects of a regenerating forest.

- Field assessment of groundwater and soil salt characteristics

Management will be facilitated by the availability of a method to assess local - scale salt sensitivity in the Intermediate and Low Rainfall Zones. This will enable local scale tuning of buffer zone demarcation and phasing of operations. Promising new techniques must be evaluated.

9.4.1.2 Ecology and Silviculture Research

Research within CALM is currently being re-structured into a series of core programmes. Several of the proposed programmes will deliver results applicable in the Southern Forests, but the karri programme is the most relevant. It provides the ecological and silvicultural technical support to the environmental and production management of the integrated harvesting operations. The proposed major short term (within 5 years) goals of this programme are to:

- Develop a preliminary data base of the vascular plant floristics of the karri ecosystem with initial emphasis on the outlying occurrences. Update the 1986 listing of flora from the Warren River Phytogeographical District and distribute the list in a form suitable for use on microcomputer.
- Determine the composition and foraging ecology of bird communities in the main belt of the karri forest, including specific examination of the residency and site fidelity of those species utilising the understorey as habitat.
- Determine the key edaphic, climatic and topographic factors that influence the growth of karri.

- o Determine the distribution and maintenance of genetic variability in karri, including those families established in provenance trials.
- o Prepare an inventory of the fungi associated with wood defects in karri.
- o Determine the relationship between bird community composition and changes in the structure and floristics of the vegetation caused by forest operations.
- o Formulate a strategy for efficient management of the genetic resources of karri.
- o Investigate the breeding system of karri and develop treatments to maximise the production of seed from orchards.
- o Evaluate the use of cuttings technology for use in karri breeding work.
- o Collaborate with operations staff to ensure production of healthy plants from the nursery.
- o Develop a model that can predict the productive potential of a site at the commencement of the rotation.
- o Determine the effect of initial spacing, thinning and fertiliser application on the growth of karri.
- o Establish further trials to investigate key aspects of karri silviculture.
- o Provide guidelines for fuel reduction burning of regenerated forests and determine the impact of burning on growth and productivity. Interactions between silviculture and fire will be considered.
- o Conduct an assessment of the economic importance of wood defects in karri particularly those caused by fungi and wood borers.
- o Improve techniques for sawing, seasoning and preservative treatment of karri.

9.4.2 Supervision and Control

The process by which CALM implements policy is described in Section 9.1, 9.2 and illustrated in Figure 25. It is also described in Sections 4.2.6-8 at the operational level. This process has controlled the operations in accordance with the standards laid down in the original EIS and those refined over time (see Section 4.2).

Additional control is exercised now by the need to obtain EPA approval for modification to the buffer system. In addition, public scrutiny of operations is ongoing, and observed practices can be measured against standards described in this ERMP/Draft EIS. Such scrutiny has occurred in the past and will continue.

9.5 MECHANISM FOR FEEDBACK

The monitoring of operations with positive feedback to correct problems as they arise is essential to the ongoing management of this industry as it is for other industries. The general mechanism for feedback and control for management of State forest is illustrated in Figure 25.

This mechanism has worked well as described in Section 4.2.11 and 4.2.12 and will be continued.

9.6 WACAP RESEARCH PROGRAMME

WACAP has been conducting research activities by both company employees and by contract, mainly with CSIRO (Commonwealth Scientific and Industrial Research Organisation).

WACAP currently has two professionally qualified Research Officers on staff plus the Commercial Manager who takes a management role in all research activities. Also, WACAP employed the services of five field staff on a casual basis during 1986.

At January 1987, there were four CSIRO personnel working full time on WACAP funded projects.

WACAP also has joint CALM/WACAP, WACAP/Alcoa research projects underway. WACAP is also involved, to a small degree, with the National Biotechnology Programme being managed by Alcoa.

Research projects and topics which WACAP is actively pursuing are many, and vary in nature. During 1986 at least 22 different research projects were being carried out. Many of these projects will, because of the long term nature of forestry research, continue well into the future. For a list and brief description of non-confidential research projects undertaken or funded by WACAP during 1986 (see Appendix G). This pro-active research programme is aimed at assisting WACAP meet long term objectives and at increasing the utilisation of existing resources.

WACAP is currently spending approximately $250,000 per annum on its research programme.

9.7 ARCHAEOLOGICAL AND ETHNOGRAPHIC ISSUES

Ethnographic and archaeological aspects of the project will be addressed by CALM, in consultation with the Western Australian Museum. Museum officers will identify any recorded sites within the licence area, such as Aboriginal burial sites, artefacts, marked trees, stone arrangements or habitation structures. CALM will use local committees to gather knowledge to check and update museum records. The need for additional surveys in selected areas of the woodchipping licence area, will be determined through on-going liaison between CALM, and the Western Australian Museum.

Current information is that the majority of known sites are in the coastal areas outside the main forest belt and the industry's activity (CALM 1987a).

The Proponent acknowledges its obligation to site protection as outlined in the Western Australian Aboriginal Heritage Act 1972-80, and will take measures to inform all personnel associated with woodchipping activities of their obligations under the Act. Operations will be modified in accordance with CALM directions, if necessary, to avoid damage to any Aboriginal sites which are identified.

REGENERATION DEVELOPMENT IN MIXED JARRAH-MARRI STANDS
CORONATION ROAD TRIAL AREA

BEFORE (1971)

Regeneration, natural jarrah-marri, two years old. Culls left standing, damaged saplings not coppiced.

(Source: Marri Woodchip Project EIS, 1973 WAFD)

AFTER (1987)

(Source: CALM, 1987)

REGENERATION DEVELOPMENT IN MIXED JARRAH-MARRI STANDS
CORONATION ROAD TRIAL AREA

BEFORE (1971)

Regeneration, natural jarrah-marri, two years old. Culls fallen, damaged saplings coppiced.

(Source: Marri Woodchip Project EIS, 1973 WAFD)

AFTER (1987)

(Source: CALM, 1987)

REGENERATION DEVELOPMENT IN MIXED KARRI-MARRI STANDS
MARCH ROAD TRIAL AREA

BEFORE (1969)

Regeneration, mostly karri, four years old. Virgin mixed karri-marri in background. Marri in foreground.

(Source: Marri Woodchip Project EIS, 1983 WAFD)

AFTER (1987)

Note: Forest to the left of the road has been cut and regenerated.

(Source: CALM, 1987)

REGENERATION DEVELOPMENT IN MIXED KARRI-MARRI STANDS
MARCH ROAD TRIAL AREA

BEFORE (1969)

Regeneration, mostly karri, four years old.

(Source: Marri Woodchip Project EIS, 1973 WAFD)

AFTER (1987)

(Source: CALM, 1987)

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11.0 GLOSSARY

advance burn	A prescribed fire that reduces fuel through a forest area before felling operations.
advance growth	Young trees that have established themselves in openings in the forest, or under the forest cover, before regeneration fellings are begun.
afforestation	Establishment of a forest in an area from which forest vegetation has always or long been absent.
age class	One of the intervals into which the range of age of trees in a forest is divided for classification or use; also the trees falling into such an interval.
age rotation	The age at which the stand is considered ready for final harvesting under the adopted plan of management.
alienation	The process of transfer of ownership of land from the State to private hands.
amenity	Those natural or man-made qualities of the environment from which man derives pleasure, enrichment and satisfaction.
amelioration	To make better or more tolerable, e.g. of soils by the addition of fertiliser.
area, seed production	A natural or planted stand of phenotypically superior trees, set aside and managed to stimulate seed production.
Archaean	Referring to rocks older than 2,600 million years.
basal area	The area of the cross section of a stem, usually of a tree at breast height (1.3m above ground on the high side of the tree). When applied to a crop, the sum of the basal area of all stems or the total basal area per unit of area.

base flow	That part of runoff that is not storm flow. Sustained by outflow from groundwater aquifers, perched water tables and the slow drainage of unsaturated soils.
basic (or export) industry	An industry which is part of the economic base activity.
block	(1) A main territorial division of a forest, generally bounded by natural features and bearing a local proper name. (2) A number of plots grouped together because they appear homogenous in respect of the variables to be studied, except for differences in experimental treatment.
bole	The main stem of a tree.
buffer	(1) Substances in the soil that oppose changes in soil reaction. (2) An area of land managed in such a way as to protect another area from outside influences.
bush	General term for all types of forest or woodland, normally applied only to indigenous forest.
butt	The base of a tree or the lower end of a log.
butt, long	Part of the lower end of a butt log cut off to remove a defect of some kind.
catchment area	The total area draining into a given waterway or reservoir.
clearing	(1) An area from which the forest growth has been removed, more or less permanently. (2) An open space in a forest.

compartment	The basic administrative unit of a forest.
competition	The struggle for existence which exists when the supply of necessary energy or materials is insufficient for the normal development of all individuals.
concentration index (or location quotient)	The relationship between a basic industry's share of employment in the local context and at the regional level.
conservation	The management of human use of the biosphere so as to yield the greatest sustainable benefit to present generations while maintaining its potential to meet the needs and aspirations of future generations. Conservation thus embraces preservation, maintenance, sustainable utilisation, restoration and enhancement of the natural environment (from: World Conservation Strategy).
control	(yield) The regulation of annual or periodic fellings.
coppice	A shoot (or shoots) arising from adventitious buds at the base of a woody plant that has been cut near ground or burnt back.
corduroy	To build a road by cross-laying it with saplings or small poles to provide traction or flotation in soft conditions.
coupe	A discrete felling area.
crystalline	Rocks composed of interlocking crystals e.g. granite.
cull	Trees of crop of merchantable size but rendered unmerchantable by defects.
cycle, hydrologic	The movement of water in nature through the whole or parts of a cycle in which, commencing as water vapour, it passes into liquid and solid form as precipitation, then into the ground or as runoff, or groundwater to larger bodies of water from which by transpiration and evaporation, the water returns as vapour to the atmosphere.

cycle, salt	The movement of sodium chloride in nature from the ocean, via the atmosphere to the land and back to the ocean.
dieback	The progressive dying, from the top downward, of twigs, branches or tree crowns.
dieback disease	In Western Australia, particularly applied to the effects of the root rot fungus Phytophthora cinnamomi (also dieback forest).
dieback disease risk	The likelihood of introduction of Phytophthora cinnamomi to a locality by either natural or artificial spread.
dieback disease susceptibility	The ease and rapidity with which the pathogen Phytophthora cinnamomi is able to bring about the decline and death of a species.
dieback-tolerant forest	Forest in which site factors and/or species combine so that tree deaths will not occur if dieback disease is introduced. Note that lack of tree deaths does not infer no effects, either on the tree or on the understorey.
dolerite	A medium-grained basic hypabyssal igneous rock.
drought index	A measure of the moisture content of heavy fuel such as logs and deep fuel beds. It indicates suppression difficulty and reflects the influence of long term past weather.
duricrust	The general term for a hard crust on the surface of, or layer in the upper horizons of, a soil in a semi-arid climate.
ecology	The study of plants and animals in relation to their environment.

economic base	A region's economic activities which involve sales to individuals or firms located outside the region, thus giving rise to an inflow of money from non-local sources.
ecosystem	The interacting system of a biological community, both plant and animal, and its non-living surroundings.
ecotype	Genetic variation within a species caused by isolation and environmental selection.
edaphic	Any soil characteristic that affects plant growth.
environmental impact statement	A written statement containing a detailed assessment of the anticipated significant beneficial and detrimental effects which projects may have on the quality of the environment.
erosion	The general processes of wearing away of materials of the earths crust by natural agencies i.e by water, wind or moving ice.
evaporation	The loss of water vapour from soil, vegetation and water bodies.
evapotranspiration	Loss of water from an area of land through transpiration of plants and evaporation from the soil.
even-aged	Applied to a stand in which relatively small age differences exist between individual trees.
exotic	A plant introduced from another locality.
fell, to; felling	The act of cutting down a standing tree or trees.
felling, clear	The felling and removal of the standing crop. Subsequent crop even-aged. (Syn. Clear cutting or clean cutting, but these terms are not favoured). See also silvicultural systems.

felling, selection	The periodic removal of exploitable trees, individually or in small groups, in an uneven-aged forest in order to realise the yield and to achieve natural regeneration.
feral	An introduced or domestic animal now living in the wild, as in feral cat.
ferruginous	Pertaining to or containing iron.
forest	An ecosystem characterised by a more or less dense and extensive tree cover. An area of land proclaimed to be forest under a Forest Act. To qualify as a forest, an area must be at least 30 metres in width, at least 0.4 hectares in area and have sufficient trees to provide 10 per cent crown cover.
forest, coppice	Forest consisting of trees derived from coppice shoots or root suckers.
forest, dry sclerophyll	Open eucalypt forest with an understorey composed mainly of sclerophytic shrubs and herbs.
forest, normal	A forest which is ideally constituted as regards growing stock, age class distribution and increment, and from which the periodic removal of produce equal to the increment can be continued indefinitely.
forest, wet sclerophyll	Tall open eucalypt forest with an understorey composed largely of mesophytic shrubs and herbs but with a sclerophytic component.
gneisses	Banded rocks formed during high-grade regional metamorphism.
granite	Light-coloured coarse-grained plutonic rock containing quartz.

group selection system	A silvicultural system in which the crop is felled in small groups either to permit regeneration to develop or to release advance growth.
habitat	The kind of place in which an animal or plant lives.
habitat	The particular type of environment occupied by organism.
high rainfall zone (HRZ)	Area where rainfall exceeds 1100mm/yr.
improvement, timber stand	All cuttings, not part of a major harvest felling, made during the life of a stand for improving the stand as regards composition, condition or rate of growth.
increment	The increase in girth, diameter, basal area, height, volume, quality or value of individual trees or crops during a given period.
increment, current annual	The growth, generally of a stand, for a specific year.
increment, mean annual	The total increment produced by a stand at a specified age, divided by the age.
incipient dieback disease	Forest in which Phytophthora cinnamomi is present or suspected, but dieback symptoms are yet to appear.
input-output table	Used to assess how each unit of operational output directly and indirectly affects the output, income and employment of other sectors of the regional, state and national economy.
interfluve	The area between rivers; especially the relatively undissected upland or ridge between two adjacent valleys containing streams flowing in the same general direction.

intermediate rainfall zone (IRZ)	Area where rainfall is between 900-1100mm/yr.
landing	A site at which logs have been accumulated for the purpose of loading on to a hauling vehicle.
laterite	Iron-rich material which hardens on exposure to the atmosphere and is associated with deeply weathered profiles.
legume	Plants belonging to the family Leguminosae.
lignotuber	A woody swelling at the base of a seedling stem, originating on the axils of cotyledons and first formed leaves and containing much bud-producing tissue capable of forming coppice shoots when the old shoot is destroyed.
lithology	Science of the nature and composition of rocks.
log	(1) To fell, haul and deliver logs (logging). (2) The utilisable part of a tree stem.
logging, split-phase	Logging operation in which the felling and snigging operations are completed before hauling commences.
low rainfall zone (LRZ)	Area where rainfall is less than 900mm/yr.
management priority area	An area of forest managed according to its dominant use under a Land Use Management Plan, such as conservation of flora and fauna, water production.
metamorphic rock	One formed in the solid state by heat and pressure, includes such rock types as gneisses and schists characterised by a strong foliation.

migmatite — A composite rock composed of igneous or igneous-appearing and/or metamorphic materials.

multiple use — The use of land, especially forest land, for several different purposes. Some types of use are compatible with each other, e.g. water production and conservation of flora and fauna, but others may not be compatible, in which case it is necessary to set a priority or even exclusive use for a particular area (see Management Priority Area).

multiplier — A ratio between a direct stimulus (employment, income or output) and the indirect effect of that original stimulus. The indirect effect can include firms supplying raw materials or services to the organisation responsible for a direct stimulus.

- Type I Multiplier = $\dfrac{\text{Direct Effect + Indirect Effect}}{\text{Direct Effect}}$

- Type II Multiplier = $\dfrac{\text{Direct + Indirect + Induced Effect}}{\text{Direct Effect}}$

niche — A particular role (or set of relationships) of organisms in an ecosystem, which may be filled by different species in different geographical areas.

overcut — The cutting of a stand or forest at a rate in excess of the growth in merchantable size classes.

pathogen — A living entity capable of causing disease.

physiognomy — The characteristic appearance of a plant community by which it can often be recognised at a distance. It is usually determined by the dominant plants of the community.

podsol	Soils with a very thin organic-mineral layer above a grey leached layer which rests upon an illuvial dark brown horizon. Iron and aluminium oxides have been leached from the A- and deposited in the B- horizon.
Precambrian	The earliest geological era. Life formed in the late Precambrian over 3,000 million years ago.
prescribed burning	The application of fire to land under such conditions of weather, soil moisture, time of day and other factors that will result in the controlled spread and intensity of heat required to accomplish specific silvicultural, environmental or fire hazard reduction objectives. (Syn. controlled burning).
Proterozoic	The more recent of the two great divisions of the Precambrian.
provenance	The geographical source or place of origin of a given lot of seeds or plants.
reforestation	The natural or artificial regeneration of a previously forested area with forest trees.
regeneration	The process of forest renewal, or the plants resulting from natural regeneration process.
regeneration, natural	The renewal of a forest by self-sown seeds, advance growth or coppice. Also applied to the plants themselves.
regrowth	Natural regeneration at the sapling or pole stage of growth.
rotation	The planned number of years between the establishment of a crop and its felling.
royalty	A prescribed fee for forest produce payable to the owner of the forest.

run-off	The total stream discharge from a catchment including both surface and sub-surface flow.
saline	Salty
scrub	Inferior growth consisting of stunted trees and shrubs.
sediment	An accumulation of material deposited by wind, water or gravity.
seed tree	A tree used for, or capable of providing, a supply of seed, especially one reserved for this purpose during regeneration felling.
selection system of cutting	A silvicultural system in which trees are removed individually over the whole area (usually in the course of a felling cycle), to maintain the stand in an uneven-aged condition.
service (or local) industry	Industries not part of a region's economic base.
silvics	The study of the growth habits of forest trees and stands in relation to environmental factors.
silviculture	The art and science of establishment and tending of forest.
slash	The unusable residue after logging or any other waste deposited on the forest floor by a tending operation such as pruning.
snig, to	To haul a log from the tree stump to a landing or loading point.
spacing	The distance between trees in a plantation. (Syn. espacement).

stumpage	A charge made for a forest product by the grower which is related to the cost of production.
sustained yield	(1) The material a forest can yield periodically in perpetuity. (2) As applied to forest policy, a method or plan of management (sustained yield management) that implies continuous production with the aim of achieving, at the earliest practicable time and at the highest possible level, an approximate balance between net growth and yield.
system, silvicultural	A method of silvicultural procedure by which crops constituting forests are tended, harvested and replaced by new crops. There are two basic types of silvicultural system, high forest and coppice forest. These two types can be further sub-divided as follows: (1) High forest (a) system with regeneration concentrated in time and space; clear felling (may be in patches or in wedges to minimise wind damage); clear felling with seed trees; shelterwood. (b) systems with regeneration diffuse in time and space; single tree selection; group selection. (2) Coppice forest simple coppice forest; coppice selection; coppice with standards.
table, water	The upper limit of that part of the soil or underlying material wholly saturated with water.
thinning	A felling made in an immature stand for the purpose of improving the growth of trees that remain without permanently breaking the canopy.

timber	A term loosely applied to forest stands or their products and often to wood in forms suitable for heavy construction.
top disposal	A tending operation after a felling in a stand where the slash is cut away from the base of retained stems to avoid damage in any subsequent fire, whether prescribed or otherwise.
topography	Detailed description of surface features, both natural and artificial, of an area.
transpiration	The loss of water vapour from a plant, mainly through the leaves.
tree	A large woody perennial plant having a single well-defined stem (bole or trunk) and a more or less definite crown, attaining a height of at least 3m.
turbidity	Discolouration of water due to suspended silt or organic matter.
unconsolidated sediments	Sediments which are loosely arranged or unstratified.
utilisation	That branch of forestry concerned with the operations of harvesting and the subsequent processing of the forest crop.
volcanics	Igneous rocks that have reached, or nearly reached the Earth's surface before solidifying.
water balance	An account of all water entering and leaving a system over a specific period.
water yield	The volume of water generated by surface runoff from a catchment area.

working plan	A written scheme of management aiming at continuity of policy and action and controlling the treatment of a forest.
yield	The quantity of forest produce available from any operation or combination of operations.

12.0 STUDY TEAM AND ACKNOWLEDGEMENTS

STUDY TEAM

W.A. Chip and Pulp Co Pty Ltd	
John Oldham	Proponent's Representative
Peter George	Proponent's Representative
Dames & Moore	
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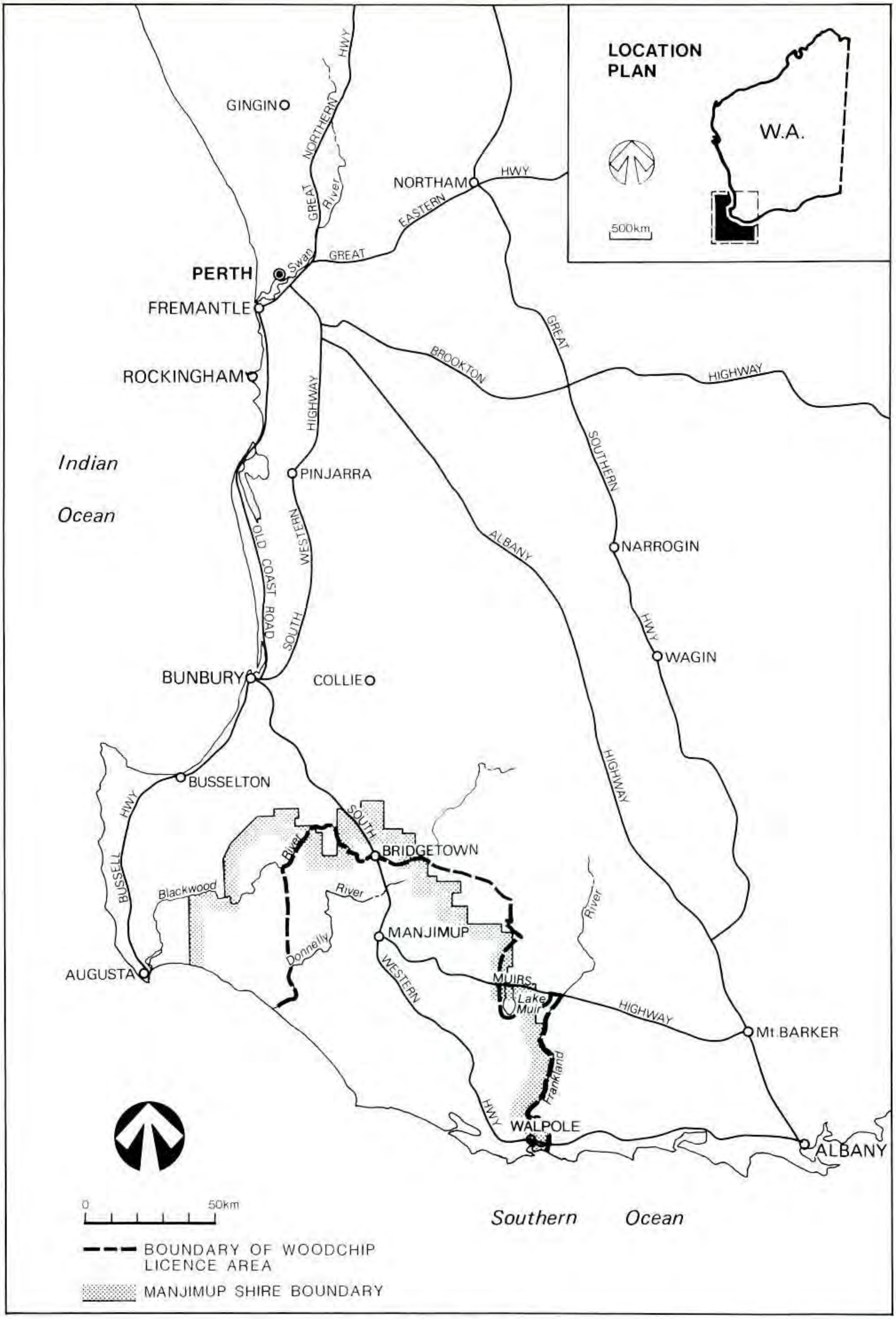
Sandra Gray	Environmental (General)
Doug Martin	Study Manager, Principal Investigator - Socio-economics
Jacqui Morris	Word Processing
Danielle Perger	Word Processing
Max Rikli	Illustration
Rhonda Sinclair	Environmental (General)
Sue Texler	Environmental (General)
John Trudinger	Lead Consultant
Margules & Partners Pty Ltd	
Hugh Dunchue	Forestry (General)
Doug Parsonson	Principal Investigator - Forestry
N.J. Morrow and Associates	
Neville Morrow	Project Management
Hans Vandenberg	Scheduling
Subconsultants	
Libby Mattiske	Vegetation and Flora
Bill McArthur	Geology, Landform, Soils

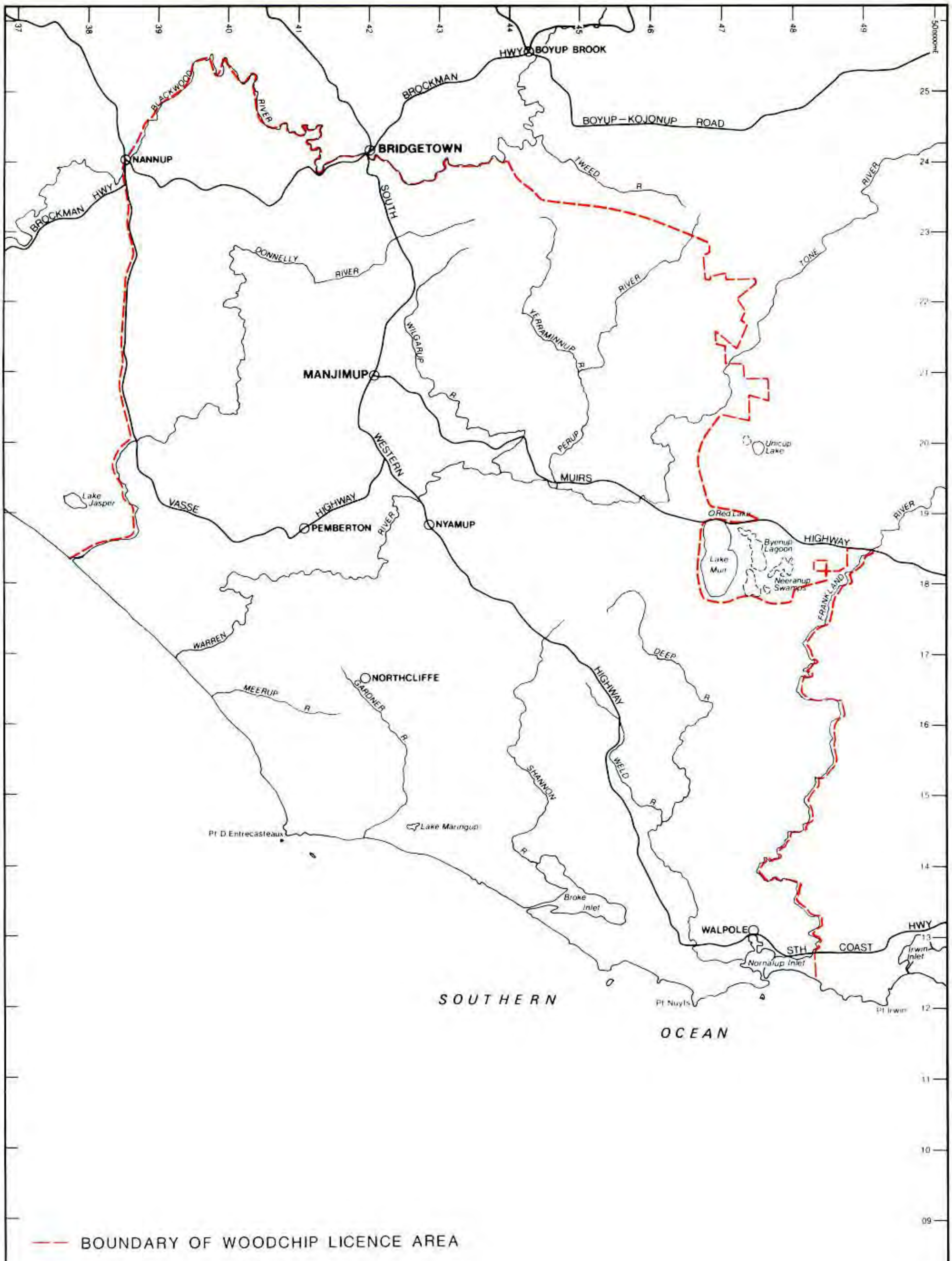
ACKNOWLEDGEMENTS

Preparation of this document would not have been possible without the full cooperation of the Department of Conservation and Land Management and its officers who provided extensive technical input. The assistance of officers of the Department of Conservation and Environment, the Water Authority of Western Australia and the W.A Museum is also acknowledged.

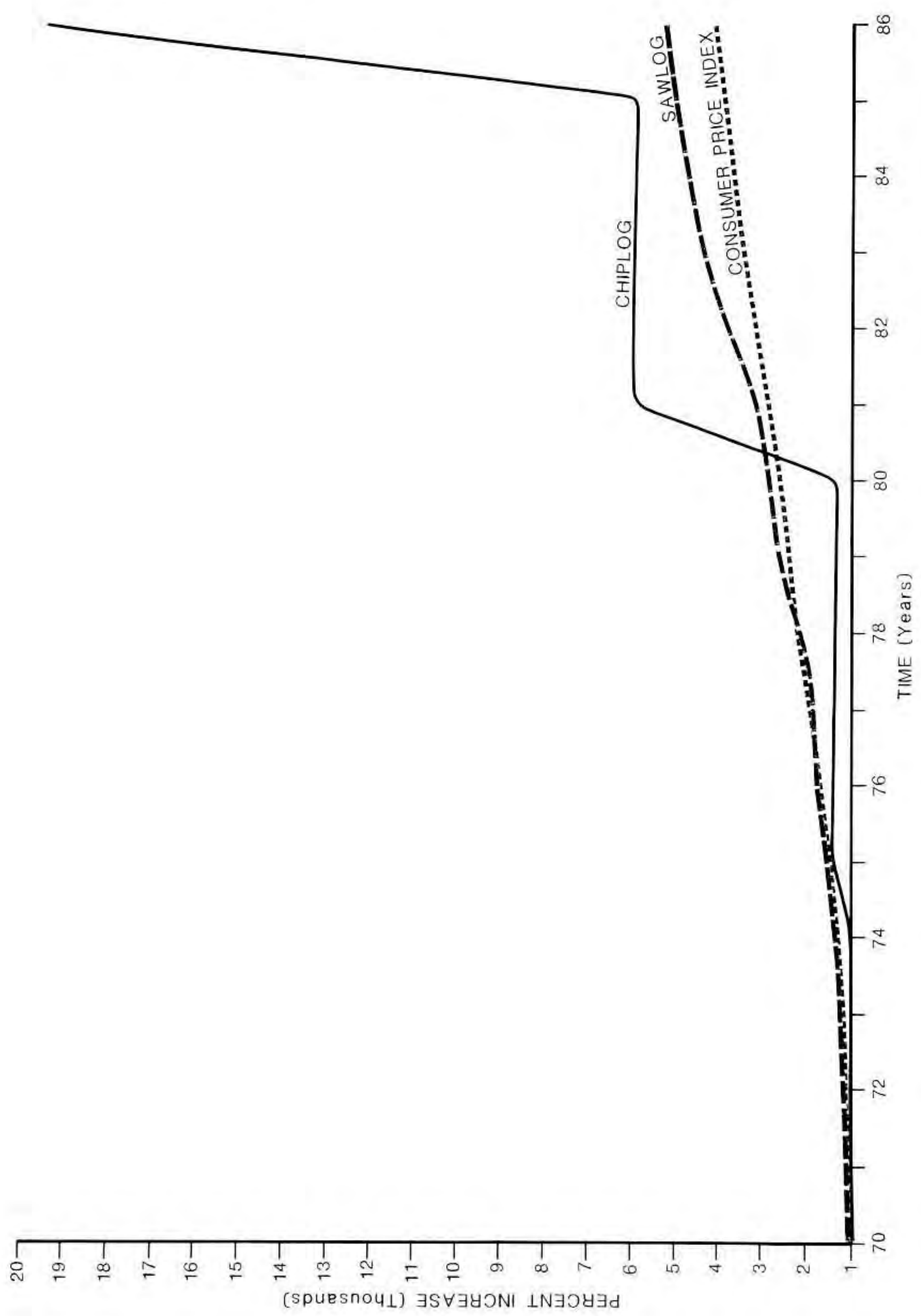
Figures



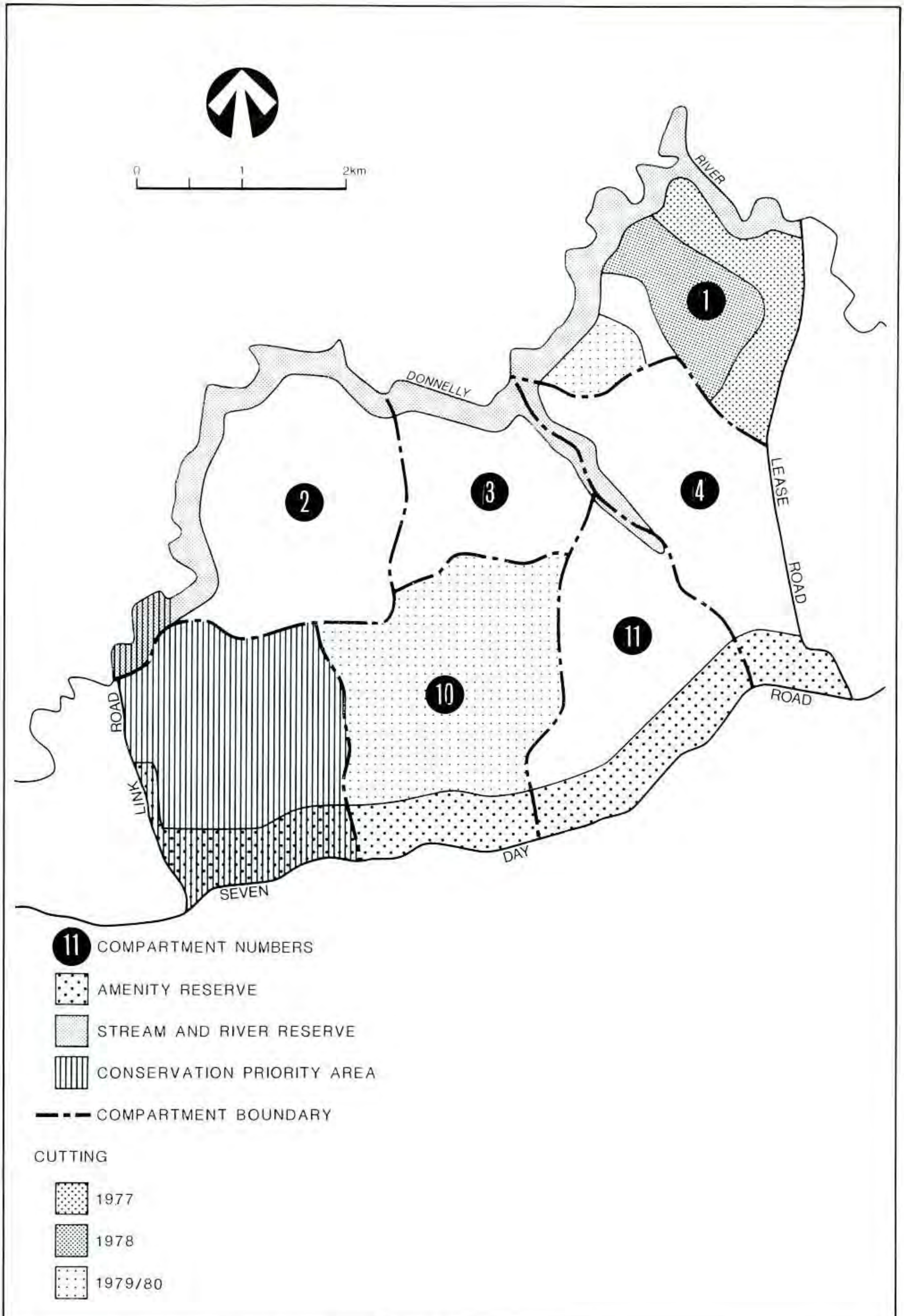
LOCALITY PLAN



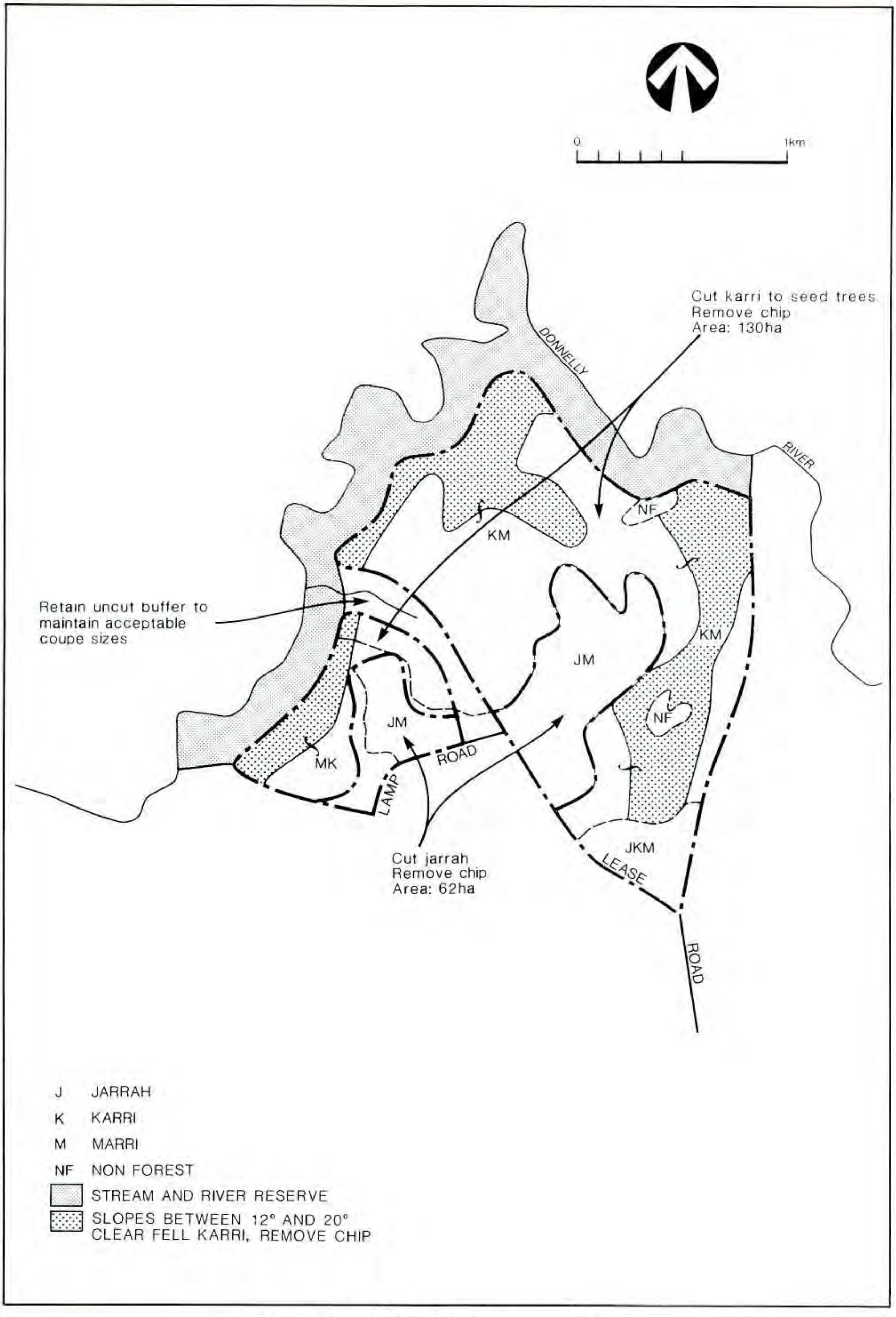
WOODCHIP LICENCE AREA



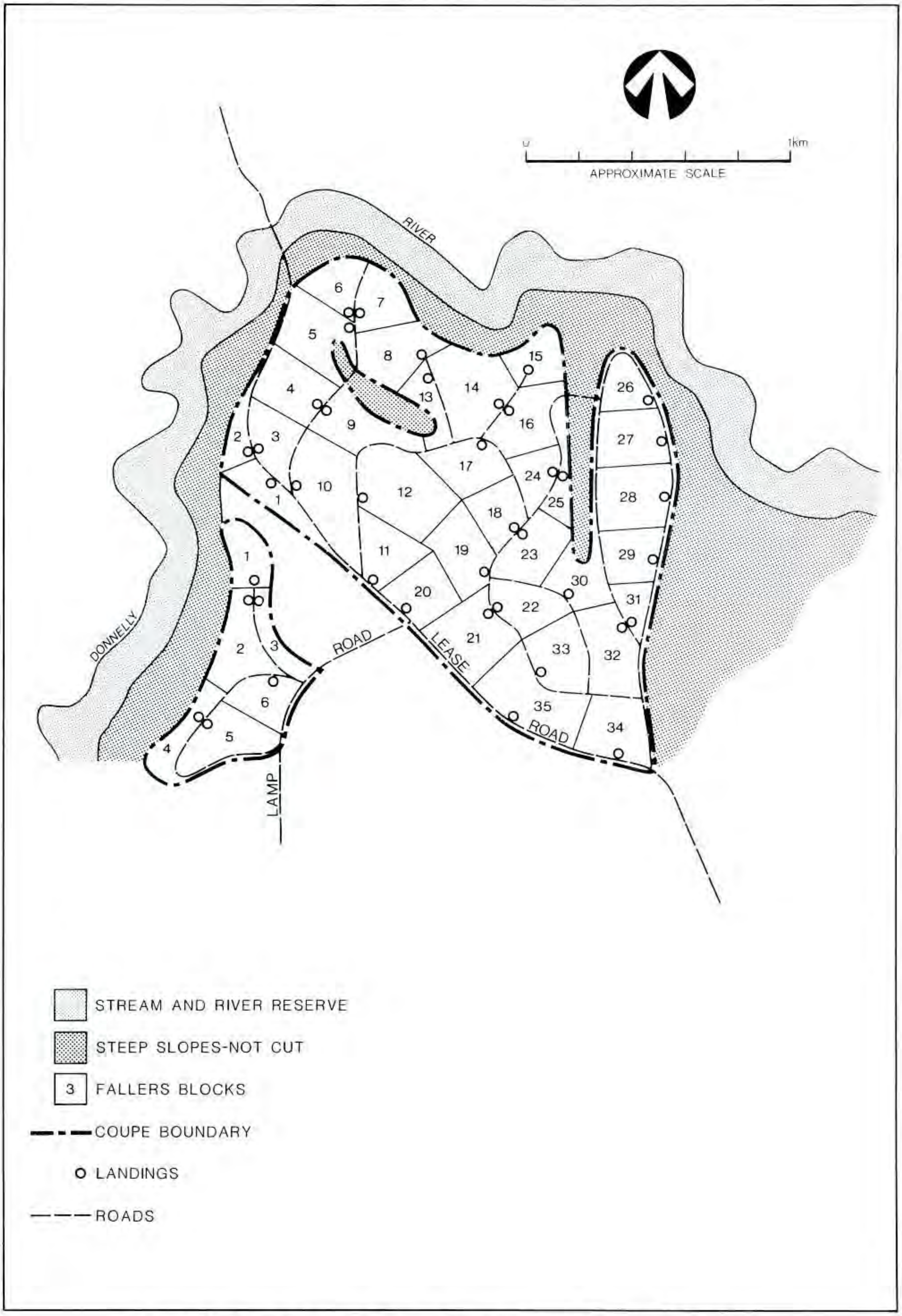
ROYALITY INCREASE RELATIVE TO CONSUMER PRICE INDEX



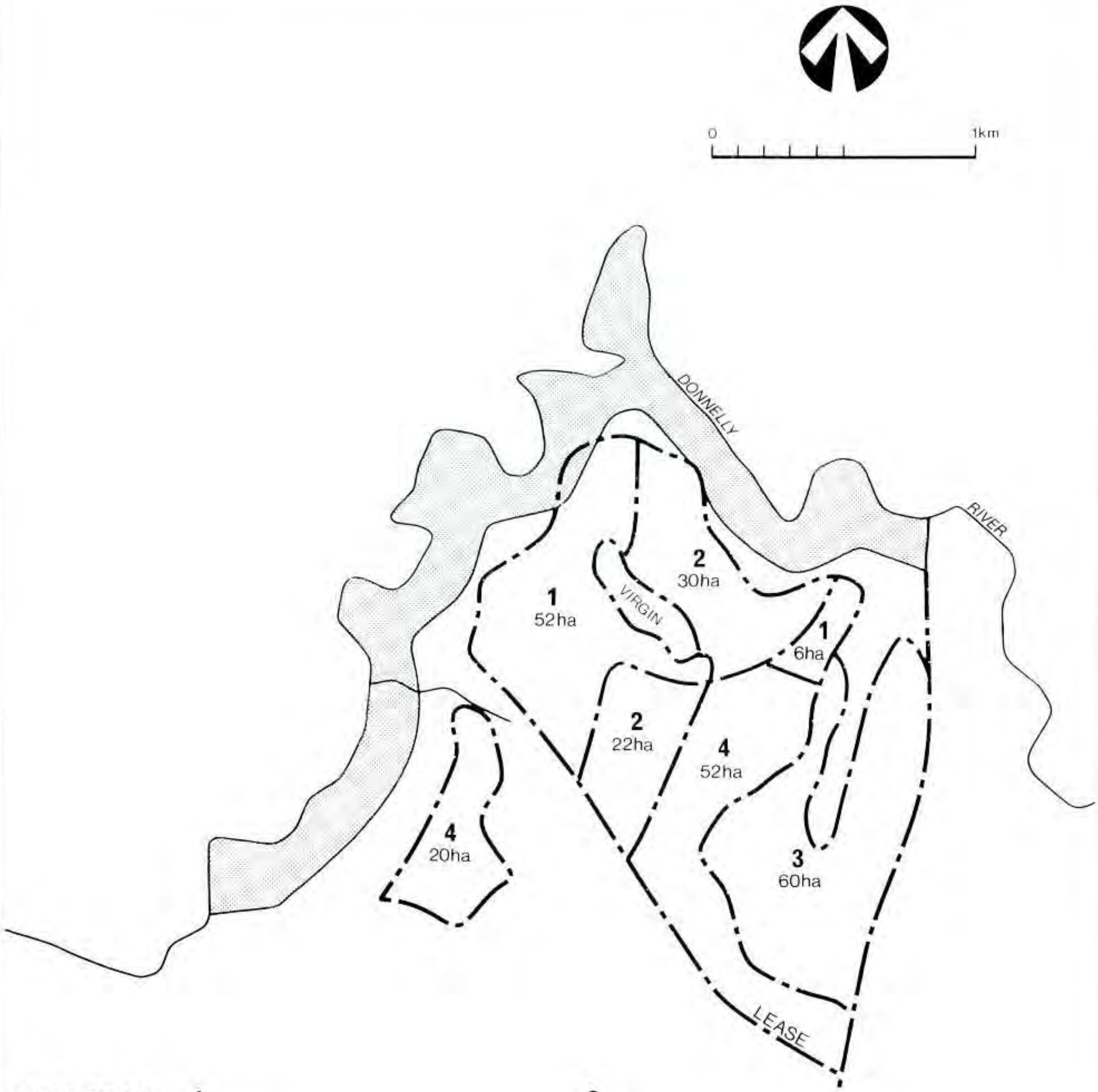
FOUR YEAR HARVESTING PLAN



ONE YEAR HARVESTING PLAN



SCHEMATIC LAYOUT OF COUPE FOR DAILY CONTROL

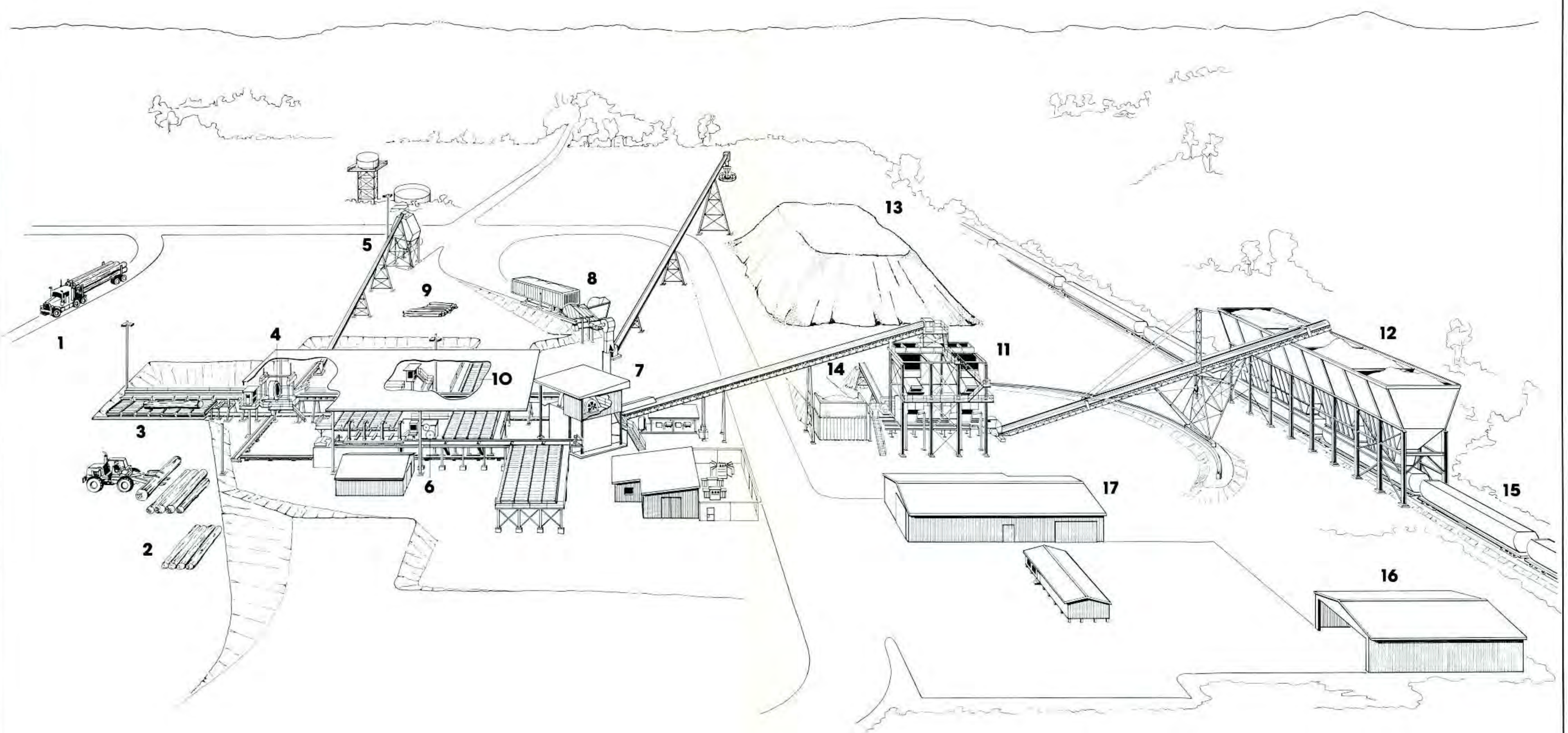


DESCRIPTION	1	2
YEAR:	1980	1980
TREATMENT:	Cull fell, scrub roll regeneration burnt	Cull fell, scrub roll regeneration burnt
SPECIES:	Karri	Karri
METHOD:	Planting	Seed Trees
STOCKING:	1250/ha (4m x 2m spacing)	37.5% by one millacre/24% by four millacre
FERTILISER:	Agras 66gm/tree	None
AREA:	58ha	52ha

DESCRIPTION	3	4
YEAR:	1981	1980
TREATMENT:	Scrub rolled, cull felled, regeneration burnt	Cull felled, scrub rolled regeneration burnt
SPECIES:	Karri	Karri
METHOD:	Planted	Planted
STOCKING:	1250/ha (4m x 2m spacing)	1250/ha (4m x 2m spacing)
FERTILISER:	Agras 80gm/tree	Agras 66gm/tree
AREA:	60ha	72ha

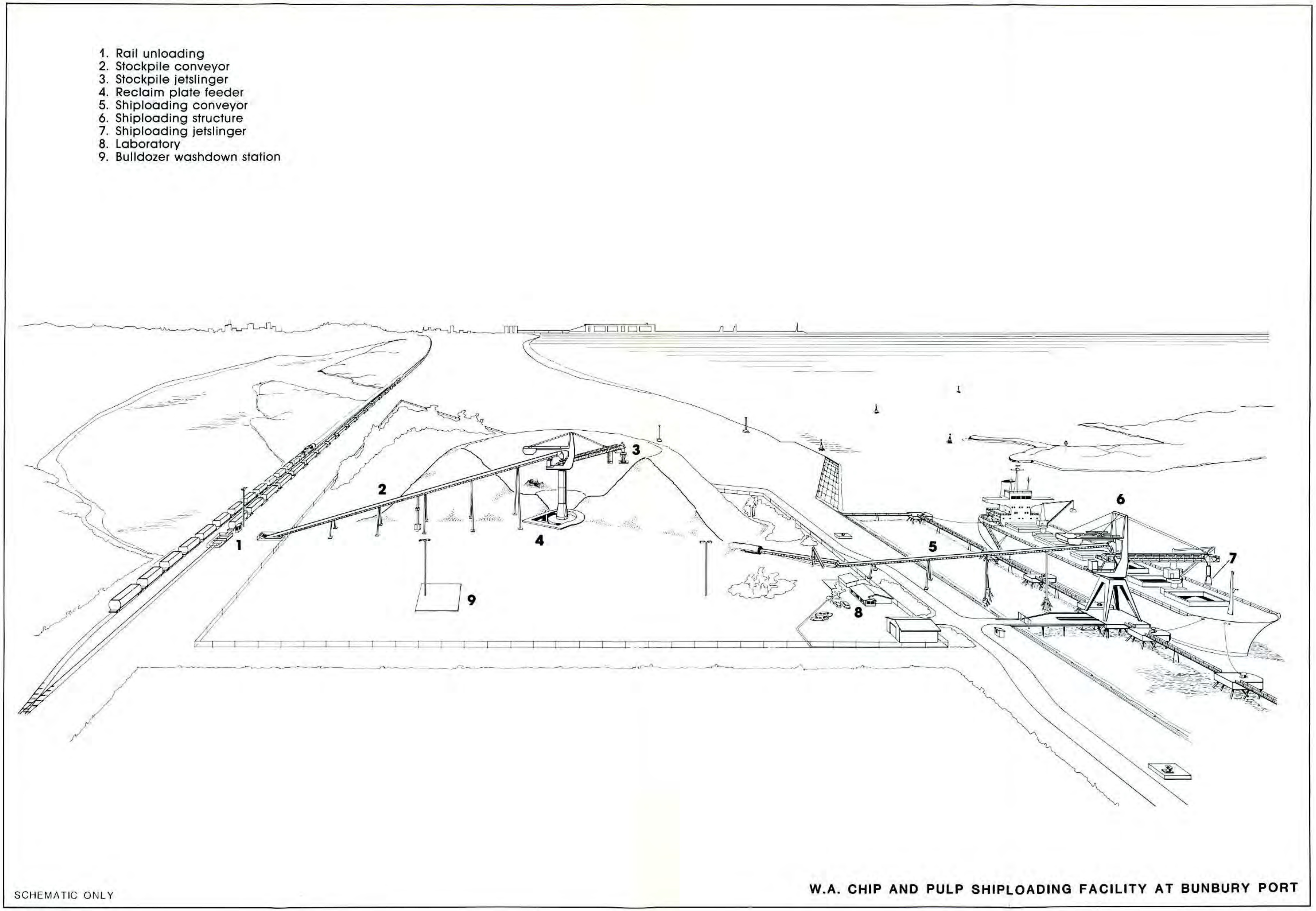
REGENERATION PLAN

1. Chiplog arrival and unload to stockpiles
2. Stockpile to infeed deck
3. Infeed deck
4. Debarker
5. Bark receival
6. Twin saws
7. Chipper
8. Sawmill residue woodchip receival
9. Chiplog from thinning regrowth forests
10. Thinning infeed deck
11. Screens
12. Rail bins
13. Stockpile
14. Stockpile woodchip recovery
15. Rail wagons
16. Mobile equipment workshop
17. Fitting and welding workshop

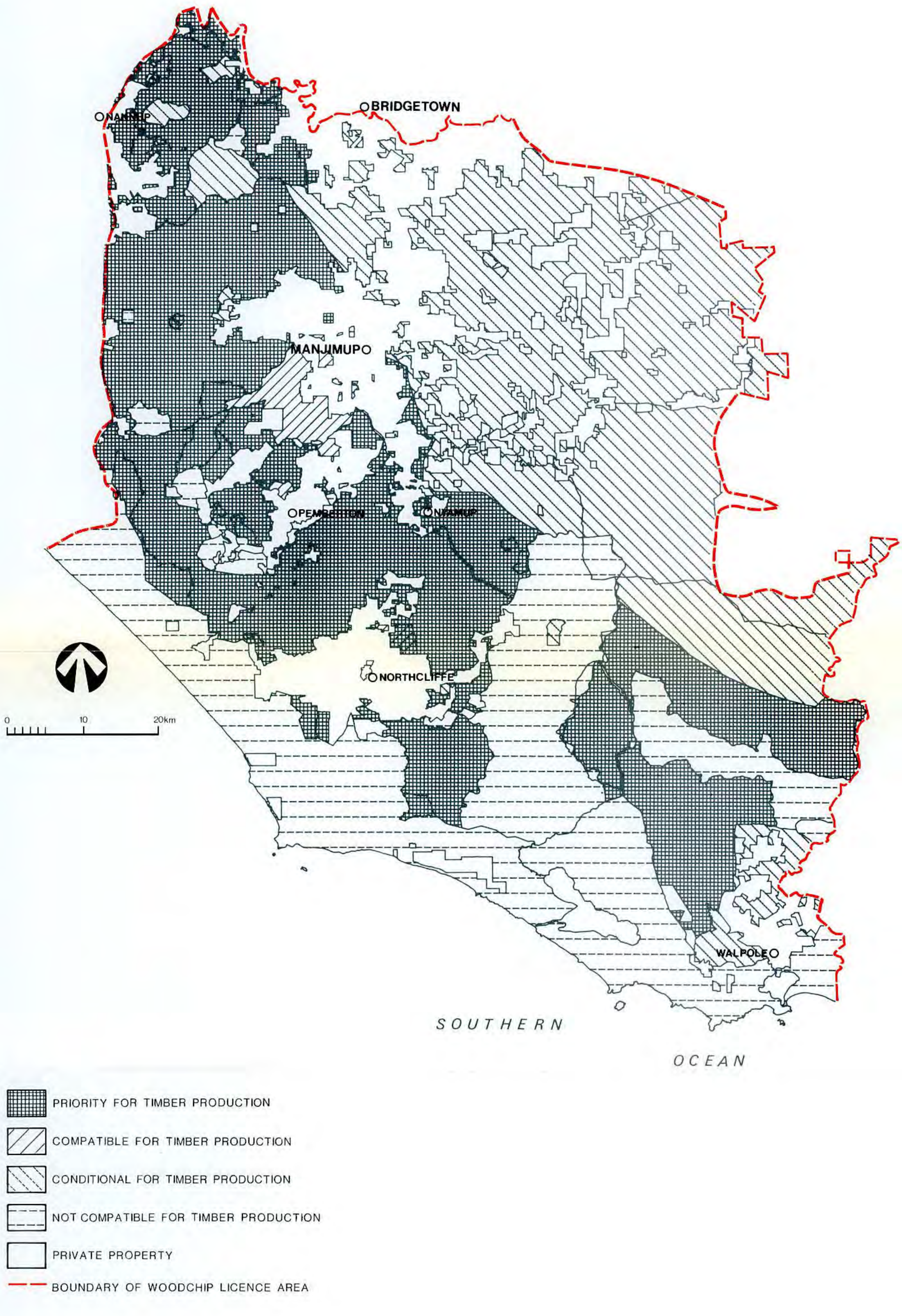


SCHEMATIC ONLY

W.A. CHIP AND PULP DIAMOND CHIPMILL FACILITY

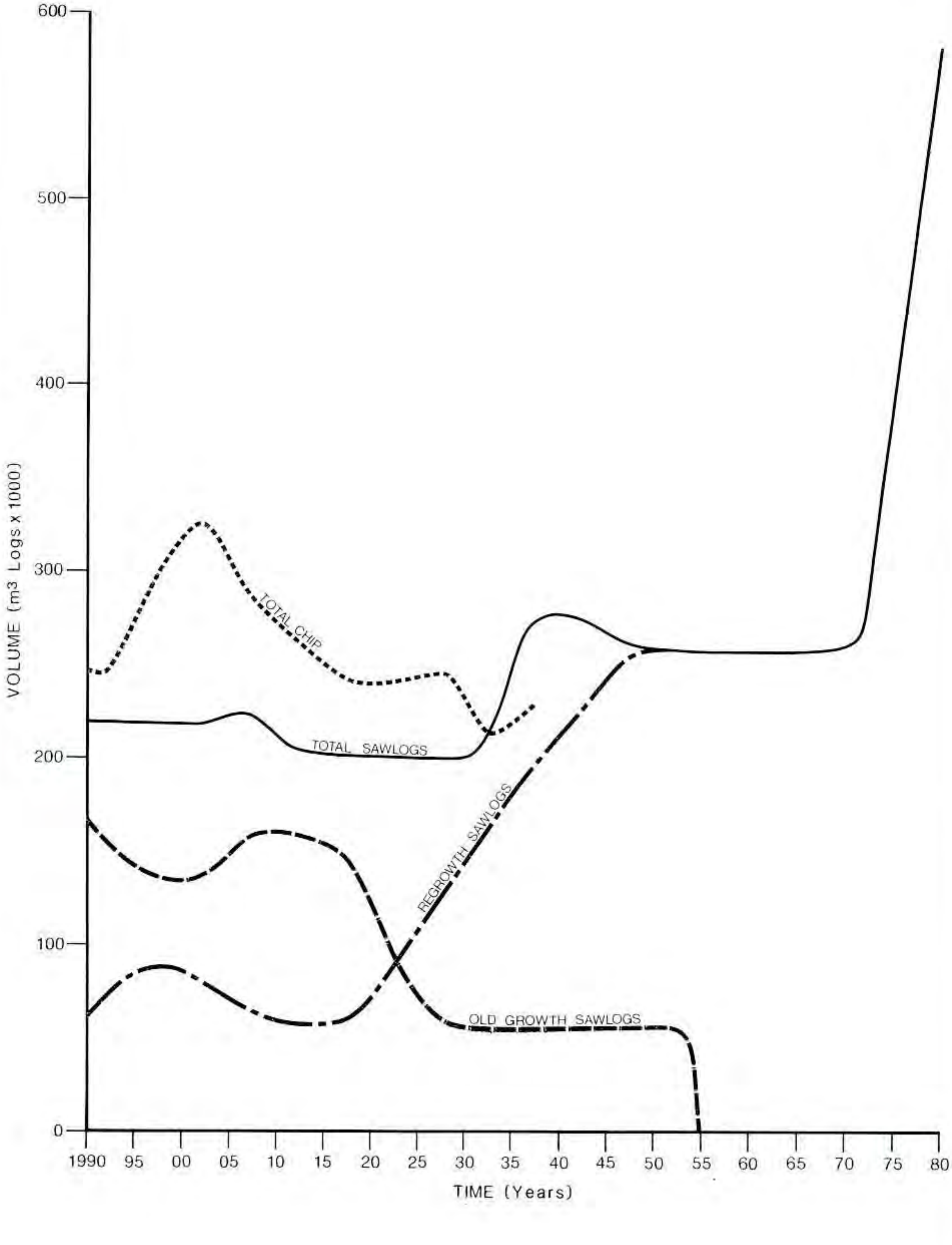


W.A. CHIP AND PULP SHIPLOADING FACILITY AT BUNBURY PORT



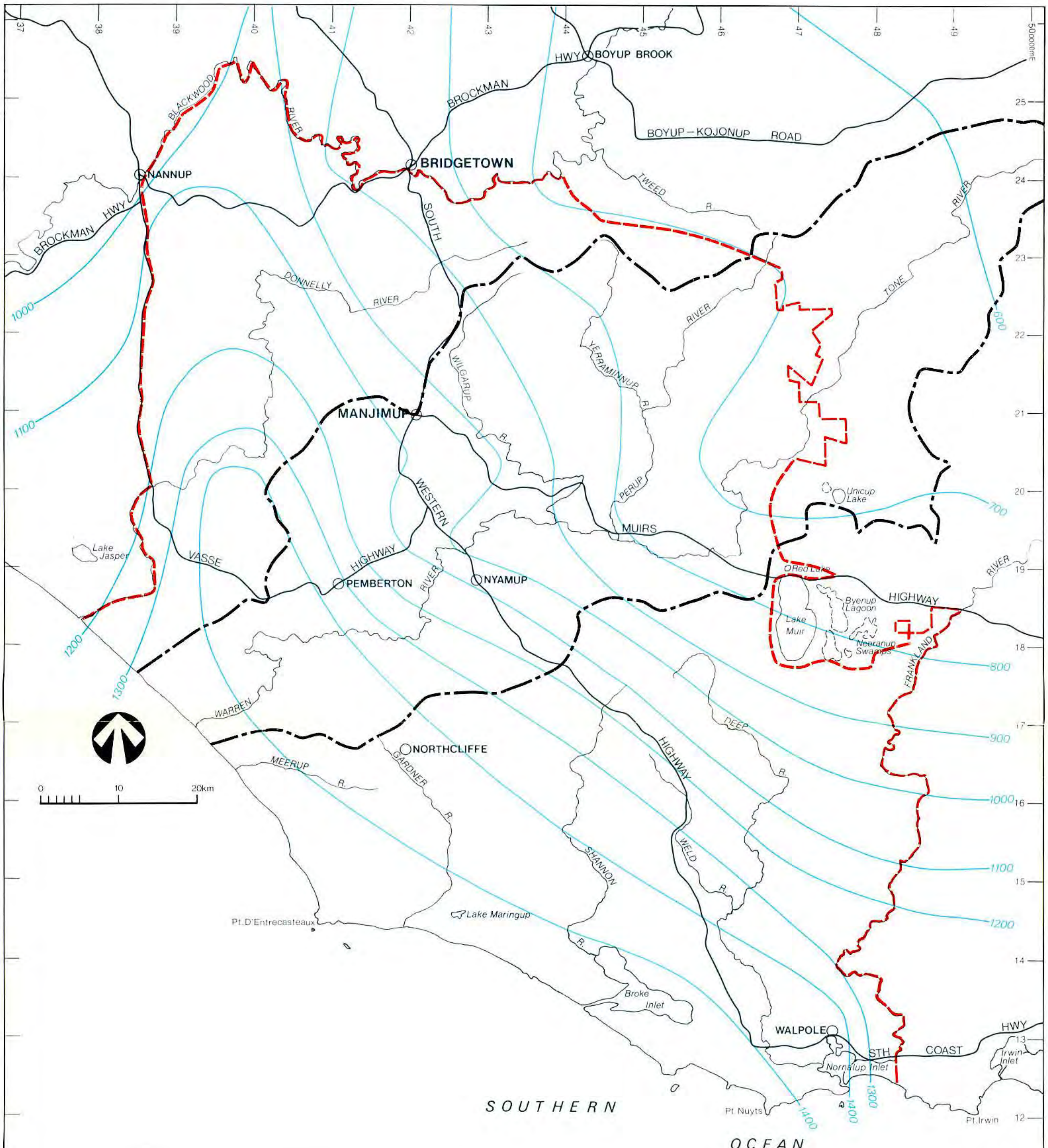
AREA AVAILABLE FOR TIMBER PRODUCTION WITHIN THE LICENCE AREA

(SOURCE: CALM)



(SOURCE: CALM, 1987)

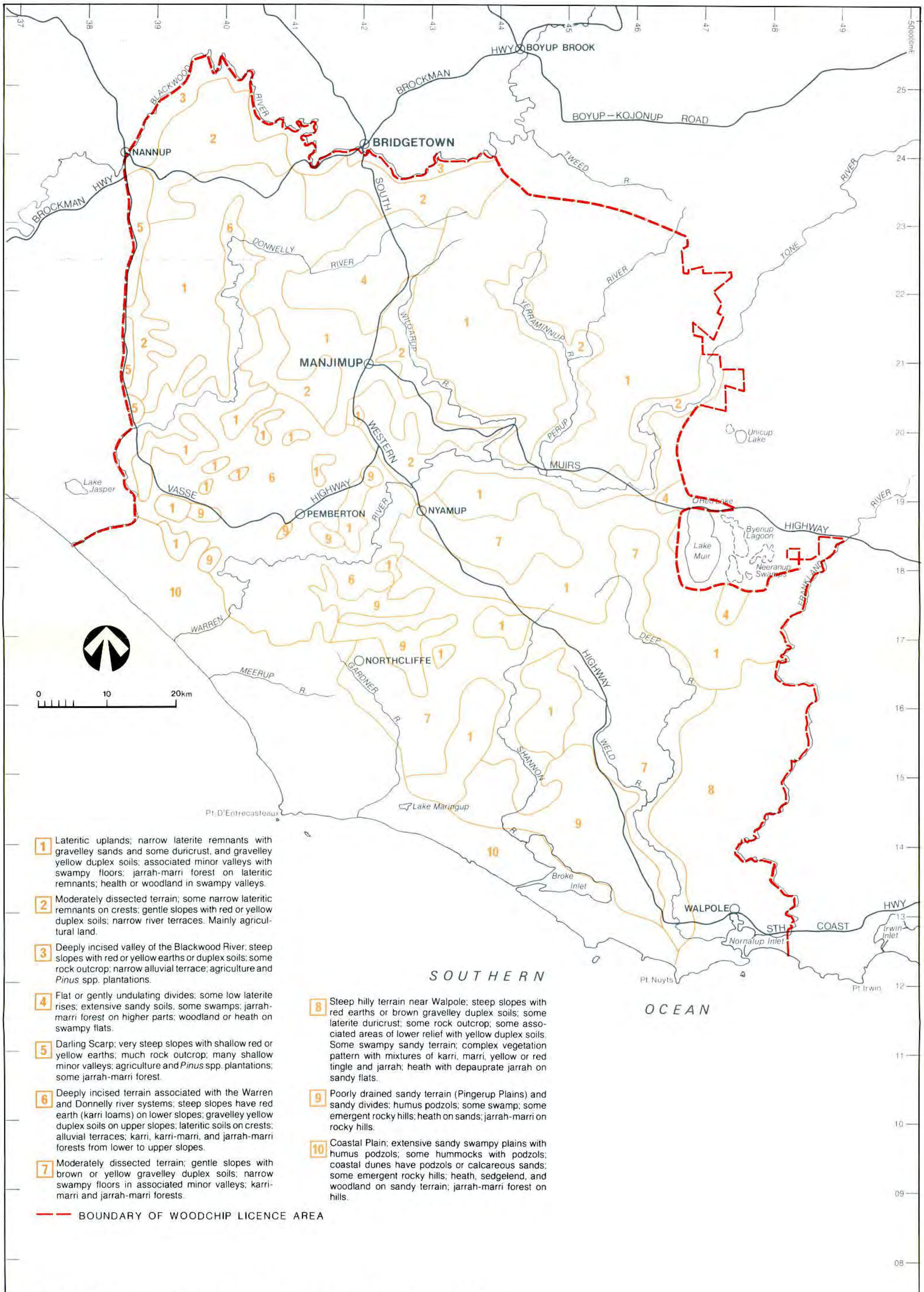
KARRI FOREST LONG TERM YIELD PROGRAMME



RAINFALL ZONES
- High rainfall zone (HRZ): greater than 1100mm/yr
- Intermediate rainfall zone (IRZ): 900-1100mm/yr
- Low rainfall zone (LRZ): Less than 900mm/yr

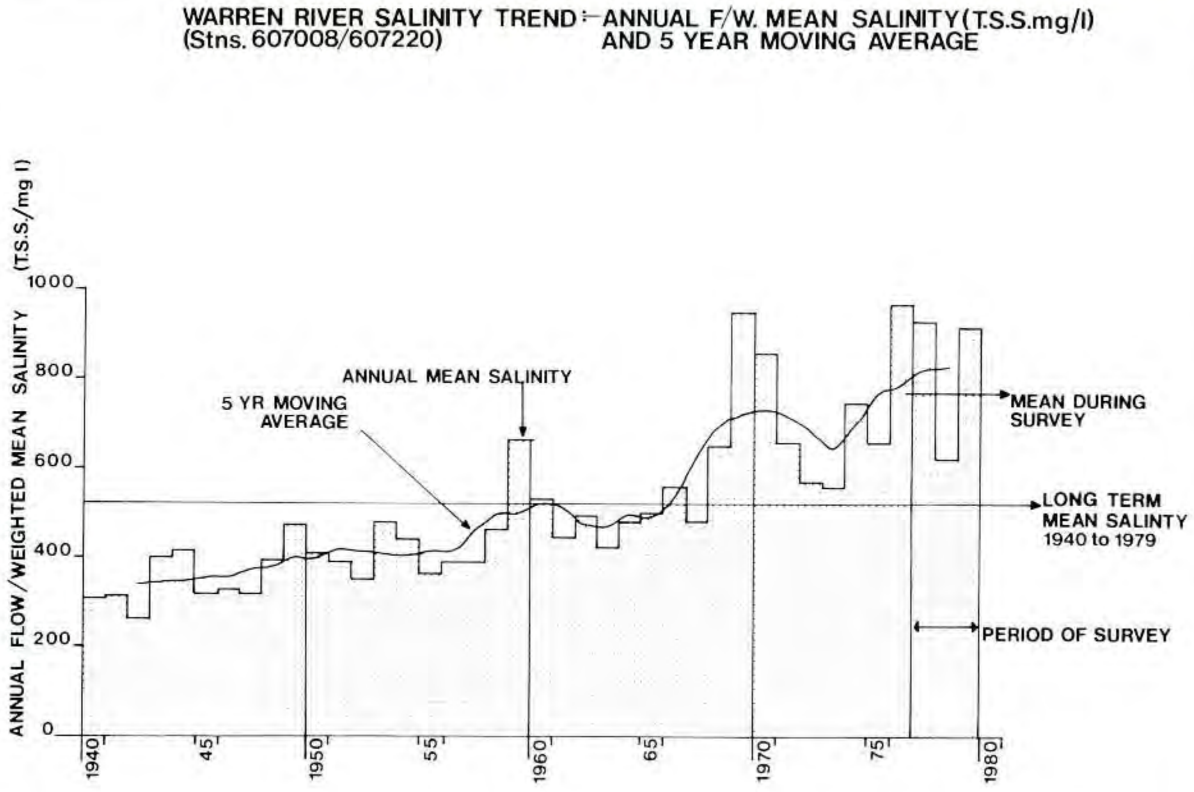
AVERAGE ANNUAL ISOHYETS (mm)
BOUNDARY OF WOODCHIP LICENCE AREA
BOUNDARY OF WARREN RIVER CATCHMENT AREA

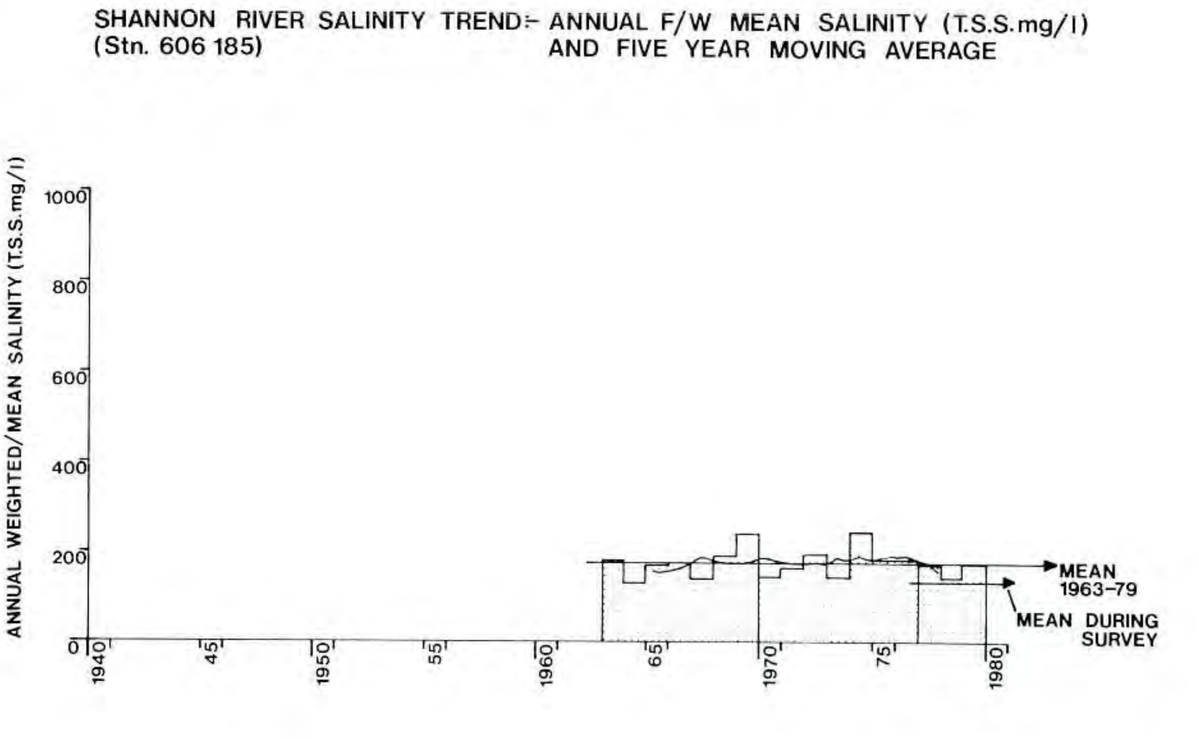
ANNUAL AVERAGE ISOHYETS FOR THE WARREN RIVER CATCHMENT



LANDFORMS AND SOILS OF THE WOODCHIP LICENCE AREA

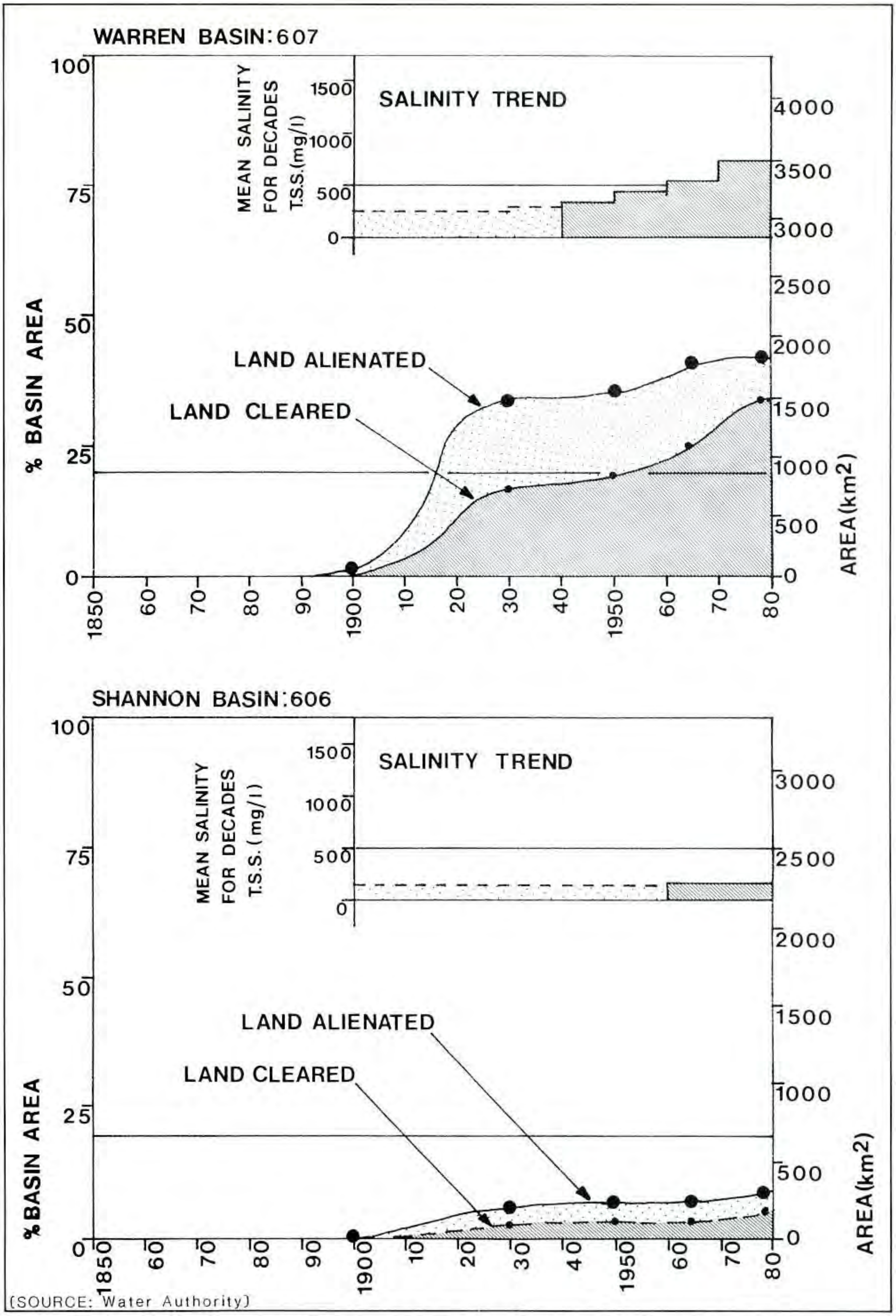
(SOURCE: McArthur & Clifton, 1975 and Churchwood et.al, in press)



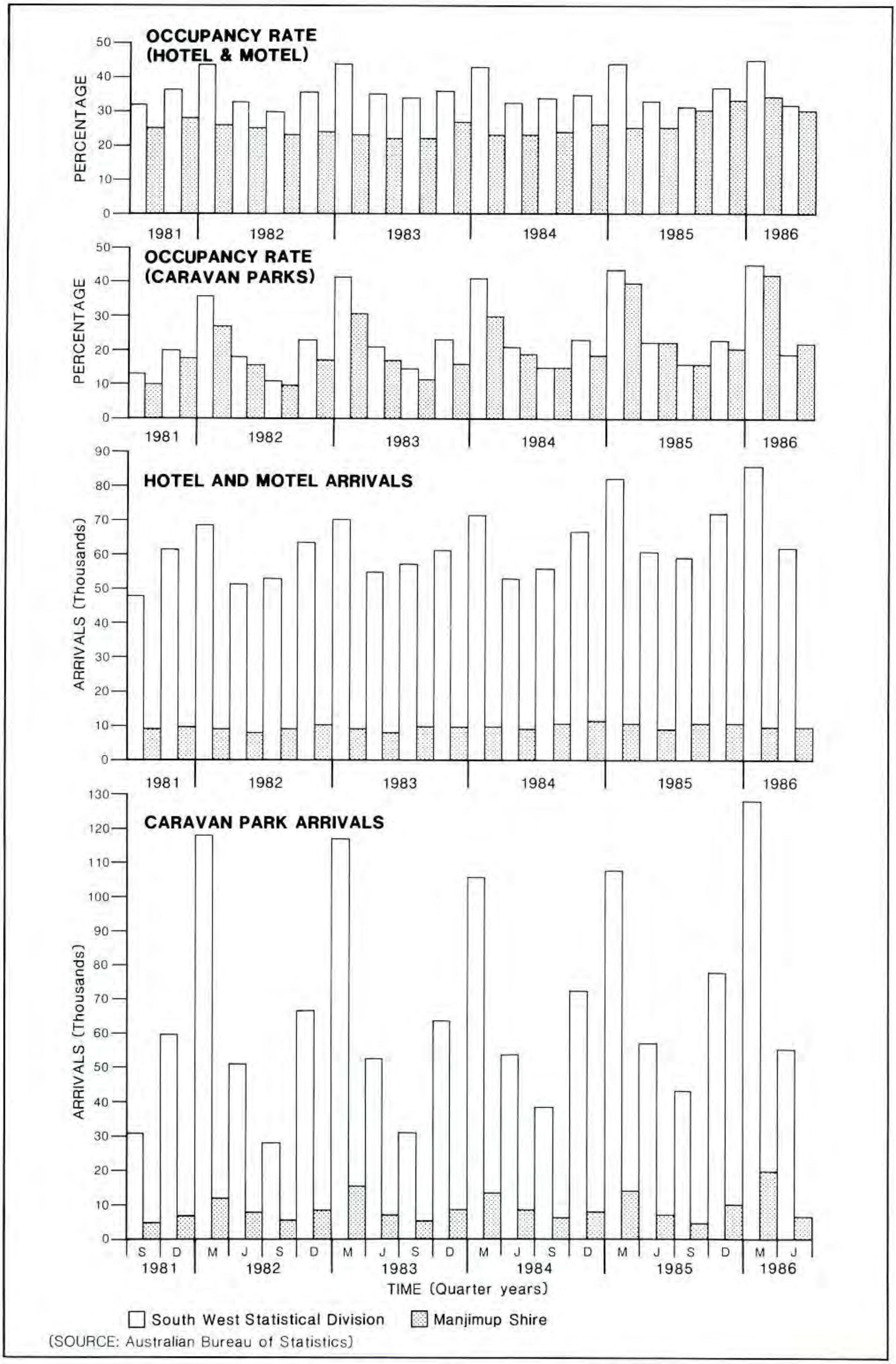


(SOURCE: Water Authority)

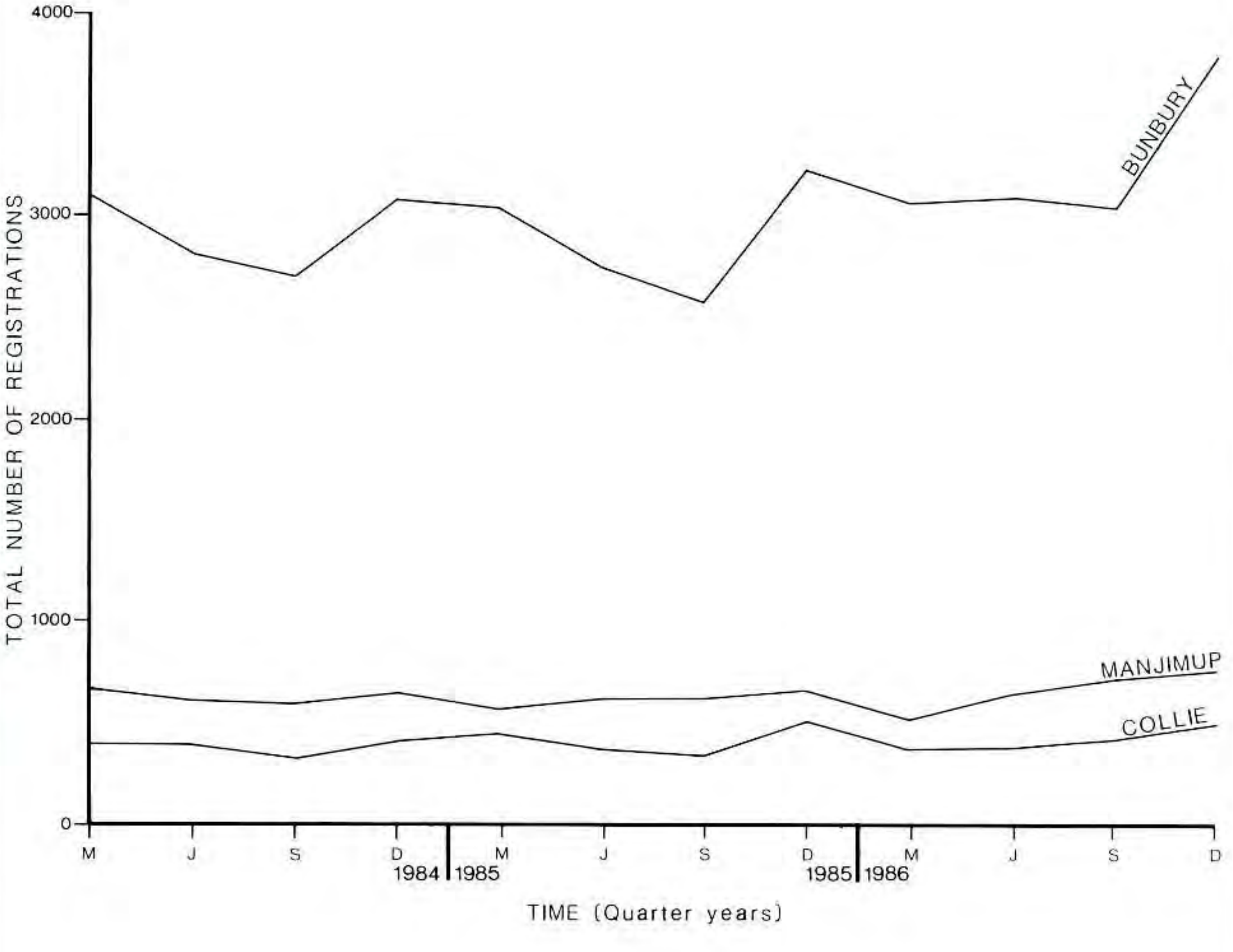
WATER QUALITY - WARREN AND SHANNON SYSTEMS



CLEARING HISTORIES - WARREN AND SHANNON SYSTEMS



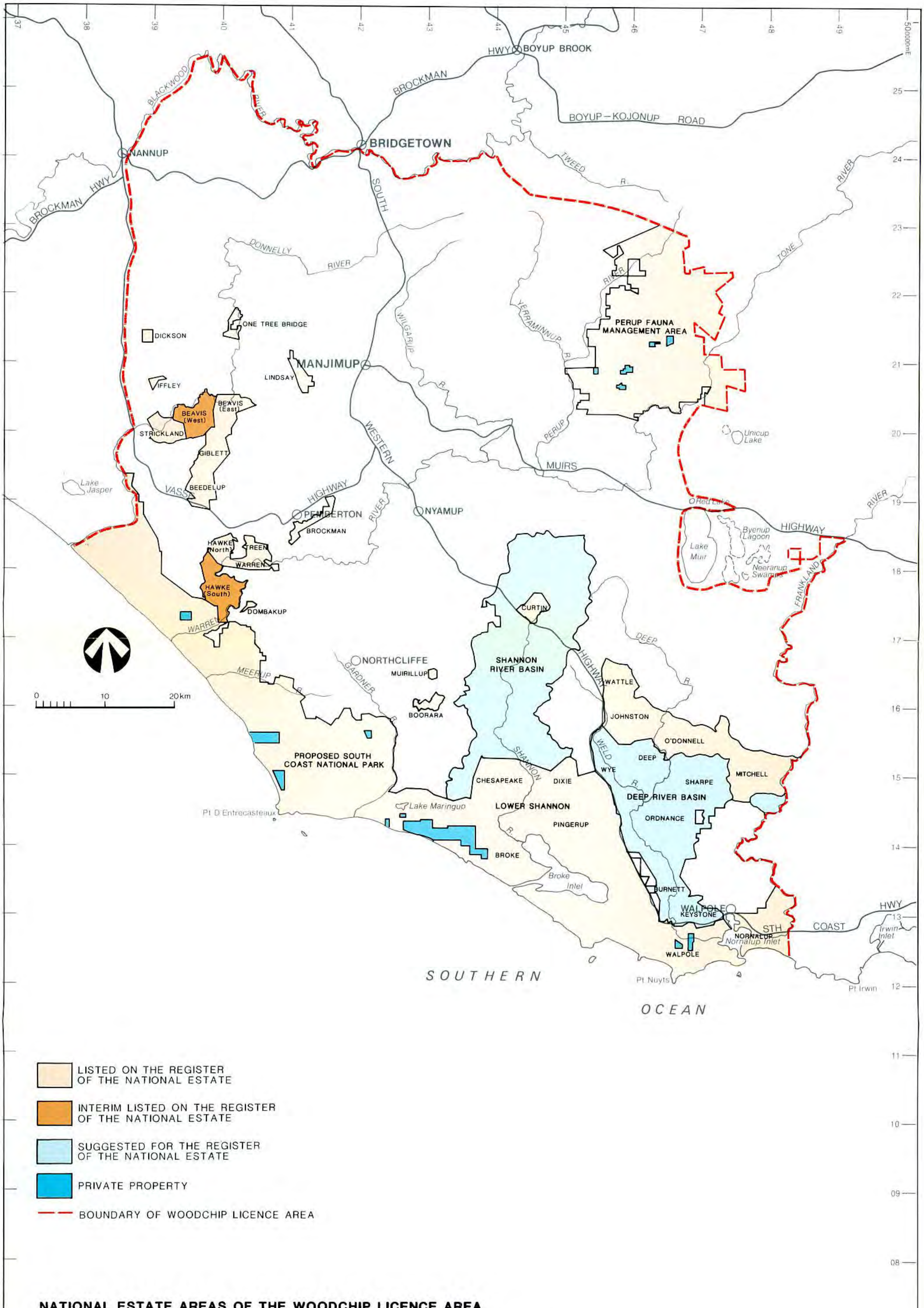
TRENDS IN LOCAL REGIONAL TOURISM



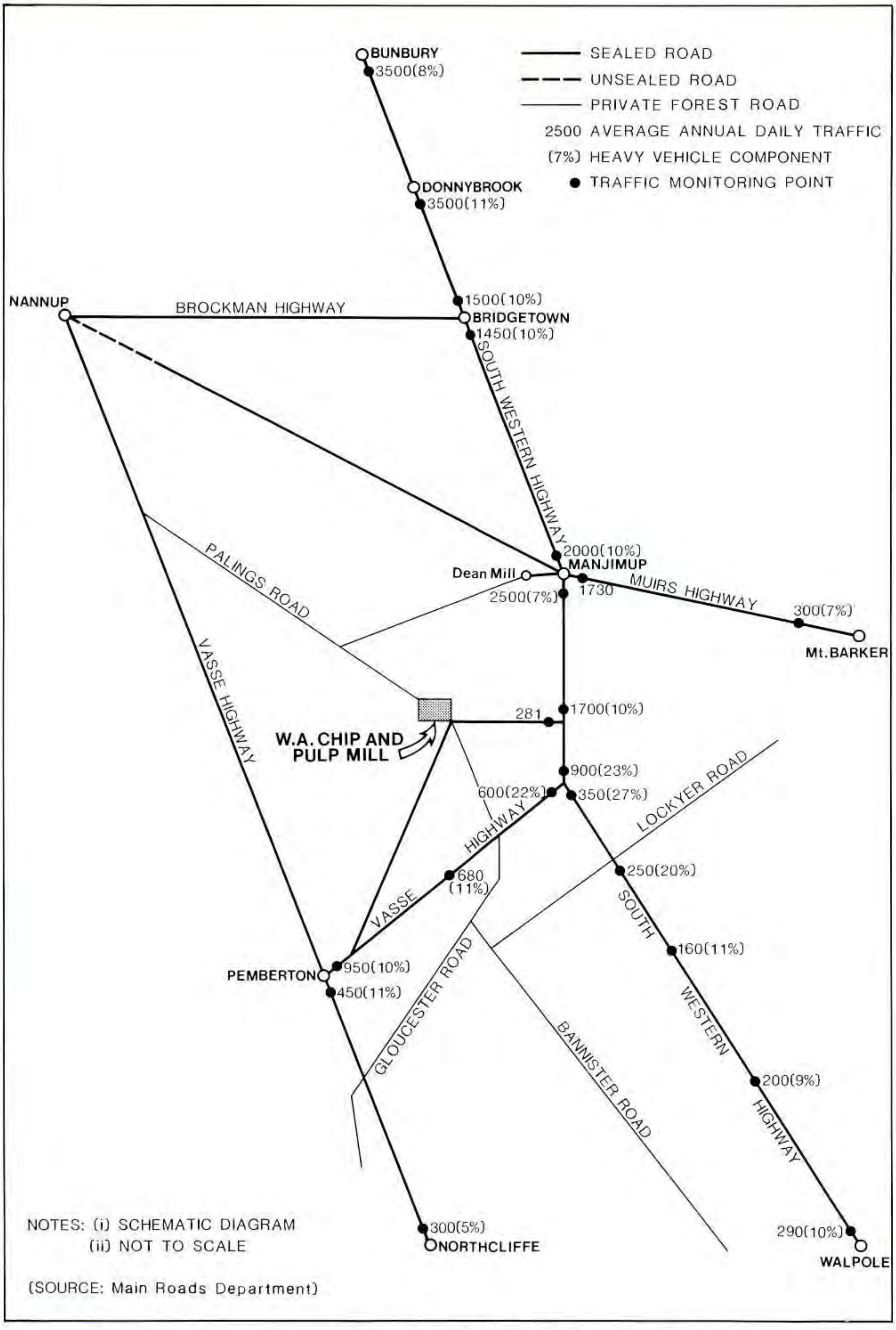
NOTE: Not to be used as official measures of actual unemployment.

(SOURCE: Commonwealth Employment Service)

TOTAL NUMBER OF REGISTRATIONS AS UNEMPLOYED



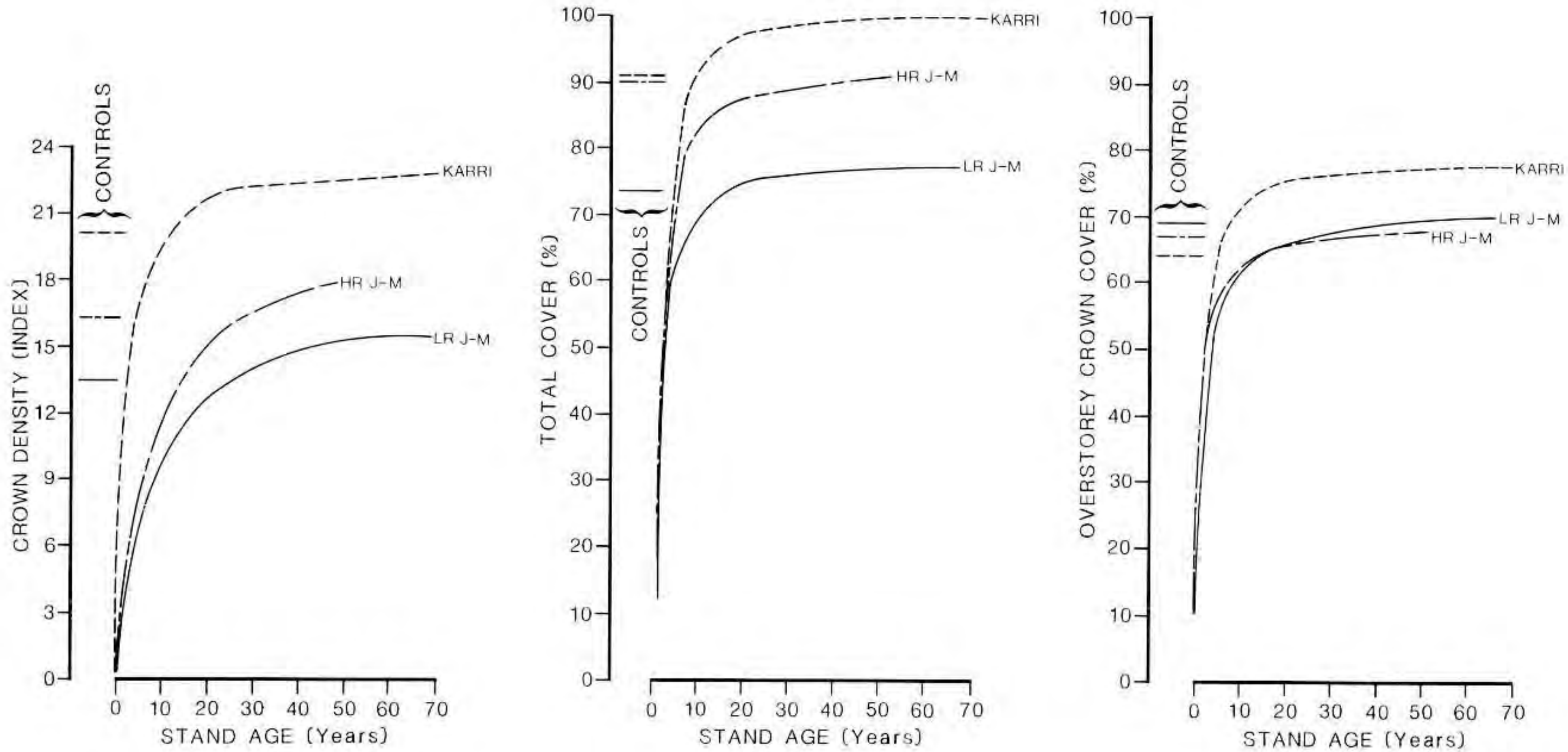
NATIONAL ESTATE AREAS OF THE WOODCHIP LICENCE AREA



EXISTING DAILY TRAFFIC (1981-1982)

Dames & Moore

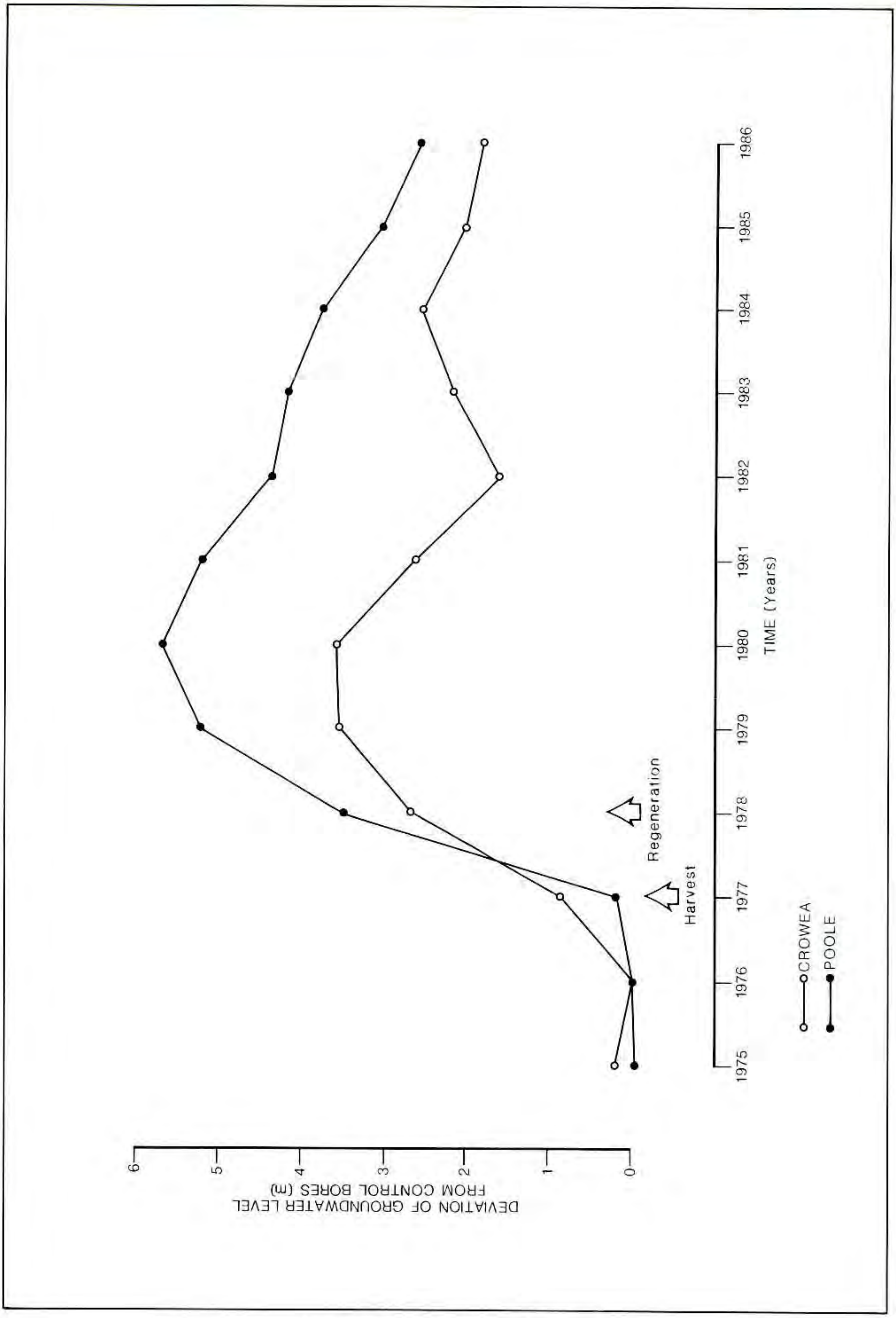
REGENERATION RATE OF VEGETATION COVER AND DENSITY



LR J-M Lower rainfall stands jarrah-marri

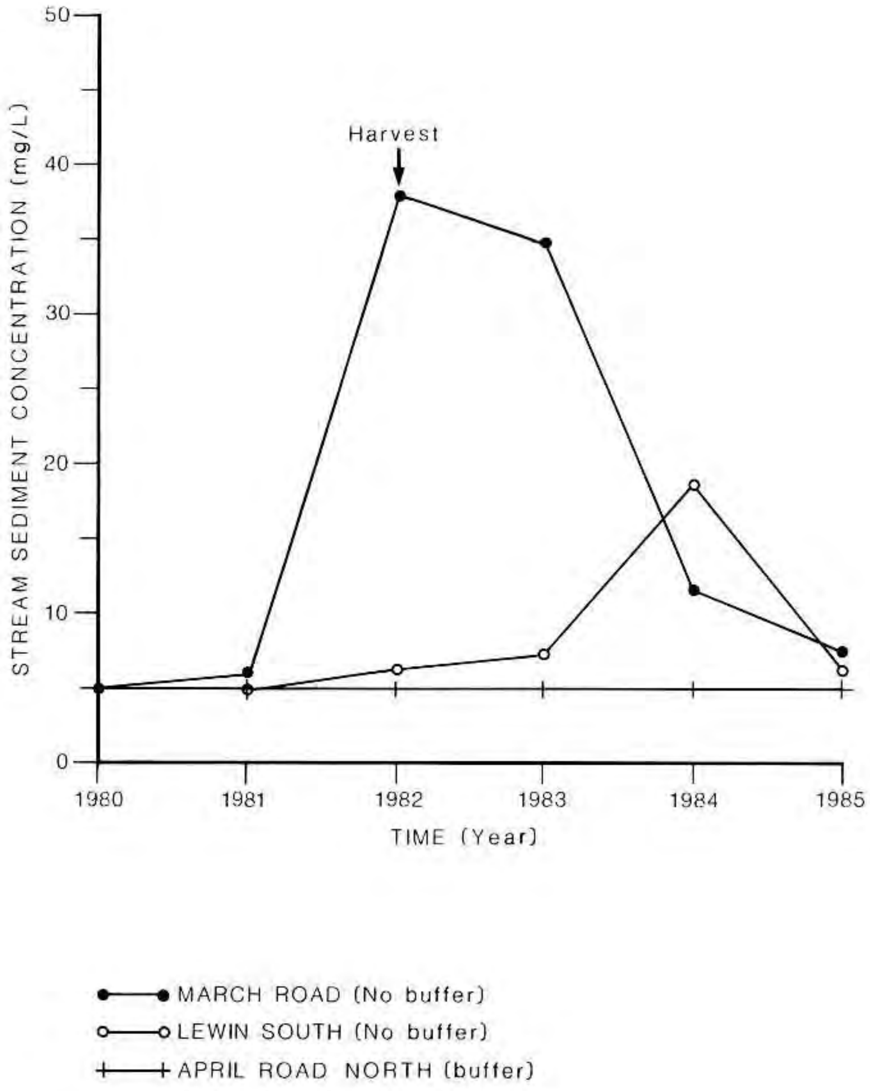
HR J-M Higher rainfall stands jarrah-marri

Figure 20

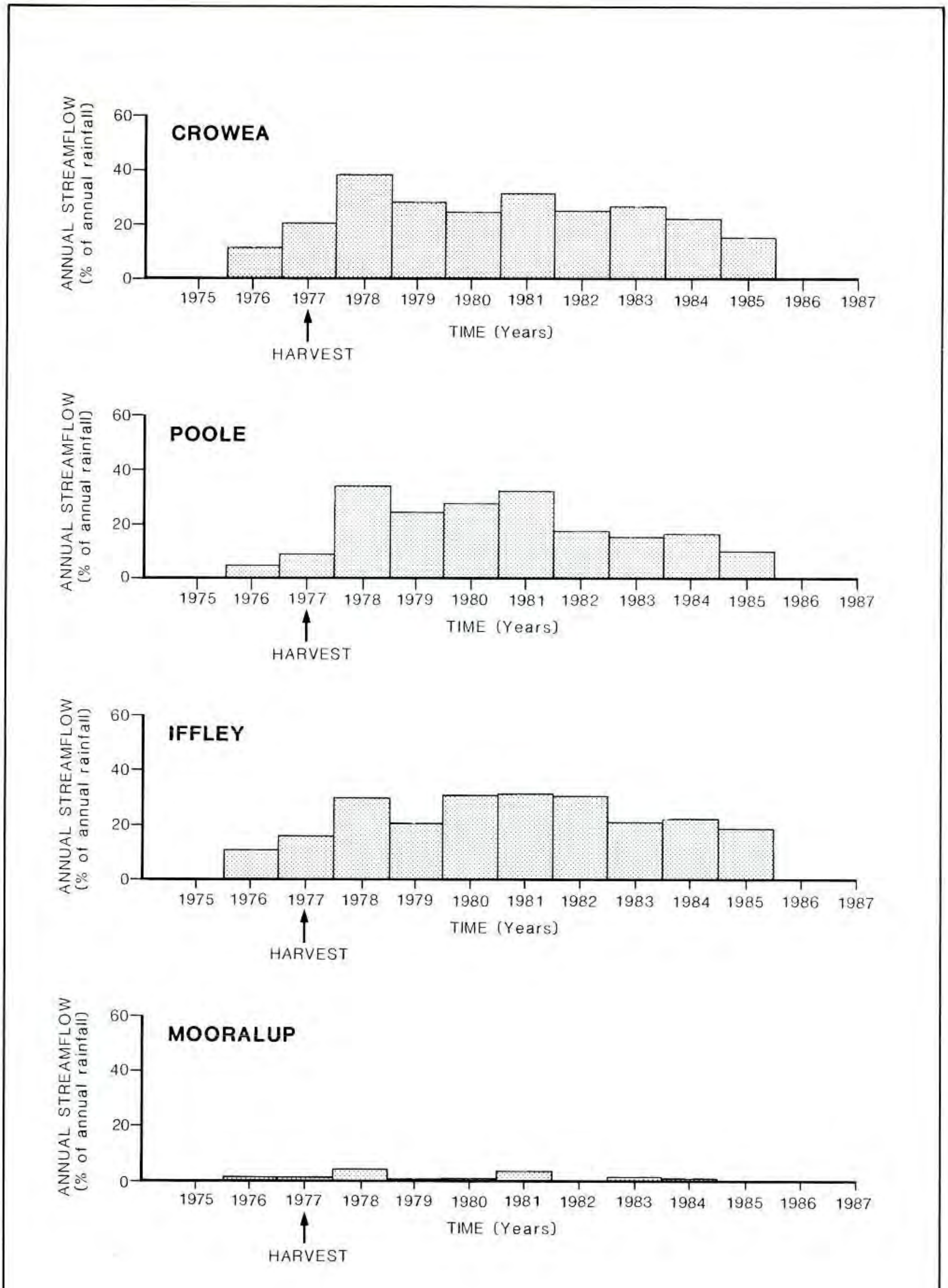


LEVEL OF GROUNDWATER

Figure 21



ANNUAL MEAN STREAM SEDIMENT CONCENTRATIONS



STREAM FLOW VOLUMES

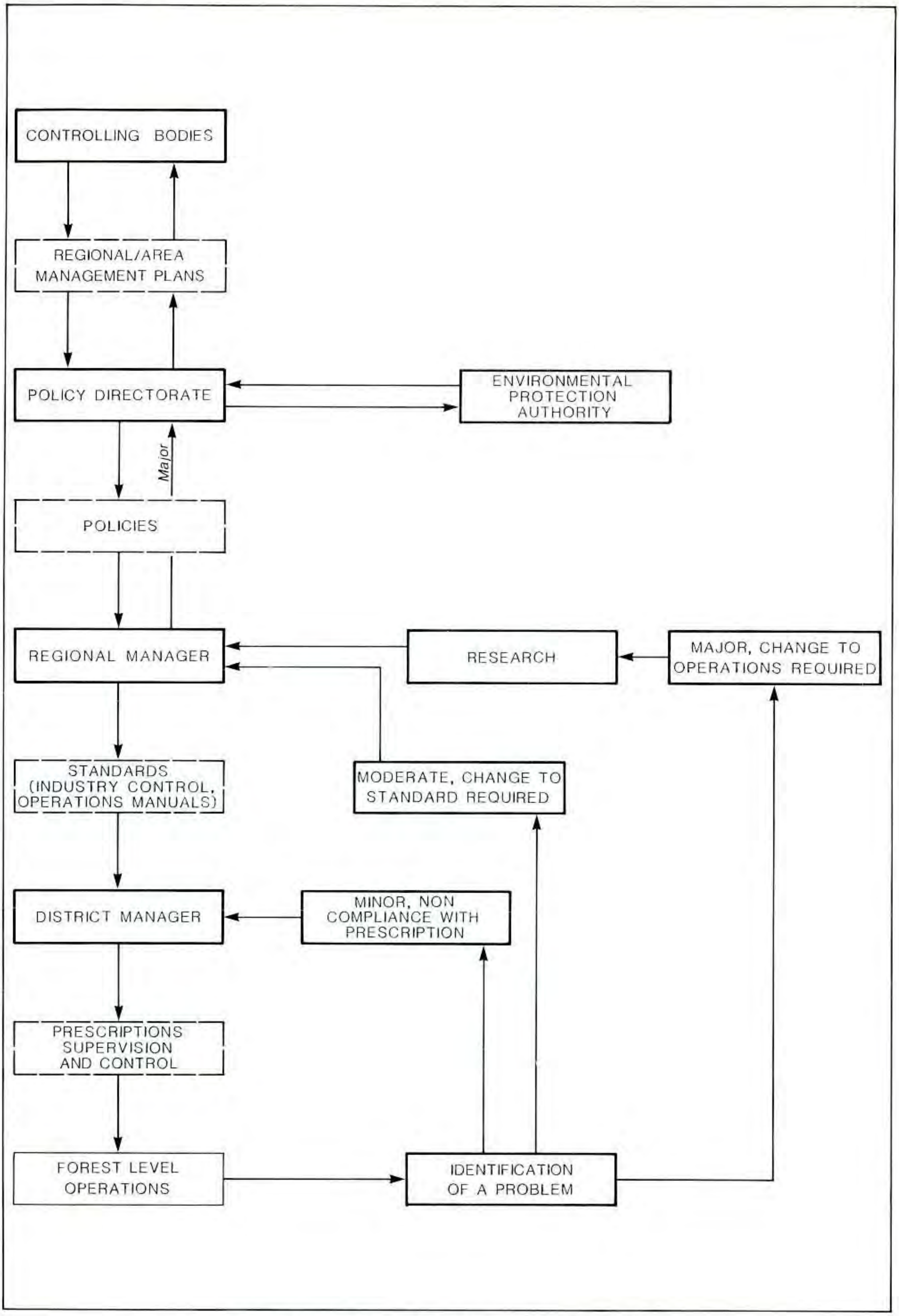
CHANGE IN IMPACTS FROM THOSE EXPECTED FROM THE PROJECT

- ■ MAJOR ADDITIONAL POSITIVE IMPACT
- ☒ MAJOR ADDITIONAL NEGATIVE IMPACT
- ▒ MINOR ADDITIONAL POSITIVE IMPACT
- ░ MINOR ADDITIONAL NEGATIVE IMPACT
- N IMPACT NOT KNOWN
- ☐ NO CHANGE

ALTERNATIVE	NATURE CONSERVATION			SOILS			WATER		RECREATION	NATIONAL ESTATE	LANDSCAPE	FIRE	SILVICULTURE			ECONOMIC			SOCIAL		FINANCIAL			OTHER INDUSTRIES			
	FLORA	FAUNA	AQUATIC	STRUCTURE	FERTILITY	SALINITY	QUALITY	QUANTITY					REGENERATION	COST	PRODUCTIVITY	OUTPUT	JOBS	OVERALL	POPULATION	FAMILIES	STATE	FEDERAL	LOCAL	SAWMILL	TRANSPORT	TOURISM	AGRICULTURE
DO NOTHING	▒	▒	N	▒	▒		▒		▒	▒	▒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	░	N
VARIATIONS TO THE AREA OF SUPPLY																											
EXTENDED AREA → Increased production				░	░		░					░	▒	▒	▒	■	■	■			■	▒	▒		▒		
EXTENDED AREA → Substitution							░					░				░					░	N	N	░	▒		
REDUCED AREA/NO CHIPWOOD SALVAGE IN NATIONAL ESTATE AREAS	▒	▒	N	▒	▒				▒	▒	▒	░	☒	☒	☒	░	░	░	░	░	☒	░	░	░	N		N
ALTERNATIVE SOURCES OF CHIPLOGS																											
PLANTATIONS → Increased production		▒	■		▒	■	■	▒	N		N	░				■	■	■		▒	■	■	■		■	N	▒
PLANTATIONS → Substitution		▒	■		▒	■	■	░	N	N	N	░	░	░	░	N	N	N			☒	N		☒	N	N	▒
ALTERNATIVE SILVICULTURAL SYSTEMS																											
SELECTION LOG ONLY		▒	N			▒	▒		N		▒	☒	░		☒		▒	N			░	░	░	░	▒	▒	
SHORTER ROTATION → Increased production	☒	☒	N	░	░	░	░	▒	░	☒	░	░			■	N	N	N	N	N	☒			☒		☒	
SHORTER ROTATION → Substitution	☒	☒							░			░	░	░	N	░	☒	░	☒	☒				☒	░		
ALTERNATIVES WHICH MAY VARY THE QUANTITY EXPORTED																											
MAXIMISING PRODUCTION	░	░	░	░	░	░	░		░			N	■	■	■	■	■	■	■	▒	■	■	■	■	■		N
ONE SHIFT	▒	▒	N	▒	▒				▒	▒	▒	░	☒	☒	☒	☒	☒	☒	░	☒	☒	☒	☒	☒	☒	▒	N
ALTERNATIVE USES OF CHIPWOOD*																											
PULP PROCESSING																■	■	■	■	■	■	■	■		■		
BOARD PRODUCTS/PANEL PRODUCTS/SCRIMBER																N	N	N			N	N	N				

*In the event that these become economically feasible.

OVERVIEW OF IMPACTS FOR ALTERNATIVES



SUPERVISION, CONTROL AND FEEDBACK FOR OPERATIONS ON STATE FOREST

Appendix A

APPENDIX A

ERMP/Draft EIS GUIDELINES

WA CHIP AND PULP CO PTY LTD

- Proposed Extension of Approvals

GUIDELINES FOR THE ENVIRONMENTAL REVIEW AND MANAGEMENT PROGRAMME/DRAFT ENVIRONMENTAL IMPACT STATEMENT*

1. SUMMARY

This section should contain a brief summary of:

- salient features of the proposal**;
- alternatives considered;
- description of existing environment and analysis of potential impacts and their significance;
- environmental monitoring, management and safeguard and commitments thereto;
- conclusions.

The summary should be in a form suitable for distribution, if appropriate, as a separate document.

2. INTRODUCTION

This introduction should include:

- identification of proponent and responsible authorities;
- background and objectives of the proposal;
- brief details, and timing of the proposal;
- relevant statutory requirements, decision-making authorities and approvals;
- purpose and structure of the ERMP/Draft EIS.

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* These guidelines reflect the requirements of a joint State-Commonwealth environmental assessment because the proponent needs to fulfil the requirements of the Commonwealth's Environment Protection (Impact of Proposals) Act as well as satisfying the EPA's requirements for an ERMP.

** The proposal is taken to include all aspects of the project such as extraction of the resource, transportation, and the sawmilling and chipping components. In some parts of the ERMP/Draft EIS there may be advantage in discussing these separately. This should be done where appropriate. The ERMP/Draft EIS will, of necessity, need to address forest management issues on private and public land.

3. NEED FOR THE DEVELOPMENT

This section is concerned with the justification for the project and projected costs (in the broad sense) and benefits at local and regional levels. For example the following items should be covered:

- The proposed development should be considered within the context of current and proposed State and interstate suppliers of export woodchips, including type and volume of supply;
- A description of a demonstrated market for woodchips and sawn timber is desirable. Will this proposal compete with other State or interstate projects?
- Benefits should also be discussed at national level and include reference to economic, employment and social factors;
- Does the project make available resources that would otherwise be lost?

4. EVALUATION OF ALTERNATIVES

The evaluation of alternatives to and within the project is one of the more important parts of an ERMP/Draft EIS.

A comparison of these in the context of the stated objectives should be included. In this way the rationale for not choosing certain alternatives should be clear as will the basis for choosing the preferred option. Consideration of environmental, social and economic implications of alternatives should be presented.

Those aspects of the proposal that are fixed or constrained should be stated (eg chipmill location, railway, port).

The following provide examples of alternatives and their potential impacts for consideration in this section:

- project not continuing;
- various levels of woodchip export;
- various areas/sources or resource supply;
- variations of chip log specifications;
- consideration of sites and technology for satellite woodchip mills;
- consideration of woodpulp processing;
- alternative forest management practices;
- integration with sawmill operations and State Forest wood supplies;
- alternative methods and sites for waste disposal;
- alternative uses of the resource;
- varying ratios of future sawlog/woodchip production;

- options for re-afforestation incentives on private property.
- alternative economic and employment opportunities including tourism, cottage industries, etc.

5. DESCRIPTION OF PROPOSAL

This should cover current operations within State Forest and private property and any proposed changes, including:

- background to project;
- overall concept;
- current export licence details;
- time schedule including projected lifetime;
- employment;
- infrastructure;
- additional auxiliary service requirements (eg power, water);
- area of supply;
- any proposed changes to transport, routes, vehicles (types and numbers);
- sawmill, woodchip mill details (facilities, workforce, hours of operation, waste disposal);
- shiploading facilities;
- forestry operations including current activities and proposed changes
  - resources including sources of supply of logs and chips (Crown land, private property, plantation, mill residues),
  - resource sustainability over long term,
  - harvesting methods including coupe details and areas excluded,
  - management prescriptions including dieback, fire, water values, regeneration, stream and road buffers,
  - sawlog and pulpwood standards, ratios,
  - relationships between forestry operations and rainfall zones;
- arrangements for roads/tracks, including alignment and drainage approach;
- future land uses on private property;
- economics of WACAP's State Forest and private property operations;
- regeneration proposals and incentives to regenerate on private land, proposed areas, species;
- mechanisms and environmental controls of activities relating to the project.

Appropriate maps and diagrams should be included.

6. EXISTING ENVIRONMENT

This section should provide an overall description of the environment and an appraisal of physical, ecological and socio-economic systems affected by the project.

It should then concentrate on the significant aspects of the environment likely to be impacted by the development (ie in particular the processes sustaining the system). Only the processes, habitats, resources and potential resources which could be influenced should be defined. Detailed inventories should be placed in appendices to the ERMP/Draft EIS.

This section should include:

6.1 PHYSICAL ENVIRONMENT

- climate and meteorology;
- landforms and drainage systems;
- soils; and
- water.

6.2 BIOLOGICAL ENVIRONMENT

- biota including rare, endangered or restricted species and their ecosystems set in local and regional context;
- diseases (including dieback and pests).

6.3 HUMAN ENVIRONMENT

- land-use including past land-uses, conservation or recreation aspects, land tenure and zoning;
- existing human-use patterns;
- road and rail systems and traffic;
- landscape;
- interactive industries and developments;
- historical, archaeological and ethnographic sites;
- current uses of timber and forests;
- sites listed on the Register of the National Estate; and
- other relevant socio-economic factors of the region.

7. ENVIRONMENTAL IMPACTS

This is an important part of the ERMP/Draft EIS and the result should show the overall effect on the total ecosystem and social surroundings of the project.

The objective of this section is to synthesize all information and predict potential impacts upon the environment in the short and long term, including beneficial impacts and the impacts of alternatives. This should include an assessment of the resilience of the systems identified in 6. to natural and man-induced pressures.

Impacts should be quantified where possible. Criteria for making assessments of their significance should be outlined. Commitments to comply with relevant standards should be demonstrated.

This section should relate to State Forest and private property within WACAP's operational area and include but not be limited by consideration of the following:

• Timber Resource (existing and regenerated native forests; and plantations)	- soils	- nutrients
		- stability/erosion/structure (compaction)
		- salinity
		- effects of rotational timber crops
	- water (surface and ground)	- quality including nutrients and chemicals (eg herbicides)
		- leachates
		- salinity
		- turbidity
		- flooding
	- biota	- fire
		- dieback disease
		- conservation, including rare, endangered or restricted species
		- effect of logging, clear felling and burning on species composition
	- landscape	- aesthetics
		- tourism
	- forestry	- regeneration
		- effect on minor forest products eg wildflowers, fencing timber, firewood, beekeeping

		- effects on rare, endangered or restricted species
		- reaforrestation on private land including biological and aesthetic effects of using exotic or non-endemic native species
	- human-use	- archaeological, historical, ethnographic sites and sites listed on the Register of the National Estate
		- traffic noise safety
		- economic implications
		- recreational and other social uses of timbered land
. Chipmill	- air emissions	- smoke
		- dust and particulates
		- odour
	- noise and vibration	
	- water emissions	- drainage/runoff
		- seepage/leachate
	- solid waste	- bark
		- other
	- services	- power
		- water
		- other
	- human-use	- any changes to the workforce
		- changed effects on existing community
		- aesthetics and noise
. Shiploading	- potential discharge of water ballast and bilge water	
	- leachate from chip stockpile	
. Overall	- revenues, royalties, Government charges	

- social and employment aspects of timber resource operations and replanting programmes

- service industries etc.

The final synthesis should include an assessment of the significance and timing of the various potential impacts identified.

8. ENVIRONMENTAL MANAGEMENT

An environmental management programme including environmental safeguards should be described on the basis of (and cross-referenced to) the synthesis of potential environmental impacts described in 7.

The purpose of the management programme is to demonstrate the manner in which potential environmental impacts can be ameliorated.

Authorities responsible for management should be clearly identified as should management administration, costs and funding. Reference should be made to CALM Management Plans. Reference should also be made to environmental standards expected by State Government authorities.

Elements of monitoring and the environmental management programme should include the impacts identified in 7. and include references to the monitoring and supervision of regeneration and to any existing or proposed control systems at State and company level (on private land) to ensure adherence to operational prescriptions.

Emphasis should be placed on the manner in which monitoring results will lead, where appropriate, to amendments to the management programme.

Environmental safeguards should be described.

Procedures for reporting the results of monitoring and management to appropriate authorities should be given.

It is important that specific commitments are given to all components and procedures of the management programme including factors relating to any activities on private property.

9. CONCLUSION

An assessment of the environmental acceptability of the project in terms of its overall environmental impact and in the context of the proposed management programme should be given.

10. REFERENCES

Glossary (definitions of technical terms, abbreviations).

ERMP/Draft EIS Guidelines

Consultations (details of consultations with government bodies and public interest groups).

Appendices including a summary of all commitments made in the ERMP/Draft EIS.

NOTE : These Guidelines should be used in the context of the attached document "Notes for the preparation of an ERMP".

Appendix B

APPENDIX B

SUMMARY OF INFORMATION ON RARE AND RESTRICTED SPECIES

WITHIN THE WOODCHIP LICENCE AREA

APPENDIX B

SUMMARY OF INFORMATION ON RARE AND RESTRICTED SPECIES WITHIN THE WOODCHIP LICENCE AREA

Note: (None of these species in the area are directly affected by the industry, refer to Section 7.0).

Department of Fisheries and Wildlife (CALM) Records: these refer to information extracted from summaries at the Wildlife Research Centre, Woodvale.

Additional Herbarium Search: This refers to a recent check of collections held by the Western Australian Herbarium (unless otherwise stated).

Species:	Acacia semitrullata Maslin
Department Fisheries and Wildlife (CALM) Records:	Occurs from Yarloop to Karridale, represented by 19 specimens from 14 localities and is geographically restricted with range of 155km.
Additional Herbarium Search:	6 collections, extending range E to Muja
Christensen et al (1985):	Not observed.
Ecological Setting:	Jarrah-marri woodland and swamp margin, once sand and sandy laterite.
Likelihood of Impact:	Only by northern extension, unlikely to be severe.
Occurrence in Reserves:	According to records at Wildlife Research Centre, it occurs in reserves.

* * *

Species:	Acacia tayloriana F. Muell.
Department of Fisheries and Wildlife (CALM) Records:	Occurs east of Karridale, represented only by 2 specimens from 2 localities, and hence poorly collected, considered geographically very restricted (45km).
Additional Herbarium Search:	1 collection, early 1900's, from Southhampton property on the Blackwood.
Christensen et al (1985):	Not recorded.
Ecological Setting:	Information inadequate.
Likelihood of Impact:	Unlikely, one occurrence on boundary of licence area, two outside it.
Occurrence in Reserves:	May occur in conservation MPAs of Central Forest Region, especially Milyeannup and Whicher Range MPA.

* * *

Species:	Aotus passerinoides Meissner
Department of Fisheries and Wildlife (CALM) Records:	Represented by 9 specimens collected from 9 localities between Pemberton and Albany, giving a restricted range of 160km.
Additional Herbarium Search:	1 collection 26km south of Shannon.
Christensen et al (1985):	In karri region, in closed scrub.
Ecological Setting:	In swamp over black sand.
Likelihood of Impact:	Direct impact unlikely.
Occurrence in Reserves:	Many collection localities in D'Entrecasteaux National Park & Walpole-Nornalup NP.

* * *

Species:	Bossiaea webbii F. Muell.
Department of Fisheries and Wildlife (CALM) Records:	Occurs in Denmark and Walpole districts, represented in W.A. Herbarium by 7 specimens from 6 localities, with a restricted geographic range of 65km.
Additional Herbarium Search:	2 collections from Denmark and Walpole.
Christensen et al (1985):	Recorded in Soho and Perup surveys.
Ecological Setting:	In jarrah forest and heath, on sandy soils.
Likelihood of Impact:	Occurs in forest subject to logging but not clear-felling.
Occurrence in Reserves:	In National Parks (Walpole-Nornalup) and Conservation MPAs (Soho, Perup).

* * *

Species:	Burchardia monantha Domin
Department of Fisheries and Wildlife (CALM) Records:	Occurs between Kojonup and Lake Muir, represented in Herbarium by 6 specimens from 5 localities, with a restricted geographic range of 70km.
Additional Herbarium Search:	3 collections between Bridgetown, Kojonup and Manjimup.
Christensen et al (1985):	A Burchardia sp. (not multiflora) recorded at Perup and Nannup.
Ecological Setting:	Swampy flats and wandoo woodlands.

Likelihood of Impact: Direct impact unlikely.

Occurrence in Reserves: Likely to be present in Perup MPA, which is in the centre of its range.

* * *

Species: Centrolepis fasciculatis Labill. (previously determined before 1979 as C. pilosa)

Department of Fisheries and Wildlife (CALM) Records: Not dealt with.

Additional Herbarium Search: 1 collection from Bramley. Recently collected in forest at Shannon townsite (Keighery pers. comm.). Also in Victoria.

Christensen et al (1985): Not recorded.

Ecological Setting: Seasonally waterlogged soil, possibly with sedges and Boronia megastigma, in eucalypt forest.

Likelihood of Impact: Probably slight, if any.

Occurrence in Reserves: The only known existing population is in the Shannon Forest reserve.

* * *

Species: Choretrum lateriflorum R.Br.

Department of Fisheries and Wildlife (CALM) Records: Represented in W.A. Herbarium by 9 specimens from 6 localities between Nannup and Albany, giving a range of 190km. Also occurs in eastern Australia.

Additional Herbarium Search: 4 collections, Pemberton, L. Maringup, Denmark and Bow River in high open jarrah forest on sandy clay.

Christensen et al (1985): Recorded in karri region, under high open karri forest.

Ecological Setting: Wide spread, scattered distribution in number of forest types.

Likelihood of Impact: Very likely, but recorded in regenerated karri stands.

Occurrence in Reserves: Likely to occur in D'Entrecasteaux, Warren, Beedelup, and Walpole-Nornalup NP and Soho MPA.

* * *

Species:	Chorizema varium Benth. in Lindley
Department of Fisheries and Wildlife (CALM) Records:	Restricted to vicinity of Walpole, represented in Herbarium by 2 specimens from 2 localities 10km apart, hence poorly collected and very restricted geographically.
Additional Herbarium Search:	Nil; specimens on loan.
Christensen et al (1985):	Not recorded.
Ecological Setting:	Karri forest in loam over granite.
Likelihood of Impact:	Nil, unless new populations found in State Forest.
Occurrence in Reserves:	Existing population in Walpole NP.

*   *   *

Species:	Danthonia pilosa R. Br.
Department of Fisheries and Wildlife (CALM) Records:	Represented in W.A. Herbarium by 2 specimens from Jarrahdale and Pemberton, hence inadequately collected but a broad range of 235km.
Additional Herbarium Search:	3 collections, Pemberton, Norseman and Byford, on granite and laterite.
Christensen et al (1985):	In Perup, in open forest of jarrah.
Ecological Setting:	Wide spread but rare, probably undercollected; occurs on wide range of sites.
Likelihood of Impact:	Likely but not severe; recorded both before and after logging.
Occurrence in Reserves:	Recorded from Perup MPA

*   *   *

Species:	Dasypogon hookerii J.Drumm. in Hook.
Department of Fisheries and Wildlife (CALM) Records:	Occurs between Donnybrook and Beedelup National Park, represented in W.A. Herbarium by 20 specimens from 18 localities, with a geographically restricted range of 95km.
Additional Herbarium Search:	2 collections, Busselton and Dardanup.
Christensen et al (1985):	Sunklands and Milyeannup.
Ecological Setting:	In open jarrah forest on moist sands and sandy loams.

Likelihood of Impact: Marginal; main occurrence west of licence area.

Occurrence in Reserves: Abundant in Milyeannup and Whicher Range MPA.

* * *

Species: Eremosyne pectinata Endl. in Endl.

Department of Fisheries and Wildlife (CALM) Records: Occurs between Augusta and Walpole, represented in W.A. Herbarium by 9 specimens from 8 localities, with a restricted geographic range of 160km.

Additional Herbarium Search: 1 at Scott River, in jarrah woodland.

Christensen et al (1985): Not recorded.

Ecological Setting: Mostly collected on edge of swamp in jarrah-marri forest, in recent burns; also on cleared land.

Likelihood of Impact: Unlikely to be adversely affected.

Occurrence in Reserves: In D'Entrecasteaux NP

* * *

Species: Eucalyptus brevistylis Brooker

Department of Fisheries and Wildlife (CALM) Records: Occurs in the vicinity of Walpole, represented in W.A. Herbarium by 11 specimens from 8 localities, considered rare and very restricted, with geographical range of 40km.

Additional Herbarium Search: 2 collections NE of Walpole, with karri.

Christensen et al (1985): At Soho, in high open forest.

Ecological Setting: Geographically restricted, but ecologically varied occurrence, both on sand and near deeply dissected valleys.

Likelihood of Impact: Can be avoided due to restricted occurrence and large size of the species.

Occurrence in Reserves: Main populations occur in Soho MPA and Walpole - Nornalup National Park.

* * *

Species: Eucalyptus ficifolia F. Muell.

Department of Fisheries and Wildlife (CALM) Records: Occurs in the vicinity of Walpole, represented in W.A. Herbarium by 15 specimens from 10 localities and considered to be rare and very restricted in distribution, with a range of 50km.

Additional Herbarium Search:	4 collections from Bow River, Walpole, Nornalup.
Christensen et al (1985):	At Soho, in woodland and low woodland.
Ecological Setting:	In woodland and low woodland, on sandy hills and plains between Denmark and Brooke Inlet.
Likelihood of Impact:	Low.
Occurrence in Reserves:	Main populations in Walpole-Nornalup and D'Entrecasteaux National Parks and in Giants and Soho MPA.

* * *

Species:	Eucalyptus guilfoylei Maiden
Department of Fisheries and Wildlife (CALM) Records:	Occurs only in the Mt Frankland-Nornalup area, represented in W.A. Herbarium by 15 specimens from 8 localities, considered to be rare and very restricted with a range of 50km.
Additional Herbarium Search:	1 collection from N. Nornalup.
Christensen et al (1985):	In Soho and Mitchell, in open forest and high open forest.
Ecological Setting:	In jarrah, marri and karri forests on loamy soil, on Frankland, Deep and Bow Rivers.
Likelihood of Impact:	Some impact probable; well represented in regenerated stands.
Occurrence in Reserves:	Represented in Walpole-Nornalup and D'Entrecasteaux National Parks and in Giants and Soho MPAs.

* * *

Species:	Eucalyptus jacksonii Maiden
Department of Fisheries and Wildlife (CALM) Records:	Restricted to the vicinity of Nornalup, represented in W.A. Herbarium by 8 specimens from 4 localities, considered to be rare and restricted with a geographic range of 20km.
Additional Herbarium Search:	1 collection from Walpole.
Christensen et al (1985):	Recorded from open forest and high open forest in Giants.
Ecological Setting:	In open high forest and open forest, in association with karri and in pure stands on Frankland and Bow Rivers.

Likelihood of Impact: Some impact probable, present in some regenerated karri stands.

Occurrence in Reserves: Strongly developed in Walpole-Nornalup National Park and the Giants MPA.

* * *

Species: *Gastrolobium brownii* Meissner in Lehm.

Department of Fisheries and Wildlife (CALM) Records: Occurs between Albany and Mt Frankland, represented in the W.A. Herbarium by 8 specimens from 5 localities, considered to be a geographically restricted species with a range of 100km.

Additional Herbarium Search: 3 collections, between Denmark and Walpole.

Christensen et al: Recorded from woodland in Mitchell.

Ecological Setting: Mainly from vicinity of granitic outcrops, Mt Frankland and eastwards to Albany.

Likelihood of Impact: Very marginal, both geographically and ecologically.

Occurrence in Reserves: In Mitchell MPA.

* * *

Species: *Grevillea drummondii* Meissner in Lehm.

Rye & Hopper (1981): Gazetted rare species occurring between Bolgart and Shannon, often close to large rocks, in eucalypt woodlands.

Department of Fisheries and Wildlife (CALM) Records: Poorly collected with less than 5 specimens in W.A. Herbarium.

Additional Herbarium Search: 9 collections, from Cataby to Northcliffe.

Christensen et al (1985): Recorded in open forest and high open forest in karri region.

Ecological Setting: Southern sub-species occurs on sandy soils below granitic outcrops, such as Shannon Rock.

Likelihood of Impact: Some impact possible, but appears to cope well with perturbance.

Occurrence in Reserves: In D'Entrecasteaux National Park.

* * *

Species:	Grevillea ripicola A.S. George
Rye & Hopper (1981):	Gazetted rare species restricted to the Collie region, in gravelly loam along river banks.
Department of Fisheries and Wildlife (CALM) Records:	Occurs around Collie. Represented in W.A. Herbarium by 5 collections, all from near Collie.
Additional Herbarium Search:	4 collections from Collie (some are probably on loan). Also recorded by Hopper (pers. comm.) near granite rock 30km east of Northcliffe.
Christensen et al (1985):	Not recorded.
Ecological Setting:	Clay, loam and gravel, often near granite outcrops.
Likelihood of Impact:	Probably slight.
Occurrence in Reserves:	None known.

*   *   *

Species:	Hemigenia microphylla Benth. in DC.
Department of Fisheries and Wildlife (CALM) Records:	Occurs between Wagerup and Palgarup, represented in W.A. Herbarium by 5 specimens from 4 localities, considered to be geographically restricted with a range of 135km.
Additional Herbarium Search:	1 collection from Harvey.
Christensen et al (1985):	Not recorded.
Ecological Setting:	Generally from moist sandy sites.
Likelihood of Impact:	Direct impact unlikely.
Occurrence in Reserves:	Not known.

*   *   *

Species:	Hemigenia podalyrina F. Muell.
Department of Fisheries and Wildlife (CALM) Records:	Occurs on Shannon Rock, represented in W.A. Herbarium by one specimen, considered to be a rare and very restricted species with only one locality.
Additional Herbarium Search:	6 collections from Wickepin and Wagin to Walpole.
Christensen et al (1985):	Not recorded.
Ecological Setting:	Broad geographic and ecological range, mostly on sandy gravels in woodland and forest.

Likelihood of Impact: Slight.

Occurrence in Reserves: In D'Entrecasteaux National Park.

* * *

Species: Hibbertia gilgiana Diels in Diels & E.Pritzel
This species is currently under taxonomic review.

* * *

Species: Kennedia glabrata (Benth.) Lindl.

Rye & Hopper: Gazetted rare species occurring on granite outcrops north of Point D'Entrecasteaux.

Department of Fisheries and Wildlife (CALM) Records: Occurs on Mt Chudalup. Represented in W.A. Herbarium by 3 specimens from one locality. Considered to be a rare and very restricted species.

Additional Herbarium Search: 1 collection from Muirullup Rock, near Northcliffe.

Christensen et al (1985): Not recorded, but subsequently by Annels (pers.comm.) on several rock outcrops near Northcliffe.

Ecological Setting: In soil pockets on granitic rocks.

Likelihood of Impact: Unlikely.

Occurrence in Reserves: In D'Entrecasteaux National Park.

* * *

Species: Hydrocotyle hirta R. Br.

Department of Fisheries and Wildlife (CALM) Records: Not dealt with, but listed by Marchant & Keighery (1979): represented in W.A. Herbarium by 1 specimen from Porongorup Range. Locally common in Porongorups in at least 3 upper valleys under karri regrowth (Keighery, pers. comm.)

Additional Herbarium Search: 1 collection from Castle Rock, Porongorup Range. Also collected by Weston along Brunswick River, and Big Brook (near Pemberton) by Annels near Pemberton and by Eichler near Walpole (Weston pers. comm.)

Ecological Setting: On loamy red soils in karri forest, in the south, and marri forest in the north.

Likelihood of Impact: Probably slight, as plant is prostrate and adapted to marri regeneration.

Occurrence in Reserves: Best represented in Porongorup National Park.

* * *

Species:	Lambertia orbifolia	C.A. Gardner
Rye & Hopper (1981):	Gazetted rare species from Busselton, Scott River and Narricup areas.	
Department of Fisheries and Wildlife (CALM) Records:	Not described.	
Additional Herbarium Search:	7 collections, mainly near Narricup and King River, and near Busselton and Scott River.	
Christensen et al (1985):	Not recorded.	
Ecological Setting:	On gravelly sands over laterite.	
Likelihood of Impact:	Nil unless new population found.	
Occurrence in Reserves:	May occur in Whicher MPA.	

* * *

Species:	Lomandra ordii	(F. Muell) Schltr.
Department of Fisheries and Wildlife (CALM) Records:	Occurs between Northcliffe and Deep River, represented in W.A. Herbarium by 6 specimens from 4 localities, considered to be a geographically restricted species with a range of 50km.	
Additional Herbarium Search:	Collections from Northcliffe-Shannon River-Walpole area.	
Christensen et al (1985):	Recorded without location, subsequently collected by Annels (pers. comm.)	
Ecological Setting:	In woodland and forest on sandy riverbanks.	
Likelihood of Impact:	Very slight.	
Occurrence in Reserves:	Main occurrence of the species is in D'Entrecasteaux National Park.	

* * *

Species:	Pentapeltis silvatica	(Diels) Domin
Rye & Hopper (1981):	Gazetted rare species occurring in jarrah forest on gravelly soils from Collie to Walpole.	
Department of Fisheries and Wildlife (CALM) Records:	Not dealt with.	
Additional Herbarium Search:	4 collections, from Collie to Denmark.	

Christensen et al (1985): Recorded from karri region, from Perup, Sunklands, Mitchell River and Frankland, in forest and woodland.

Ecological Setting: In jarrah woodland and forest on gravelly soils.

Likelihood of Impact: Very likely, but species recorded after heavy logging and regeneration burns at Iffley where it was not recorded before hand.

Occurrence in Reserves: Known to occur in Perup and Mitchell MPAs, also likely in D'Entrecasteaux National Park.

Because of the relative commoness of this species in southern forests, as indicated by post-1982 collections and surveys, this species was deleted from the Schedule in 1982.

*   *   *

Species: Prasophyllum triangulare Fitzg.

Patrick & Hopper (1981): Gazetted rare species growing on sands and laterites near Perth, Albany and Margaret River.

Department of Fisheries and Wildlife (CALM) Records: Occurring between Margaret River and Albany, represented in W.A. Herbarium by 7 specimens from 4 localities, considered to be poorly collected.

Additional Herbarium Search: 4 collections from Albany, Stirling Range and NW of Nannup.

Christensen et al (1985): Not recorded.

Ecological Setting: In marginal jarrah-marri woodland, in sand and sandy loam soils, scattered occurrence around but not within the licence area.

Likelihood of Impact: Nil to slight, as it has not been recorded from the more productive central forests.

*   *   *

Species: Pultanaea skinneri F. Muell.

Patrick & Hopper: Near Bunbury, Collie and Boyanup, in damp sands and gravels.

Department of Fisheries and Wildlife (CALM) Records: Occurring between Collie and Jalbargup, represented in the W.A. Herbarium by 7 specimens from 5 localities, geographically restricted with a range of 90km.

Additional Herbarium Search: 8 collections, from Brunswick Junction to Nannup.

Christensen et al: Recorded in Sunklands, from open forest.

Ecological Setting:	In open jarrah-marri forest and swamp margins on moist sandy soils.
Likelihood of Impact:	Only marginally if operations extend north of Blackwood River.

* * *

Species:	Restio ustulatus F. Muell. ex Ewart & Sharman
Department of Fisheries and Wildlife (CALM) Records:	Occurs between Ambergate and Scott River, represented in W.A. Herbarium by 6 specimens from 6 localities, considered to be a geographically restricted species with a range of 60km.
Additional Herbarium Search:	3 collections from Capel, Augusta and near Denmark.
Christensen et al:	Not recorded, or else not identified to species level.
Ecological Setting:	In sandy swamps.
Likelihood of Impact:	Unlikely unless species found within licence area, even then only very slight due to preference for swamps.
Occurrence in Reserves:	Suitable habitat common in Nornalup and D'Entrecasteaux National Parks.

* * *

Species:	Schoenoplectus pungens (M.Vahl) Palla (= Scirpus pungens)
Department of Fisheries and Wildlife (CALM) Records:	Occurs between Bunbury and Deeside, represented in W.A. Herbarium by 2 specimens from 2 localities, considered to be a poorly collected species with a geographic range of 140km.
Additional Herbarium Search:	No new collections.
Christensen et al:	Not recorded or else not identified to species level.
Ecological Setting:	Inadequate information, swamp indicated.
Likelihood of Impact:	Slight.
Occurrence in Reserves:	Inadequate information.

* * *

Species:	*Tetratheca parvifolia* J. Thompson
Department of Fisheries and Wildlife (CALM) Records:	Occurring between Capel and Lowden, represented in W.A. Herbarium by 5 specimens from 3 localities, considered to be rare and geographically very restricted, with a range of 45km.
Additional Herbarium Search:	No new collections.
Christensen et al:	Not recorded.
Ecological Setting:	In open forest, between Capel and Lowden.
Likelihood of Impact:	Only by northern extension of operations.
Occurrence in Reserves:	Not known.

* * *

Appendix C

APPENDIX C

SOIL PROFILES

APPENDIX C

SOIL PROFILES

This appendix presents typical soil profiles for the four main soil groups within the Woodchip Licence Area. The four main groups are:

(i) The Lateritic Soils,
(ii) The Yellow Duplex Soils,
(iii) The Red Earths,
(iv) The Brown Gravelly Duplex Soils.

THE LATERITIC SOILS

Profile 1, Laterite,KS-Uc 4.2

Ref: P 644; McArthur and Clifton 1975

Location: Thornhill Rd, 15km NW, of Pemberton; $34^{o}22'$S., $115^{o}56'$E.

NO.	DEPTH (cm)	DESCRIPTION
1	0-7	Dark reddish brown (5YR3/4) loamy sand; 99% gravel
2	7-15	Reddish brown (5YR4/4) loamy sand; 99% gravel
3	15-30	Brown (5YR4/6) sandy loam; 81% gravel
4	30-60	Brown (5YR4/8) sandy loam; 87% gravel
5	60-90	Light Brown (5YR5/6) sandy loam; 93% gravel

Analytical data

NO.	pH	Loss on ignition (%)	Org. C (%)	Total N (%)	P (%)	Silt (%)	Clay (%)	Exchangeable cations (m-equiv/100g soil) Total	Ca	Mg	K	Na
1	6.0	5.7	3.3	0.13	<0.01			8.5	2.6	1.1	0.18	0.51
2	5.9	3.3		0.07		6	4	5.0	0.7	0.2	0.12	0.30
3	6.1	3.8	0.05			6	7	3.4	0.7	<0.1	0.08	0.11
4	6.0	5.2		0.02				2.8	0.3	<0.1	0.06	0.08
5	6.3	7.5		0.01		4	9	2.7	0.3	<0.1	0.10	0.10

THE YELLOW DUPLEX SOILS

Profile 2, Yellow podzotic soil, Dy3.62

Ref: P 649; McArthur and Clifton 1975

Location: Marri and Dombakup Rd intersection, 11km S. of Pemberton; 34°34'S., 116°01'E.

NO.	DEPTH (cm)	DESCRIPTION
1	0-7	Dark reddish brown (10YR3/3) loam; light gravel
2	7-15	Grey brown (7.5YR4/2) loam; light gravel
3	15-30	Brown (7.5YR4/4) loam; light gravel
4	30-60	Brownish yellow (10YR/6/6) medium clay with brown mottles
5	60-90	As for 4 above with faint brown mottles

Analytical data

NO.	pH	Loss on ignition (%)	Org. C (%)	Total N (%)	P (%)	Silt (%)	Clay (%)	Exchangeable cations (m-equiv/100g soil)				
								Total	Ca	Mg	K	Na
1	6.6	9.9	6.8	0.12	0.02	9	4	11.0	5.0	1.7	0.2	0.4
2	6.8	8.4		0.10		8	14	6.4	3.4	1.4	0.2	0.4
3	6.6	6.9				7	16	5.2	1.2	<0.7	0.1	0.3
4	6.7	9.5				5	33	4.4	0.5	<0.7	0.1	0.2
5	5.5	13.6						1.7	0.1	<1.1	0.1	0.2

THE RED EARTHS

Profile 3, Red Earth, Gn2.15

Ref: P 320; McArthur and Clifton 1975

Location: Burma Rd, 480m E. of Gloucester Tree, Pemberton; 34°26'S., 116°04'E.

NO.	DEPTH (cm)	DESCRIPTION
1	0-2	Dark brown (7.5YR3/2) friable sandy loam; light gravel
2	2-25	Dark reddish brown (5YR3/3) friable sandy loam; moderate gravel
3	25-62	Red-brown (2.5YR3/8) sandy loam; crumbly; moderate gravel
4	62-87	Red-brown (2.5YR3.5/6) loam; crumbly; fragments of decomposed rock
5	87-100	Discarded; as for 4 above but less red
6	100-118	Brown (7.5YR5/8) clay loam; much decomposed rock
7	118-150	Weathered rock with brown medium clay in crevices

Analytical data

NO.	pH	Loss on ignition (%)	Org. C (%)	Total N (%)	P (%)	Silt (%)	Clay (%)	A Total	Exchangeable cations (m-equiv/100g soil) Ca	Mg	K	Na
1	6.7	19.1	9.5	0.35	0.03	13	4	46	9	11	0.5	0.4
2	6.7	10.7		0.16		13	4	29	6	2	0.3	0.2
3	7.0	7.2										
4	7.0	5.0				12	12	6	2	1	0.1	0.1
5	Discarded											
6	6.6	7.5				12	14					
7	66	7.5					12	14				

A Exchange capacity estimated at pH 8.4

THE BROWN GRAVELLY DUPLEX SOILS

Profile 4 : Classification; gravelly red duplex soil, Dr5.62
Ref : P175; McArthur and Clifton 1975
Location : Beardmore Rd, 1.0km east of Dough Rd; 34°49'S., 116°40'E.

NO.	DEPTH (cm)	DESCRIPTION
1	0-5	Light brown (7.5YR5/4) loamy sand; moderate gravel
2	5-10	Light brown (7.5YR5/4) loamy sand; moderate gravel
3	10-20	Yellowish-brown (7.5YR5/6) sandy loam; moderate gravel
4	30-40	Yellowish-brown (7.5YR5/5) sandy loam; high gravel
5	50-60	as above
6	70-80	Yellow-brown (7.5YR5/8) sandy light clay; massive; high gravel
7	80-90	as above
8	90-100	as above

Analytical data

NO.	Reaction pH	Total Salts (%)	Organic Carbon (%)	Nitrogen (%)	P (%)	Gravel (%)	Silt %	Clay %	Exchangeable Cations (m-equiv./100g soil) Total	Ca	Mg	K	Na
1	6.3	103	3.1	0.1	0.01	30	7	5	9.4	1.7	1.2	0.2	0.2
2	6.3	126				30							
3						40							
4	6.7	113				60							
5	6.4	90				60	7	13	2.5	0.4	0.3	<0.1	0.2
6	6.8	48				60							
7						60							
8	6.5	54				60	10	30	2.1	0.3	0.2	0.1	0.1

Appendix D

APPENDIX D

NATIONAL ESTATE AREAS CHIPWOOD LICENCE

APPENDIX D

NATIONAL ESTATE AREAS CHIPWOOD LICENCE

AREA (CALM Forest Blocks)	PROPOSED CALM* TENURE	PROPOSED CALM* USE	NATIONAL ESTATE STATUS	PROPOSED HARVESTING ACTIVITY *
Proposed South Coast National Park - Nornalup to Scott River 116000ha	National Park	Nature Conservation	Registered	None
Wattle, Johnston, O'Donnell, Mitchell Crossing, Soho	National Park	Nature Conservation	Registered	None
Perup Fauna management area Balban, Yendicup, Moopinup, Yackelup, Camelar, Chariup, Boyicup - 38000ha	Forest Park	Multiple Use (fauna)	Registered	None
One Tree bridge - Gordon block	Forest Park	Multiple Use (Recreation)	Registered	Thinning of regrowth karri
Scabby Gully catchment Lindsay block	State Forest	Water Production	Registered	Thinning of regrowth undertaken to promote water runoff
Dickson - square mile reserve	Nature Reserve	Nature Conservation	Registered	None
Iffley	State Forest	Forest Production	Registered	None
Dombakup	Forest Park	Multiple Use (Conservation)	Registered	None
Strickland Forest Block	Nature Reserve	Nature Conservation	Registered	None
Brockman Forest Block	National Park	Recreation	Registered	None
Warren, Beedelup (Pemberton National Parks), Hawk (North), Treen	National Park	Nature Conservation Recreation	Registered	None
Boorara - Forest Block	Forest Park	Multiple Use (Conservation)	Registered	None
Muirillup	Forest Park	Multiple Use (Recreation)	Registered	None
Beavis (east) - Giblett Forest Blocks	State Forest	Forest Production	Registered	None - will be burning buffer for life of project
Lower Shannon, i.e. Chesapeake, Dixie, Pingerup, Broke	National Park	Nature Conservation Recreation	Registered	None
Beavis Block (west)	State Forest	Forest Production	Interim list (OBJECTION)	Karri/marri sawlog and chiplog production
Walpole - Nornalup National Park and adjacent areas -	National Park	Nature Conservation	Interim list	None
Hawke Block (south)	State Forest	Forest Production	Interim list (OBJECTION)	Karri/marri sawlog and chiplog production
Shannon basin excluding those areas already listed	National Park	Nature Conservation Recreation	Nomination	None
Deep River Basin - Wye, Deep, Dawson, Burnett, Sharpe	State Forest	Forest Production	Nomination	Karri/jarrah/marri saw-logging and chiplogging
- Keystone	Forest Park	Multiple Use (Conservation)	Nomination	None

* 1987 Draft Regional Plan

Appendix E

APPENDIX E

SUMMARY OF CALM MANUALS ON CURRENT PRACTICE

APPENDIX E

SUMMARY OF CONTENT OF THE INDUSTRY CONTROL MANUAL

Item 1 Sawlog Specifications - Southern Forest Region Mills

Describes the minimum length and crown diameter for first grade jarrah and karri logs for each mill. Sets out the procedures for docking of logs to protect utilisable volume.

Item 2 Specifications of Chiplogs to WACAP

Describes the minimum standards with regard to length, crown diameter, charcoal, bend, rot and bole deformation acceptable for a chiplog.

Item 3 Karri Peeler Log Specification and Operations Checklist

Describes the acceptable diameter and lengths. Sets out specifications for rot, heart position, borers and pinholes, shakes, shape, limb, dry side and gum. Describes administrative procedures required to sort, deliver and account logs.

Item 4 Specification for Supply of Untreated Round Timber for Bridge Construction and Operations Checklist

Describes permissable defects with regard to rot, sapwood, gum rings, splits/shakes and knots. Specification for tolerances allowable in straightness, length and mid diameter are prescribed. The administrative procedure to sort, deliver and account for logs is described.

Item 5 Operations Checklist for Batten Logs to Monier and Contract 85H1 (Brookes)

Describes log quality, segregation, delivery and accounting procedures for each operation.

Item 6 Log Segregation for Bush Landings in Chipwood Licence area

Describes the method by which logs are segregated between the major licence holder, the local sawmilling licence holder, the pre paid forest produce licence holder and the chipmill. Administrative procedures for checking the chipmill landings for sawlogs are described and the responsibility for taking them to a sawmill detailed.

Item 7 Log Segregation at WACAP Chipmill Landing

Describes the procedure for segregating potential sawlogs which arrive on the chipmill landing.

Item 8 Logging Plans and Contractual Arrangements

Describes the planning process and constraints due to coupe size, coupe dispersal, stream, road and amenity reserve, balancing sawlog to mill area, quality mix, balanced haul distance, burning buffers, fuel requirements, use of seed trees and sawlog/chiplog ratio balance. Defines the requirement on the forest officer for checking the annual logging plan coupes with regard to the cutting prescription, coupe boundaries, steep slope areas and winter logging capabilities. Describes the contractual arrangements possible for bush and haulage operations.

Item 9 Salvage Log Prescription for Log Parcels Outside Annual Logging Plans

Describes procedures for salvage of material that may arise due to windthrow, S.E.C. line clearing, etc. Sub-divides parcels into greater or less than $100m^3$ and describes contractual, environmental standards authorisation and segregation procedures.

Item 10 Jarrah Silviculture Prescription

Describes the objective for silviculture then outlines the requirement for advance burning, tree marking, tops disposal burning and stand improvement. A checklist for the forest officer determining the cutting pattern on the coupe is provided.

Item 11 Karri Silviculture Prescription

Describes the specification, spacing, species, protection and marking procedure for clear-felling with seed trees. Extraction of seed trees following the burn is described and procedures to minimise soil damage and seedling damage are set down.

Item 12 Commercial Thinning of Karri Regrowth Stands

The criteria for the selection of trees to be retained based on dominance, crown, form, spacing, species and damage is set down. The intensity of thinning is determined by co-dominant height as prescribed. Control of the operation with regard to tops disposal, track construction, fallers blocks, soil disturbance and retained basal area is described.

Item 13 Coupe Planning Prescription

Describes procedures to locate then demarcate coupe boundaries and internal management boundaries. The requirement for roading, scrub rolling, locating landings, log dumps and snig track layout are set down.

Item 14 Coupe Control Prescription

Describes the procedure for marking fallers blocks and doing intermediate and final inspections.

Item 15 Environmental Protection Prescription

Tables the approval required for logging operations in different land use designations. Describes the requirement for stream reserves, amenity reserves. Details prescriptions for protection of stream reserves during logging.

Item 16 Dieback Hygiene Logging Prescription

Describes the objectives for hygiene in logging. Outlines the planning process required for hygiene logging in jarrah forest with regard to mapping, sevenway tests, impact assessment, moist or dry soil logging, lead times, allocation of sub-coupes, season and dieback category, logging sequence. The requirement for road location, construction and operation of gravel pits is detailed. The present system for operation in disease risk area (DRA) as it relates to logging and the requirements for plant and equipment cleandown is described. Split phase logging as a means to prevent introduction of dieback from the landing to the coupe is described.

Item 17 Logging Disturbance Control Prescription

Outlines the method of control to limit the area of unacceptable soil disturbance. Categorises the extent of damage to soils and sets maximim limits. Outlines the survey technique to be used to assess damage and the coupe closure mechanism.

Item 18 Erosion Control Prescription

Defines factors relevant to erosion control, i.e. streams, watercourses, sedimentation, turbidity and stream reserve. Details planning required and prescribes procedures for scrub-rolling, felling, snig track and landing placement and stream reserves. Specification for the positioning and frequency of cross drains according to slope and soil type are given.

Item 19 Steep Slope Logging Prescription

Details the identification of steep slope areas and sets down guidelines with regard to sequence of logging single watersheds, snigging, machine movements, utilisation, soil moisture, condition burning and rehabilitation.

Item 20 Forest Officers Checklist and Coupe Inspection Report

Provides a checklist of all points to be looked for in coupe control.

Item 21 Fallers Block Certification Sheet

Formal certification sheet for checking of utilisation and erosion control.

Item 22 Industry Roading Prescription

Details requirements for planning with regard to alignment, river crossings, clearing, gravel pits, and safety. Defines construction standards in width, disposal of debris, table drains and crossings. Responsibility for, and standard of, ongoing maintenance is outlined.

Item 23 Traffic Control Signs

Specifies the type of sign and when it is to be used in bush operations.

Item 24 Gravel Pit Working and Rehabilitation Prescription

Sets out the requirements for gravel pit operation with regard to dieback hygiene, placement, numbers of pits and access. Rehabilitation of the pit with regard to top soil replacement, ripping of floor, battering of banks and drainage is prescribed.

Item 25 Summary of Demarcation Procedures and Forest Markings

Sets out a field marking standard for coupes, sub-coupe dieback hygiene boundaries, fallers blocks, trees or logs requiring further attention, dieback boundaries, retained trees, seed trees, trees to be felled and log marking.

Item 26 Approved Abbreviations for Blocks Within Southern Region and Chipwood Licence Area

Gives a list of all forest block names and their official abbreviation.

SUMMARY OF CONTENTS OF SOUTHERN FOREST REGION OPERATIONS MANUAL

2.1 Measurement of Forest Fuel Quantity

Describes how to stratify and sample an area of forest to determine fuel quantities to be used for prescribed burning.

2.2 Direct Measurement of Eucalypt Surface Litter Moisture Content

Describes the correct procedures for preparation of a fuel sample and its measurement using the Speedy and Marconi Moisture Meters.

2.3 Hardwood Burning Prescription Preparation

Details the factors requiring consideration and the limits to them in prescribing a fuel reduction burn. These include fuel type and quantity, season of burn, acceptable scorch limits, values to be protected and method of burning.

2.4 Prescribing Fires in Regrowth Karri Forest

Describes the techniques and procedures required to successfully prescribe a fuel reduction burn in karri regeneration which has not previously been burnt. Tables of fuel weight with basal area are given. Guidelines on tree size, soil dryness index, fuel moisture content and burning conditions are given.

2.5 Hardwood Burn Preparation

Sets out guidelines to be used in stag falling and scrub-rolling to prepare for the burning of an area of forest. A decision model for when to stag fall is provided.

2.6 Guidelines for Edging

Gives guidelines with regard to preplanning, selection of conditions, prescribing, timing, safety, method of lighting and record keeping.

2.7 Slash Burning Prescription - Karri

Sets out a checklist of points to be considered in drawing up a prescription for burning post logging karri slash.

2.8 Slash Burn Guidelines

Details methods and factors affecting slash burning. Covers fuel quantity and type, fuel moisture content, weather conditions, burning techniques, organisational structure and safety.

2.9 Jarrah Regeneration Burning

Provides guidelines to prescribing jarrah regeneration burning based on the type of forest, the cutting employed and the soil dryness index limits.

2.10 Post Burn Procedures for Aircraft, Hand and Regeneration Burns

Sets out the procedures required to inspect a burn for safety and to assess it for achieved objectives. The recording mechanism is defined.

2.11 Policy for Scrub-rolling Prior to Prescribed Burning Operations

Sets out the guidelines for scrub-rolling with regard to approval process, land tenure and use, dieback hygiene, depth and landscape considerations.

3.1 District Duty Officer Responsibilities

Provides a checklist of duties for the officer responsible for fire control in a District. Covers weather forecasts, fuel moisture calculations, detection and action on event of a fire being detected.

3.2 Use of Chemical Fire Retardants

Describes how fire retardants work and the composition of the favoured one. Specifies the mixing ratio, application technique, storage and safety and health procedures.

3.3 Fungicide in Fire Tanker Water

Describes the treatment of water to kill spores of Phytophthora cinnamomi. Gives the mixing ratio and safety procedures for sodium hypochlorite and copper sulphate.

3.4 Mopping Up

Sets out the standards required in making the edge of burn safe. Covers rake trails and dozer breaks, detailing techniques for use of water, soil and push in. Environmental protection and safety are included.

3.5 Manning Fire Towers

Describes the equipment, qualifications required and techniques for operating a fire lookout tower.

3.6 Fire Detection Using Spotter Aircraft

Describes the responsibility of pilot and forest officer in determining a daily work schedule, reporting of smokes, and safety. Standard detection hours are given along with SAR procedure.

3.7 Water Point Construction and Maintenance

Sets out the standard for water points in fire control with regard to location, frequency, capacity and maintenance.

3.8 Fire Suppression Decision Models

Gives checklist in the form of decision flowchart to assist fire controllers to assess appropriate suppression strategy for different land uses.

4.1 Regeneration Prescription Guidelines

NOT COMPLETED

4.2 Top Disposal in Karri Regrowth Stands

Outlines the technique for safely removing logging debris from the base of retained stems to prevent damage during burning operations.

4.3 Tops Disposal in Jarrah Regrowth Stands

Outlines the technique for safely removing logging debris from the base of retained stems to prevent damage during burning operations.

4.4 Standards for Coupe Preparation for Karri Regeneration Burning

Sets out standards for roading, breaking up of large areas into cells, scrub-rolling, stag falling, edge push in and signposting. Protection of stream reserves and preparation of control point is described.

4.6 Gravel Pit Rehabilitation

Standards for preparation of a disused pit for planting are described. Areas covered are dieback hygiene, ripping, drainage, battering of banks and use of retained top soil.

4.7 Landing and Snig Track Rehabilitation for Planting

Sets out pre-planning required to identify and mark in the field areas to be ripped. Describes standard of ripping required, areas to be avoided, and erosion control considerations.

4.8 Direct Seeding for Karri Regeneration

Sets the objective in terms of seeds/ha then describes how using a hand seeder the appropriate amount of seed can be distributed.

4.9 Planting Open Rooted Nursery Stock

Describes the limits on planting stock, season of planting, layout of planting area, plant spacement, fertiliser application and accident prevention.

4.10 Assessing Regeneration Success in Karri Forest

Describes the setting out of a sampling system to estimate the percentage survival in regenerated coupes.

4.12 Seed Forecasting Prior to Karri Logging

Describes how to assess the seed crop on felled karri trees to determine the coupes suitability for seed tree regeneration.

4.15 Planting Container Stock Eucalyptus

Describes the planting technique for jiffy pat stock. Fertilisation with 25gm of DAP is described.

4.16 Direct Seeding of Shrub Species on Rehabilitated Areas

Outlines the direct seeding of understorey species for revegetation of severely disturbed areas particularly for erosion control. Describes seed collection, seed preparation, site preparation, time of sowing and sowing method.

5.1 Strategic Roading for the Protection of Hardwood Regeneration

Sets out the intensity of roading to be maintained or constructed for protection of regrowth. Defines two levels of roads to isolate areas of 2000ha then 500ha and describes their standard.

5.2 Maintenance of Access for Fire Control

Describes the standards required for maintenance of access roads around regenerated karri coupes with regard to roadside vegetation control, log removal, drainage and sign posting.

5.3 Access Construction for Blackberry Control Works

Gives the principles to be applied in creating environmentally acceptable access for blackberry control work. The consideration of alternatives is given prominance.

5.4 Road Construction Specification

Sets out the specifications for clearing width, surface width, culvert requirement, curve requirement, slope requirement, gravel depth, sign posting, hygiene and maintenance for main access, secondary access and minor access.

6.1 Obtaining Meteorological Observation

Describes the level of accuracy required, how to take readings and the acceptable instruments from which to take them. Observations covered are air temperature, relative humidity, dew point, wind direction, wind speed, rainfall, air pressure, cloud and low wind direction.

6.2 Stevenson Screen Siting

6.3 Maintenance of Meteorological Instruments

A daily, weekly and monthly, and as required, checklist is given for maintenance tasks

6.4 Armillaria Recognition

NOT COMPLETED

7.2 Vehicle Washdown Procedure

Outlines the procedure for the removal of soil, mud and root material from vehicles to facilitate dieback hygiene. Procedures for wet soil and dry soil are given.

7.3 Hygiene in Road Maintenance

Details the procedures required to ensure dieback innoculum is not brought on site or spread from an existing site in road maintenance operations such as surface grading, surface maintenance and patch gravelling.

7.4 Procedures for Sampling Sites Possibly Infected with Phytophthora cinnamomi.

Outlines the techniques to obtain a sample of root material to test if it is infected with Phytophthora cinnamomi.

8.1 Definition of Area with Particular Conservational Value

A guide setting out the level of authority required to approve operations in particular areas.

8.2 Scope of Operations Allowed in these Areas

A decision guide setting out the level of authority required for various operations on all CALM land

Appendix F

APPENDIX F

CONVERSION FACTORS AND PLANTATION GROWTH RATES

APPENDIX F

CONVERSION FACTORS AND PLANTATION GROWTH RATES

- o Cubic metres Chiplogs to tonnes chiplog

Marri:	1.241 tonnes/m^3
Karri:	1.154 tonnes/m^3
Mixed sp:	1.215 tonnes/m^3

Source: CALM Current Conversion Factors 1987

- o Tonnes Chiplogs to Tonnes Green Woodchips

12% Loss Chiplogs to Woodchips being:
10% Bark
2% Fines (sawdust, undersize chips)

Source: WACAP Current Conversion Factors

- o Average Yield from Private Property Forest

50m^3/ha chiplogs

Source: WACAP

- o Growth Rates of Eucalypt Plantations

WACAP quote an average figure or 20m^3/ha/yr as the expected mean annual increment over 15 years for their E. globulus plantations. This is based on their own trial results viz;

- o Millards Block - E. globulus Trial. MAI of 29m^3/ha/yr over 11 years. This trial is located on a fertile karri loam in a 1200mm rainfall zone.

- o Shankleys Block - E. globulus Trial. MAI of 20.7m^3/ha/yr over 19 years. The coppice from this trial is growing at a MAI of 18.7 after 4.75 years. Where it has been thinned down to 3 stems per stump at age 1. The site is a much poorer one than Millards, the original vegetation was predominantly Jarrah, the average annual rainfall 800mm and the soils a poor lateritic loam.

- o Channybearup mixed species trial. At age 5.5 years the following MAI's have been achieved:

- E. globulus	40m^3/ha/yr
- E. maidenii	21-43m^3/ha/yr
- E. saligna	30-35m^3/ha/yr
- E. viminalis	27-35m^3/ha/yr
- E. brookerann	29m^3/ha/yr

This trial is located in a 1100mm rainfall zone on a fertile karri loam.

o Yield Estimates for Plantations

WACAP plan to harvest their plantations when they reach a standing volume of around 300m^3/ha based on a MAI of 20m^3/ha/yr. This should take place at age 15.

Appendix G

APPENDIX G

DESCRIPTION OF THE NON-CONFIDENTIAL WACAP RESEARCH PROGRAMME

APPENDIX G

DESCRIPTION OF WACAP RESEARCH PROGRAMME

FOURACRES KARRI THINNING TRIAL

This was established for two purposes:

1. As an observation example to show farmers comparisons of an unthinned karri forest with a thinned forest. This is hoped to help persuade other farmers the advantages to be gained from thinning their own regrowth karri forest.
2. To obtain quantitative data on the growth response with the remaining trees following a thinning operation.

Two permanent plots were established, one in a recently thinned area and the other in an adjacent unthinned area. Both sites are within an area of even-aged regrowth karri forest.

It is expected that annual assessments will reveal trends of declining growth rates in the unthinned forest as competition between trees for nutrients and water increases. The thinned plot assessment is expected to reveal an increasing growth rate as trees are released from competition.

BOYANUP PLANTING SURVIVAL COUNT

At the end of the 1984 planting season a large number of *Eucalyptus globulus* LABILL ssp *globulus* seedlings were planted at WACAP's proposed Forest Products Complex site near Boyanup.

A survival count was made on this block to assess the establishment capability of *E. globulus* ssp *globulus* (Tasmanian Blue Gum) under very harsh climatic circumstances as well as poor soil types. An assessment of growth rate will be made in the near future to find if the surprisingly good survival rate is followed by an adequate growth rate. This will help future decisions on the viability of establishment of Tasmanian blue gum on marginal quality sites.

SPECIES/PROVENANCE TRIALS

WACAP has established trials on four sites, all four were assessed early in 1986. The objective of these trials is to find the species that will maximise volume production on each site type. The results for each area are summarised below.

(a) Channybearup Trial:

This species/provenance trial has produced the best growth rates of all WACAP trial sites. This assessment has indicated E. globulus ssp globulus, provenance Taranna, Tasmania, will produce the greatest volumes on good quality karri loam pasture sites. Also showing good potential except for its survival rate is E. viminalis, provenance Bruthen, Victoria.

(b) Knox's Block:

E. globulus ssp globulus provenance Barnback, Tasmania, is the fastest growing species on this site. Again E. viminalis, provenance Bruthen, Victoria, appears to have a good growth potential but poor survival.

(c) The remaining two blocks, Fitz's Block and Boddington, show E. globulus ssp globulus to be the most successful. Both these sites are low quality.

Annual assessment of all four areas will continue so growth patterns for each species can be obtained.

The Channybearup Trial also included a site preparation trial. At this stage of the rotation, it appears the best survival and growth will be obtained after ploughing. This preparation is favoured over ripping and herbicide spraying or just ripping alone.

ROUTINE PLANTATION ASSESSMENTS

Three WACAP tree farms were assessed in early 1986. The aims of the assessments were to survey their health and vigour and to calculate the average growth rate at this stage, for each area.

TREE IMPROVEMENT PROGRAM

Because WACAP aims to establish 300 tree farms on its own lands and to encourage other land owners to do the same, it is important to obtain the greatest growth rates possible from each hectare of land. It is the ongoing aim of this program to improve the genetic stock and hence the growth rate and quality of the trees and other landowner's tree farms.

For the first two months of 1986, a total of 17 different WACAP and CALM plantings were searched to find trees with better than average characteristics.

Material from some of the selected trees was collected and taken to Murdoch University where it was used in the development of vegetative propagation techniques as part of the National Biotechnology Programme.

A hot bed tunnel at the Five Acre Nursery in Manjimup was also modified by WACAP into a controlled environment house. This is used in trials by WACAP to develop a vegetative propagation method for Tasmanian blue gums. Once this is done, superior individuals with increased growth rates and other qualities will be cloned and used as the basis for future WACAP tree farms.

PULPING STUDY

The aim of this study was to determine the pulp and papermaking characteristics of timber resources not currently utilised in Western Australia.

From January through to March of 1986 WACAP officers collected a wide range of samples. In all, 135 regrowth marri, karri and jarrah trees were sampled from forest blocks from Walpole to Mundaring. As well, samples of old growth karri chiplogs and sawmill residues were collected, and jarrah sawmill offcuts were also collected from eight sawmills. Routine export woodchip mixtures were collected from four vessels loading out of the WACAP facility at Bunbury.

All pulping analysis of air dried woodchips was carried out by Dr. Cedric Fallick of the CSIRO Division of Chemical and Wood Technology in Perth.

MIXED PINE/EUCALPYT PROGRAMME

In 1985 WACAP and CALM initiated a series of joint trials aimed at producing hardwood pulpwood within a pine plantation. At present there is only a limited market from small sized pines removed in the first thinning operations. One option for this timber is to replace the trees to be thinned with species of commercial use. As yet no trends have been observed because the plantations are too young.

Further trials established in 1986 have continued this approach, and have also included an extensive eucalypt species trial.

Further mixed pine/eucalypt trials are planned in 1987.

HERBICIDE TRIALS

Herbicide trials were established on private property in 1985 and 1986 in conjunction with the Department of Agriculture in Manjimup.

Assessment of the 1985 herbicide trial has revealed an opportunity for a sizable reduction in herbicide costs when establishing trees in pasture areas. The trial compared various types and combinations of pre-planting and post-planting herbicide sprays on pastures dominated by Rye and Fog grasses. A new treatment was found that would give the same or better knock down and residual control of grasses than the present standard treatment plus provide substantial reductions to herbicide costs.

Assessment was based on seedling survival rate and average height, as well as residual grass and weed cover.

Another herbicide trial was established in 1986. The aim of this trial was to find a type and rate of herbicide that gives the most efficient control of grass and weeds on a Kikuyu dominated site. Early indications are that there is a cheaper control for Kikuyu than the standard application treatment.

FERTILISER TRIALS

Fertiliser trials were established in 1985 and 1986. The trials were each on different soil types with a different site history. Different types of fertilisers and different rates were trialled. Also included was a tablet form of fertiliser, of which some were treated so that they would release nutrients at a slower rate.

As yet no definite conclusions as to variety, rate or form that will give a better growth response than the present standard application have been reached.

SOUTH STIRLING DEMONSTRATION PLANTING

In 1985 and 1986 demonstration plantings of various eucalypt species were established in the area south of the Stirling Ranges. The purpose was to demonstrate to local farmers some of the benefits of trees on farms. Benefits demonstrated were the stabilisation of windblown sandy soil, windbreak effects (such as stock protection) and timber production.

Soil stabilisation has already become evident but it will be some years yet until the full windbreak effects and timber production capabilities are revealed.

JOINT WACAP/ALCOA *E. GLOBULUS* SSP *GLOBULUS* TRIAL

A provenance trial for *E globulus* ssp *globulus* was established on land owned by Bunnings Forest Products Pty Ltd at Boddington in 1985. Boddington is 100km SE of Perth, suffers a harsh climate, and has a low rainfall (640mm/yr). This trial is to select the provenance of Tasmanian Blue Gums that will adapt best to harsh climates and poo soils. No evaluation of this trial has yet been tabulated.

SUNKLANDS (JARRAHWOOD) COPPICE TRIAL

A plantation of *E. globulus* ssp *globulus* at the Sunklands, near Busselton, was made available for research to WACAP by CALM. The plantation was due for thinning by CALM in 1986. In return for making the trial area available WACAP is now carrying out this operation by thinning one section each month for 12 months. The purpose of this exercise is to find which month(s) will promote the most prolific coppice regrowth from the stumps.

WHEATBELT SPECIES SELECTION

The Muresk Institute of Agriculture and WACAP are jointly establishing an arboretum of species that have timber production potential in the wheatbelt climate and also species with various windbreak capabilities.

WACAP selected a wide range of eucalypt, acacia and pine species that had the potential to fulfill one or both of these purposes. The arboretum layout was designed so that each species would combine with its neighbouring species to create the desired tree form, be it ground level windbreak or maximum height growth.

A site for this arboretum has already been chosen and the block will be established in 1987.

MISCELLANEOUS SPECIES

In 1985 small trials of Pawlonia fortunei, Populus nigra and Cunninghamia lanceolata were established, to determine if these showed potential for planting on private property as an alternative to existing timber producing trees.

SHANKLEY'S BLOCK COPPICE TRIAL

This area was clear-felled in December 1981 when the E. globulus ssp globulus was 19 years old. The plot is divided into 3 sections of unthinned coppice regrowth, coppice thinned to two or three stems per stump in 1982 and coppice thinned to two or three stems per stump in 1983.

The first volume assessment of this block was made in 1986. The results have been very encouraging with quite high growth rates in all three plots being recorded. The plot with coppice thinned at age 2 (1983) is producing the biggest coppice stems.

COMPARISON OF VOLUME FUNCTIONS

A need was recognised within WACAP to establish an accurate method or formula for approximating the volume of growing Tasmanian blue gum trees. However, there was a limited amount of accurate volume measurements on which the volume function approximations could be compared.

It has been found that no one volume function is accurate for all sizes of trees, but an acceptable level of accuracy has been reached using different formulas developed by WACAP and others for different size classes.

WOOD PRESERVATION AND PRESSURE TREATMENTS

Research has begun to find possible alternative uses, other than pulpwood, of the E. globulus ssp globulus timber. Pressure treating poles with preservatives may make the timber a more valuable product for uses such as fence posts or light building material.

Trials into the ability of the logs to uptake the preservatives and their resistance to cracking or drying are presently being undertaken.

ACACIA SPECIES TRIAL

A very small stand of Acacia elata was found and after measurement it was established that the growth rate for these trees was excellent and the pulp yield (on a small sample) compared well with the E. globulus ssp globulus pulp yield. After correspondence with the Institute for Commercial Forestry Research (South Africa), it was decided to establish an Acacia species trial on a low quality sites, because it has been found in South Africa that acacias can sometimes be grown more profitably on poor sites than eucalypts. The trial will be established in 1987.

ECTOMYCORRHIZAL TRIAL

A joint CSIRO/WACAP programme researching the opportunities of increasing the growth rate of eucalypt plantations, by innoculating seedlings with specific ectomycorrhizal fungi, was commenced in 1986. Ectomycorrhizas boost tree growth by growing on the surface of the roots, thus increasing the root surface area enabling a more efficient nutrient and moisture uptake.

Various types of fungus were collected during 1986 and have been cultured in the CSIRO laboratories in Perth. Laboratory and glass house tests on seedlings innoculated with mycorrhizas have found that some ectomycorrhiza increased seedling growth by twenty fold and field planting of the more promising fungi tested so far will be established in the 1987.

SUMMARY OF RESEARCH FOR INDIA

As a courtesy to an Indian Company for their co-operation when WACAP staff visited their operations, WACAP investigated two problems the Indian Company were experiencing, these were:

1. The causes and control of Pink Disease (Corticium salmonicolor Berk and Br) which has infested their eucalypt plantations.

2. Selection of species most suited to the local growing conditions.

It was found that Pink Disease is a fungus that attacks the stem and branches of trees. Most damage occurs to younger individuals and that the disease rarely kills a tree outright. The most effective control would be to remove any nearby mango trees because these act as an intermediate host to the fungus.

On the advice of CSIRO, Canberra, several suitable species for the region were suggested.

SITE PREPARATION TRIAL

A WACAP tree farm planted to E. globulus ssp globulus in 1984, was incorporated in a trial to determine growth response from different levels of site preparation, prior to planting.

The block was assessed in 1986 for average height and diameter trees growing in areas of each treatment. The areas with the greatest soil preparation had not only the best survival but the largest trees as well. Further site preparation trials are planned in 1987.

SEED COLLECTION

A total of about 18 kilograms seed has been collected from two locations in the South West. This is sufficient to plant about 130 hectares of plantations. Not all this seed will be planted out in 1987, some will be held back for later plantings to keep a genetic diversity in each years plantations.

SEED SIZE CLASSING TRIAL

It has been suggested that the cause of small, weak seedlings and trees may relate back to the original size of the seed. A quantity of Geeveston E. globulus ssp globulus seeds was sieved into different size clases and sown into jiffy pots according to their size groupings. Assessment will be based on each group's ability to germinate, survival rate, seedling growth and finally, when they have been planted out, on tree growth and vigor.

Appendix H

APPENDIX H

PLANT SPECIES COLLECTED IN THE SURVEY AREA SINCE 1968

APPENDIX H

PLANT SPECIES COLLECTED IN THE SURVEY AREA SINCE 1968 AND SUBSEQUENTLY RECORDED FROM REGENERATED AREAS

All plant species names have been checked against Green (1985) for taxonomic corrections.

203RP - Data in this column refers to number of occurrences recorded in the 203 Plots by Inions in regeneration studies of karri forest.
CR - Crowea Forest Coupe
P - Poole Forest Coupe
I9 - Iffley 9 Forest Coupe
M2 - Murrilup 2 Forest Coupe
B - Data Collected Before Logging
A - Data Collected After Logging and Regeneration

PLANT FAMILY & SPECIES	REGENERATED AREAS								
	KARRI						JARRAH		
	203 RP	CR B	CR A	P B	P A	I9 B	I9 A	M2 B	M2 A
ADIANTACEAE									
Adiantum aethiopicum L.	1	-	-	-	-	-	-	-	-
DENNSTAEDTIACEAE									
Pteridium esculentum (G. Forster) Cockayne	176	X	X	X	X	X	X	X	X
LINDSAEACEAE									
Lindsaea linearis Sw. in Schraeder	0	X	X	X	X	X	X	X	X
ZAMIACEAE									
Macrozamia riedlei (Fischer ex Gaudich.) C. Gardner	84	X	X	X	X	X	X	X	X
PODOCARPACEAE									
Podocarpus drouynianus F. Muell.	23	X	X	X	X	X	X	X	X
POACEAE									
* Aira caryophyllea L.		-	-	-	-	-	-	X	X
* Alopecurus geniculatus L.		-	-	-	-	-	-	X	X
Amphiphogon laguroides R. Br.		-	-	-	-	X	X	-	-
* Amphipogon sp.	1	-	-	-	-	-	-	-	-
* Avena barbata Link. in Schrader		-	X	-	-	-	-	-	-
* Briza maxima L.		-	-	-	-	-	-		X
* Briza minor L.		-	-	-	-	-	-	X	X
Bromus sp.		-	-	-	-	-	-	X	X
Danthonia caespitosa Gaudich. in Freyc.		X	X	-	-	-	-	-	-
Danthonia pilosa R. Br.		-	-	-	-	-	-	X	X
Echinopogon ovatus (G. Forster) P. Beauv.		-	-	-	-	-	-	X	-
* Holcus lanatus L.		-	-	X	X	-	-	X	X
* Lolium sp.		-	-	-	-	-	-	X	X
Microlaena stipoides (Labill.) R. Br.		X	X	X	X	-	-	X	X
Poa drummondiana Nees		X	X	-	-	-	-	-	-
Poa poiformis (Labill.) Druce	3								
Tetrarrhaena laevis R. Br.	179	X	X	X	X	X	X	-	X
* Vulpia bromoides (L.) Gray		-	-	-	-	-	-	X	-
CYPERACEAE									
Cyathochaeta avenacea Benth.	1	-	-	-	-	X	-	-	-
Gahnia trifida Labill.	3	-	-	X	-	X	X	X	X
Lepidosperma angustatum R. Br.	1	X	X	X	X	X	X	-	-
Lepidosperma effusum Benth.	52	X	X	X	X	-	-	-	-
Lepidosperma leptostachyum Benth.	93	X	X	X	X	X	X	X	X
Lepidosperma tetraquetrum Nees in Lehm.	1	X	X	X	X	X	X	-	-
Mesomelaena stygia (R. Br.) Nees in Lehm.		-	-	-	-	X	X	-	-
Mesomelaena tetragona (R. Br.) Benth.		-	-	-	-	X	X	-	-
Tetraria octandra (Nees) Kuek.		-	X	-	-	-	-	-	-
RESTIONACEAE									
Anarthria scabra R. Br.		-	-	-	-	X	X	-	-
Hypolaena exsulca R. Br.		-	-	-	-	X	X	-	-
Loxocarya fasciculata (R. Br.) Benth.	1	-	-	-	-	-	-	-	X
Loxocarya flexuosa (R. Br.) Benth.	1	X	X	-	-	-	-	-	-

PLANT FAMILY & SPECIES	REGENERATED AREAS								
	KARRI					JARRAH			
	203	CR		P		I9		M2	
	RP	B	A	B	A	B	A	B	A
JUNCACEAE									
Juncus acutus L.		-	-	-	-	-	X	-	X
Juncus planifolius R. Br.		X	X	-	-	-	-	-	-
DASYPOGONACEAE									
Dasypogon bromeliifolius R. Br.		-	-	-	-	X	X	-	-
Dasypogon hookeri J. Drumm. in Hook.		-	-	-	-	X	X	-	-
Kingia australis R. Br. in P. King	0	-	-	-	-	-	X	-	X
Lomandra endlicheri (F. Muell.) Ewart		X	X	X	X	-	X	-	X
Lomandra purpurea (Endl.) Ewart	4	-	-	-	-	-	X	-	-
XANTHORRHOEACEAE									
Xanthorrhoea gracilis Endl. in Lehm.	1	-	-	X	X	X	X	-	-
Xanthorrhoea preissii Endl. in Lehm.	0	-	-	-	-	X	X	X	X
PHORMIACEAE									
Dianella revoluta R. Br.		-	-	-	-	X	X	X	X
Stypandra imbricata R. Br.	1	-	-	-	-	-	-	X	X
ANTHERICACEAE									
Agrostocrinum scabrum (R. Br.) Baillon		-	-	-	-	X	-	-	X
Borya nitida Labill.		-	-	-	-	X	-	-	X
Caesia parviflora R. Br.		-	-	-	-				
Chamaescilla corymbosa (R. Br.) F. Muell. ex Benth.		-	-	-	-	-	X	-	-
Johnsonia lupulina R. Br.		-	-	X	-	X	X	-	-
Sowerbaea laxiflora Lindley		-	-	-	-	-	-	X	X
Thysanotus dichotomus (Labill.) R. Br.		X	X	X	X	-	-	-	-
Thysanotus isantherus R. Br.		-	-	-	-	X	-	-	-
Thysanotus multiflorus R. Br.	2	-	-	-	-	-	-	-	X
Thysanotus patersonii R. Br.	3	X	-	-	-	-	X	-	-
Thysanotus pauciflorus R. Br.		-	-	-	-	X	X	-	-
Thysanotus triandrus (Labill.) R. Br.		X	X	-	-	-	-	-	-
Tricoryne humilis Endl. in Lehm.		-	-	-	-	-	-	-	X
COLCHICACEAE									
Burchardia multiflora Lindley		-	-	-	-	-	X	-	X
Burchardia umbellata R. Br.		-	-	-	-	X	X	-	-
Wurmbea pygmaea (Endl.) Benth.		-	-	-	-	-	X	-	X
HAEMODORACEAE									
Anigozanthos flavidus Redoute & DC.	12	X	X	X	X	X	X	X	X
Conostylis setigera R. Br.		-	-	-	X	X	X	-	X
HYPOXIDACEAE									
Hypoxis glabella R. Br.		-	-	-	-	-	-	-	X
IRIDACEAE									
Orthrosanthus laxus (Endl.) Benth.		X	-	-	-	-	-	X	X
Orthrosanthus sp.	10								
Patersonia occidentalis R. Br.		-	-	-	-	X	X	X	X
Patersonia umbrosa Endl. in Lehm.	8	X	X	X	X	X	X	X	X
* Romulea rosea (L.) Ecklon		-	-	-	-	-	-	-	X
ORCHIDACEAE									
Acianthus reniformis (R. Br.) Schltr.		-	-	-	-	-	X	-	-
Caladenia dilatata R. Br.		-	-	-	-	X	X	-	-
Caladenia flava R. Br.		-	X	-	-	X	X	-	X
Caladenia latifolia R. Br.		-	X	-	-	-	X	-	-
Caladenia longiclavata E. Coleman		-	X	-	-	X	-	-	-
Caladenia menziesii R. Br.		-	X	-	-	-	X	-	-
Caladenia radiata Nicholls		-	-	-	-	-	X	-	-
Caladenia sericea Lindley		-	X	X	-	-	-	-	-
Corybas dilatatus (Rupp & Nicholls) Rupp & Nicholls ex Rupp		-	-	X	-				
Cryptostylis ovata R. Br.		-	-	X	-	-	-	-	-
Diuris longifolia R. Br.		X	-	-	-	X	X	-	-
Elythranthera brunonis (Endl.) A.S.George		-	-	-	X	-	X	-	-
Elythranthera emarginata (Lindley) A.S. George		-	-	-	-	-	X	-	-

PLANT FAMILY & SPECIES	REGENERATED AREAS								
	KARRI					JARRAH			
	203 RP	CR B	CR A	P B	P A	I9 B	I9 A	M2 B	M2 A
ORCHIDACEAE (cont'd)									
Epiblema grandiflorum R. Br.		-	-	-	-	-	-	-	X
Eriochilus dilatatus Lindley		-	-	-	-	-	X	-	-
Eriochilus scaber Lindley		-	X	-	-	-	-	-	-
Gastrodia sesamoides R. Br.		X	-	X	-	-	-	-	-
Microtis alba R. Br.		-	X	-	-	-	-	-	X
Microtis unifolia (G. Forster) H.G.Reichb.		-	-	-	X	-	-	-	-
Prasophyllum fimbria H.G. Reichb.		X	X	-	X	-	-	-	-
Prasophyllum parvifolium Lindley		-	-	-	-	-	X	-	-
Prasophyllum regium R.S. Rogers		-	X	-	-	-	-	-	-
Prasophyllum sp.		-	-	-	-	X	-	X	X
Pterostylis nana R. Br.		-	-	-	X	X	X	-	-
Pterostylis recurva Benth.		-	-	-	-	X	X	X	X
Thelymitra pauciflora R. Br.		-	-	-	-	X	-	-	-
CASUARINACEAE									
Allocasuarina decussata (Benth.) L.Johnson	79	X	X	X	X	X	X	-	-
Allocasuarina fraseriana (Miq.) L.Johnson		-	-	-	-	X	X	-	-
PROTEACEAE									
Adenanthos barbigerus Lindley		-	-	-	-	X	X	-	-
Adenanthos obovatus Labill.		-	-	-	-	X	X	-	-
Banksia attenuata R. Br.									
Banksia grandis Willd.	5	X	X	X	X	X	X	X	X
Banksia littoralis R. Br.		-	-	-	-	X	X	X	X
Banksia littoralis var. seminuda R. Br.	1								
Conospermum caeruleum R. Br.	2	-	-	-	-	-	-	-	-
Conospermum capitatum R. Br.		-	-	-	-	X	X	-	-
Conospermum flexuosum R. Br.		-	-	-	-	X	X	-	-
Dryandra bipinnatifida R. Br.		-	-	-	-	X	X	-	-
Dryandra nivea (Labill.) R. Br.		-	-	-	-	X	X	-	-
Grevillea brevicuspis Meissner in Lehm.		-	-	-	-	X	X	-	-
Grevillea quercifolia R. Br.		-	-	-	-	X	X	-	-
Hakea amplexicaulis R. Br.	2	-	-	-	X	X	X	X	X
Hakea ceratophylla (Smith) R. Br.		-	-	-	-	X	X	-	-
Hakea lasiantha R. Br.	1	X	X	X	X	X	X	-	-
Hakea lissocarpha R. Br.		-	-	-	-	X	X	X	X
Hakea oleifolia (Smith) R. Br.		-	-	-	-	-	-	X	X
Hakea ruscifolia Labill.		-	-	-	-	-	-	X	X
Hakea varia R. Br.		-	-	-	-	X	X	-	-
Isopogon sphaerocephalus Lindley		-	-	-	-	X	X	-	-
Persoonia longifolia R. Br.	30	X	X	X	X	X	X	X	X
Petrophile diversifolia R. Br.	1	-	-	-	-	X	X	-	-
Synaphea petiolaris R. Br.		-	-	-	-	X	X	-	-
Xylomelum occidentale R. Br.		-	-	-	-	X	X	-	-
SANTALACEAE									
Choretrum lateriflorum R. Br.	1	-	-	-	-	-	-	-	-
Exocarpos sparteus R. Br.		-	-	X	-	-	-	-	-
Leptomeria cunninghamii Miq. in Lehm.	3	-	-	-	-	X	X	-	-
AMARANTHACEAE									
Ptilotus manglesii (Lindley) F. Muell.		-	-	-	-	-	-	X	X
RANUNCULACEAE									
Clematis pubescens Huegel ex Endl. in Endl.	177	X	X	-	-	X	X	X	X
Ranunculus colonorum Endl. in Endl.	6	X	X	-	-	X	X	X	X
LAURACEAE									
Cassytha racemosa Nees in Lehm.	3	X	X	X	X	X	X	X	X
BRASSICACEAE									
* Cardamine hirsuta L.		-	X	-	-	-	-	-	X
DROSERACEAE									
Drosera pallida Lindley		X	X	X	X	X	X	-	-
Drosera sp.		-	-	-	-	X	X	-	-

PLANT FAMILY & SPECIES	REGENERATED AREAS								
	KARRI					JARRAH			
	203 RP	CR B	CR A	P B	P A	I9 B	I9 A	M2 B	M2 A
PITTOSPORACEAE									
Billardiera floribunda (Putterl.) F.Muell.	3	-	X	X	X	-	-	X	X
Billardiera variifolia DC.	21	-	-	-	-	-	-	X	X
Sollya heterophylla Lindley		-	-	-	-	-	-	X	-
ROSACEAE									
* Acaena agnipila Gand.		-	-	-	-	-	-	X	X
MIMOSACEAE									
Acacia alata R. Br. in W.T.Aiton	1	-	-	-	-	X	X	X	X
Acacia browniana H.L.Wendl.	7	X	X	X	X	X	X	-	-
Acacia divergens Benth.	8	X	X	X	X	X	X	-	-
Acacia extensa Lindley		-	-	-	-	X	X	X	X
Acacia myrtifolia (Smith) Willd.	4	X	X	-	X	-	-	X	X
Acacia pentadenia Lindley	66	-	-	X	X	-	-	-	-
Acacia pulchella R. Br. in W.T.Aiton	10	X	X	-	-	X	X	X	X
Acacia saligna (Labill.) H.L.Wendl.		-	-	-	-	X	X	X	X
Acacia urophylla Benth. ex Lindley	49	X	X	X	X	X	X	X	X
Paraserianthes lophantha (Willd.) I.Nielsen in I.Nielsen	3	X	X	X	X	-	-	-	-
PAPILIONACEAE									
Bossiaea laidlawiana Tovey & P.Morris	71	X	X	X	X	X	X	-	-
Bossiaea linophylla R. Br. in W.T.Aiton	9	X	-	-	-	X	X	X	X
Bossiaea ornata (Lindley) Benth.	2	X	X			X	X	X	X
Chorizema diversifolium DC.	19	-	-	-	-				
Chorizema ilicifolium Labill.	44	X	X	X	X	-	-	X	X
* Cytisus proliferus L.f.		-	-	-	-	-	-	-	X
Daviesia cordata Smith		-	-	-	-	X	X	X	X
Daviesia divaricata Benth. in Endl.		-	-	-	-	X	X	-	-
Daviesia horrida Preiss ex Meissner		-	-	-	-	X	X	-	-
Daviesia incrassata Smith		-	-	-	-	X	X	-	-
Daviesia preissii Meissner in Lehm.		-	-	-	-	X	X	-	-
Eutaxia obovata (Labill.) C.Gardner		-	-	-	-	-	-	-	-
Gompholobium amplexicaule Meissner in Lehm.		-	-	-	-	X	-	-	-
Gompholobium marginatum R. Br. in W.T.Aiton		-	-	-	-	-	X	-	-
Gompholobium ovatum Meissner in Lehm.		-	-	-	-	-	X	-	-
Gompholobium polymorphum R.Br. in W.T.Aiton		X	X	-	-	-	-	X	X
Hardenbergia comptoniana (Andrews) Benth. in Endl.	36	X	X	-	-	-	-	X	X
Hovea chorizemifolia (Sweet) DC.		X	-	-	-	X	X	-	-
Hovea elliptica (Smith) DC.	61	X	X	X	X	X	X	X	X
Hovea trisperma Benth. in Endl.		-	-	X	-	-	-	-	-
Kennedia carinata (Benth.) Domin		-	-	-	-	-	-	X	X
Kennedia coccinea Vent.	6	X	X	-	-	X	X	X	X
* Melilotus sp.	1	-	-	-	X	-	-	-	-
Mirbelia dilatata R. Br. in W.T.Aiton		-	-	X	X	-	-	-	-
Oxylobium lanceolatum (Vent.) Druce	9	X	X	X	X	X	X	-	-
Pultenaea reticulata (Smith) Benth.		-	-	-	-	X	X	-	-
Sphaerolobium medium R. Br. in W.T.Aiton	2	X	X	X	X	X	X	X	X
Sphaerolobium macranthum Meissner in Lehm.		X	-	-	-	X	X	-	-
GERANIACEAE									
* Geranium molle L.		-	-	-	-	-	-	X	X
Geranium sp.	3								
Pelargonium australe Willd.		-	X	-	-	-	-	X	X
Pelargonium rodneyanum Lindley		-	-	-	-	-	-	X	X
OXALIDACEAE									
Oxalis corniculata L.		-	-	-	-	-	-	X	X
LINACEAE									
Linum marginale Cunn. ex Planchon		-	-	-	-	X	X	X	X

PLANT FAMILY & SPECIES	REGENERATED AREAS								
	KARRI					JARRAH			
	203 RP	CR B	CR A	P B	P A	I9 B	I9 A	M2 B	M2 A
RUTACEAE									
Boronia crenulata Smith	0	-	-	-	-	X	X	-	-
Boronia denticulata Smith	0								
Boronia gracilipes F. Muell.	39	X	X	X	X	X	X	-	-
Boronia molloyae J.Drumm. in Hook.		-	-	X	X	-	-	-	-
Boronia spathulata Lindley	0	-	-	-	-	X	X	-	-
Chorilaena quercifolia Endl. in Endl.	96	X	X	X	X	-	-	-	-
Crowea angustifolia Smith in Rees	25	X	X	X	X	-	-	-	-
Eriostemon spicatus A.Rich.		-	-	-	-	X	X	-	-
Phebalium anceps DC.		X	X	-	-	-	-	-	-
TREMANDRACEAE									
Platytheca galioides Steetz in Lehm.		-	-	-	-	X	X	-	-
Tetratheca affinis Endl. in Endl.		-	-	-	-	X	X	-	X
Tetratheca setigera Endl. in Endl.		-	-	-	-	X	X	-	X
Tremandra diffusa R. Br. ex DC.	4	X	X	X	-	X	X	-	X
Tremandra stelligera R. Br. ex DC.	109	X	X	X	X	X	X	-	-
POLYGALACEAE									
Comesperma calymega Labill.		-	-	-	X	-	-	X	X
Comesperma confertum Labill.	4	X	X	X	X	X	X	X	X
Comesperma flavum DC.		-	-	-	-	X	X	-	-
Comesperma volubile Labill.		-	-	X	-	X	X	-	-
EUPHORBIACEAE									
Beyeria sp.	4	-	-	-	-	-	-	X	X
Phyllanthus calycinus Labill.		-	-	-	-	-	-	X	X
Poranthera huegelii Klotzsch in Lehm.		X	X	X	X	X	X	-	-
Poranthera microphylla Brongn.		-	-	-	-	-	-	-	X
Ricinocarpos sp.	9	-	-	-	-	X	X	-	-
STACKHOUSIACEAE									
Stackhousia huegelii Endl. in Endl.	0	X	X	-	-	X	X	X	X
Tripterococcus brunonis Endl. in Endl.		-	-	-	-	X	X	-	-
RHAMNACEAE									
Trymalium floribundum Steudel in Lehm.	140	X	X	X	X	X	X	X	X
MALVACEAE									
Sida hookeriana Miq. in Lehm.	0	-	-	-	-	-	-	-	X
STERCULIACEAE									
Lasiopetalum floribundum Benth.	80	X	X	X	X	-	-	-	-
Thomasia pauciflora Lindley	5	-	-	X	X	-	X	-	-
Thomasia quercifolia (Andrews) Gay	49	X	X	X	X	-	X	-	-
Thomasia triloba Turcz.		-	-	X	X	-	-	-	-
DILLENIACEAE									
Hibbertia amplexicaulis Steudel in Lehm.	25	X	X	X	X	X	X	X	X
Hibbertia aurea Steudel in Lehm.		-	-	-	-	X	-	-	-
Hibbertia commutata Steudel in Lehm.	11	-	-	-	-	X	X	-	X
Hibbertia cuneiformis (Labill.) Smith in Rees	81	X	X	X	X	-	-	-	-
Hibbertia cunninghamii W.T.Aiton ex Hook.	2	-	-	-	-	X	X	-	-
Hibbertia furfuracea (R. Br. ex DC.) Benth.	9	-	-	-	-	-	-	-	-
Hibbertia glaberrima F. Muell.		-	-	-	-	-	-	X	X
Hibbertia grossulariifolia (Salisb.) Salisb.	3								
Hibbertia inconspicua Ostenf.		-	-	-	-	X	X	X	X
Hibbertia perfoliata Endl. in Endl.		X	X	X	X	-	-	-	-
Hibbertia serrata Hotchk.	27	X	X	-	-	-	-	-	-
Hibbertia silvestris Diels. in Diels. & E.Pritzel		-	-	-	-	X	-	-	-
VIOLACEAE									
Hybanthus calycinus (DC. ex Ging.) F.Muell.		X	X	X	X	-	-	-	-
Hybanthus debilissimus F. Muell.	9	-	-	-	-	X	X	-	-
Hybanthus floribundus (Lindley) F. Muell.		-	-	-	-	X	X	-	-

PLANT FAMILY & SPECIES	REGENERATED AREAS								
	KARRI					JARRAH			
	203	CR		P		19		M2	
	RP	B	A	B	A	B	A	B	A
THYMELAEACEAE									
Pimelea angustifolia R. Br.		-	-	-	-	-	-	X	X
Pimelea clavata Labill.	64	X	X	-	-	-	-	-	-
Pimelea rosea R. Br.		-	-	-	-	X	X	X	X
Pimelea spectabilis Lindley	6	-	-	X	X	X	X	-	-
Pimelea sylvestris R. Br.		-	-	-	-	-	X	-	-
MYRTACEAE									
Agonis flexuosa (Sprengel) Schauer in Lehm.	15	X	X	-	-	X	X	X	X
Agonis juniperina Schauer in Lehm.	0	X	-	X	X	-	-	-	-
Agonis linearifolia (DC.) Schauer in Lehm.		X	X	X	X	X	X	-	-
Agonis parviceps Schauer in Lehm.	3	X	X	X	X	X	X		X
Astartea fascicularis (Labill.) DC.		-	-	-	-	-	X	X	-
Beaufortia decussata R. Br. in W.T.Aiton		-	-	-	-	X	X	-	-
Eucalyptus calophylla Lindley	60								
Eucalyptus diversicolor F. Muell.	201								
Eucalyptus guilfoylei Maiden	10								
Eucalyptus jacksonii Maiden	2								
Eucalyptus marginata Donn ex Smith	10								
Eucalytpus megacarpa F. Muell.	1								
Eucalyptus patens Benth.	6								
Hypocalymma cordifolium (Lehm.) Schauer in Lehm.	2	-	-	X	-	-	-	-	-
Hypocalymma robustum Endl. in Endl.		-	-	-	-	X	X	-	-
Kunzea recurva Schauer in Lehm.		-	-	-	-	-	X	-	-
Melaleuca huegelii Endl. in Endl.		-	-	-	-	X	X	-	-
Melaleuca incana R. Br.		-	-	-	-	-	-	X	X
Melaleuca polygaloides Schauer in Lehm.		-	-	X	X	-	-	-	-
Melaleuca thymoides Labill.		-	-	-	-	X	X	-	-
Pericalymma ellipticum (Endl.) Schauer in Lehm.		-	-	-	-	-	X	-	-
HALORAGACEAE									
Gonocarpus benthamii Orch.	4	X	X	X	X	X	X	X	X
Gonocarpus diffusus (Diels) Orch.		-	X	-	-	-	-	-	-
APIACEAE									
Daucus glochidiatus (Labill.) Fischer	1	-	X	-	X	-	-	-	X
Hydrocotyle plebeja A.Rich		-	X	-	X	-	-	-	-
Pentapeltis silvatica (Diels) Domin		-	-	-	-	-	X	-	-
Platysace compressa (Labill.) Norman	1	-	-	-	X	-	X	-	-
Platysace tenuissima (Benth.) Norman	3	-	-	-	-	X	X	-	-
Trachymene pilosa Smith in Rees		-	-	-	X	-	-	-	-
Trachymene sp.		X	-	X	-	-	-	-	-
Xanthosia atkinsoniana F. Muell.		-	-	-	-	-	-	-	X
Xanthosia candida (Benth.) Steudel	2	X	X	-	X	X	X	X	X
Xanthosia huegelii (Benth.) Steudel	2	X	X	-	-	-	X	-	X
EPACRIDACEAE									
Astroloma pallidum R. Br.		-	-	-	-	X	X	-	-
Leucopogon australis R. Br.	3	-	-	-	-	X	X	X	X
Leucopogon capitellatus DC.	16	X	X	X	X	X	X	X	X
Leucopogon obovatus (Labill.) R. Br.		-	-	-	-	-	-	X	X
Leucopogon propinquus R. Br.	37	X	X	X	-	X	X	X	X
Leucopogon verticillatus R. Br.	73	X	X	X	X	X	X	X	X
PRIMULACEAE									
Anagallis arvensis L.		-	-	-	-	-	-	X	X
LOGANIACEAE									
Logania serpyllifolia R. Br.	9	X	X	X	X	X	X	X	X
Logania vaginalis (Labill.) F. Muell.	32	X	X	-	-	X	X	-	-
Mitrasacme paradoxa R. Br.		X	X	X	X	-	-	-	-

PLANT FAMILY & SPECIES	REGENERATED AREAS								
	KARRI						JARRAH		
	203 RP	CR B	CR A	P B	P A	19 B	19 A	M2 B	M2 A
GENTIANACEAE									
* Centaurium spicatum (L.) Fritsch ex Janchen		X	X	X	X	-	-	X	X
MENYANTHACEAE									
Villarsia parnassifolia (Labill.) R. Br.	0	-	-	-	-	-	X	-	-
Villarsia sp.	1								
CONVOLULACEAE									
Dichondra repens Forster & G.Forster	1	-	-	-	-	-	-	-	-
LAMIACEAE									
Hemigenia incana (Lindley) Benth.		-	-	X	-	-	-	-	-
Hemigenia saligna Diels in Diels & E.Pritzel		-	-	-	-	X	X	-	-
SOLANACEAE									
* Solanum nigrum L.		-	X	-	-	-	-	-	-
SCROPHULARIACEAE									
Gratiola peruviana L.		-	-	-	X	-	-	-	-
* Parentucellia viscosa (L.) Caruel in Parl.		-	X	-	X	-	-	-	-
Veronica plebeia R. Br.	4	-	-	-	-	-	-	-	X
OROBANCHACEAE									
* Orobanche minor Smith		-	-	-	-	-	-	X	X
LENTIBULARIACEAE									
Utricularia sp.	3	-	-	-	-	-	-	-	-
PLANTAGINACEAE									
* Plantago lanceolata L.		X	-	-	-	-	-	-	-
MYOPORACEAE									
Myoporum oppositifolium R. Br.	3								
RUBIACEAE									
Opercularia hispidula Endl. in Endl.	87	X	X	X	X	X	X	X	X
Opercularia volubilis R. Br. ex Benth.	31	-	-	-	-	-	-	-	-
LOBELIACEAE									
Isotoma hypocrateriformis (R. Br.) Druce		-	-	-	-	X	X	X	X
Lobelia alata Labill.		-	X	-	X	X	X	X	X
Lobelia rhombifolia Vriese in Lehm.		-	X	X	X	X	X	X	X
Lobelia tenuior R. Br.		-	-	-	-	-	-	-	X
GOODENIACEAE									
Dampiera cuneata R. Br.		-	-	-	-	-	-	-	X
Dampiera hederacea R. Br.	14	X	X	X	X	X	X	-	-
Dampiera linearis R. Br.	1	-	-	-	-	X	X	-	-
Dampiera trigona Vriese in Lehm.		-	-	-	-	X	-	-	-
Lechenaultia biloba Lindley		-	-	-	-	X	X	-	-
Lechenaultia floribunda Benth. in Endl.		-	-	-	-	-	X	-	-
Scaevola microphylla Benth.	30	-	X	X	X	-	-	-	-
Scaevola striata R. Br.		-	X	-	-	X	X	-	-
Velleia trinervis Labill.		-	-	-	-	X	X	X	X
Velleia foliosa (Benth.) Krause in Engl.		-	-	-	X	-	-	-	-
Velleia macrophylla (Lindley) Benth.	2	X	-	X	X	X	X	X	X
STYLIDIACEAE									
Levenhookia pusilla R. Br.	2	X	-	X	X	X	X	X	X
Stylidium adnatum R. Br.	35	-	-	-	-	-	X	-	X
Stylidium amoenum R. Br.	0	X	X	X	X	-	-	X	X
Stylidium calcaratum R. Br.		-	-	-	-	X	X	X	X
Stylidium corymbosum R. Br.		-	-	-	-	X	X	-	-
Stylidium falcatum R. Br.		-	-	-	X	-	-	-	-
Stylidium fasciculatum R. Br.		-	-	-	X	-	-	-	X
Stylidium junceum R. Br.		X	X	X	X	-	-	-	-
Stylidium pritzelianum Mildbr. in Engl.	1	-	-	-	-	-	-	-	-
Stylidium rhynchocarpum Sonder in Lehm.	8	X	X	X	X	X	X	-	-
Stylidium schoenoides DC.		-	-	-	-	X	X	-	-
Stylidium spathulatum R. Br.		-	-	-	-	-	-	-	X

PLANT FAMILY & SPECIES	REGENERATED AREAS								
	KARRI						JARRAH		
	203 RP	CR B	CR A	P B	P A	19 B	19 A	M2 B	M2 A
ASTERACEAE									
Actinobole condensatum A. Grav.		-	-	-	-	-	-	-	X
* Arctotheca calendula (L.) Levyns		-	X	-	-	-	-	-	X
Asteridea pulverulenta (Lindl.) Druce.		-	-	-	-	-	-	-	X
Brachycome iberidifolia Benth. in Endl.		-	-	-	-	X	X	X	X
* Carduus pycnocephalus L.		-	X	-	-	-	-	-	X
* Cirsium vulgare (Savi.) Ten.		-	-	-	-	-	-	X	X
Craspedia pleiocephala F. Muell.		-	-	-	-	-	X	X	X
Helichrysum bracteatum (Vent.) Andrews		-	-	-	-	-	-	-	X
Helichrysum ramosum DC.	9	-	X	-	-	-	-	X	X
Helipterum cotula (Benth.) DC.		-	-	-	-	-	-	X	X
* Hypochoeris glabra L.		X	X	X	-	X	X	X	X
Ixiolaena viscosa Benth. in Endl.		-	X	-	-	-	-	-	-
Lagenifera huegelii Benth. in Endl.		X	X	-	-	X	X	-	X
Olearia axillaris (DC.) F. Muell. ex Benth.		-	-	-	-	-	X	-	-
Olearia pimeleoides (DC.) Benth.	1	X	X	-	-	X	X	-	-
Olearia sp.		X	-	-	-	-	-	-	-
Pseudognaphalium luteo-album (L.) Hilliard & B.L.Burtt		-	X	-	X	X	X	X	X
Senecio lautus G.Forster ex Willd.		-	-	-	-	X	X	-	-
Senecio quadridentatus Labill.		-	X	-	-	-	-	-	-
Senecio ramosissimus DC.	4	X	X	-	-	-	-	-	X
* Sonchus asper Hill		-	X	-	-	-	-	-	-
Waitzia citrina (Benth.) Steetz in Lehm.		-	-	-	-	X	X	-	X

Appendix I

APPENDIX I

CALM CORRESPONDENCE

DEPARTMENT OF CONSERVATION AND LAND MANAGEMENT

HEAD OFFICE
HACKETT DRIVE CRAWLEY
WESTERN AUSTRALIA
Phone (09) 386 8811
Telex AA 94585
Facsimile (09) 386 1578

STATE OPERATIONS HEADQUARTERS
50 HAYMAN ROAD COMO
WESTERN AUSTRALIA
Phone (09) 367 0333
Telex AA 94616
Facsimile (09) 367 0466

Please address all correspondence to Executive Director, P.O. Box 104, COMO W.A. 6152

Your Ref:
Our Ref:
Enquiries:
Phone:

Mr Douglas Martin
Project Manager
Dames and Moore
26 Lyall Street
SOUTH PERTH WA 6151

Dear Mr Martin

RE: **WACAP LICENCE RENEWAL ERMP**

In response to your letter of 26 February, the following would apply in the absence of a chipwood industry to utilise residue from sawlogging operations.

I would attempt to meet the sawlog yield strategy as detailed in the Regional Plans and Timber Strategy paper to protect the timber industry and its associated community benefits.

Notwithstanding this I would not willingly allow a silvicultural system to be employed which degrades the productivity of the stand by not providing for full regeneration of cut over areas. This then means mixed species stands would have to be treated to remove cull trees. The cost for this would be quite high and based on current operations I would need to seek an additional $750 000 from Government to fund it.

In view of the revenue loss from chipwood royalty of approximately $5.75 million and the current economic climate, the chances of such funds becoming available are remote.

Under the circumstances my preferred line of action would be to reduce sawmilling level, particularly in the Karri, to a level at which full regeneration treatment could be funded.

It is not possible to put a precise figure on this but it could be substantial.

Yours sincerely

Syd Shea
EXECUTIVE DIRECTOR

5 March 1987

Appendix J

APPENDIX J

PROVISIONS OF THE FOREST PRODUCE (CHIPWOOD) LICENCE NO. 1588

SCHEDULE

WESTERN AUSTRALIA

FORESTS ACT, 1918

WOOD CHIPS AGREEMENT ACT, 1969

FOREST PRODUCE (CHIPWOOD) LICENSE

LICENSE No. ....

THIS IS TO CERTIFY THAT pursuant to the provisions of an Agreement made the day of 1969 BETWEEN the State of Western Australia of the first part W.A. CHIP & PULP CO. PTY. LTD. whose registered office is situated at 49 Charles Street, Perth in the said State (in the Agreement and hereinafter called "the Company" which term shall include the successors and permitted assigns of the Company) of the second part and BUNNING TIMBER HOLDINGS LTD. whose registered office is situated at 49-61 Charles Street, Perth, aforesaid (in the Agreement called "the Guarantor") of the third part (which Agreement was ratified by the Wood Chips Agreement Act, 1969) the Company is hereby licensed for a period commencing on the day of 19 and expiring fifteen (15) years after the date of the first export of wood chips under or for the purposes of the said Agreement to fell cut and remove each year during the currency hereof a quantity of MARRI KARRI JARRAH or other species of timber not suitable for saw-milling or other special purposes as defined by the Conservator of Forests (hereinafter called "the Conservator") measured in the round sufficient to produce five hundred thousand (500,000) tons green weight of chips per annum on and from the area delineated on the plan in the Schedule hereto for the purposes but upon and subject to the terms covenants and conditions set out in the said Agreement and to the provisions of the Forests Act, 1918 and the regulations thereunder in force for the time being (as modified by the said Agreement).

This license is granted subject to the following special conditions:—

1. The Company shall and will use the area bona fide exclusively for the purposes of the said Agreement.

2. Subject to the payment of the royalty hereby reserved and the observance and performance by the Company of the terms covenants and conditions contained in the said Agreement and the conditions herein contained, this license shall continue in force for the period stated unless suspended or forfeited and cancelled in the meantime for breach of the conditions herein.

3. The Company shall pay to the Conservator or officer authorised by him a royalty of one dollar and seventy-seven cents ($1.77) for each and every one hundred (100) cubic feet of log timber measured in the round obtained under this license.

Such royalty shall be payable forthwith as accounts are rendered from time to time by or on behalf of the Conservator to the Company; PROVIDED THAT if payment be made within the calendar month following the month during which the timber was obtained a discount will be allowed thereby reducing the royalty payable hereunder to one dollar and fifty cents ($1.50) per hundred (100) cubic feet. In lieu of volume measurement a conversion factor to weight may be used to simplify and reduce cost of measurement.

4. The royalty payable under this license will apply for the first five (5) years from the commencement of production of chips. Thereafter it may be reviewed and adjusted every five (5) years in the light of royalty payable generally on hardwoods cut for other purposes and having regard to the F.O.B. price of wood chips at the time of review compared with the F.O.B. price of wood chips at the commencement of exports. For the purposes of this condition "F.O.B. price" shall have the same meaning as in Clause 22 of the said Agreement.

5. The Company shall at the end of each calendar month complete returns showing all timber obtained under this license and such other information as may be required by regulations, and such returns, verified by statutory declaration, shall be forwarded to the Forest Officer in Charge within three (3) days of the close of each month.

6. After commencement, operations shall be carried on continuously unless exempted by the Conservator.

7. All log timber obtained under this license shall be chipped at a plant approved by the Conservator to be erected on the chipping mill site referred to in Clause 1 of the said Agreement. No alterations which may affect the capacity or efficiency of the plant as approved shall be made without the prior approval of the Conservator.

8. The Company shall submit to the Conservator annually plans showing approximately the area over which it is desired to conduct felling operations during the following twelve (12) months, and the main haulage routes proposed to be used from such areas to the mill. The cutting section and haulage routes shall be subject to the approval of the Conservator, and when approved, all logging operations shall conform with such approval.

9. The Company shall from time to time, as required by the Conservator, confine its operations to certain defined coupes within the said area. Such defined coupes shall be cut out to the satisfaction of the Forest Officer in Charge before a further coupe is made available for cutting.

When logging operations have been completed on any coupe to the satisfaction of the Forest Officer in Charge, such coupe shall thereupon be closed to further cutting by the Company.

The right is reserved to the Conservator to excise from the license area at any time without compensation to the Company in respect thereof any area that has been cut over by the Company for chipwood timber and any area which may be required for roads, railways, or any other works of public utility or convenience.

10. The Company shall exercise strict supervision and control over the operations of all timber workers and other persons employed under the terms of this license with a view to preventing any breach of the Forests Act or Regulations and avoiding damage to regrowth and other standing timber during felling and hauling operations.

11. All trees on the area suitable for chipwood with the exception of those marked or otherwise indicated by a Forest Officer for retention shall be felled, cut and utilised.

12. All trees cut into or felled or otherwise available under this license shall be utilised with the minimum of waste, down to minimum length of seven (7) feet and minimum diameter of nine (9) inches, to the satisfaction in all respects of the Forest Officer in Charge.

13. The tops of any felled trees which fall close to other potentially useful trees reserved for cutting shall be snigged back therefrom by the Company into open places to the satisfaction of the Forest Officer in Charge. Avoidable or unreasonable damage to growing trees from felling, snigging, loading and hauling operations shall be paid for by the Company at rates as assessed by the Conservator, not exceeding the rate currently applying for that type of forest produce.

14. The Forest Officer in Charge may prohibit the use of any roads or tracks for log hauling or may give directions from time to time regarding the roads or tracks on or by which the timber cut under this license may be removed or taken through any part of State Forest and such directions shall be observed by the Company. Any damage to existing roads or tracks resulting from the felling or removal of timber by the Company shall be repaired by the Company at its own expense to the satisfaction of the Forest Officer in Charge.

Where dispute arises with shared use of roads under the control of the Conservator, the Conservator shall be the sole arbiter and his decision shall be final.

15. The Company is hereby authorised to fell, cut and remove such forest produce as herein provided on pastoral or other leases or holdings within the said license area which do not confer on the lessees or holders the right to forest produce, with full and free liberty to the Company, its servants, workmen and agents, with or without conveyances, at all reasonable times to enter upon, depart from and pass over such pastoral or other leases for such purpose; provided always that the authority hereby given shall not relieve or be deemed to relieve the Company from liability to lessees or holders in respect of any actionable damage caused by the Company, its servants, workmen or agents upon such pastoral or other leases or holdings aforesaid.

16. This license shall not be construed as authorising the Company to cut through, break down or otherwise interfere with any fencing or other improvements erected upon or adjacent to the license area.

17. The Company shall at its own expense and without delay—

(a) remove from all roads and tracks through or adjacent to the license area or from any land the property of an adjoining owner, all logs or other debris of any description; and

(b) make good any damage to fences, telephone lines or other improvements,

resulting directly or indirectly from its operations.

18. The Company shall keep closed all gates used by it, and shall take all necessary action to prevent the ingress or egress of stock into or from any area within the license area enclosed by fences which may have been damaged as a result of its operations.

19. The Company shall not fell any trees on areas under cultivation or established pasture within the license area except with the written concurrence of the owner or occupier of any such areas.

20. The right is reserved to the Conservator to direct the disposal of logs suitable for sawmilling or other special purposes in such quantities and under such conditions as he may from time to time determine.

21. The Company when working on any catchment area shall observe and comply with the by-laws of the Department of Water Supply Sewerage and Drainage and take all action necessary in order to prevent the pollution of the catchment area and shall observe such requirements as may be prescribed from time to time by the Department of Water Supply Sewerage and Drainage or any authorised officer of that Department.

22. This license shall not be transferred without the consent in writing of the Conservator.

23. The Company shall observe and comply with the provisions of the Bush Fires Act, 1954, and the amendments thereof and the regulations thereunder and in force for the time being. Any breach of the said Act and/or regulations shall be a breach of the conditions of this license.

24. The Company shall take all such necessary precautions as may be indicated by a Forest Officer to prevent the occurrence or spread of fires within the license area and shall be liable to the Conservator for damage caused within the said area or on any State Forest, Timber Reserve or Crown land by any fire on or extending from the said area during the currency of this license unless the Company can prove to the satisfaction of the Conservator that such fire or fires, without any act or omission on the part of the Company, originated outside the license area and/or arose through some cause beyond its control.

25. The Company and all persons employed by it on the license area shall at all times during the term of this license co-operate with officers of the Forests Department in preventing and suppressing bush fires and shall, when called upon by any such officer, act under his instructions in fire fighting or preventing outbreaks of fire. All persons who in response to such demand shall render the assistance required, shall be remunerated by the Conservator at the prescribed rates.

26. As security for the observance and performance of its obligations under this license, the Company has deposited at the office of the Forests Department, Perth, the sum of One thousand dollars ($1,000) and a Bond with approved surety for the payment of Twenty thousand dollars ($20,000).

27. In default of payment by the Company of the royalty hereby reserved or of the due observance and performance by the Company of the terms covenants and conditions contained in the said Agreement or the conditions of this license or the observance by the Company of the provisions of the said Acts and regulations or any of them to which

this license is subject, the Conservator may suspend this license for such time as he may think fit, or by notice in writing to the Company, cancel and determine this license, and thereupon the deposit may be forfeited, together with all timber felled or sawn on the said area, and may seize all machinery or other plant the property of the Company, but without prejudice to the rights of the Conservator to recover royalty in arrear, and in respect of any other claims against the Company.

28. If any question shall arise as to the observance and performance by the Company of the conditions of this license, or in case of any dispute in relation to the felling, sawing or removal of timber, or as to the quantity of timber felled or sawn, the same shall be decided by the Conservator, whose decision shall be final.

29. Any notice in writing to the Company may be given to or served on the Company by forwarding the same by prepaid registered post to the Company at its registered office for the time being in the said State AND any such notice shall be deemed to have been duly given or served on the day on which it would be delivered in the ordinary course of post.

30. The Company accepts this license and agrees with the Conservator to observe and perform the conditions and obligations of this license and to pay the royalty hereby reserved.

THE SCHEDULE ABOVE REFERRED TO:

DATED at this day of 19

SIGNED by the Conservator of Forests in the presence of: } Conservator of Forests

The Common Seal of W.A. CHIP & PULP CO. PTY. LTD. was hereunto affixed by the Authority of the Directors in the presence of: }

IN WITNESS whereof this Agreement has been executed by or on behalf of the parties hereto the day and year first hereinbefore mentioned.

SIGNED SEALED AND DELIVERED by THE HONOURABLE CRAWFORD DAVID NALDER, M.L.A. in the presence of—	C. D. NALDER [L.S.]

C. W. COURT,
Minister for Industrial Development.

A. C. HARRIS,
Conservator of Forests.

The Common Seal of W.A. CHIP & PULP CO. PTY. LTD. was hereunto affixed by the Authority of the Directors in the presence of—	C. R. BUNNING G. M. BUNNING [C.S.]
The Common Seal of BUNNING TIMBER HOLDINGS LTD. was hereunto affixed by the Authority of the Directors in the presence of—	C. R. BUNNING G. M. BUNNING [C.S.]

By Authority: ALEX. B. DAVIES, Government Printer

1 year old treefarm near Manjimup

12 year old treefarm near Nannup

WACAP TOWARDS 2005