A PERSPECTIVE

FOR

MULTIPLE USE PLANNING

IN THE

NORTHERN JARRAH FOREST

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FOREWORD

Public demand for forest benefits has now reached a stage where scarcity imparts special values on each requirement, because of limited resources.

A policy of multiple-use management has therefore been adopted in order to realise the fullest degree of public satisfaction from the available forest resources. Within the framework of this policy, the objective of the planning perspective is to translate past experience and the salient results from the recently-expanded governmental and co-operative research effort into a practical basis for future multiple-use management of the northern jarrah forests. These increased research outputs have substantially improved the scientific foundation for land management in the region and have facilitated the definition of management parameters according to the particular attributes of each basic land management category.

Existing economic and legal constraints as well as current management and resource use have also been taken into account.

The objective has been to accommodate as many compatible uses as possible within each land management category subject to the requirement of catchment protection which has special significance in the Region.

Conservation of Flora and Fauna also needs special attention. This has been dealt with in a detailed submission to the Conservation through Reserves Committee under which a number of carefully selected areas are to be managed primarily for this purpose.

The perspective is drawn primarily from the viewpoint of multiple use management in the northern jarrah region. Nonetheless, it establishes principles that can be applied to State Forests as a whole. It also establishes a framework for more broadly based regional land use plans.

Management of the forest resource is a major factor in the region, and because of mutual interactions cannot be divorced from other forms of land management in adjacent areas. This is especially true in the case of saline waters entering the forest from agricultural areas to the east.

Obviously, the Forests Department is not fully competent to deal in detail with all other land uses involved, and additional inputs covering such topics as the significance of agriculture, future urban developments, water storage management etc. would be required.

The planning perspective has been circulated to various authorities which have a direct involvement in the use of the forest.

Comment will also be sought from other responsible bodies and industries using the forest. This latter group has offered active co-operation in the implementation of these management proposals.

As time progresses, any new inputs will be incorporated and the study will also be amended in the light of new research data becoming available, thus continuously maintaining the relevance of the perspective. This is necessary as multiple use management is a constantly evolving dynamic process, the objectives of which require modification in the light of changes in public demand as well as changes in the resource base.

In the meantime, the Forests Department is proceeding to apply these principles to prepare a detailed operational management plan for the Dwellingup Division, where a wealth

of additional background data is already available. Similar plans will then be prepared and adopted as the basis for operational management of forest land throughout the northern jarrah region.

B. J Beggs.

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Conservator of Forests

A PERSPECTIVE FOR MULTIPLE USE PLANNING IN THE NORTHERN JARRAH FOREST

INTRODUCTION

The Forests Department is required to provide a multiplicity of benefits from the northern jarrah forest according to the inherent capabilities of the environment, the existing statutory constraints and the recognised public demand. This objective is attainable because sufficient data are now available for a comprehensive and environmentally responsible regional plan.

Data have resulted from management experience and research into dieback disease, hydrology, ecology, recreation and land use. These have highlighted environmental gradients across the forest and shown that the effects of various management practices on these can be broadly predicted.

At the same time the Forests Department has recognised changing social attitudes and has been developing policies which take account of intangible benefits in addition to the traditional objectives of timber production and catchment protection.

This document sets the overall perspective for the development and subsequent implementation of detailed proposals. In doing this the region has been divided into six management zones based on geomorphology and climate. However, for detailed local planning it is envisaged that site vegetation zoning will be more appropriate and precise.

The management strategies proposed supplement the Forests Department policy on multiple land use.

1. ENVIRONMENTAL FEATURES

The region referred to as the northern jarrah forest has an area of 784 000 hectares. It is flanked by the Helena catchment in the north, the Collie catchment in the south, the Darling Scarp on the west and the agricultural belt on the east. In addition, it includes outlying timber reserves within the eastern agricultural belt, such as Boyagarring, Wandering, Marradong, Saddleback and Quindanning Blocks but excludes Dryandra. Pronounced environmental gradients occur.

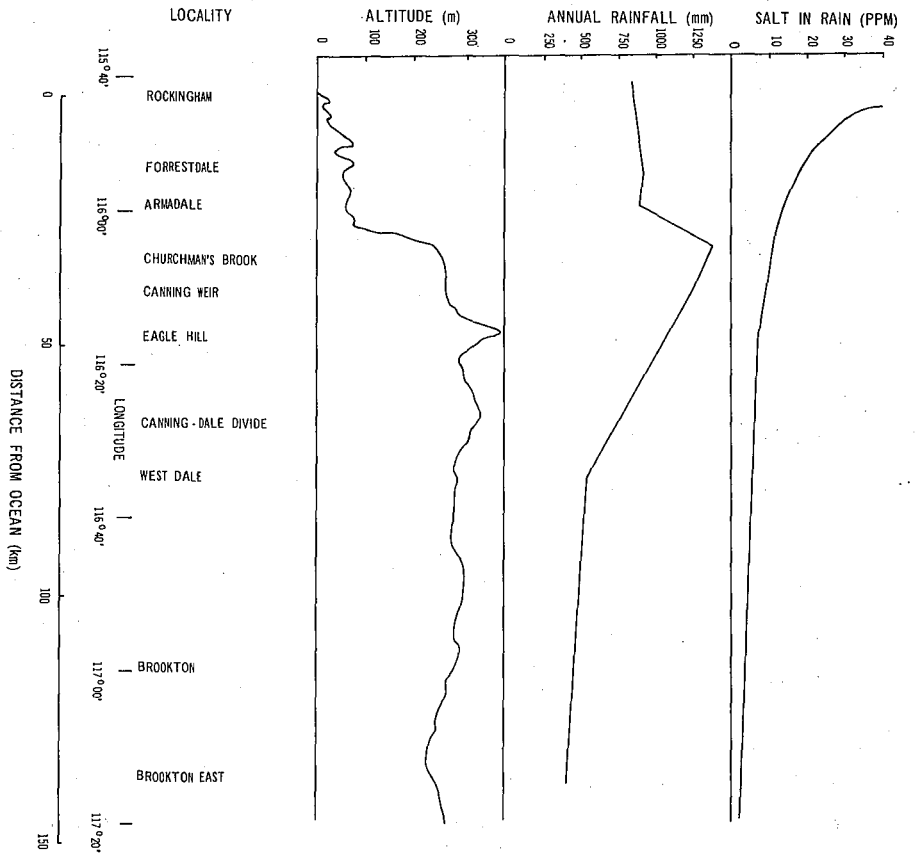
1.1 Climate and Hydrology

The region is characterised by a Mediterranean climate with a pronounced winter rainfall and hot dry summers. There is a marked excess of rainfall over evaporation in winter, and a large deficit in summer.

A number of gradients affecting water quantity and quality can be recognised across the forest belt.

a) Rainfall varies from about 1 300 mm/annum in the west to about 600 mm/annum in the east (Figure 1).

FIG. 1. TYPICAL RAINFALL & TOPOGRAPHIC CROSS SECTION OF THE REGION



b) As annual rainfall decreases less salt is flushed from the soil and a greater quantity of salt accumulates in the profile.

c) In the east, deeply weathered soils and a gently undulating landscape result in lower runoff and sluggish drainage.

d) Forest vigour and density also influence water yield. This is lowest in dense regrowth stands, and highest on cleared land and forest destroyed by dieback. A higher yield is accompanied by increased flushing of salts from the soil, and water quality may deteriorate.

Hydrological data are not well documented for the northern jarrah forest as a whole. One of the better known areas is within the Dwellingup Forests Division where the Forest Department, Public Works Department, C.S.I.R.O. and the Hunt Interdepartmental Committee have been carrying out hydrological research programmes.

Here the following gradients can be recognised:

a) Yield varies from about 2 000 m^3/ha/annum (20-25% of incoming rainfall) near the western escarpment, to 1 000 m^3/ha/annum at the 1 150 mm isohyet (about 11% of the incoming rainfall), to about 250 m^3/ha/annum at the eastern extremities of the forest belt. (Figure 2 at back of report).

b) Salinity increases to the east. The highest yielding streams close to the escarpment have a weighted average salinity of 150 ppm or less, ranging up to 250 ppm about the 1 150 mm isohyet, to greater than 550 ppm along the eastern boundary. (Figure 3, at back of report).

c) Paradoxically salt yield is greatest in the west where quantities in excess of 150 kg /ha/annum have been recorded compared to less than 100 kg /ha/annum further east.

Salinity is not yet a problem in the forested parts of these catchments. However, salt storage and baseflow salinity measurements suggest that extreme care must be taken in management practices in the eastern portion of this region. For this reason, management strategies must differ between east and west. A central transitional zone has also been selected for conservative management until adequate data dispel doubts on how the proposed management practices will affect water quality.

The salinity of rivers whose headwaters rise in the eastern agricultural belt is already high. For example, the main tributaries of the Murray River have weighted average salinities in excess of 2 200 ppm (t.d.s.) east of the forest belt although this is reduced to 1 000 ppm after its passage through State Forest.

Turbidity of most streams is relatively low and to date no major cases of biological pollution have been recorded.

1.2 Geomorphology and Soils

The main forest block consists of a plateau between 250 and 360 metres high (Figure 1) penetrated by several steep flanked monadnocks and isolated hills. The highest of these is Mt. Cooke (582 metres). Most of the streams originate in broad open valleys in the eastern forests and drain westwards, their valleys becoming more incised. However, the Murray, Helena, Dale and Collie Rivers have deeply dissected valleys in the eastern as well as the western zone.

The plateau is chiefly underlain by granite and gneiss penetrated by quartz diorite dykes. These rocks crop out in the dissected valleys, the slopes and summits of the monadnocks, hills and the escarpment, giving rise to fertile, but shallow, red earths.

On the remainder of the plateau these parent materials are overlaid by products of deep weathering in the form of laterites on the ridges and sands in the broad valleys. The dominant soil type on the ridges is ironstone gravel with a

sandy matrix. The main feature of these soils is their marked phosphate-fixing capacity and hence their low fertility.

The broad valleys are found mostly in the eastern part of the forest belt. The soils consist of grey and yellow sands, in a landscape characterised by swampy drainage lines, seasonally waterlogged valley floors, and gently undulating slopes. These features are strongly developed in the Collie Coal Basin.

The northern jarrah forest is a large and heterogenous area. Since both climate and geomorphology show a marked east-west gradient, and also form an appropriate mapping unit for regional planning, the area has been divided into six basic management categories, namely:

a) Dissected River Valleys and Scarp in the High Rainfall Zone - (more than 1 150 mm/annum) -

This unit includes the Helena and Darkin surfaces (Mulcahy et al., 1972).

b) Lateritic Uplands in the High Rainfall Zone (more than 1 150 mm/annum) -

This unit includes the laterite-mantled uplands (Mulcahy) and several minor occurrences of other surfaces.

c) Dissected River Valleys in the Low Rainfall Zone (less then 1 025 mm/annum) -

This unit includes the Darkin surface (Mulcahy) and refers to the valleys of the Murray, Dale, Collie and Helena Rivers.

d) Broad Valleys and Depressions in the Low Rainfall Zone (less than 1 025 mm/annum) -

Includes the Beraking and Goonaping surfaces (Mulcahy) and the Randall surface (Havel, 1975),

and is strongly developed in the Collie Coal Basin. Locally it is desirable to separate Mulcahy's Beraking surface, with sands over dense mottled clays on the valley floors, from the Goonaping surface, with grey and yellow sands on low divides and heads of gullies. In terms of salinity, the former generally has salt and saline groundwater close to the surface, whereas the latter is predominantly salt free. The yield of water from this unit tends to be low, due to a combination of mild slopes, deep porous soils (Goonaping only) and low rainfall.

e) Lateritic Uplands in the Low Rainfall Zone (less than 1 025 mm/annum) -

Includes the gently undulating laterite mantled uplands, the steeper Nockine surface and the dissected lateritic slopes (Mulcahy).

f) Monadnocks (found mainly in the intermediate and low rainfall zones; less than 1 150 mm/annum) -

Comprises the high granite residuals (Mulcahy) and the Cooke surface (Havel, 1975), but also includes some of the more prominent isolated hills (e.g. Mt. Saddleback, Mt. Ross).

The central transitional zone (1 025 - 1 150 mm/annum) where the effects of management practices on hydrology are currently in doubt, will, for the time being, be managed conservatively together with the lower rainfall zone.

1.3 Vegetation

The vegetation also reflects the joint influence of climate and geomorphology, and hence of topography and soils. A number of broad vegetation zones based on the components of the middle and upper canopy levels can be recognised:

a) Dissected River Valleys and Scarp in High Rainfall Zone

On the scarp and adjacent dissected valleys, jarrah (Eucalyptus marginata), is confined to the deeper soils. The tree species which characterise this landform are wandoo (E. wandoo), E. laeliae, E. haematoxylon, E. lane-poolei and Casuarina huegeliana.

In the valleys of major rivers blackbutt (E. patens) and marri often become dominant over jarrah. E. rudis and Banksia littoralis var. seminuda are more prominent in these areas. Understorey species are characterised by tall Bossias and Acacias. Dieback incidence is low on these better drained and fertile soils.

b) Lateritic Uplands in the High Rainfall Zone

This belt formerly carried tall jarrah forest mixed with marri (E. calophylla), with an understorey of Banksia grandis, Casuarina fraseriana and Persoonia longifolia. This type is heavily infected by dieback, however cells of dieback-resistant types characterised by blackbutt and bullich (E. megacarpa) are developed in minor upland valleys. Occasionally, heavily dieback-infected, stunted jarrah with Xylomelum occidentale and Nuytsia floribunda occurs on sandy upland valleys within this zone.

c) Dissected River Valleys in Low Rainfall Zone

As rainfall decreases jarrah is gradually replaced by wandoo and the understorey of tall Bossias and Acacias in the west is displaced by shorter Acacias and Gastrolobiums.

d) Lateritic Uplands in Low Rainfall Zone

This zone is dominated by jarrah, mixed with wandoo on the more dissected lateritic slopes and Nockine surfaces. Eastwards the height and density of the forest decreases and there is a gradual disappearance of Banksias, Persoonias and Casuarinas. E. drummondii forms a low open woodland where the lateritic profile has been truncated down to kaolinitic clay. The outliers of State Forest have strong development of powderbark wandoo (E. accedens) on uplands and Casuarina huegeliana on stony slopes.

e) Broad Valleys and Depressions in Low Rainfall Zone

The seasonally waterlogged valley floors carry thickets of Melaleuca scrub and scattered E. rudis. They are flanked by either wandoo woodland on heavier textured soils, or by jarrah woodland on sandier soils (Goonaping surface). The deep strongly leached sands carry a low woodland of Banksia attenuata, Banksia menziesii and Nuytsia floribunda.

f) The monadnocks carry vegetation varying from jarrah, marri and Casuarina huegeliana woodlands, through shrubland to bare rock. The vegetation in the intermediate rainfall zone is transitional between corresponding site-vegetation types in the low and high rainfall zones.

1.4 Dieback Disease

This disease is a most important factor in land use planning because of its devastating effects on the vegetation where jarrah and Proteaceous elements play an important part.

The pattern of dieback occurrence is the result of an interaction between environmental factors and historical events. Broadly its impact is most damaging in high rainfall areas, on poorly drained areas and on nutrient deficient soils. The intensity of human activity strongly influences the rate of spread, hence the greatest damage has taken place adjacent to the western scarp, in areas logged since the introduction of logging tractors and trucks, and in intensely developed areas (e.g. Collie Coal Basin).

These generalisations explain the pattern of existing dieback infections. The disease is largely absent from the transitional and eastern zones of the region, and it is imperative that this remain so to avoid deterioration in forest values, including water quality (Figure 4).

2. ECONOMIC AND LEGAL CONSTRAINTS

2.1 Legal Tenure of Land

The bulk of the land is State Forest dedicated in several stages under the 1918 Forest Act. Alienation can only take place with the consent of both houses of State Parliament. Timber Reserves under the Forest Act can be revoked by Executive Council proclamation.

Much State Forest is also gazetted as water catchment. Where this occurs forest management practices are constrained by the regulations governing catchment protection.

Numerous small reserves (e.g. water, conservation, camping, recreation etc.) are vested in various authorities. Where they occur within or adjacent to State Forest they are usually managed in conjunction with it. No National Parks occur within the main forest belt although two small parks adjoin it (Lesmurdie and Serpentine).

The private land forms large continuous blocks along the eastern and western perimeters of State Forest, corridors along rivers and roads, and small individual developments.

Properties are generally small to medium sized and owned by individuals. A few large forested holdings owned by timber companies occur alongside State Forest.

2.2 Catchments

Irrespective of ownership all land falling within gazetted catchments supplying water to the Metropolitan Region is subject to regulations proclaimed under the Metropolitan Water Supply, Sewerage and Drainage Act, (1909-1975). The other catchments (supplying Goldfields, agricultural and Great Southern towns, various local town supplies and irrigation requirements) are controlled by the Public Works Department (Country Water Supply Act 1947-1976) (Figure 5).

Many of the streams have been dammed but a number, including the Murray, are still untapped. Regulations governing the management of catchments for other than irrigation cover a wide range of human activities, and mainly concern agriculture and recreation.

2.3 Mining Leases

The entire northern jarrah forest is covered by three leases for the mining of bauxite under special mining agreements (Figure 6).

The leases confer upon the holders the right to mine bauxite on all Crown land within the lease, including State Forest and Timber Reserves. Rehabilitation of the mined areas to the satisfaction of the Conservator of Forests is a condition of the lease.

Coal mining has been carried out to the south-east of Collie for some 80 years and leases are granted under the Mining Act, 1904-1973. Rehabilitation of mined areas is a condition in some of these leases.

Gravel leases and licenses are issued primarily to Government bodies under the Forest Act. These are widespread in the forest belt, adjacent to areas of development.

2.4 Town Planning

The townsites of Mundaring Weir, Jarrahdale, Dwellingup and Collie, together with the Karnet Rehabilitation Centre, occur within the region. The Metropolitan Region Scheme covers a large part of the northern jarrah forest. A Town Planning Scheme covers the whole of the Collie Shire.

Town planning measures are controlled by the relevant local authority under powers conferred by the Local Government Act (1960-1975) and the Town Planning and Development Act (1928 as amended). All proposals are subject to the approval of the Minister for Town Planning who has the advice of the Town Planning Board.

Apart from control of building and health regulations the Shire have the power to rezone land for residential or industrial purposes.

2.5 Timber Permits and Apiary Sites

Some of the region is covered by timber permits. These confer upon the holders the right to harvest timber under the direction and supervision of the Forests Department, subject to a prescribed allowable cut and the payment of royalties on timber removed.

Numerous apiary sites are leased for honey production.

2.6 Plant Quarantine

In an attempt to control the spread of dieback disease and to define the existing infection, the Forests Department has declared the eastern portion of the State Forest to be subject to quarantine, under the Act for the Amendment of the Forest Act (Prevention and Eradication of Disease 1974).

The areas under quarantine are those in which the disease is considered to be present in sufficiently low levels to warrant protection and corrective action. The planned quarantine period is three years, during which time all access is prohibited except on a few good quality roads (some restricted to dry weather use only). (Figure 7).

2.7 Communications

Major communications lines within and adjacent to the region are shown in Figures 5 and 8. A number of authorities have responsibility for construction and maintenance of these, even though they traverse State Forest. These include -

a) Rail: Westrail

b) Road: Main Roads Department, relevent Local Authorities, Forests Department

c) Powerlines: State Energy Commission

d) Pipelines: Public Works Department, Metropolitan Water Supply, Sewerage and Drainage Board

e) Airfields: Private property owners, Forests Department

f) Bauxite Conveyor Belts: ALCOA (Australia)

2.8 Other Organisations

Numerous organisations use forest land - these are shown in Appendix 1.

3. CURRENT MANAGEMENT AND RESOURCE USE

3.1 Agriculture

The State Forests are bounded by agricultural land on all sides. In addition, there are several enclaves of private property, especially in the Helena and Wellington catchments. The contribution of the latter to the total agricultural

production of this State is small.

To the west the land has been cleared for dairying (with and without irrigation) and grazing. Eastwards from the scarp hobby farms, horse studs and more intensive forms of agriculture (horticulture, pig farming, market gardening) occur. Further east grazing (cattle, sheep) and cereal growing (oats, barley) become more dominant, before eventually being displaced by the typical wheat/sheep farms of the wheatbelt.

3.2 Mining

The more important products are bauxite, coal and gravel. Clay, dolerite and granite have also been extracted. Mineral tenements for a variety of other "minerals" have been pegged.

Gravel is obtained from the surface horizons of the lateritic profiles and has provided the foundation for most of the road systems in this zone. The main Roads Department, Local Government, Forests Department and other public utilities are the principal users. Most pits are relatively small, and many have now been replanted. Where possible, co-ordination of sand and gravel supplies is planned for.

All of the State's production of coal is mined at Collie by both open cut and underground methods. Production has exceeded two million tonnes per annum. In the 80-odd years since mining commenced, some 500 ha of forest have been cleared. Site restoration of open cut areas and on spoil dumps is continuing.

All of the current State's production of bauxite is mined at Jarrahdale and at Del Park, by ALCOA. ALWEST propose to mine at Mt. Saddleback. The current level of operations by ALCOA exceeds 100 ha per annum. The area of

forest destroyed by mining is estimated as 800 ha at Jarrahdale (1963 to 1974) and 200 ha at Del Park (1972 to 1974). There is close liaison between the Forests Department, ALCOA and other government agencies with respect to site restoration.

3.3 Water

Some 90 per cent of the water used in the Perth Metropolitan Area comes from catchments in this region. In addition, water is provided for the agricultural and goldfields areas, as well as for irrigation supplies. Current use in Perth exceeds 600 litres per person per day. This requirement has doubled within the last 10 years and demand is expected to increase in the future.

Two authorities (P.W.D. and M.W.S.S.D.B.) are responsible for the construction of headworks and for distribution. Dams are of two main types (terminal storage and pipehead) and are often managed as a conjunctive system. Catchment management has been a prime responsibility of the Forests Department.

Catchments where moderate agricultural clearing has occurred (Helena and Wellington) are approaching the upper limits of the recommended salinity standards for drinking and for irrigation. Flows from forested catchments have low salinity, bacterial and silt contents.

3.4 Sawn Timber Production

Sawmilling commenced soon after European settlement. Prior to the introduction of treemarking in the 1920s the forest areas were virtually clean cut. Selective cutting took place until 1968, when the relationship between mechanised logging and dieback incidence was proven. The current system aims at a heavy cut to reduce the area traversed by logging equipment and so minimise the amount of forest placed at risk from dieback.

Timber is allocated to companies by either a sawmilling permit, or a license. Under a license the holder receives his intake on a short-term basis with little security of tenure. The permit system gives a holder the exclusive right to remove timber from an allocate area with considerable security of tenure. The following table summarises the current situation:

	Number	Annual Permissible Intake (m^3)	Number Directly Employed (Bush + Mill)
Permits	10	236 174	345
Licences	8	34 548	93
Total	18	270 722	438

(Does not include Wundowie's firewood operations, Agnew Clough).

This represents about 25 per cent of the State's annual hardwood cut (logwood only). Because of higher royalties (due to the proximity of key markets) this area's contribution to royalty input is about 30 per cent. The level of employment (bush and sawmill) is about 20% of the total for this industry.

Logging operations have much potential to spread dieback and a considerable effort is being applied to develop tech-

niques of logging and permit control which minimise the risk. Progress has been made with techniques such as summer stockpiling, greenline cutting, strict hygiene measures and education of personnel in this industry.

Some 20 per cent of this State's pine plantations are situated within this region. Future plantation programmes will concentrate on the Sunklands, the Blackwood Valley, Swan Coastal Plain and areas near Collie. This region's contribution to the pine area will then decrease to about 10 per cent of the total.

3.5 Town Planning

The area occupied by townsites is small but nonetheless significant because:

a) adjacent land uses are subjugated by the creation of a buffer zone which arises either formally or informally;

b) human activity is concentrated and hence increases the potential for water pollution and dieback spread;

c) regional land use is affected by the provision of necessary communication lines.

With the exception of Collie, all existing townsites lie within the high rainfall zone. Collie lies within the intermediate rainfall zone.

Township	Catchment	Catchment Use
Mundaring Weir	Lower Helena	Existing
Jarrahdale	Gooralong	Proposed
Karnet	Dirk Brook	Proposed
Dwellingup	Murray	Proposed
Collie	Wellington	Existing

The environmental risks created by these townships are greater in the low rainfall zone, with its inherent hydrological problems and low dieback incidence. Should the need arise for additional urban or industrial zones in the future, these should preferably be sited within the high rainfall zone, subject, of course, to economic and social constraints.

3.6 Communications Lines

Communication lines serve the other forms of land use but in doing so are a land use in their own right. The control of these lines is varied from statutory authorities (e.g. Main Roads Department) to private companies (e.g. bauxite conveyor belts).

3.7 Flora and Fauna

There are no large flora and fauna reserves or National Parks within the area. A considerable number of small reserves vested in several authorities occur within and on the edge of State Forest.

In addition, the Forests Department has set aside a number of areas for special management (flora and fauna conservation). These total 70 000 ha of core area and an additional 110 000 of buffer. The greatest long term threat to these reserves is posed by dieback disease.

The region provides habitat for over 25 species of native mammals and a very wide range of birds and reptiles. Other fauna include frogs, fish, insects and soil microfauna. As long as a diverse range of vegetational ecotypes is adequately conserved, the future of these species will be assured.

3.8 Recreation

These forests are used for a wide range of recreational activities ranging from passive (driving for pleasure, pic-

nicking, nature study) to active (bushwalking, orienteering, horse riding). A number of pursuits involve motorised recreation (motor rallies, trial and mini bikes).

The area is readily accessible from main centres of population; Perth, Bunbury and Collie. Surveys indicate that recreation levels approach 300 000 visitor days and that demand is increasing by some six per cent each year.

Facilities are not uniformly spread, for the visitors have shown preferences for particular sites (especially rivers and streams, bodies of water, or broken country with views). Liaison is maintained with individual clubs and organisations representing the various activities (e.g. C.A.M.S., W.A.M.C.A., and W.A.M.B.A.). In some cases (Scouts, Community Recreation Council) leases have been prepared.

The greatest dangers posed by recreation are over-use, pollution, spread of dieback, fire and litter.

Education, planning and management and the provision of adequate facilities should reduce these to an acceptable level.

3.9 Minor Forest Products

Five hundred apiary sites are located in this zone. In addition, many beekeepers place hives on private property adjacent to, or within the forest belt. Sites are issued providing there is no conflict with existing land use, dieback hygiene requirements are satisfied, and the site is at least three km from an adjacent site.

Supply of industrial firewood is centred on the Agnew-Clough Wundowie operation. The annual intake of about 130 000 tonnes per annum is supplied from the north of the region. Firewood for domestic use is also produced by both commercial cutters (licensed, 5 600 tonnes per annum) and individuals collecting their own supply (unlicensed).

Mining timber is supplied for the coal mines near Collie. At the height of the deep mining era some 15 000 m^3/annum of jarrah were used but this has now decreased to about 3 000 m^3.

Licenses are issued under the Forest Act for the commercial gathering of plant material on State Forest. The wildflower industry markets its product in the form of fresh flowers for street sales or perfume manufacture, dry floral arrangements and seed. A large part of this industry is based on private land.

3.10 Fire Protection

Fire is a natural phenomenon of our environment and it is considered that, prior to European settlement, much of the forest was frequently burnt by aboriginal hunters. Following settlement and subsequent development, fuel began to build up and fires became less frequent, but more dangerous.

A Policy of fire exclusion was practised by the Forests Department between 1919 and 1954 when the policy of fuel reduction by prescribed burning commenced. However, it was not until the devastating fires of 1961 that the application of this policy widened to cover all State Forest, on a frequent rotation. Most areas are now burnt under prescribed conditions each 3 to 7 years, depending on the inherent fire risk.

Techniques have been developed and perfected to allow aerial ignition of large areas at a time (up to 5 000 ha). Manual prescribed burning is still carried out, but is usually limited to small high risk areas, (up to 400 ha).

A number of alterations to fire protection policy have resulted from decades of fire research and practice, which give greater emphasis to conservational, environmental and aesthetic values. These include:

a) burning during the wildflower display period is discouraged along major roads for conservation and aesthetic reasons.

b) burning roadsides over long distances simultaneously is to be avoided for aesthetic reasons.

c) burning is discouraged where meteorological conditions indicate smoke pollution problems to Perth and south-west townships.

d) attempts are not made to burn a high proportion of any one area. Prescriptions are set at limits which will ensure unburnt pockets comprising about 20-40% of the area. This policy was adopted in the light of research into the ecology of many forest animals; particularly the swamp dwellers.

4. PROPOSED MANAGEMENT STRATEGIES

The management categories are shown in Figure 9. Land-forms, physical features and land uses for each category are summarised in Table 1.

4.1 Dissected River Valleys and Scarp, High Rainfall Zone (more than 1 150 mm/annum)

Current Land Uses

a) Water storage (large storage dams and small pipehead dams).

b) Recreation, (passive and active), based on optimal opportunity for land and water based recreation and proximity to centres of population.

c) Silviculture of *Pinus radiata*, based on high soil fertility and high rainfall.

d) Conservation of flora and fauna.

e) Silviculture of indigenous hardwoods, in particular blackbutt and jarrah.

f) Grazing of cattle and sheep on improved (clover) and rough pastures.

g) Horticulture, market gardening and intensive animal production.

Quarrying is not a major land use within State Forest. Most of the operational quarries are situated on privately owned land. It can be a significant form of land use in economic terms, but may have detrimental visual impact.

Dams constructed wholly within the Helena surface are usually of the pipehead type, due to the steep stream gradient. They tap the highest yielding tributaries, but have poor buffering (against pollution, salt and variations in flow) and storage capacities. Dams constructed at the junction of Helena and Darkin surface have greater storage, but are normally located above the highest yielding tributaries. The two types can be operated in conjunction. The slopes of the valleys have a high yield of water.

Recreational activities include canoeing, swimming, fishing, hiking, orienteering, picnicking, pleasure-driving, trial and trail bike riding, horse riding and camping.

Pine plantations are subject to economic (small size, large perimeter) and environmental problems (shallow soils, erosion). Other sites offer economic and silvicultural advantages (Sunklands, coastal plain) and are the preferred alternatives.

The vegetation does not have high susceptibility to dieback, but has suffered from frequent wildfires. The fauna of this unit is not well documented.

The productivity of the indigenous forest is limited in parts by poor stocking (due to shallow soils), by a high proportion of non-commercial species, and by the high level of fire damage.

Grazing is handicapped by steep slopes and high clearing costs. Control of the residual vegetation presents considerable problems. Intensive agriculture conflicts with water values, particularly water quality criteria.

Management Strategy

a) Existing areas of pine plantations will not be extended where water or conservation values will be prejudiced. Within existing plantations clear-felling and replanting may be replaced by natural regeneration. Mechanisation of logging must give priority to soil conservation.

b) Special management areas will be selected and zoned so as to leave some free of human impact and to contain recreation to an acceptable level in others. Conservation (flora and fauna) and catchment protection are best achieved above or between dams. Recreation is best achieved below existing dams.

c) The conflict between recreation and domestic water supply can be expected to intensify. Recreation should be directed to

(i) streams not dammed
(ii) below existing dams and at the dam wall
(iii) around dams used for irrigation

d) Existing facilities within current domestic water supply catchments should be upgraded (particularly ablution blocks).

e) The role of silvicultural techniques (including fire) in catchment management, is being investigated. The hardwood forest will be managed extensively, giving due regard to aesthetics and erosion control.

f) Pipelines must be planned and installed with great care so as to avoid erosion and siltation.

g) Streams draining townsites should be monitored to assess water purity.

h) Should the need arise for additional townsites, they are preferably located in this western zone.

4.2 Lateritic Uplands, High Rainfall Zone (more than 1 150 mm/annum).

Current Land Use

a) Hardwood silviculture, based on high stocking rates, a high proportion of merchantable species and high growth rates.

b) Bauxite mining, based on the large and deep deposits, whose value is enhanced by their proximity to ports.

c) Catchment protection, important because of the high rainfall and low accumulation of salt.

d) Recreation, based on proximity to centres of population, and ready access.

e) Conservation of indigenous flora and fauna. At risk because of widespread dieback disease.

None of these land uses is without limitations. The growth rates of the indigenous hardwoods, though the highest in the region, are not as high as those of karri or pine. The potential is further reduced by the widespread occurrence of dieback. The bauxite has a lower alumina content than that mined elsewhere in Australia, but also a lower degree of impurities. Water yield is reduced by high infiltration, storage and evapotranspiration rates. The landscape lacks variety. There are no known rare or endangered species within it.

Management Strategy

a) A survey is in progress to assess if viable areas of undisturbed forest remain within this unit. If none can be found, an adequate area of logged-over but dieback-free forest will be located, set aside as a special management area (flora and fauna conservation) and allowed to progress to maturity without further human disturbance.

b) Mining is acceptable here (particularly in the western parts of this zone, where a considerable area is already infected by dieback), because:

(i) the possibility for increases in salinity is believed to be low;
(ii) the scope for spreading dieback is low since most gullies are already infested;
(iii) the reduction of the vegetative cover increases water yield;
(iv) the vegetation is already disturbed by dieback, can no longer be considered natural and will need to be rehabilitated. Within existing catchments a minimum cover to increase water yield, restore aesthetic appeal and provide for erosion control is proposed.

In parts of this zone there is considerably less dieback and mining would not be a preferred form of land use, since areas which are dieback affected offer a more suitable alternative.

c) The residual healthy stands of upland jarrah forest (which could represent less than 20 per cent of the area, after mining) will be managed for timber production and water. This involves the restriction of motorised access, and silviculture to maximise increment on the crop trees and to increase water yield.

d) Stands affected by dieback will be salvage logged and rehabilitation with native or exotic eucalypts is proposed. Aesthetic species with timber and honey potential are preferred, subject to the needs of water catchment. For the effective programming of this work, the areas which are proposed for mining should be known well in advance, so as to avoid the mining of an already rehabilitated site.

e) Recreation should be channelled into areas not used for domestic water supply. The more damaging forms of motorised recreation could be absorbed in mine and gravel pits.

f) Rehabilitation of dieback areas and of mine pits offer considerable flexibility in options (particularly when not on existing water supply catchments). Timber production, water production, recreation and aesthetics can be favoured, depending on the best use for each area. Restoration activities are being planned on a composite basis, catchment by catchment.

g) In view of the mosaic of vegetation types, the adequacy of existing fire protection techniques will be reassessed. The use of fire to increase water yield is being considered.

h) From the forest and catchment protection viewpoint, the optimum location for lines of communication is the Swan Coastal Plain or the agricultural area east of the forest belt.

Where it is essential that lines of communication (e.g. S.E.C. transmission lines) must be routed through State Forest, they are best located here, though conflict with reservoirs and aesthetics do occur. It is recognised that parts of some transmission lines (especially near Muja) may need to be located in State Forest. These lines should, as far as possible, avoid areas which are salt prone.

i) Gravel (for use in areas where dieback is already widespread) should be obtained mainly from this zone, subject to the normal constraints. It is important to recognise both the need to provide gravel at an economical rate and the disbenefits of gravel borrowing operations. The location of pits must consider both these factors.

4.3 Dissected River Valleys, Low Rainfall Zone (less than 1 025 mm/annum

Current Land Uses

a) Catchment protection
b) Mixed farming
c) Hardwood silviculture
d) Silviculture of Pinus radiata
e) Conservation of fauna and flora
f) Recreation

Although the steeper slopes and shallower soil result in a high yield of water, this is partly offset by the lower rainfall. In addition, the salinity risk is higher than for the corresponding unit in the high rainfall zone. The risk of pollution and of erosion are accentuated by a high proportion of agricultural land.

The limitation to hardwood silviculture is the lower productivity. Although silviculture of Pinus radiata is favoured by the higher fertility of the soils, its potential is reduced by a combination of shallow soils, steep slopes and low rainfall.

Existing reserves are inadequate to meet the need for flora and fauna conservation. The greater fertility of the soils and the resultant scatter of farms have favoured the spread of exotic plants and animals. This has been accentuated by fire of above-average frequency and severity.

Recreation in the upper Helena Valley has been virtually

excluded by legal constraints. The eastern portion of the Murray Valley is still open to recreation, but its potential is less than for the higher rainfall zone (greater distance from population centres, smaller and more seasonal streamflow and some interference by farm fencing).

Management Strategy

a) Further alienation and clearing of forested land should cease. Resumptions and a moratorium on clearing should be considered. The need to develop a viable combination of agriculture and forestry should be stressed to farmers.

b) Cleared areas of farmland resumed by the Crown should be revegetated with deep rooted perennials, resistant to dieback.

c) Conversion of native forest to pine plantations has ceased. Existing plantations will be managed so as not to prejudice water supplies.

d) Areas to be managed for flora and fauna conservation have been surveyed.

e) Cutting in the native forest will be managed conservatively so as not to conflict with the objectives of water production (erosion, salinity). Adequate crown cover will be retained or restored by prompt regeneration.

f) Further recreational facilities will be developed in the Murray Valley, where this does not conflict with quarantine needs.

g) No further town planning should be considered without adequate environmental safeguards.

4.4 Lateritic Uplands Low Rainfall Zone (less than 1 025 mm/annum

Current Land Uses

a) Hardwood silviculture based on jarrah and wandoo

b) Catchment protection

c) Conservation of flora and fauna

d) Agriculture, primarily grazing but with some cereals

e) Potentially, this land unit could be mined for bauxite. It has marginal potential for dry-land recreation.

Most land uses are subject to serious limitations. The value of the hardwood is reduced by the lower productivity. The jarrah areas have been only slightly affected by dieback. The wandoo sites are not susceptible. These uplands contribute little to streamflow and although the yield is increased by clearing, there is an excessive rise in salinity.

Agricultural clearing on uplands increases salinity problems on the valley floors. Due to the high capacity of the soils to fix phosphates, heavy fertiliser applications are required.

The bauxite deposits are smaller in size and more dispersed. Distances to seaports are greater, lowering the profitability. The increased distance from centres of population and the relatively few all-weather access roads lower the potential for recreation. The area is virtually free of dieback and gross disturbance from human activity. Adequate areas of virgin forest still exist and the area is rich in plant species. Rare animal species such as the numbat

(Myrmicobius fasciatus) are present in viable populations.

Management Strategy

a) In view of its low productivity and its importance to catchment protection and to conservation, this land unit should be viewed primarily as a protection forest.

b) The main requirement is the retention of an adequate vegetative cover of deep rooted perennials. This means extreme caution with respect to the possible introduction of dieback, the earliest possible regeneration of cut over stands and the artificial revegetation of areas denuded in the past.

c) Further alienation and clearing of forested crown lands should cease. Resumption of selected farms should be considered. The need to develop a viable combination of agriculture and forestry should be stressed to farmers.

d) Bauxite mining should not be permitted within existing catchments until research carried out under the Hunt Steering Committee establishes that any adverse effects can be reversed sufficiently rapidly by the revegetation of mine areas, or by other means. The proposed mining by ALWEST (Mt. Saddleback) is situated in a catchment which is already brackish and is not currently used for water supply.

e) Motorised recreation should be excluded from water supply catchments, other than on all-weather roads. Extensive recreation should be directed into areas which are not significant for water supply. In contrast, intensive recreation will be directed to the west of existing dams.

f) The options for setting aside areas (flora and fauna conservation) are still open. One representative of each type should be in the virgin condition and this should be duplicated by a second, where some degree of disturbance will be acceptable.

g) Because of the area's high topographic position, the risk of spread if dieback is introduced is extreme. This fact, and the need to maintain an adequate cover, necessitates that logging should occur only where adequate safeguards are assured.

h) Construction of new lines of communication or upgrading of existing facilities must be minimal and planned with extreme care, so as not to spread dieback or increase the area cleared.

i) Gravel for local use should come from healthy areas.

4.5 Broad Valleys and Depressions, Low Rainfall Zone (less than 1 025 mm/annum)

Current Land Uses

a) Catchment protection

b) Agriculture

c) Hardwood silviculture

d) Conservation of flora and fauna

Agricultural development is subject to serious limitations. The porous soils of the Goonaping surface are low in nutrients and fertiliser is rapidly leached. Clearing of the Beraking surface causes salinity problems, the death of the more productive pasture species, sheet and gully erosion.

The potential for timber production is limited. There are large areas of treeless swamps and very open woodland with a winter access problem. The logs are generally short and defective. Although a fair potential for pine planting has

been demonstrated, there are hydrological risks involved and the distance to market is a further handicap. An exception is on sedimentary soils of the Collie Coal Basin, which are largely free of salinity problems, sufficiently close to the industrial centres of Collie and Bunbury, and badly affected by dieback.

The potential for conservation is high. The vegetation is structurally and floristically varied, is free of dieback and gross disturbance and contains some rare fauna. It is generally distant from the centres of population, and is traversed by few all-weather roads. Access is particularly difficult in late winter and early spring, when the wild-flowers are most attractive.

Coal is obtained by surface and underground mining. Though not of high quality, it is the mainstay of power generation for the south-western portion of the State.

Because of its low topographical position, disturbances in the surrounding countryside are difficult to exclude. Any dieback on the uplands readily gravitates on to the Goonaping surface, which has a high proportion of susceptible tree and shrub species.

Management Strategy

a) In view of its low productivity and its importance to catchment protection and to conservation, this land unit is viewed primarily as a protection forest.

b) Although not a prime area for water production, the main requirement in order to protect the water supply is the retention of an adequate vegetative cover. This means extreme caution with respect to the possible introduction of dieback, the earliest possible regeneration of cutover stands and the artificial revegetation, with deep rooted perennials, of areas denuded in the past.

c) Further alienation and clearing of forested Crown land should cease. Resumption and a moratorium on clearing should be considered. The need to develop a viable combination of agriculture and forestry should be stressed to farmers.

d) Motorised recreation should be excluded from water supply catchments, other than on all-weather roads. Extensive recreation should be directed into areas which are not important for water supply, preferably on all-weather roads.

e) The options for setting aside conservation areas (flora and fauna) are relatively open. One representative of each type should be in the virgin condition and this should be duplicated by a second, where some degree of disturbance will be acceptable.

f) Because of the risk of introducing dieback and the need to maintain an adequate cover, logging should only occur where adequate safeguards are assured.

g) Coal mining operations (Collie Basin) should be planned in advance and closely supervised to reduce any adverse environmental effects and to facilitate rehabilitation. Areas affected either directly (by mining) or indirectly (by the spread of dieback) should be rehabilitated with the appropriate techniques. Objectives in rehabilitation include aesthetics, recreation, soil conservation and, possibly, the creation of "wetland" habitats for fauna.

h) Pine plantation establishment will be expanded within the disturbed parts of the Collie Coal Basin, using both Pinus radiata and P. pinaster. In other areas, plantation establishment will be restricted to small plantings for research purposes.

i) Areas used as sand leases must be carefully selected, so as to minimise the risk if dieback is introduced.

j) New lines of communication (S.E.C., roads etc) should be rerouted, if possible.

k) No future town planning should be considered without adequate environmental safeguards.

4.6 Monadnocks (found predominantly in the intermediate rainfall zone (1 025 to 1 150 mm/annum) and low rainfall zone

The major forms of land use are catchment protection, flora and fauna conservation and recreation. This unit has low significance for hardwood silviculture, and has not been utilised for quarrying because adequate sources are available from the escarpment, closer to the markets.

The combination of steep slopes, large exposure of bare rock, shallow loamy soils and low vegetative cover contribute to high surface run-off and low evapotranspiration. However, much of this runoff tends to be dissipated on the mildly sloping, porous, lateritic uplands and Randall surface. The potential for erosion and turbidity is very high, particularly where the unit adjoins a major valley.

Its elevation gives outstanding views. This is enhanced by numerous rock outcrops and the great structural and floristic diversity of the vegetation. This results in a high aesthetic value and a rich recreational experience. Many of the monadnocks are readily accessible, as they occur close to the Albany Highway and within 80 km from Perth. An all-weather gravel road terminates a short distance from the summit of Mt. Dale. The unit is better suited for active than passive recreation, except where a road surface exists to the summit.

The value to fauna and flora conservation is based on the great topographic and edaphic diversity, which together provide a wide range of habitats. Of particular interest is the considerable shift in tree species with a relatively minor change in climate, and the tendency for southern shrub species to occur as outliers. Although the mammalian fauna is poorly known, a large number of bird and reptile species are present. Its

elevation minimises the risk of dieback introduction by natural means, but aggravates the danger of spread once an infection is established.

Hardwood silviculture is handicapped by poor access, low stand productivity, low stand density and the high proportion of non-commercial species and as a consequence virgin and lightly logged stands of timber are common.

In the past this unit has been of considerable importance to fire protection, and fire towers were built on many of the summits. Its importance has declined with the change to aerial detection.

Management Strategy

a) This unit will be regarded primarily as protection forest (flora, fauna, catchment). Adequate conservation areas are being selected.

b) Recreational activity must be strictly zoned due to the high risk of erosion, introduction of dieback and pollution.

(i) Where there are no all-weather roads to the summit motorised access will be excluded (e.g. Eagle Hill, Mt. Cooke).

(ii) Where an all-weather road exists (Mt. Dale) access will be restricted to one slope only.

(iii) Active recreation on foot should be encouraged where the danger of biological pollution is least, or where adequate parking and toilet facilities have been provided.

c) Logging activity may be permitted on the lower slopes, subject to adequate environmental safeguards.

4.7 The Intermediate Rainfall Zone

This zone is a transition between the high and low rainfall zones. To the west the occurrence of dieback is high and the salinity risk is low, whereas to the east the reverse applies.

This is considered to be a critical management zone because of possible salinity and the interaction between timber, bauxite mining and conservation values (flora and fauna). It requires intensive evaluation and monitoring (especially with respect to hydrology and dieback) before responsible management decisions on future use can be taken. Current management prescriptions should reflect extreme caution. For all land uses with a hydrological and dieback impact (mining, agriculture, sawmilling) the constraints appropriate to the low rainfall zone should apply, at least until the situation is clarified. The maintenance and restoration of a disease-free, deep-rooted, perennial crop on these sites is of vital importance.

Due to its transitional nature, relatively narrow width and uncertainties regarding future management, detailed discussions of land uses is considered premature at this stage.

4.8 Future Action

Having framed the overall perspectives for management, the Forests Department has already commenced a detailed study in the Dwellingup Forest Division. (Figures 2, 3 and 10 refer). It is intended that detailed studies for the other Divisions will follow, and produce management prescriptions for implementation in the field.

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APPENDIX 1.

THE EXTENT OF USE OF THE NORTHERN JARRAH FOREST

Apart from numerous individuals, many organisations use the northern jarrah forest. Below is a list of known groups and organisations, classified according to their legal authority:

A. WITH STATUTORY AUTHORITY

Public Works Department
Metropolitan Water Supply, Sewerage & Drainage Board
Mines Department
Department of Agriculture
Agricultural Protection Board
Department of Conservation and Environment
Department of Fisheries and Wildlife
Forests Department
Geological Survey
Lands & Surveys Department
Local Authorities
Metropolitan Region Planning Authority
Town Planning Department
Police Department
Westrail
Telecom Australia
State Energy Commission
Stage Emergency Service
Police & Customs (Australia)
Department of Defence
Alcoa (Australia)
Alwest
Pacminex
Western Collieries
Griffin Collieries
Department of Services and Property
Main Roads Department
Department of Science and Meteorology
Environmental Protection Authority
Soil Conservation Advisory Committee
Conservation Through Reserves Committee
Department of Corrections
Public Health Department
Road Traffic Authority
Department of Industrial Development

B. LIMITED STATUTORY POWERS

Bush Fires Board
C.S.I.R.O.
National Parks Board
Community Recreation Council
Department of Tourism
Forest Produce License holders
Apiary Site lessees
Forest Lease holders
Meteorological Bureau
Bureau of Mineral Resources
W.A. Wildlife Authority

C. WITHOUT STATUTORY AUTHORITY

Hunt Inter-Departmental Committee
Water Purity Committee
Recreation and sporting bodies (motorised & non-motorised)
University of Western Australia
Western Australian Institute of Technology
Murdoch University
W.A. Museum
Charter Tours Companies
Education Department
Kings Park Board (seed collection)
Various conservation bodies (Wildflower Society, Naturalist Club)
Scouts/Guides
Darling Range Advisory Committee
Forest Products Association
Farmers' Union

TABLE 1
(to be read in conjunction with Figure 9)

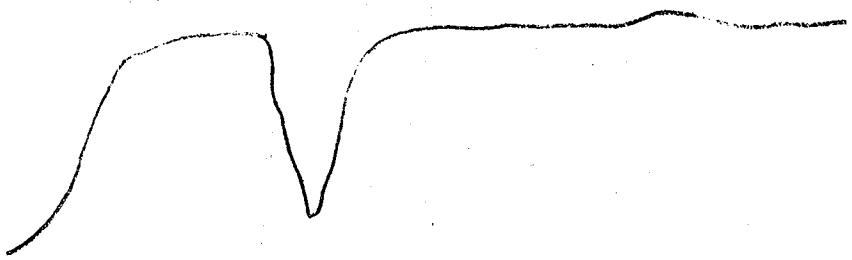
ZONE		WESTERN HIGH RAINFALL (More than 1 150 mm p.a.)	
LANDFORMS		Scarp and Dissected River Valleys	Lateritic Uplands
STYLISED LANDFORM SHAPE			
SURFACES	Name	"Helena, Darkin"	"Lateritic uplands"
	Type	Erosional	Stable
SOILS		Red earths	Laterites
VEGETATION	Dominants	Jarrah Marri Wandoo Blackbutt	Jarrah Marri
	Height (metres)	30 + m	30 + m
DIEBACK -	Occurrence	moderate	high
	Susceptibility	mod. - low	moderate
	Protection from Natural Spread	non protectable	protectable
WATER YIELD		high	moderate
SALT STORAGE		low	low-moderate
CURRENT MAJOR USES		Agriculture Hardwoods National Parks Pine Plantations Quarrying Recreation Water Storage	Bauxite mining Hardwoods Recreation
PROPOSED MAJOR USES (Within State Forest)		Water Supply Water storage Recreation Hardwoods Flora/Fauna Pine Plantations	Water Supply Bauxite mining Hardwoods Flora/Fauna Recreation

TABLE 1 continued

CENTRAL, INTERMEDIATE RAINFALL
(1 025 to 1 150 mm p.a.)

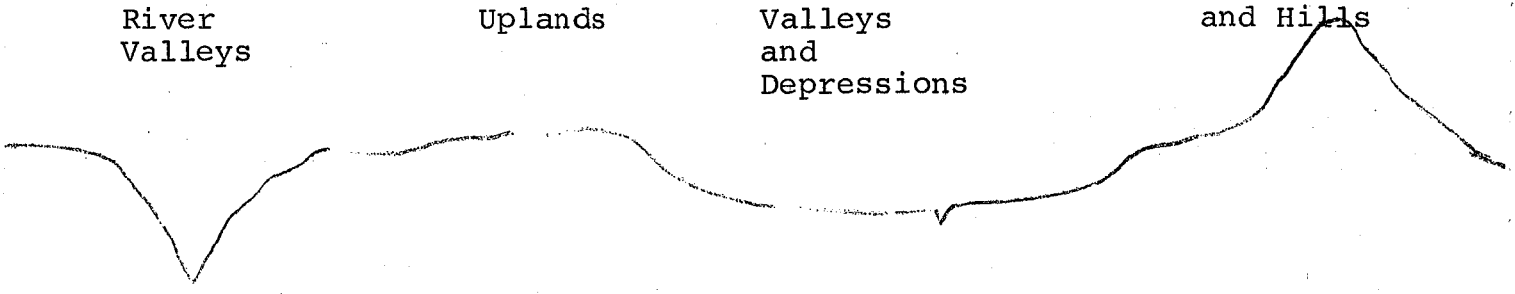
Dissected River Valleys	Lateritic Uplands	Broad Valleys and Depressions	Monadnocks and Hills
			
"Darkin"	"Lateritic uplands"	"Beraking Goonaping"	"Residuals Cooke"
Erosional	Stable	Depositional	Erosional
Red earths	Laterites	Sands and clays	Rock, shallow earths
Blackbutt Marri Jarrah	Jarrah Marri	Jarrah Marri	Jarrah Marri Rock Sheoak
30m	25 - 30m	25 - 30m	25 m
moderate	mod. - low	mod. - high	low
low	moderate	high	moderate
non protectable	protectable	non protectable	protectable
high	mod. - low	low	high
low- mod.	mod. - high	low	low
Agriculture Hardwoods Pine plantations Recreation Water storage	Hardwoods	Agriculture Coal mining Hardwoods	Hardwoods Recreation
Water Supply Flora/Fauna Hardwoods Recreation Pine Plantations	Water Supply Hardwoods Flora/Fauna	Flora/Fauna Hardwoods Coal Mining) Pine Plantations) (In the Collie Basin)	Flora/Fauna Recreation

TABLE 1 continued

EASTERN, LOW RAINFALL
(Less than 1 025 mm p.a.)

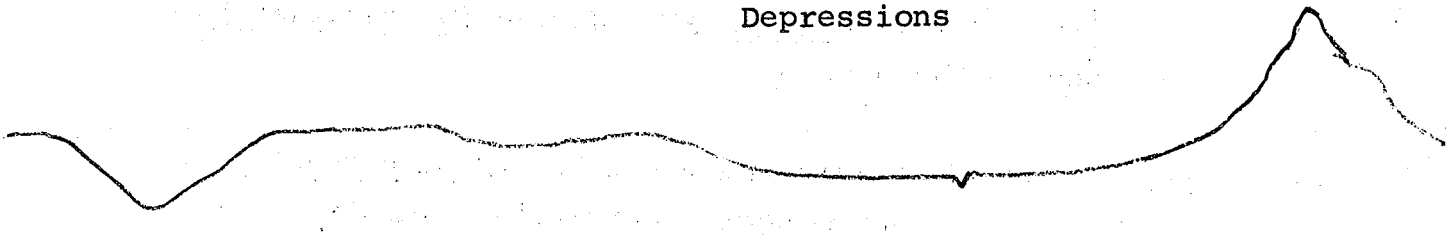
Dissected River Valleys	Lateritic Uplands	Broad Valleys and Depressions	Monadnocks and Hills
			
"Darkin"	"Lateritic uplands, Nockine"	"Beraking, Goonaping"	"Residuals, Cooke"
Erosional	Stable	Depositional	Erosional
Red earths	Laterites	Sands & Clays	Rock, shallow earths
Wandoo Jarrah	Jarrah Wandoo Powder Bark	Jarrah (sands) Wandoo (clays)	Jarrah Marri Rock Sheoak
25 m	25 m	20 - 25 m	25 m
low	low	low	low
low	mod. - low	high	moderate
non protectable	protectable	non protectable	protectable
moderate	low	low	high
mod. - high	high	low (sands) high (clays)	low
Agriculture Hardwoods Pine plantations Recreation	Hardwoods	Agriculture Coal Mining Hardwoods	Hardwoods Recreation
Water Supply Conservation Hardwoods Recreation	Hardwoods Flora/Fauna	Flora/Fauna Hardwoods Coal Mining) Pine Plantations) (In the Collie Basin)	Flora/Fauna Recreation

FIGURE 10

VEGETATION MAP - DWELLINGUP DIVISION

1. Scarp type - Dominant species include marri (E. calophylla), wandoo (E. wandoo), E. laeliae, and rock sheoak (C. huegeliana). Jarrah (E. marginata) is confined to the deeper soils.

2. Murray Valley (western) type - Blackbutt (E. patens) and marri are often dominant. Jarrah is a lesser component. Flooded gum (E. rudis) and river banksia (B. littoralis var seminuda) are present near stream lines.

3. Murray Valley (eastern) type - wandoo becomes dominant over jarrah. Flooded gum and tea tree (M. raphiophylla) are present near streams.

4. Lateritic uplands (western) type - jarrah - marri forest with understorey of bull banksia (B. grandis), sheoak (C. fraserana) and emu bush (P. longifolia). More dissected and of higher quality than 5.

5. Lateritic uplands (intermediate) type - less dissected and poorer quality than 4. Species associations are similar between these two types.

6. Lateritic uplands (eastern) type - jarrah - marri forest with wandoo more prominent. Understorey species of types 4 and 5 become less common. Drummond's gum (E. drummondii) is present on shallow soils.

7. Broad valleys and depressions type - thickets of Melaleuca shrubs and flooded gum on valley floors. Wandoo woodland (on clays) or jarrah woodland (on sands) adjoin these. Deeply leached sands carry banksias (B. attenuata, B. menziesii) and Christmas tree (N. floribunda).

8. Monadnock and hills type - jarrah, marri and rock sheoak. Shrublands and areas of bare rock with mosses and lichens.

9. Eastern forest type - jarrah, wandoo or powderbark wandoo (E. accedens) share dominance. Rock sheoak found on shallow soils.

FIG. 2

MULTIPLE LAND USE PLANNING
DWELLINGUP DIVISION

ANNUAL WATER YIELD

ANNUAL YIELD m^3 HECTARE^{-1}

- > 2000
- 1001 - 2000
- 501 - 1000
- 250 - 500
- < 250

0 5 10 15 Kilometres

0 5 10 miles

JARRAHDALE
PIPEHEAD DAM
SERPENTINE DAM
MT. COOKE
MT. SOLUS
SERPENTINE
ALBANY HIGHWAY
WESTERN HIGHWAY
SOUTH
NORTH DANDALUP
RIVER
NORTH BANNISTER
WANDERING RD.
ALBANY HIGHWAY
BANNISTER HILL
BANNISTER
DEL PARK ROAD
NORTH EAST ROAD
SOUTH DANDALUP DAM
ROAD
DWELLINGUP
MT. WELLS
MARRADONG ROAD
INGLEHOPE
NANGA
WARDONA DAM
NANGA ROAD
MURRAY RIVER
RIVER
BODDINGTON
MARRADONG
HOTHAM RIVER
MT. KEATS
GEORGE TOWER
TUMLO HILL
MURRAY RIVER
QUINDANNING ROAD
MT. SADDLEBACK

BOUNDARY OF STATE FOREST
(INCLUDES SOME LAND NOT UNDER THE CONTROL OF THE FORESTS DEPARTMENT)

FIG. 3

MULTIPLE LAND USE PLANNING
DWELLINGUP DIVISION

0 5 10 15 Kilometres

0 5 10 miles

SALINITY

WEIGHTED AVERAGE SALINITY mg L^{-1} T.D.S.

- < 100
- 100 - 250
- 251 - 500
- > 500

JARRAHDALE
HIGHWAY
PIPEHEAD DAM
SERPENTINE DAM
MT. COOKE
MT. SOLUS
SERPENTINE
ALBANY
HIGHWAY
RIVER
NORTH BANNISTER
WANDERING RD.
ALBANY
BANNISTER HILL
HIGHWAY
BANNISTER
DEL PARK
NORTH EAST ROAD
SOUTH DANDALUP DAM
ROAD
DWELLINGUP
MT. WELLS
MARRADONG ROAD
INGLEHOPE
BODDINGTON
NANGA
WAROONA DAM
NANGA ROAD
MURRAY RIVER
ROAD
RIVER
MARRADONG
HOTHAM
MT. KEATS
GEORGE TOWER
TUMLO HILL
MURRAY RIVER
QUINDANNING ROAD
MT. SADDLEBACK

BOUNDARY OF STATE FOREST
(INCLUDES SOME LAND NOT UNDER THE CONTROL OF THE FORESTS DEPARTMENT)

FIG. 4

MULTIPLE LAND USE PLANNING NORTHERN JARRAH FOREST JARRAH DIEBACK DISTRIBUTION

SCALE 1 : 750000

Kilometres 10 0 10 20 30

10 5 0 5 10 15 miles

LEGEND

STATE FOREST, TIMBER RESERVES. (FORESTS ACT) AND OTHER LAND UNDER CONTROL OF FORESTS DEPT.

ISOLATED PATCHES OF DIEBACK.

UP TO 2% DIEBACK.

2% TO 20% DIEBACK.

GREATER THAN 20% DIEBACK.

NOTE: DIEBACK BOUNDARIES ARE GENERALISED. SUSPECT DIEBACK IS INCLUDED UNDER GENERAL HEADING OF DIEBACK.

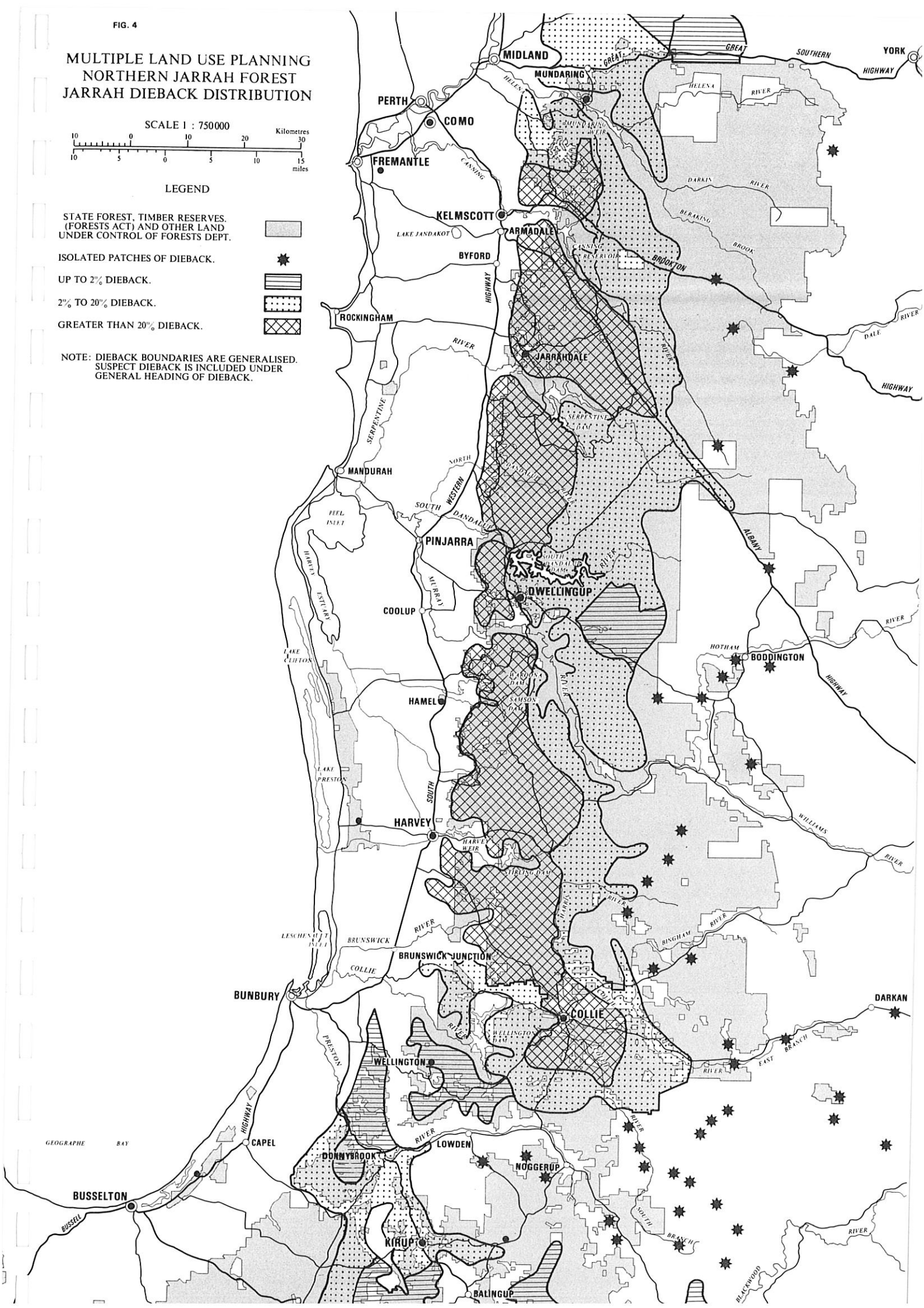


FIG. 5

MULTIPLE LAND USE PLANNING NORTHERN JARRAH FOREST WATER CATCHMENTS

SCALE 1 : 750000

Kilometres 10 0 10 20 30

10 5 0 5 10 15 miles

LEGEND

STATE FOREST, TIMBER RESERVES. (FORESTS ACT) AND OTHER LAND UNDER CONTROL OF FORESTS DEPT.

1 HELENA RIVER
2 LOWER HELENA
3 BICKLEY UPPER & LOWER
4 VICTORIA
5 KANGAROO GULLY
6 CHURCHMAN BROOK
7 NEERIGEN
8 WUNGONG BROOK
9 CANNING
10 SERPENTINE
11 LOWER SERPENTINE
12 SERPENTINE PIPEHEAD
13 DIRK BROOK
14 NORTH DANDALUP
15 LITTLE DANDALUP
16 SOUTH DANDALUP
17 MURRAY RIVER WATER RESERVE
18 WAROONA
19 SAMSON
20 BODDINGTON
21 MURRAY
22 LOGUE BROOK
23 STIRLING
24 HARVEY
25 COLLIE RIVER
26 WELLINGTON
27 GLEN MERVYN

PIPELINES

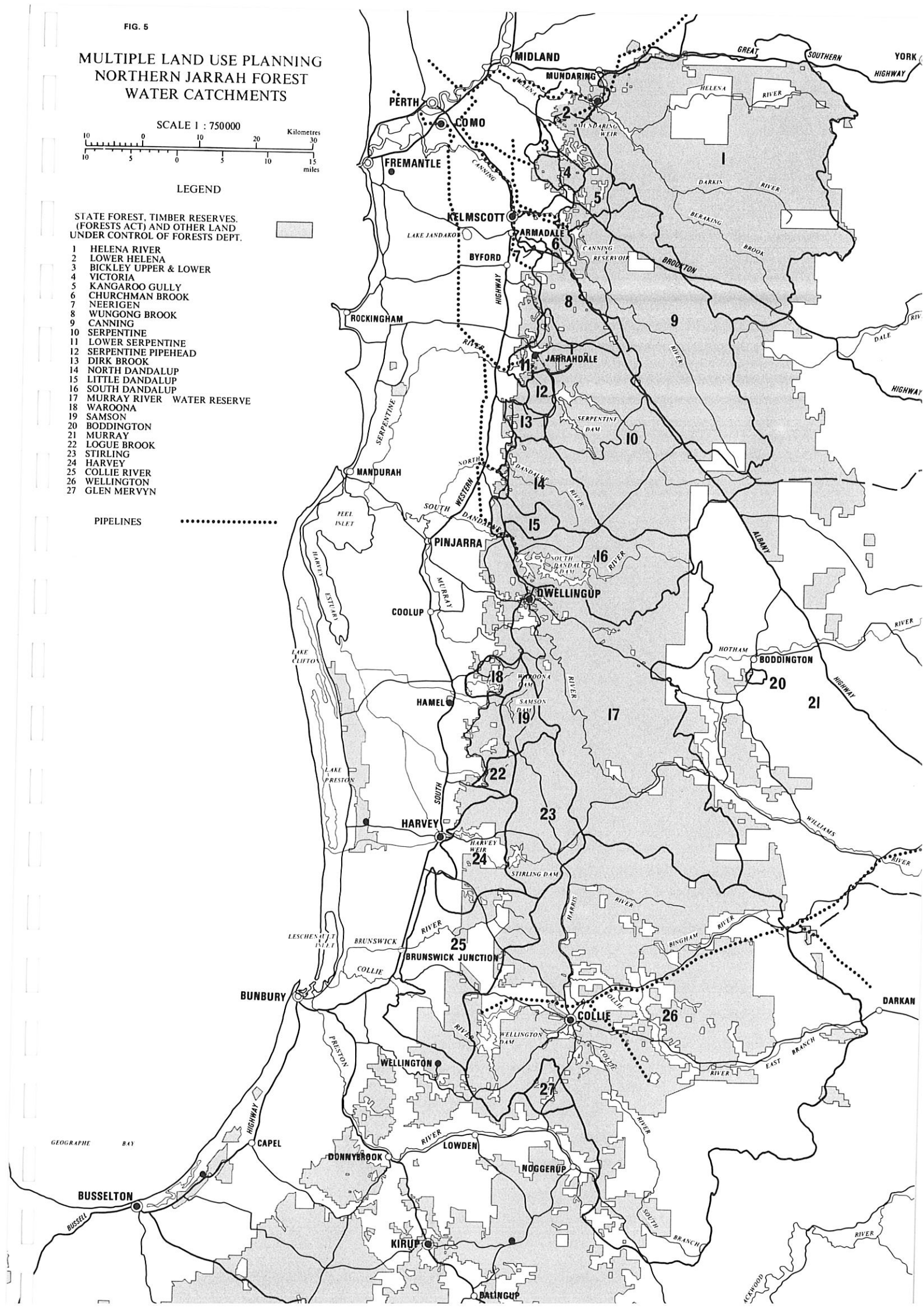


FIG. 6

MULTIPLE LAND USE PLANNING NORTHERN JARRAH FOREST MINING

SCALE 1 : 750000

Kilometres 10 0 10 20 30

miles 10 5 0 5 10 15

LEGEND

STATE FOREST, TIMBER RESERVES, (FORESTS ACT) AND OTHER LAND UNDER CONTROL OF FORESTS DEPT.

MINERAL CLAIMS OVER STATE FOREST AS AT 21-8-76

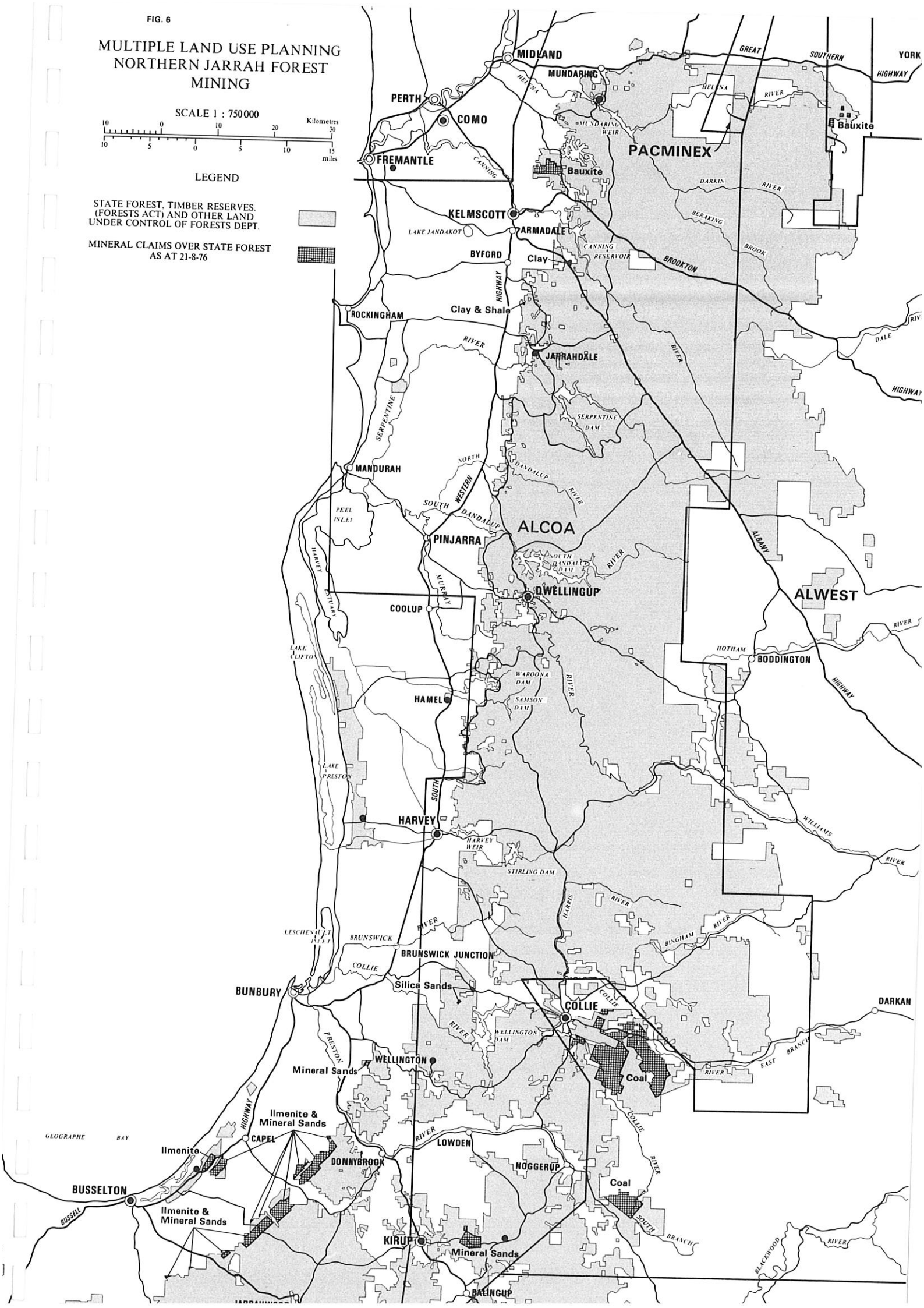


FIG. 7

MULTIPLE LAND USE PLANNING
NORTHERN JARRAH FOREST
JARRAH DIEBACK QUARANTINE AREAS

SCALE 1 : 750000

Kilometres 10 0 10 20 30

miles 10 5 0 5 10 15

LEGEND

STATE FOREST, TIMBER RESERVES, (FORESTS ACT) AND OTHER LAND UNDER CONTROL OF FORESTS DEPT.

QUARANTINE AREA

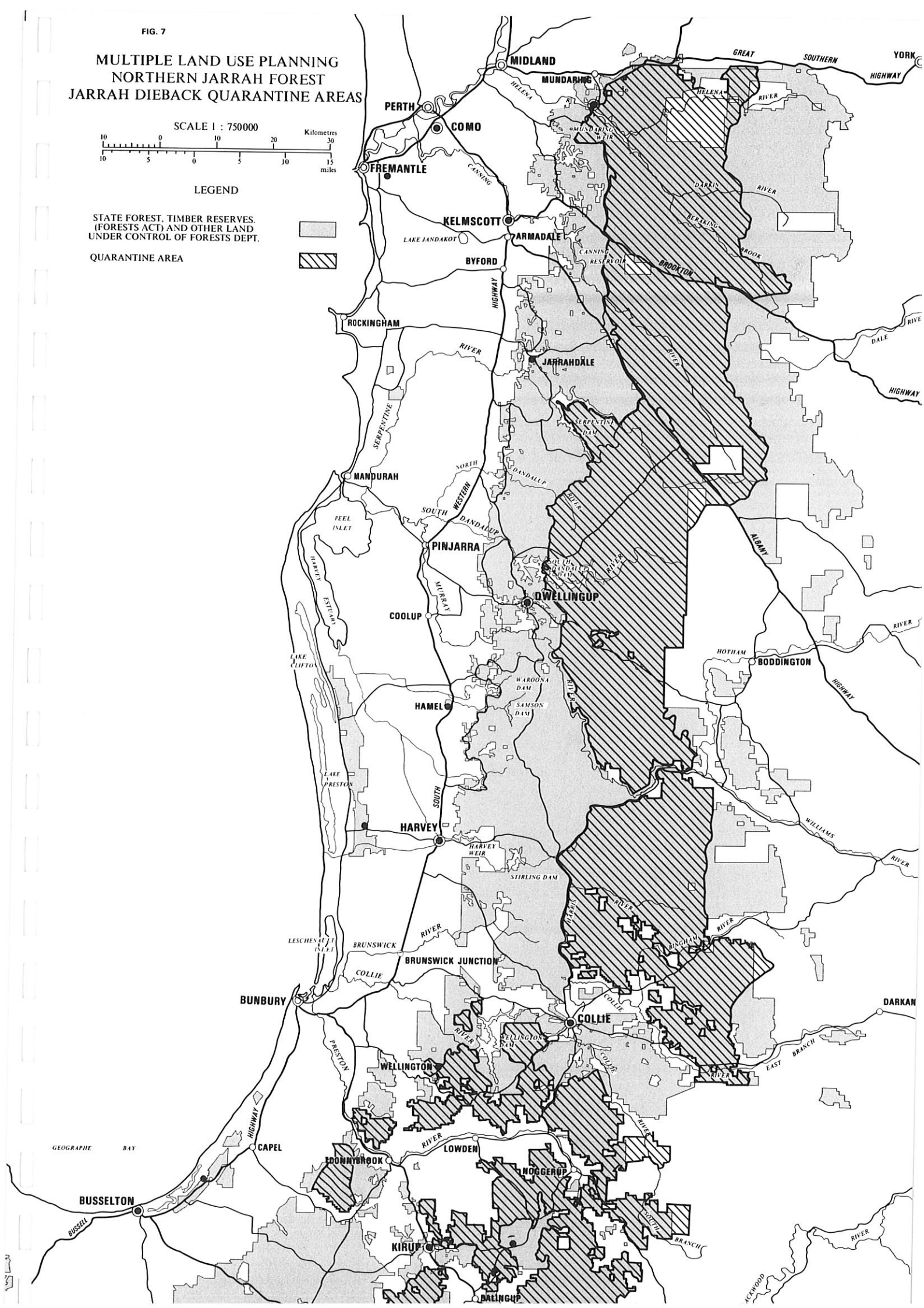


FIG. 8

MULTIPLE LAND USE PLANNING NORTHERN JARRAH FOREST COMMUNICATIONS

SCALE 1 : 750000

Kilometres 10 0 10 20 30

10 5 0 5 10 15 miles

LEGEND

STATE FOREST, TIMBER RESERVES. (FORESTS ACT) AND OTHER LAND UNDER CONTROL OF FORESTS DEPT.

RAILWAYS

PROPOSED ALWEST RAILWAY.

ALCOA CONVEYOR ROUTE.

LANDING GROUNDS.

TRANSMISSION LINES.

PROPOSED TRANSMISSION LINES.

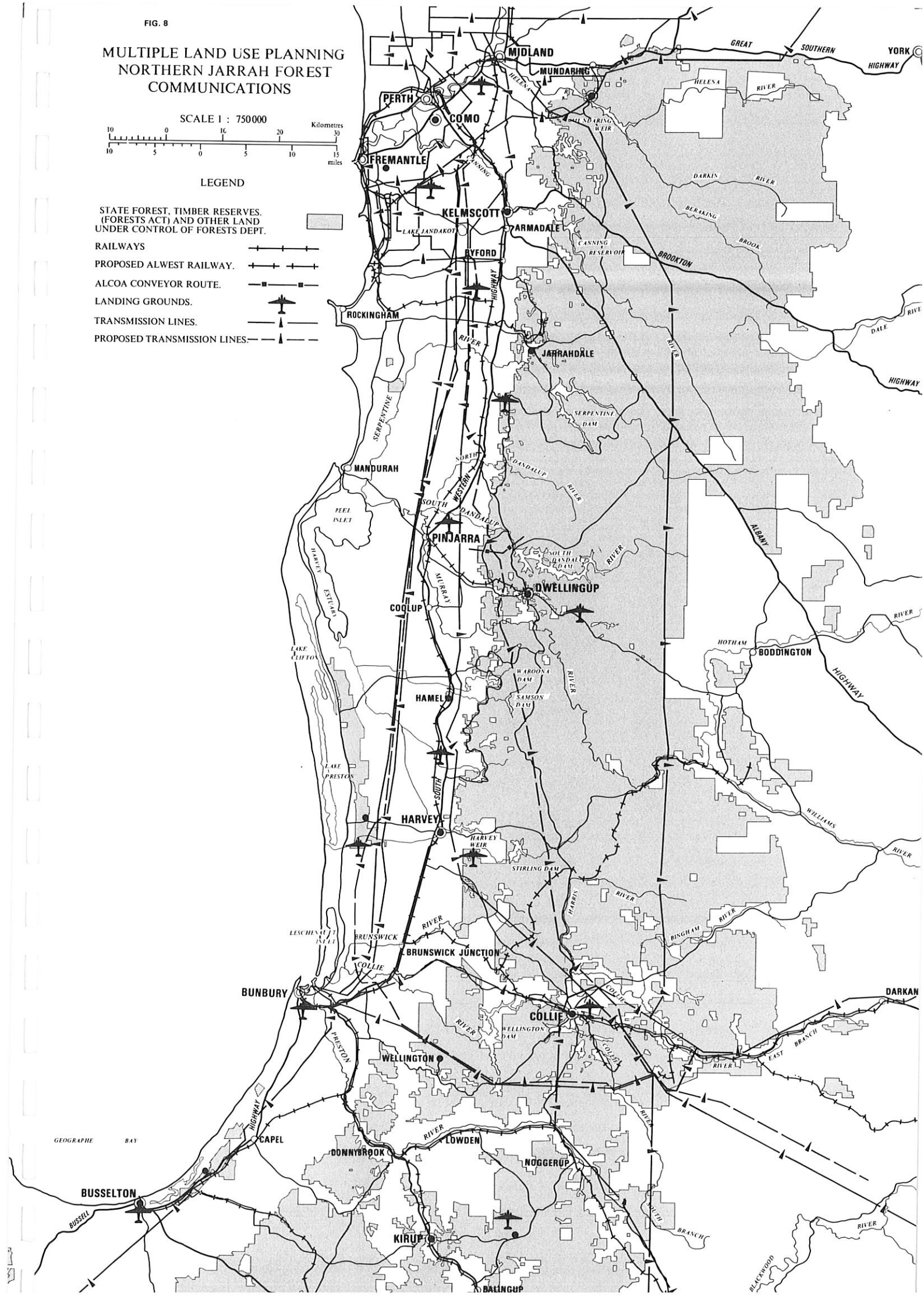


FIG. 9

MULTIPLE LAND USE PLANNING NORTHERN JARRAH FOREST MANAGEMENT CATEGORIES

SCALE 1 : 750000

Kilometres 10 0 10 20 30

10 5 0 5 10 15 miles

LEGEND

- COASTAL PLAINS
- STATE FOREST, TIMBER RESERVES, (FORESTS ACT) AND OTHER LAND UNDER CONTROL OF FORESTS DEPT.
- NATIONAL PARKS
- PINE PLANTATIONS

STUDY AREA

- ISOHYETS
- MONADNOCKS
- DISSECTED RIVER VALLEYS
- BROAD VALLEYS & DEPRESSIONS
- LATERITIC UPLANDS

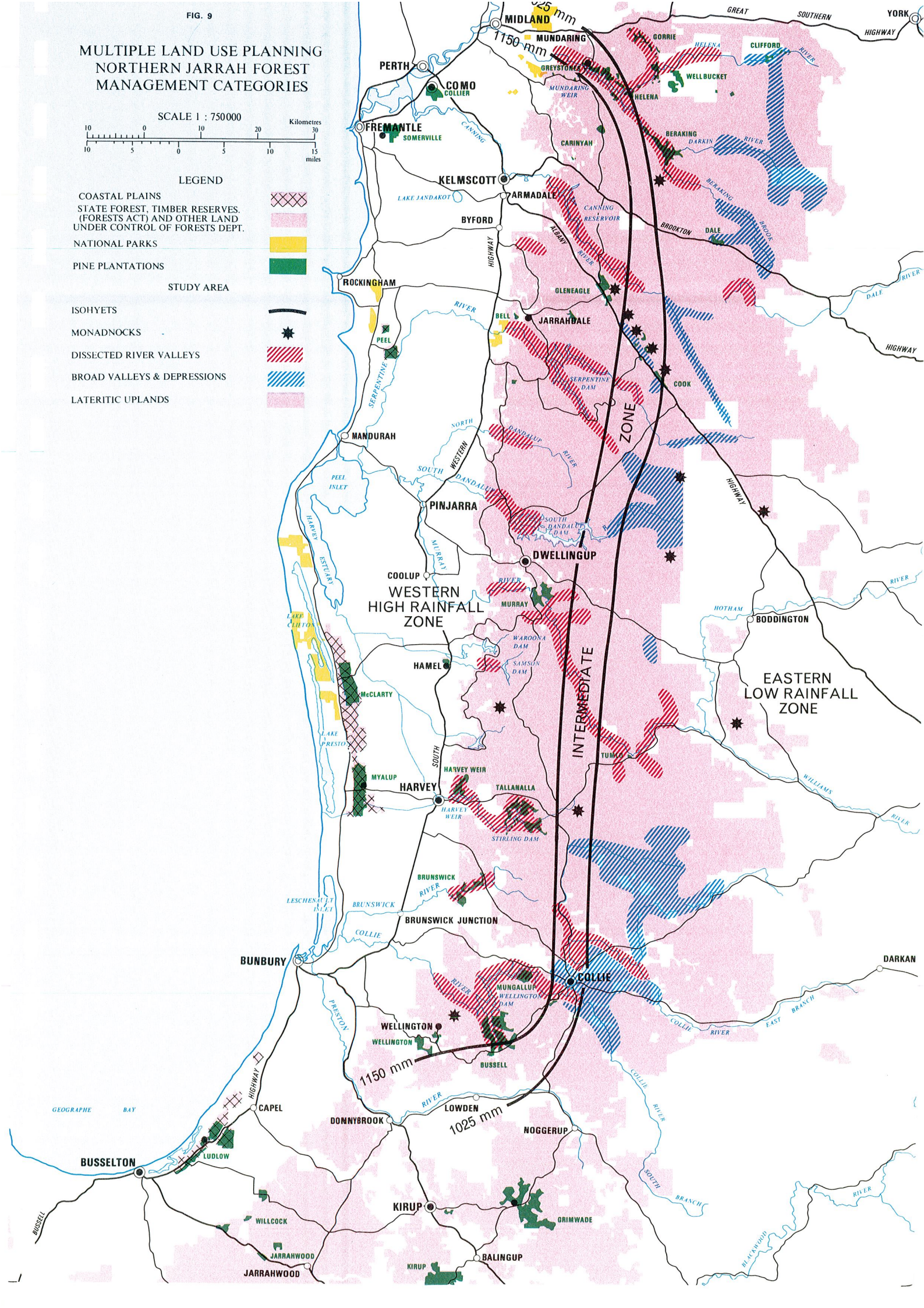


FIG. 10

MULTIPLE LAND USE PLANNING
DWELLINGUP DIVISION

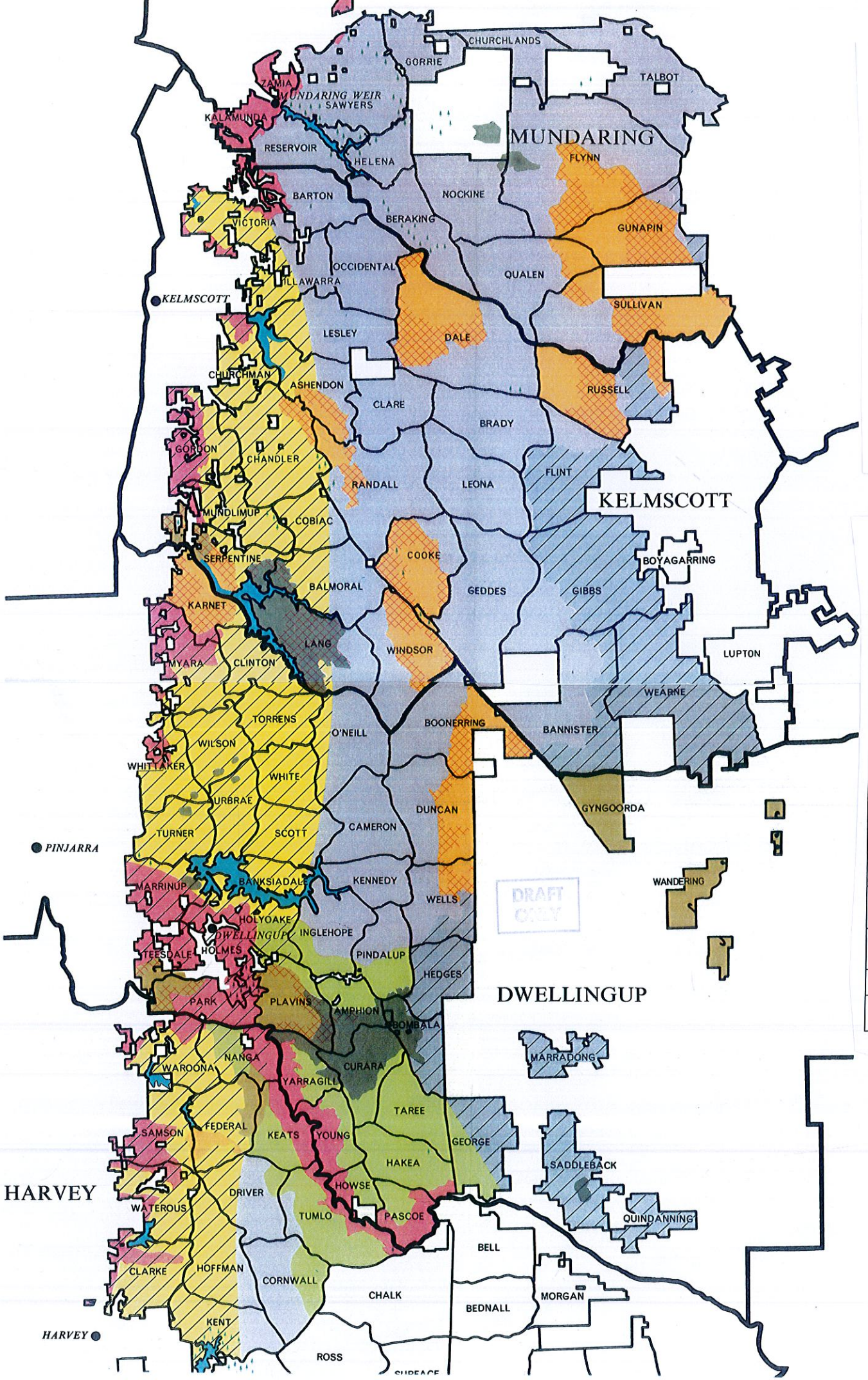
0 5 10 15 Kilometres
0 5 10 miles

VEGETATION

- SCARP TYPE
- MURRAY VALLEY (WESTERN) TYPE
- MURRAY VALLEY (EASTERN) TYPE
- LATERITIC PLATEAUX (WESTERN) TYPE
- LATERITIC PLATEAUX (INTERMEDIATE) TYPE
- LATERITIC PLATEAUX (EASTERN) TYPE
- SWAMP & BROAD VALLEY TYPE
- MONADNOCK TYPE
- EASTERN FOREST TYPE

JARRAHDALE
HIGHWAY
WESTERN
SOUTH
ORTH
IDALUP
PIPEHEAD DAM
SERPENTINE DAM
MT. COOKE
MT. SOLUS
SERPENTINE
ALBANY
HIGHWAY
RIVER
NORTH BANNISTER
WANDERING RD.
ALBANY
BANNISTER HILL
HIGHWAY
BANNISTER
BODDINGTON
MARRADONG
RIVER
DEL PARK
ROAD
NORTH EAST ROAD
SOUTH DANDALUP DAM
ROAD
DWELLINGUP
MT. WELLS
MARRADONG ROAD
INGLEHOPE
NANGA
ROAD
WAROONA DAM
MURRAY RIVER
NANGA
MT. KEATS
TUMLO HILL
MURRAY RIVER
QUINDANNING ROAD
HOTHAM
GEORGE TOWER
MT. SADDLEBACK

BOUNDARY OF STATE FOREST
(INCLUDES SOME LAND NOT UNDER THE CONTROL OF THE FORESTS DEPARTMENT)



MULTIPLE LAND USE PLANNING NORTHERN JARRAH FOREST MANAGEMENT PRIORITY AREAS

LEGEND FOR PRIMARY LAND USES

- CONSERVATION OF FLORA & FAUNA MPA
- BUFFER ZONE FOR CONS OF FLORA & FAUNA MP
- CONSERVATION OF FLORA & FAUNA MPA CATCHMENT PROTECTION MPA
- BUFFER ZONE FOR CONS OF FLORA & FAUNA & CATCHMENT PROTECTION MPA
- SCIENTIFIC MPA
- BUFFER ZONE FOR SCIENTIFIC MPA
- CATCHMENT PROTECTION MPA
- WATER PRODUCTION MPA
- RECREATION MPA
- TIMBER PRODUCTION MPA
- CATCHMENT PROTECTION MPA TIMBER PRODUCTION MPA
- BAUXITE MINING - (Least impact on catchments)
- RESERVOIRS
- PINE PLANTATIONS

SCALE 1: 250 000

5 0 5 10 kms

N

TABLE 2 **ALLOCATION OF OTHER USES TO MANAGEMENT PRIORITY AREAS**

MANAGEMENT PRIORITY	SECONDARY USES	TERTIARY USES*	INCOMPATIBLE USES
Conservation M.P.A.	Catchment Protection Scientific Study	Recreation Timber salvage and regeneration Honey production	All activities which alter structure or composition of the forest or introduce dieback disease.
Conservation / Catchment protection } M.P.A.	as above	as above	as above
Catchment protection M.P.A.	Conservation of flora and fauna Scientific study Honey production Wildflower management	Recreation Timber production Bauxite mining Communication lines	All activities which introduce dieback disease, remove native cover without the provision of successful regeneration or increase the risk of erosion and pollution.
Water production M.P.A.	Catchment protection Timber production Bauxite mining Scientific study Communication lines Wildflower management	Recreation Conservation of flora and fauna Honey production	All activities which restore a dense deep rooted vegetative cover throughout the area or increase risk of erosion, siltation chemical or biological pollution.
Recreation M.P.A.	Conservation of flora and fauna Honey production Catchment protection Scientific study Wildflower management	Timber production Bauxite mining Communication lines	All activities which permanently destroy the aesthetic appeal of the landscape or require the cessation of recreational activities.
Timber production M.P.A.	Catchment protection Conservation of flora and fauna Recreation Scientific study Wildflower management Honey production	Communication lines	All activities which permanently destroy the productive capacity of the forest.
Timber Production / Catchment Protection } M.P.A.	as above	as above	as above
Scientific Study M.P.A.	Catchment Protection Timber production Bauxite mining Wildflower management	Recreation Conservation of flora and fauna Honey production Communication lines	All activities detrimental to the scientific objectives of the study.
Pine Plantations	Catchment Protection Scientific study	Recreation Communication lines	All activities which endanger the plantation especially those which could increase the frequency of fire.
Water Storage (domestic)	nil	nil	All activities detrimental to water quality.
Water Storage (irrigation)	Recreation e.g. fishing picnics	Recreation e.g. power boating water skiing camping	All activities which cause serious erosion to banks or damage to engineering structures.

* Tertiary uses may be permitted but only as long as there will be no significant harm to the primary use.