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AFFORESTATION WITH PINES IN THE DONNYBROOK SUNKLAND

STATEMENT OF INTENT

MARCH 1975

FORESTS DEPARTMENT OF WESTERN AUSTRALIA

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AFFORESTATION WITH PINES IN THE

DONNYBROOK SUNKLAND

STATEMENT OF INTENT

Forests Department
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Barrack Street
PERTH W.A.

Dieback affected forest, Canebreak Road.

Pinus radiata, $3\frac{1}{2}$ years old, in a diseased area, Canebreak Road.

Tea tree flat, Margaret Road. These wet sites will not be planted.

Blackwood River - to be reserved for recreation.

Unaffected jarrah forest near Blackwood River. Part of the recreation reserve. Not to be planted.

Canoeists on the Blackwood River.

AFFORESTATION WITH PINES IN THE DONNYBROOK SUNKLAND

STATEMENT OF INTENT

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SUMMARY

The project envisages the conversion of some 60,000 hectares of degraded dieback-infected native forest into pine plantations over a period of 30 years.

The additional softwood area is required to provide the resource base for current industrial developments and to ensure that the major proportion of the State's timber requirements will be met from local sources by 2000.

The area selected is scenically unattractive, has few special biological features or other major attractions and is the main additional area available for large scale planting. Broad swathes ~~swales~~ of native forest will be retained, separating the plantations which will occupy about 20 per cent of the total area. Planting will proceed in two or more localities simultaneously.

The effects of the project on major environmental factors are considered to be:

1. Hydrology

   Little effect on surface hydrology in view of the relatively free underlying sediments. Restoration of tree cover is likely to be beneficial in offsetting the present and anticipated destruction of native vegetation by dieback.

   Silvicultural techniques already developed at Wanneroo are directly applicable with management of underground water supplies.

2. Vegetation

   Based on extensive surveys, the native flora contains little of special significance, except in the Whicher Ranges where a substantial area will be excluded from the project. The vegetation types scheduled for conversion will continue to be represented in the hardwood buffer areas and two other areas are to be set aside for special management for flora protection.

3. Fauna

   Field surveys indicate a similar situation and similar proposals apply.

4. Recreation

   Except for the valley of the Blackwood River and perhaps the Whicher Ranges to a lesser extent, the area is of little recreational interest. Adequate areas are to be set aside in these localities to protect such recreational values as occur.

5. Scenic

Recreation is closely allied to scenery and similar comments apply. Variety will be added to an otherwise monotonous landscape by the proposed project and special treatment will be given to protection of scenic values in minor localities as the project develops.

The project is considered to have little adverse effects on environmental factors and its hydrological effects could in fact be advantageous.

Substantial social and economic benefits are foreseen as follows:

1. Initial stabilisation of the local forestry workforce followed by a substantial expansion within the next 5 years creating potential for seasonal employment in the local agricultural workforce.

2. Possible combination of stock agistment with plantation establishment to both silvicultural and agricultural advantage.

3. Consolidation of the resource base for existing and currently planned industry on a fully integrated and decentralised basis.

INTRODUCTION

The Forests Department is proposing to establish extensive pine plantations in selected portions of State Forest in the area known as the Donnybrook Sunkland. The following statement has been prepared to explain, in some detail, the proposed plantation development, the environmental implications of the project and the precautions being taken to prevent any deleterious effects.

The need to supplement the indigenous hardwood timber supplies with local plantation grown softwood in Western Australia has been outlined in a submission to a House of Representatives Standing Committee on Environment and Conservation. Basically the reason for a continued pine planting programme is to provide the ongoing resource base for current industrial development and provide for the timber requirements of future populations of this State. It is imperative that the timber production demand on the State's limited eucalypt forests be reduced and it is extremely unlikely that a sufficient, reliable supply of timber products will be available from external sources in the future.

The limited area of land, suitable for pine planting, available to the Forests Department, has been a major restriction on the pine planting programme. The Department's policy has been to use repurchased farmland as far as possible rather than convert high quality native forest to pines, but the possibilities of repurchasing any further significant areas of suitable farmland are remote. Few properties are being offered for sale and the prices asked have become unrealistically high. The situation is critical in that in order to maintain a Pinus radiata planting programme beyond 1980 the Forests Department must either purchase a great deal more farmland at these inflated prices or proceed with conversion of poor quality native forest.

The large area of poor quality forest between Nannup and Busselton, known as the Donnybrook Sunkland, has been shown, by trial and experiment, to be suitable for commercial pine production under appropriate nutritional regimes. This forest is badly degraded by jarrah dieback and a large proportion will inevitably be killed by this disease. Intensive research has shown that Pinus radiata can be grown successfully on selected sites here, even where the original forest has been killed by the root rot fungus Phytophthora.

There are no other large areas of proven, suitable soil with adequate rainfall available to the Department for planting Pinus radiata. The Forests Department has considered the environmental aspects of the conversion to pine plantation of some 60,000 ha out of the total Sunkland area of 283,000 ha and can see no valid reasons against the proposal on these grounds. The present state of the Department's knowledge and the reasoning on these aspects are set out and discussed in the ensuing chapters of this document.

The greater part of the area (approx. 80%) will be retained as natural forest and managed with multiple-use objectives. Planting will be in a number of cells containing much of the country worst affected by dieback and separated by broad swathes of native forest.

The vegetative types to be converted to plantations will continue to be adequately represented as it is not intended to convert the full extent of suitable soils into plantations. Areas of special value of interest, such as those of ecological, water supply or recreational import, will be demarcated and covered by special management priority plans to ensure the protection and preservation of those particular values.

From the social viewpoint, the project will stabilise the existing departmental work forces at Nannup, Margaret River and Ludlow until 1978, after which a substantial expansion can be anticipated, either in the form of direct employment or of employment on a seasonal contract basis, to which the predominantly agricultural local work force is ideally suited.

From the economic viewpoint, the project offers the advantages of cheaper establishment and maintenance than on repurchased land in the nearby Blackwood Valley, even if such land were available.

Favourable topography and geographic concentration will consolidate a highly economic large scale integrated processing industry in the locality, thus fostering the process of decentralisation.

1. GENERAL DESCRIPTION OF THE SUNKLAND

1.1 Location

The area generally referred to as "the Sunkland" is a tract of forest south of Busselton and west of Nannup, some 240 km south of Perth (see Locality Plan, Plan No.1). The nearest major town is Busselton (population 7,600) while a developing regional centre, Bunbury (pop. 20,000) is only about 48 km further to the north. Other smaller towns in the locality are Margaret River (800), Donnybrook (1000) and Nannup (200).

To the north the Sunkland is bounded by the intensively developed coastal plain, the scene of a large dairy and beef cattle grazing industry. To the west and south there is a large area of partly developed sheep and cattle grazing country around Cowaramup, Margaret River, Augusta and Scott River. On the east the Sunkland is bounded by well developed grazing country in the Upper Capel, Cundinup and Nannup districts, by existing Forests Department plantations around Nannup and by high quality State Forest east of the Vasse Highway.

The area is traversed in part by the Busselton-Nannup railway and by the Vasse and Brockman Highways.

1.2 Tenure

The Sunkland is a large compact block comprising mainly State Forest with some relatively small areas of Timber Reserve and vacant Crown Land (see Tenure Plan, Plan No.2). Narrow strips of private property have been developed for agriculture along the Blackwood River and St. John's Brook. Along the northern edge of the Sunkland several mineral claims are held by companies mining heavy minerals (ilmenite, zircon) near Capel.

1.3 Area

The total area of public land in the block referred to as the Sunkland is approximately 283,000 ha, composed of:-

State Forest	258,000 ha
Timber Reserve	12,500 ha
Crown Land	12,500 ha
Total	283,000 ha

2. ENVIRONMENTAL DATA

2.1 Climate

This part of Western Australia has a typically Mediterranean type of climate with hot, dry summers and cool, wet winters. The average annual rainfall in the Sunkland is about 1150 m.m falling on 120-150 days of the year. Rainfall isohyets on Plan No.1 (source; Weather and Climate in Western Australia by J. Gentilli) show a marked trend for increasing rainfall from the north to the south. The rainfall is very reliable and, being derived mainly from frontal activity, the rain is rarely of high intensity. Temperatures are moderate; the mean daily maximum at Bunbury ranging from 28 degrees C in February to 16 degrees C in July, with frosts a rarity except in some low-lying areas.

With a growing season of eight months this climate is ideally suited to the growth of Pinus radiata (Ref. Comm. Met. Bureau Climatic Survey. Region 16. South West Western Australia).

2.2 Geology and Land Forms

As its name implies the Sunkland lies between two north-south geological faults as shown on the locality plan - (See Plan No.1). These are the Darling Fault, coinciding with the Darling Scarp, and the Dunsborough Fault which runs from Dunsborough to Augusta. The Sunkland is a low undulating plateau 100 to 180 metres above sea level with a general slope from east to west and from north to south. It is composed mainly of mesozoic sediments up to 3,000 metres in thickness, lying between the Precambrian granites east of the Darling Fault and the granitic gneiss of the Leeuwin-Naturalist Ridge. The only surface occurrences of igneous rock in the Sunkland are occasional outcrops of Bunbury basalt. (Refer. Geological Surveys. Geology of the Southern Perth Basin by D.C. Lowry - Record No. 1965/17).

The area is dissected by the westward flowing Blackwood River and by three smaller rivers flowing north and west. The Ludlow and Sabina Rivers are ephemeral streams flowing only through the winter and spring. The Margaret River flows for a longer period.

In the south towards the coast the country is low lying and swampy. The swamps are thought to have formed through the blocking of drainage lines by coastal dunes.

2.3 Hydrology

The water resource in this region is considerable and will undoubtedly be utilised in the future.

At present the only major utilisation of water from the area is the water supply for Margaret River township from a dam on the Margaret River. All the streams

rising in the Sunkland are fresh including the tributaries of the Blackwood, Rosa Brook and St. John's Brook. The Blackwood River itself which rises in agricultural areas to the east is of high salinity.

Underground water is the major water resource in the Sunkland. The upper sections of the sedimentary strata contain very large quantities of potable water. The re-charge rate of these aquifers has been estimated by the W.A. Geological Survey to be 300,000 m3 per day. (Refer. D.B. Collett. Water Resources of the South West of W.A.)

2.4 Soils

The sediments of the Sunkland are capped by laterites and sand. The typical pattern is for the ridge tops to be composed of sandy lateritic gravels with a variable amount of massive ironstone. Broad depressions even in the higher country are generally filled with sand of varying depth over the laterite. Downslope the soils are sandy at the surface often becoming heavier in texture at depth. The lowest country is generally poorly drained and waterlogged for much of the year. The outstanding characteristic of the soils of the Sunkland is their extremely poor natural fertility.

More detailed descriptions and discussion of soil types is given in the section, 4.1, dealing with site mapping.

2.5 Vegetation

2.5.1 Forest types

The predominant forest type in the Sunkland is open jarrah (E. marginata) forest of poor quality. In general, marri (E. calophylla) is a minor component of the forest, although it does become more important on the more favoured sites in the valleys, especially along the Blackwood River. The few, small areas of high quality forest are confined to occasional outcrops of "Bunbury basalt". The largest such areas are in Canebreak and Milyeannup Blocks south of the Blackwood.

2.5.2 Survey and Mapping

The entire area is covered by Forests Department vegetation type maps compiled from air photos. Most of the area has been more recently mapped on a broader scale by F.G. Smith (W.A. Department of Agriculture: Vegetation Map Busselton, Augusta 1973).

Smith (Plan 11) has mapped the vegetation of a large section of the Sunkland on the basis of structural criteria of the tallest stratum such as life-form, height and density. He has classified the majority of the area as type B2, open forest with trees 10-30 m in height, with minor areas of B1 (closed forest 10-30m), F1 (closed sedgeland) D2 (open scrub over 2m in height, characterised by Kingia australis and a shrubby form of jarrah); C4 (low open woodland, trees less than 10m) and B3 (open woodland).

A detailed examination of the vegetation of the area is being undertaken in the site surveys currently in progress. A list of plant species known to occur in the Donnybrook Sunkland is appended as Appendix B 2.

2.5.3 Impact of Phytophthora cinnamomi

In the early 1950's the dieback disease Phytophthora cinnamomi made its appearance. The particular combination of highly susceptible vegetation, gentle topography and moist soils predispose the Sunkland to very rapid spread of the disease. At the present time 16 percent of the total area is affected (See Plan No.3).

Because of the extreme susceptibility of the Sunkland forest, it is inevitable that, even without any new infections, some 60 percent of the forest in this area will be wiped out by the irrevocable extension of these existing infections. (See Dieback Risk Plan, Plan No.4).

2.6 Fauna

Two intensive fauna surveys have been carried out in the region, covering all habitat types. These studies have shown that the Sunkland contains a typical assemblage of animals for jarrah forest of this type. There appears to be no unusual or rare animals. The only rare reptile found is Mueller's snake (Rhiniplocephalus bicolor).

A complete list of all fauna so far known to be present in the area and a summary of surveys is given in Appendix No.1.

3. LAND USE

3.1 Past Use

The Sunkland forest has been utilised since the early years of the century by the hardwood sawmilling industry, the generally small log size being offset by cheap extraction. Sawmills are still operating on the Sunkland forest, at Jarrahwood, Nannup, Witchcliffe and Busselton.

The Sunkland was unattractive to the early settlers who passed it by for more remote but more fertile land. Very little of it has been alienated for agriculture due no doubt to its obvious poor soil fertility. Almost the entire Sunkland area was traversed by land classification teams from the Lands Department in the period 1918-1930. However, alienation was not proceeded with, possibly because of the sad experiences at the time with the Group Settlement Scheme. Since 1950 the use of artificial fertilisers has made this type of land more attractive and there has been some pressure for alienation of public land in the region. However, there appears to be no real shortage of farming land in the region as evidenced by the fact that in the Margaret River-Augusta Shire 40% of the alienated land is still undeveloped.

The area contains no special features of geological or historical interest and very little of scenic value apart from the Blackwood River. The river has been used for many years for fishing for perch and the freshwater crayfish (marron) and in recent years there has been an upsurge in its use for canoeing. As it is the largest river in the south west corner of the State this activity is expected to increase in the future.

3.2 Future Use

The Department's proposals for multiple use management of the Sunkland forest are illustrated on Plan No.7. Careful consideration is being given in the planning to avoid adverse environmental effects and in fact to conserve and improve the quality of the environment.

Out of a total area of some 283,000 ha, about 60,000 ha (21%) will eventually be converted to pine plantation over a period of thirty years. Some 33,000 ha are to be set aside as special management priority areas for the preservation or development of particular features, e.g. recreation, special ecological types etc. The remaining 190,000 ha will be managed as natural hardwood forest although the depredations of dieback will undoubtedly necessitate some rehabilitation treatment, - probably replanting with disease-resistant hardwoods.

4. POTENTIAL FOR PINE PLANTING

4.1 Site Mapping

An essential prerequisite to pine plantation development is a careful survey to delineate suitable soil types. Since early 1971 an officer has been engaged full time on site survey programme basically concerned with soil types, but with a considerable research content, to determine to what extent native vegetation can be used as a rapid predictor of suitability of a site for pine.

This programme has enabled the Department to accumulate an extensive fund of data on vegetation types and their occurrence in the Sunkland. (Unpublished Department report).

Soils have been mapped so far for about half the area north of the Blackwood and it is anticipated that the field work for the whole of that area will be completed by autumn 1975. At that time it will be possible to delineate accurately plantation cell boundaries and other special purpose areas.

The soils have been classified into seven distinct types as listed below:

Type 1 - Lateritic soils. Ironstone boulders or gravel in a sandy matrix. Sometimes with massive ironstone sheets.

Type 2 - Shallow sands over gravel or boulders. Less than 50 cm depth to gravel.

Type 3 - Deep sandy soils of yellowish-brown colour.

Type 4 - Deep grey sands.

Type 5 - Soils with sandy loam or heavier texture, depth and colour variable.

Type 6 - Soils of heavy texture over gravel in clay.

Type 7 - Soils of moderately heavy texture and strong red colour, associated with drainage lines.

A mapping technique has been developed which combines aerial photograph interpretation and ground traversing by foot or vehicle. The photo interpretation is quite reliable for types 1, 2 and 7, while types 5 and 6 are mapped with fair reliability. Types 3 and 4 cannot be separated with confidence on the photographs except that the extreme phases of dryness and wetness on the grey sands is obvious from vegetation density. Ground traversing is therefore used to separate 3 and 4 and to provide a constant check on boundaries of the other types.

The Laterite soils (Type 1) comprising heavy gravels and ironstone are not considered suitable for planting with pine.

The deeper sands and sandy loams, i.e. Types 3, 4 and 5, are the most suitable soils for P. radiata.

The shallow sands, (Type 2) are less attractive and will require more intensive site preparation such as deep ripping.

Type 6 is a difficult site for pines due to heavy soil texture but it is anticipated that future research could overcome these problems if required. This type is of restricted occurrence north of the Blackwood River.

Type 7 soils, located along drainage lines are too wet for P. radiata without considerable drainage work. These sites are prime fauna refuges so it is unlikely they will ever be utilised for planting to any extent.

The distribution of the soil types is extremely variable. This is illustrated by Attachment 5 which is a sample of the soil plans on which plantation planning is based. The same plan is shown in Attachment 6 with the soil types amalgamated into plantable and unplantable types. It can be seen that it is impossible to set out the plantations on a rectangular grid basis. Whatever plantation layout is adopted the boundaries will inevitably be sinuous and there will always be islands of native forest scattered throughout the pines and along the drainage lines.

4.2 Pine Trial Plots

Small areas of P. radiata and P. pinaster, mainly the latter species, were planted at Willcock plantation in 1952-1954, but this development was not proceeded with due to lack of soil survey information and inadequate

nutritional research. Sufficient well grown pine remains to justify the belief that given proper site selection, site preparation and fertiliser treatment, P. radiata can be grown very satisfactorily in the Sunkland. P. radiata is considered the more desirable species because of its faster growth rate and greater productivity.

A number of small trial plots of pines was established in the Sunkland between 1954 and 1969 but, almost without exception, they consisted of P. pinaster only.

The first really comprehensive trial plot of P. radiata was planted in 1969 in a multispecies trial for the rehabilitation of a dieback-affected site. This plot received good site preparation and phosphate fertiliser and growth was exceptional from the start. This success prompted the current phase of systematic nutrition and establishment research aimed at providing techniques for planting P. radiata on as wide a range of sites as possible in the Sunkland.

Plantings in 1970, 71 and 72 extended the plots to cover all major soil types in the Sunkland except Type 1. The total area of plots established now stands at some 120 ha. The new series of plots contains at least 100 ha of P. radiata, the remainder being P. pinaster P. taeda, P. elliottii var elliottii, P. muricata and P. caribea.

4.3 Results of Experimental Work

On all recent plots the early growth of P. radiata is extremely good. Initial survival is very high, never less than 95 per cent and there are very few problems from scrub competition. It is anticipated that large scale pine planting in this area will require very little, if any chemical weedicide for control of weed competition.

Recent research can be summarised as follows:-

(a) Thorough site preparation is essential and some drainage works will be required on most sites.

(b) In the early years (say up to age 5) phosphorus is the principal deficient major nutrient. A spot application of 100 gm superphosphate per tree is required at planting and it is likely that two more broadcast applications will be necessary during a rotation, probably about 200kg/ha at age 3 and the same amount again at age 8-10. Thereafter the normal nutrient recycling pattern is likely to provide sufficient phosphate for the requirements of the crop.

(c) Most soils in the Sunkland are critically deficient in zinc and marginal with respect to manganese and copper. Some areas of high organic content are also critically deficient in copper. At this stage no other minor element seems likely to influence pine growth.

(d) These minor element deficiencies are readily cured by a foliar application of the sulphate salts of all three elements in water.

All trial plots have been located on dieback diseased sites to evaluate any possible impact of the disease on the pine. It is known that P. radiata is susceptible to Phytophthora cinnamomi up to about age 3 and beyond age 30 in the open-grown situation. Observation in the last three years suggests that the disease may possibly kill a handful of pines in the first two years after planting but the incidence of deaths decreases with increasing age until at age four years none are lost. The place of dieback disease in relation to pine is kept under constant observation but it is most unlikely it will ever be a serious problem. The growth and development in the 1969-1972 trial plots shows that the early growth of P. radiata (7.5 metres in 5 years) is very satisfactory.

Under the favourable moisture regime in the Sunkland it is confidently expected that growth rates beyond this age will be equivalent to the overall average for P. radiata in Western Australia.

5. DEVELOPMENT PLANS

5.1 Preliminary Broadscale Planning

Broadscale planning envisages approximately one fifth of the Sunkland being planted to pines. The remainder will be left as natural forest, i.e. some 60,000 ha of pine plantation are proposed in a total area of 283,000 ha.

Pines will be established in a number of discrete "cells" ranging in size from 1,000 to 10,000 ha and separated from each other by at least two km of natural forest. Plan No.7 illustrates the distribution and extent of the plantation cell proposals.

5.2 Area retained as Natural Forest

The large and continuous areas of natural forest left unplanted will include the full range of ecological types in the Sunkland. This will receive similar management to jarrah forest elsewhere, with regular prescribed burning for fire protection. Some rehabilitation work will be required on dieback affected areas.

A number of Management Priority Areas have been defined. These are areas of special environmental significance and they will receive special attention to ensure the preservation or development of these special features. e.g.:-

(a) Recreation

The Blackwood River in its course across the Sunkland provides a most valuable recreation area. Because of its high salt content the river is unlikely to be dammed for water supply purposes and its use for recreation (i.e. canoeing, fishing etc.) will undoubtedly increase. A broad strip of land on either side of the river is to be set aside for recreational purposes (see also Plan No.7).

(b) Biological Reserve

The whole of Milyeannup Block (about 5,700 ha) is to be given special status to ensure that it remains an undisturbed "benchmark" area. It is one of the least disturbed parts of State Forest anywhere in W.A., having no interior roads at all. The only entry by vehicles to the interior was along a seismic survey line some years ago. This exploration activity is thought to be responsible for the only occurrences of dieback disease in the block. Most of it is believed to be protectable from the disease. There have been some small gravel pits opened along the Brockman Highway but these have been closed and a small pine plot along the southern boundary will not be extended.

Milyeannup is particularly well suited for preservation as a biological reserve as it contains a wide diversity of vegetation types from high quality jarrah forest to sedgeland.

(c) Forest Reserves

At least two forest reserves are planned. One, in the Whicher Range, had been selected to preserve a major occurrence of Eucalyptus haematoxylon. Recently the "Committee for Conservation through Reserves" has recommended the setting aside of a tract of country in the same area for conservation of Flora and Fauna. There is no intention that this interesting piece of forest should be converted to pines. In fact special care will be taken to ensure the protection of the natural vegetation here.

Another proposed forest reserve is a one kilometre strip on either side of St. John Brook downstream from the private property. This area carries some of the best quality natural forest in the Sunkland.

The approximate areas under each future land use category are as follows:-

		Hectares
Recreational Reserve	Blackwood River	20,000
Forest Reserve	Whicher-Bovell	6,000
	St. John Brook	1,300
Biological Reserve	Milyeannup	5,700
Pine Plantation		60,000
Hardwood Forest		190,000
	Total	283,000 ha

5.3 Plantation Cells

The plantation cells have been selected following soil and site survey. They consist mainly of plantable land, i.e. the deep sandy soils but there will be pockets of varying size of unplantable land within the cells. Similarly large areas of plantable types exist within the hardwood forest not planned for conversion to plantations. Attachments 5 and 6 are examples of the soil maps produced in the site survey. They show the very variable and complicated pattern of soil type distribution.

The development of each plantation cell will be carefully planned in advance. Using the soil plan as a basis, a sub-division plan is prepared showing proposals for the plantation layout as regards:-

(a) Area to be planted - by species
- by year of planting

(b) Road system

(c) Fire control proposals

An example of a subdivision plan is included as Attachment 11.

Some aspects of planning, shown on this plan are:-

(a) Areas of unsuitable soil left unplanted.

(b) Species other than P. radiata for special purposes:

e.g. 1. for fire control buffers:

2. to use soils considered doubtful for P. radiata.

(c) Fairly intensive roading system to provide access for fire control.

(d) Proposals for fuel reduced buffers for fire control.

(e) Any features requiring special treatment.

5.4 Planting Programme

As explained in the preamble, the Sunkland planting project is intended to make up the deficiency in this State's projected softwood requirements when repurchased private property in the Blackwood Valley is fully planted in about 1978 (The exact date is subject to minor change as small areas of private property are currently being obtained through exchange for isolated pockets of State Forest elsewhere). In a project of this nature it is not possible to begin a large planting programme overnight. It is necessary to phase in the programme gradually. In the present case some further large scale establishment trials to be undertaken aim at simplifying procedures and developing the most efficient establishment techniques.

The tentative planting programme is as follows:-

1975	-	80 ha
1976	-	120 ha
1977	-	200 ha
1978	-	500 ha
1979	-	1000 ha
1980/2000	-	2000 ha per year

Once the full level of planting has been achieved it is intended development will proceed in several cells at the one time, rather than being concentrated in one cell.

5.5 Economics of Pine Planting in the Sunkland

The light open forest of the Sunkland (often already degraded by Phytophthora) can be cleared and prepared for planting at a relatively low cost. The easy topography also helps in both establishment and management by allowing efficient use of machinery.

Current establishment costs on large scale trials in 1974 in the Sunkland are as follows:-

	$
Windrow and rootrake	70 per ha
Final clearing	45
Site preparation (double ploughing plus mound ploughing)	37
Planting	30
Initial fertiliser	15
Total	$197 per ha

This compares well with $240/ha for establishment in steeper country with heavier vegetation in areas to the east of the Darling Fault.

Because of the very thorough site preparation which is achieved by double ploughing, scrub regrowth is not expected to be a problem in the Sunkland and early pine growth is rapid. On the other hand the pines will need a continuing fertiliser regime: at least in the early years. The small quantities to be applied will have no effect on water quality. Apart from fertiliser costs other maintenance costs are expected to be lower than elsewhere because of the easy terrain and economies of scale.

The rates of growth achieved in trial plots up to five years of age suggest that the productivity of the Sunkland plantations will be at least as high as that achieved with P. radiata in other major plantation centres.

Without considering inflation (which would be expected to increase the money value of future returns,) benefit cost analysis shows that, on present day costs and returns, an average quality P. radiata plantation should return better than 7% compound interest on the investment. The economics of these proposed plantations are therefore considered to be very favourable.

It is not considered that the economics of converting the degraded Sunkland forest to pines needs to be compared to an alternative use for agriculture. Abundant, well located land alienated for agriculture is available to the west of the Sunkland forest for development in what promises to be the major State dairying venture. In certain of the pine cells it is planned to consider cattle grazing under leasehold, combined with pine growth. This would increase interim returns but requires further large scale research.

6. ENVIRONMENTAL IMPACT OF PINE PLANTING

6.1 Impact on Hydrology

The conversion of part of the Sunkland to pine plantation is unlikely to have any serious effect on the hydrology of the area. The current and future degrading effect of dieback in the region will decrease evapotranspiration and greatly alter water yield.

In the short term, clearing for pine planting is likely to produce an increase in runoff compared with that under healthy hardwood forest. As this pine crop grows its water useage will increase to the point where it matches or even exceeds that under native forest. Studies by the Forests Department in the Wanneroo area north of Perth have indicated it is possible to manipulate water yield by varying the silvicultural system within limits which still achieve the timber production goals set. For water management it may be desirable to manipulate stand density to maximise evapotranspiration on certain dieback intensive areas.

A more serious effect of changed catchment characteristics elsewhere in Western Australia is increased salinity following clearing or even a marked change in the forest cover. To test for this possibility, extensive monitoring of the salinity levels of most major streams in the Sunkland has been going on for over 12 months. A considerable amount of data has been collected which indicates that the impact of dieback or conversion of native forest to pines in this area is unlikely to result in increased water salinity.

All the catchments sampled have been outlined in Plan No.8. Each sample point has been shown with its number and the crude mean total soluble salts (TSS) content for the whole period since sampling began. The length of sample period varies from eight to twelve months.

These means are considered to be adequate for comparative purposes, although the hydrological information would be greatly improved by more complete flow data, which so far are only available from the P.W.D. flow meters on the Margaret and Ludlow Rivers.

In general, the data show that where a stream has its catchment entirely within the zone of sedimentary parent material, i.e. the Sunkland proper, TSS values are very low, of the order of 150-200 mg/litre. As soon as a catchment extends onto the Precambrian shield to the east the TSS values rise appreciably to about 500 mg/litre. The latter areas, are partly developed for farming and subject to permanent clearing. They show an increase in water salinity following the removal of forest cover similar to that found in certain sections of the northern catchment areas.

This is a good illustration of the importance of the soil parent material in determining whether there will be a salinity problem. On the Precambrian granite shield the dominant soil type is the classical lateritic profile of gravel and ironstone overlying a deep zone of Kaolin clay. It is the "pallid zone" clay which contains the salt and any increase in throughflow of water due to agricultural clearing brings about removal of salt into the groundwater. The sedimentary Sunkland area does not have this deep zone of clay formed in situ. Observation suggests also that the forest in the Sunkland does not play the same role in regulating runoff as it does on the main plateau. The water table is generally very much closer to the surface so that the trees have very much shallower root systems.

Rehabilitation of dieback areas with pines will minimise any likely deleterious effect on water quality associated with rises in water table due to destruction of native vegetation by dieback.

Data from sample point 2, located in a small catchment which is 90 percent cleared and converted to pines indicates there has been no increase in salinity compared with the adjacent uncleared catchment (see Appendix No.4). In view of the low salt levels in the underlying sediments it is expected this evaluation will also apply in the case of larger areas being converted to pine.

Much of the Margaret River catchment is severely affected by dieback disease and has been heavily cut over to salvage millable timber. This has not adversely affected water quality. Salinity levels now are on a par with other streams in the Sunkland which have had only slight disturbance. Plan No.9 shows the catchment area in relation to disease-affected forest and the position of the sampling points. The results of the weekly water samplings for the last 12 months are given in Appendix No.3 for each of the six sample points in the catchment. Base flow figures are generally in the range 200-250 mc/litre which is quite satisfactory.

Underground water is the major water resource in the area. It is probable that exploitation of these underground supplies will provide the cheapest and greatest yield of water in the future. Current research and limited experience with bores tapping aquifers in the Wanneroo area suggest the pine planting project is compatible with this activity.

6.2 Impact on Vegetation

In Section 5.2 (c) it is shown that vegetative disturbance for pine planting will be restricted to approximately 20 percent of the Sunkland area and largely comprises the area most susceptible to dieback.

In the plantation cells, the overstorey will be removed and many of the understorey species will either be removed or much reduced in extent. However, a change almost as great as this is inevitable due to the activity of Phytophthora cinnamomi which is a dominant factor of the environment in the area.

Certain sites such as the lateritic ridges, and the wet flats and the riparian segments will be more or less untouched by the planting project. Apart from the buffer areas between the cells, other areas such as the more dissected country in the northern part of the Sunkland will be avoided because the proportion of plantable soils is too low to justify plantation development and they could have useful amenity value.

Part of the plantation area is likely to be managed on a pines with pasture regime with livestock grazing on an agistment basis.

6.3 Impact on Fauna

Changes to vegetation within the 20 percent to be gradually converted to pines will undoubtedly affect some fauna. The larger macropods are likely to be favoured by the pine planting project. Some smaller marsupials such as the quokka are likely to be little affected since their prime habitat will not be changed. Others, such as the honey possum might also be affected. These are not rare species and will be adequately catered for in the very large undeveloped areas and in the forest areas south of the Blackwood.

It is difficult to estimate what effect the project might have on the bird population. Some birds, such as ducks will no doubt be favoured by the water storages which will be developed for firefighting purposes; others such as honeyeaters will lose part of their food source. Some species will be favoured by the extensive forest edge situation which the plantation will create. Possibly the richest bird population is found in the dry Kingia-jarrah shrubby flats (Smith's type D4 high open shrubland), which appear unsuitable for pine planting.

6.4 Impact on Recreation

Recreation in the area is focussed on the main water courses and is generally seasonal in character. In winter and spring the Blackwood River is much used by canoeists. Due to the paucity of large rivers in the south west this activity will probably increase in the future. A broad strip of land on both sides of the river where it runs through State Forest has been set aside for recreational purposes.

In summer, pools on the main watercourses are used for fishing for the freshwater crayfish (Cheraps tenuimanus - marron). The increased roading associated with pine planting might mean the marron population would be more intensively fished. No other direct detrimental effect is foreseen. Swimming in permanent pools such as Barrabup Pool will continue.

The only other recreation, apart from some illegal kangaroo shooting, is some wildflower viewing along main roads in spring. Since the plantation cells intrude on main through roads only in a very minor way this activity will not be reduced to any significant extent.

Apart from along the watercourses, the jarrah forest of the Sunkland is rather monotonous and unattractive aesthetically. Any person viewing the depradations of dieback within this situation must agree that the variety added by well-sited and well-managed pine plantations can only improve the future aesthetic appeal of the area.

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APPENDIX I

FAUNA SURVEY DATA

(i) February 1974

(ii) October 1974

(iii) Fauna List

Whicher

Margaret Rd.

Crossing Rd

Great West Rd.

Lawson Rd.

McAtee Rd.

St. Johns Brook

Cambray

KEY TO SYMBOLS

Sealed Road
1st Class Road
2nd Class Road
3rd Class Road
Railway W.A.G.R.
Telephone Line
Powerline
Block Boundary
Land Districts Boundary
Private Property
Karri (Occurrence)

Forests Dept. Headquarters
Sawmill
Lookout Tower
Survey Reference Tree Theodolite
Survey Reference Tree Compass
Post Office
Leading Ramp
Permanent Water Supply
Permanent Water Supply Developed

OCTOBER 1974

TRAPPING LINES

SPOTLIGHT ROUTES

FEBRUARY 1974

1:126 720

Kilometres

Miles

INDEX TO ADJOINING SHEETS

BUSSELTON | KIRUP | AUGUSTA | MANJIMUP | PEMBERTON

B. J. BEGGS
CONSERVATOR OF FORESTS
AUGUST 1973

SUNKLANDS FAUNA SURVEY

(i) A PRELIMINARY STUDY OF FAUNA IN THE PROPOSED PINE PLANTING AREAS OF THE SUNKLANDS

by

P. SKINNER

April 1974

Research Branch
Forests Department
WESTERN AUSTRALIA

SUMMARY

A preliminary survey of areas to be planted with pine in the Sunklands region near Jarrahwood, carried out in February 1974, has indicated the presence of at least 8 indigenous and 6 introduced mammals and 50 species of birds. Elevan species of lizards, 2 of snakes, 3 of frogs and 4 of fish were also found.

Two areas were studied in some detail. One, recently burnt, was typical of lateritic soils containing good quality Jarrah. The second, unburnt for some time, contained poorer quality Jarrah interspersed with sandy flats. No previous fauna work had been carried out in either area by the Forests Department.

The indications from this short survey were that the diversity and density of mammal, bird and reptile species were apparently fairly normal for Jarrah forest. However these indications will need to be checked out by a further survey, both in the 2 areas covered and in the 3 areas not touched in this survey.

INTRODUCTION

The survey dealt with in this report was undertaken at the request of Pine Research Branch, during early February 1974, to provide preliminary information on fauna before more intensive studies are commenced. These studies are likely to be another survey before the start of pine planting, followed by monitoring surbeys during and after the areas conversion to pine.

The survey should be studied in conjunction with one carried out in Nannup pine plantations 2 weeks later. The comparison of species encountered in the two surveys has some relevance, though it should be emphasized that the Nannup pines were planted mainly on older cleared farmland. Thus a change in species present had already probably occurred before the pines were planted, because of the conversion to farmland.

The unpublished Research Branch Report, No. 22, Forests Commission, Victoria, and subsequent secondary statements, are extremely relevant to any study of flora and fauna in pine plantations.

THE STUDY AREAS

Within the proposed planting area are 5 sections to be planted, priorities 1, 2, 3, 4 and 5 respectively. The sections come within the B2 Open Forest area of the Vegetation Map (Busselton and Augusta region) of W.A., published by the W.A. Department of Agriculture. Priority 1 was shosen as an area typical of the lateritic, good quality Jarrah, with an open understorey of Banksia grandis and Persoonia longifolia. Priority 4 was chosen as an area of poorer quality Jarrah, or Jarrah/Marri mixture containing sandy flats, blackboy

swamps and patches of Banksia verticulata woodland. Ground cover in priority 4 was relatively heavy, with Dasypogon and monocote predominant.

Priority 1, recently burnt, was to the north of Vasse Highway, and bounded by No. 6, No. 8 and Quilergup roads. Priority 4, a larger unburnt area, was bounded by Gt. North road in the west, Sabina and Hill roads in the north, Lilly and Jalbarragup roads to the east, and Mowen road in the south.

The Margaret River and creeks in the south, and Sabina River and creeks in the north, provided the numerous sandy flats and swamps in priority 4.

The entire region has been lightly cut-over in the past 15 to 20 years.

METHODS

(i) Trapping

Three types of traps were used, seventy-seven 33 cm x 10 cm x 10 cm Elliott folding aluminium traps, eighty 15 cm x 10 cm breakback rat traps, and fifteen 56 cm x 20 cm x 20 cm wire cage traps. All were baited with universal bait - a mixture of peanut butter, bacon, raisins, oatmeal and wheat-germ, and in each trapping line the traps were alternated, e.g. alternate Elliott and breakback, with each eleventh being a wire cage trap. There was thus more chance of catching a variety of species.

Five trap lines were set, the number and type of trap and period set being determined by the type of terrain in each line. This method better achieved the object of finding out the variety and abundance of species present overall rather than a comparison of species within the different terrains.

(ii) Observations

(a) Daylight observations.

Fauna sighted whilst moving through the area on foot or in vehicles were recorded, though no attempt was made to count the relatively numerous Grey Kangaroo (Macropus fuliginosus) or Brush Wallaby (Macropus irma). Any evidence of fauna activity, such as scats, diggings or prints were recorded. Swamps and flats were examined for signs of reptiles and small creeks and water holes fished with a small net.

(b) Night observations.

Observations were made from a vehicle with two spotlights, 4 spotlighting runs being made between the hours of dusk and 10 p.m. The runs were planned to cover a variety of terrain.

RESULTS

(i) Trapping

Trapping results are given in Tables 1 and 2. Mammals captured were the Southern bush rat (Rattus fuscipes), Common rat (Rattus rattus), Common House mouse (Mus musculus), Mardo (Antechinus flavipes), and Native Cat (Dasyurus geoffroii). Smiths Skink (Egernia carinata) and Mourning skink (Egernia luctuosa) were also caught.

As expected, the South bush rat and Mourning skinks were caught in the denser areas near swamps or creeks. The mardos were caught in areas of reasonably thick ground cover, all near old logs and felling slash. The Smiths Skinks were caught in most types of terrain.

No. 8 road traps produced only 2 mammal species, a Common rat, and a Native cat. The recent burning here is a probable cause of the low result of mammals. There was however, an abundance of Smiths Skinks.

In all areas trouble was experienced with ants eating the bait.

(ii) Observations

(a) Daylight. All lizards, frogs, snakes and fish, apart from the 2 species of lizard trapped and the minnow netted at night, were found in daylight. Lizards were found under rocks or logs or in blackboy stumps and caught by hand. Frogs and snakes were observed while walking or travelling in the vehicle. The fish were caught in creeks or water holes by a small hand net.

Some animals were identified by prints, scats or runnels. Table 4 lists all mammal species identified and the evidence of their presence.

(b) Night. Spotlighting results are presented in Table 3. Number of observations are about average for Jarrah bush. The Ridge and Whicher Road run gave a higher average figure per hour and per mile than the other three runs, which was expected as the terrain here is more broken by creeks and gullies with patches of thick undergrowth. The two unidentified sightings were small, hopping type animals, not seen clearly because of the very thick undergrowth.

Numerous bats were seen on all the spotlighting runs, comprising at least 2 species. One bat was shot and has been identified by the W.A. Museum as a Chalinolobus gouldii. Attempts to catch bats in mist nets were unsuccessful, though the nets were erected in several different localities and left for several hours each night.

SYSTEMATIC ACCOUNT OF MAMMALS

1. ORDER MARSUPIALA

A. Family Macropodidae

1. Western Grey Kangaroo, Macropus fuliginosus.
No attempt was made to count this species, which was seen frequently by day and night throughout the entire survey area. The population appears to be about normal for this type of bush.

2. Brush Wallaby, Macropus irma.

This species also was frequently seen throughout the survey area, by day and night. There appears to be a relatively high population in most localities.

3. Tammar, Macropus eugenii.

None was seen, though suitable habitats occur throughout the area. There is a report of a small wallaby in the St. John's Brook locality, only a few miles from the proposed pine planting areas. A cursory examination of St. John's Locality indicated the presence of a small wallaby, which could be a Tammar.

4. Quokka, Setonix brachyurus.

None were seen or trapped as this is a particularly retiring and trap-shy species, and time did not allow the erection of large pen-type traps. There were very definite signs of quokka habitation in several of the swamps and creeks with thick ground vegetation where many runnels were seen. Quokkas have also been trapped recently in Sabina Road by Mr Shugg.

B. Family Phalangeridae

5. Common or brush-tailed possum, Trichosurus vulpecula.

Three individuals were seen, all by spotlight at the western and north-eastern ends of priority 4 area. None were trapped, though this species can be caught in wire traps. Though no definite signs of common possum were seen elsewhere it is likely that the species is scattered throughout the survey area, as the habitat is similar. The population appears to be very low.

C. Family Petauridae

6. Ringtail possum, Pseudocheirus peregrinus.

None were seen, and no evidence of their presence. The nearest recorded sighting is from Nannup, where one was recorded in the pine plantations in February 1974.

D. Family Burramyidae

7. Pygmy possum, Cercartetus concinnus.

None were seen, but a nest was found in a blackboy on Sabina Road, possibly belonging to this species. There is also a museum recording for this vicinity.

E. Family Tarsipedidae

8. Honey possum, Tarsipes spencerae.

No evidence for this species was found, but there is a museum record from near Mowen Road.

F. Family Peramelidae

9. Short-nosed bandicoot, Isoodon obesulus

There is a museum record of this species in the vicinity, and it is quite common in the Margaret River/ Cowaramup region to the west. Chances of its occurrence

in the survey area are high. The unidentified animals sighted on the Ridge/Whicher road spotlight run could well have been bandicoots.

G. Family Dasyuridae

10. Native Cat or Chuditch, Dasyurus geoffroii.

Only one specimen was caught, by a wire cage trap, in the recently burnt area. The habitat throughout the survey area was suitable and this species probably occurs throughout.

11. Native squirrel or wambenger, Phascogale tapoatafa.

There are museum records from the vicinity. Records of this species come mainly from traffic casualties. It is seldom seen or trapped in the bush, and could well be present in the survey area.

12. Mardo, Yellow-footed pouch mouse, Antechinus flavipes.

Three individuals were caught, all in breakback traps in the Margaret and George Road trapping lines. All 3 were in relatively heavy undergrowth and either in or near old logging slash - a habitat favoured by this species. None were caught in the recently burnt area - studies being carried out at Dwellingup indicate that this species apparently disappears from a locality for 15 months or so after a burn.

13. Dunnart, Sminthopsis murina

There are museum records from the vicinity, but none were seen. The habitat is suitable for the species, and it is almost certain that they occur here. There is a definite recording from near Dido road, either in or very near the priority 5 planting area.

2. ORDER RODENTIA

Family Muridae.

14. Southern bush-rat, Rattus fuscipes.

Five individuals were caught on 3 separate trap lines. Four of these were on creeks or swamp and the fifth in thick undergrowth on a sandy flat. There are numerous suitable areas for this species in which it undoubtedly occurs throughout the area.

15. Water rat, Hydromys chrysogaster

None were seen, but it is quite possible they occur along the Margaret and Sabina rivers and tributaries.

16. Common rat, Rattus rattus

Three specimens were caught, and each in a different locality. Two of these were in thick undergrowth on George and Margaret roads, and the third within the recently burnt area of No. 8 road. This latter however was captured in a patch of unburnt scrub near a creek.

17. House mouse, Mus musculus

Two specimens caught, both on Margaret road in medium scrub. Mus musculus is caught fairly easily in both Elliott and breakback traps, so if the population is high it is likely that greater number would have been caught.

3. ORDER CHIROPTERA

18. Bats. At least 2 different species were seen in flight, There are probably several more within the area. Attempts to capture specimens by mist netting or shooting yielded only one, which has been identified by the W.A. museum as a Chalinolobus gouldii. Sightings were numerous throughout each spotlighting run.

4. ORDER LAGOMORPHA

19. Rabbit, Oryctolagus cuniculus

Rabbits were evident, though not abundant, in some localities. Scats and scratchings were seen, but very few specimens. The area does not appear to have a high population.

5. ORDER CARNIVORA

20. Dingo, Canis familians

None were seen in the area. A few miles to the south, near Canebreak road, a torn up grey Kangaroo and canine prints were discovered. The evidence suggests dingoes rather than foxes.

21. Fox, Vulpes vulpes

Identified from prints. Very few scats were seen. It probably occurs throughout the area, though it is not abundant. One of the common food sources of the foxes, i.e. rabbits, are not plentiful, which may account for its apparent low density.

22. Feral cat, Felis cattus

Prints were seen but no specimens sighted. Probably occurs throughout the area in small numbers. None was caught in wire-cage traps as would be expected if population was high.

6. ORDER MONTREMATA

23. Echidna or spiney anteater, Tachyglossus oculeatus. No evidence seen. The habitat is suitable for this species and they could be present.

7. ORDER EQUIDAE

24. Horse, Equus caballus

Last reported sightings in the locality date back 15 years. Several scats were seen in different localities so there are apparently a few still in the area.

DISCUSSION

1. Limitations of the Study.

This survey was not intended to be exhaustive, only a preliminary study. There are several reasons why the results must be interpreted with caution.

(a) Study areas.

The proposed pine planting area is large and divided into 5 sections in order of planting priority. While 2 of these sections are mainly good quality Jarrah in lateritic soils, and the other 3 mainly poorer quality Jarrah or Jarrah/Marri containing sandy flats and swampland, each section has some diversity of soil, topography and vegetation within it. To cover each type of terrain within each section thoroughly would be impossible without months of work, and is outside the scope of ecology section.

By choosing 2 representative areas and working across a variety of terrain, as much as possible has been achieved in the limited time available.

(b) Trapping.

Trapping has been confined to limited areas, and to 3 types of traps only. Since small mammals usually occur in low densities and uneven distribution, it is unlikely that all types of small mammals present were caught. Season of trapping is also important, it is quite possible that a bigger catch might have been made at a different time of year.

Some animals are trap-shy and almost impossible to detect. Others however, might be caught in different types of trap. Pen-traps, pit-traps, snares, bottle traps etc. are all necessary for a complete survey, and time and personnel available did not allow for all these.

(c) Spotlighting.

Four runs were carried out in diverse localities, but time spent was still limited. Particularly as time had to be found for trying to capture some of the numerous bats by shooting or mist-netting.

Only one team, using two spotlights from a moving vehicle, was possible each night. Several of the larger types of mammal, such as brush wallaby and common possum, were sighted, but the heavy undergrowth and dense foliage made sightings of possible smaller ground-dwelling or arobreal mammals difficult. Some spotlighting excursions on foot could well be profitable in some areas.

More intensive spotlighting in selected areas is also necessary. On the final run, in the vicinity of Ridge and Whicher roads, unidentified animals were glimpsed. These could well have been native cats or bandicoots, but the possibility of their being something more uncommon, such as Bettongia penicillata, could amply repay a more sustained effort in this vicinity.

(d) Scat analysis, prints and runs.

Interpretation of these is a very important part of any survey. Of the 14 mammal species listed, 4 were identified by prints and runnels. The Quokka for instance, is seldom seen and hard to trap, but scats and runnels in a suitable habitat is a good indication of its presence. In flats and sandy areas prints are a most useful source of identification. Time is needed to search for such signs, and undoubtedly more would have been found had the survey been extended.

Very few scats were found and these yielded no new information.

DISCUSSION OF RESULTS

The result of the survey, considering the above limitations, appears satisfactory. A total of 8 indigenous and 6 introduced species of malla, 50 birds, and 20 of other vertebrate fauna identified in 5 days is about what might be expected in the type of country covered.

The survey has given only a rough estimation of the abundance of the larger mammals, no reliable estimate of population or densities of smaller mammals, and has almost certainly failed to find some species of mammals, birds and reptiles that are there. An interesting record in the bird list is that of the Emu wren, which to our knowledge has not previously been reported from this area.

It provides a useful source of information to assist in any planning of operations in the area however, and gives a base for any future, more intensive, fauna work, which were the main objects of the survey.

The survey failed to find positive evidence of some mammals that could be expected there - bandicoots (Isoodon obesulus) and dunnart (Sminthopsis murina) for example, though museum reports and other indications make their presence likely. There are outside reports of a variety of other animals there, some dating back a long time, but others more recent. It is possible that Woilie (Bettongia penicillata) could still exist in the area, there is an old museum record for the Whicher ranges. Other reports seem extremely unlikely, e.g. hopping mouse, rabbit-eared bandicoot. It was believed that the brumby (feral horse) was no longer there, the last report being a brief sighting in the mid 1950's. The scat evidence suggests that there are still a few around however.

The 2 sightings of small unidentified animals in the Ridge Road/Whicher Road area are tantalising. These could well be quite common species, but until this is proved, the possibility of something rarer should not be discounted.

The past history of logging and burning in the area was not investigated too closely, as this was not really relevant to the object of the study. There appears to be nothing unusual in the pattern, periodic burning and felling has taken place and the effect on the native fauna has been similar to elsewhere. The proportion of introduced to indigenous fauna is also about the same as elsewhere.

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ACKNOWLEDGEMENT

We wish to acknowledge the assistance of the staff of the W.A. Museum, Perth, in identification of species and provision of museum records.

TABLE I

TRAPPING RESULTS

Area	No. of trap nights (all types)	Mammals	No. of Individuals	Reptiles	No. of Individuals	Trap success percentage		
						Mammals	Reptiles	Combined
Margaret Road	263	Rattus rattus Antechinus flavipes Mus musculus	1 2 2	Egernia carinata Egernia luctuosa	14 1	1.9	5.7	7.6
No. 8 Road	165	Rattus rattus Dasyurus geoffroii	1 1	Egernia carinata	9	1.2	5.5	6.7
River Swamp	16	Rattus fuscipes	2	Egernia luctuosa	3	12.5	18.7	31.2
George Road	130	Rattus rattus Antechinus flavipes Rattus fuscipes	1 1 2	Egernia carinata Egernia luctuosa	6 4	3.1	7.7	10.8
Ridge/Whicher Rd.	64	Rattus fuscipes	1	Egernia carinata	1	1.6	1.6	3.1

TABLE 2

BREAKDOWN OF SPECIES CAUGHT IN DIFFERENT TRAP TYPES

Trap Type	SPECIES CAUGHT						
	Rattus rattus	Rattus fuscipes	Mus musculus	Antechinus flavipes	Dasyurus geoffroii	Egernia Carinata	Egernia luctuosa
Elliott	-	2	1	-	-	16	4
Break back	3	2	1	3	-	14	4
Wire Cage	-	1	-	-	1	-	-

TABLE 3

MAMMAL SPOTLIGHTING RESULTS

Area	Hours	Miles travelled during spotlighting	Specimens detected	Specimens per hour	Specimens per mile	Remarks
Cave Break Margaret, Gt. North and Crossing roads	1.3	6.3	2 brush-tailed possum	1.5	0.3	
Molloy and Margaret Roads	1.1	4.8	2 grey Kangaroo	1.8	0.4	2 Tawny frogmouth also seen
Gt. North road and George road and Blunsdon road	1.2	6.4	2 Grey Kangaroo	1.7	0.3	
Ridge and Whicher roads	2.0	10.1	2 brush wallaby 1 Grey Kangaroo 1 brush-tailed possum 2 unidentified	3.0	0.6	6 Tawny frogmouth also seen Unidentified animals were small hopping animals.

TABLE 4

MAMMAL SPECIES IDENTIFIED

Species	Trapped	Observed	Shot	Identified from prints, scats or runnels	Spotlight
Antechnius flavipes	*				
Dasyurus geoffroii	*				*
Trichosurus vulpecula				*	*
Macropus fuliginosus		*		*	
Macropus irma		*		*	
Setonix brachyurus					
Mus musculus	*				
Rattus rattus	*				
Rattus fuscipes	*				
Oryctolagus cuniculus		*		*	
Equus caballus				*	
Vulpes vulpes				*	
Felis catus				*	
Chalinolobus gouldii			*		*

NB. These species were identified by the survey team within the proposed pine planting area. Other species recorded by the W.A. Museum and other sources, in or near the area, are mentioned in the "Systematic account of mammals".

BIRDS IDENTIFIED

Emu	Dromaius novaehollandiae
Little Grebe	Podiceps novaehollandiae
Little Black Cormorant	Phalacrocoras sulcirostris
Little Pied Cormorant	Phalacrocorax melanoleucos
Darter	Anhinga rufa
White-faced Heron	Ardea novaehollandiae
Brown Bittern	Botsurus poiciloptilus
Mountain Duck	Tadorna tadornoides
Black Duck	Anas superciliosa
Maned Goose	Chenoetta jubata
Whistling Eagle	Haliastur sphenurus
Brown Hawk	Falco berigora
Brush Bronzewing	Phaps elegans
White-tailed Black Cockatoo	Calyptorhynchus baudini
Western Rosella	Plalycercus icterotis
Red-capped Parrot	Purpureicephalus spurius
Parrot	Barnardius zonarius
Frogmouth	Podargus strigoides
Owlet-Nightjar	Aegotheles cristatus
Kookaburra	Dacelo gigas
Sacred Kingfisher	Halcyon sancta
Bee-eater	Merops ornatus
Tree Martin	Petrochelidon nigricans
Pipits	Anthus novaeseelandiae
Black-faced Cuckoo-shrike	Coracina novaehollandiae
Red-winged Wren	Malurus elegans
Emu Wren	Stipiturus malachurus
Western Warbler	Gerygone fusca
Broad-tailed Thornbill	Acanthiza apicalis
Western Thornbill	Acanthiza inornata
Woebill	Smicrornis brevirostris
Scarlet Robin	Petroica multicolor
Western Yellow Robin	Eopsaltria griseogularis
White-breasted Robin	Eopsaltria georgiana
Grey Fantail	Rhipidura fuliginosa
Willy Wagtail	Rhipidura leucophrys
Golden Whistler	Pachycephala pectoralis
Black-capped Sitella	Neositta pileata
Rufous Tree-creeper	Climacteris rufa
Spotted Pardolate	Pardalotus punctatus
Silvereye	Zosterops gouldi
Spinebill	Acanthorhynchus superciliosus
Tawny-crowned Honeyeater	Gliciphila melanops
New Holland Honeyeater	Phylidonyris novaehollandiae
Little Wattle Bird	Anthochaera chrysoptera
Red-eared Firetail	Zonaeginthus oculatus
Dusky Wood Swallow	Artamus cyanopterus
Squeaker	Strepera versicolor
Western Magpie	Gymnorhina dorsalis
Raven	Corvus coronoides

LIST OF REPTILES, AMPHIBIANS AND FISHES IDENTIFIED

Lizards	Phyllodactylus marmoratus	(C)
	Varanus gouldii	(O)
	Tiliqua rugosa	(O)
	Egernia luctuosa	(T)
	Egernia carinata	(TO)
	Lygosoma billardieri	(C)
	Lygosoma initiale	(C)
	* emiergis peronii	(C)
	* Otenotus impar	(C)
	* Cryptoblepharus plagiocephalus	(C)
	Legless lizard (unidentified)	(C)
Snakes	Demansia nuchalis affinis	(O)
	Notechis soutatus occidentalis	(O)
Frogs	Hyla	(C)
	Limnodynastos dorsalis	(C)
	Helioporus eyrei	(C)
Fishes	Galaxias occidentalis	(N)
	Brachygalaxias nigrostriatus	(N)
	Edelia vittata	(N)
	Nannatherina balstoni	(N)

C - caught by hand

O - observed

T - trapped

N - netted

N.B. Three lizards marked by * identified by W.A. Museum. Remainder follow the identifications in "A Handbook of the lizards of Western Australia" by L. Glauert.

(II) FAUNA SURVEY

DONNYBROOK SUNKLANDS

15th - 28th OCTOBER 1974.

P.C. KIMBER, K.I. PENTONY, P.R. SKINNER

FAUNA SURVEY. - DONNYBROOK SUNKLANDS

INTRODUCTION

The geomorphological zone known as the Donnybrook Sunklands lies between the Nannup fault scarp in the east and the Naturaliste-Leeuwin ridge on the west coast. It is bounded in the north by coastal sands and in the south by large dune systems. Surveys of the fauna in State forests within this zone were made in February and October 1974. This report describes the results of the latter survey in detail, but also incorporates additional species located in the February survey. A separate report exists for the February survey.

The purpose of the survey was to forecast the impact of a projected pine plantation scheme on fauna populations, and to locate any animal species or animal/vegetation/soil association which may be of exceptional scientific interest and therefore require particular attention in planning the pine project. A team of five completed the present study period 15th - 28th October 1974. Intermittent visits to the area and trapping was also carried out for three weeks prior to the main study period.

Geomorphology, Soils and Vegetation

The geomorphology and soils have been dealt with in detail by Smith (1951). The study areas encompass two main geomorphic types; the deeply incised valley of St. John's Brook, and the gentle to moderate undulating surface of Smith's low plateau. A generalised catenary series of the low plateau commences with dry lateritic ridges and upper slopes with pisolite gravels and a sandy matrix, through sandy lower slopes to silty, moist valley bottoms. Jarrah forest dominates the series with the exception of very moist valley bottoms where dense scrub is dominant, typical of the north-western jarrah forest swamps.

St. John's Brook carries recent moist soils of above average fertility, the undergrowth is denser than in the plateau country and blackbutt (Eucalyptus patens) contributes significantly to the tree canopy.

An aberrant soil/plant association occurs in patches throughout the sunklands but is apparently independent of any geomorphological characteristic. It is called the Kingia suite by Smith (1951), and is typified by moderate to sparse waist high scrub with stunted trees of jarrah and marri up to 6 metres high. The vegetation is reminiscent of heath types and is probably maintained by fire and edaphic conditions. Evidence exists of impeded drainage in elevated topographical situations and the soils (not examined in detail) appear to have a high clay fraction. Kingia australis is frequent.

West Australian Museum Records

The West Australian museum have records of 9 mammal species within the area of State Forest in the sunklands. An additional 11 mammal species are recorded within 20 km of State Forest.

The Study Areas.

1. St. John's Brook and Cambray. A steeply incised valley with fresh, moist soils and a jarrah/marri/blackbutt forest association. The area contains a large perennial watercourse with extensive pools. Burnt under prescription in spring 1973.

2. Great West, and Macatee Roads. Typical undulating plateau country with extensive sandy lower slopes and flats. Last burnt in 1969-1970.

3. Whicher Block. Plateau country dominated by laterite ridges and relatively steep sided valleys with little development of sandy lower slopes and flats.

4. Lawson Road. An example of the Kingia suite. Last burns in 1969-1970.

METHODS

Trapping, shooting, netting, spotlighting and searching were the basic methods in all study areas except Lawson Road where observation and searching were the only methods employed.

1. Trapping. The bulk of the trapping effort was with backbreak rat traps, and possum traps which catch alive animals up to the size of a quokka. Elliot traps were used in Whicher and Cambray for a few days but contributed little to the overall trapping effort. Small fish traps were placed in tributaries of St. John's Brook, and the main river was netted with a $2\frac{1}{2}$ inch mesh gill net for 1 night.

   Wire pen traps with a falling door mechanism were erected in the St. John's Brook and Whicher areas. These are effective for quokka and short-nosed bandicoot.

   Mist nets were used at Macatee Road, Whicher and Cambray to take small species of birds which are not readily observed.

2. Spotlighting. Spotlighting runs were made along St. John's Brook and at Cambray and Whicher. Each run was started shortly after dusk, continued for $1\frac{1}{2}$ to 2 hours and covered 10-14 km. Two spotlights were operated from one vehicle on each run.

3. Shooting. Approximately three hours were spent shooting bats at Cambray. Five birds were shot at various localities for laboratory specimens.

4. Observation and Searching. Nearly all bird records were direct observations aided by an Audubon bird-call.

   Searching resulted in the location of many reptiles some amphibians, and the spoor and scats of the larger mammals.

RESULTS

The results of the survey are presented in a way which permits the association of fauna concentrations with habitat type and locality. Where comprehensive lists are given these include species located in the February 1974 survey but which were not found in the survey on which this report is based.

The relative success of the various study methods are shown in Appendix 1 and species check lists in Appendix 2 and 3.

Species Representation.

The total number of species identified from both surveys was as follows:

Mammals	-	18 (of which 6 were introduced species)
Birds	-	74
Lizards	-	19
Snakes	-	5
Tortoises	-	1
Frogs	-	9
Fish	-	6
Crustaceans	-	1

Animal Distribution by Plant/Soil Associations.

All records of captures on the various soil/plant associations are shown in Table 1 which gives an indication of favoured habitats.

TABLE 1

Animal Captures by Plant/Soil Associations

Association	Animal Numbers							
	Mammals		Lizards		Frogs		Totals	
	Nos.	Spp.	Nos.	Spp.	Nos.	Spp.	Nos.	Spp.
Laterite ridges and upper slopes	2	2	14	7	1	1	17	10
Sandy valleys and Lower Slopes	10	6	31	10	18	5	59	21
Swamps	16	3	0	0	Not Studied		16	3
Steep valleys, Fresh soils	9	2	3	2	14	4	26	8

The most populous association in terms of both individuals and species was the sandy lower slope and valley situation. Laterite ridges and upper slopes had the low mammal populations typical of these habitats in the northern jarrah forest (Schmidt and Mason, 1973). However, they were surprisingly rich in lizards.

Swamp areas, although yielding only moderate captures, are an important habitat for the quokka (Setonix brachyurus),

short-nosed bandicoot (Isoodon obesulus), and mardo (Antechinus flavipes). Captures of these species were confined to swamps. Sixty percent of southern bush-rat (Rattus fuscipes) captures were also in swamp.

The steep, fresh valley habitats had been burnt one year prior to the survey. This factor undoubtedly reduced small mammal populations which have not yet recovered to their pre-fire levels. Capture data was consequently not indicative of the potential of the area. Larger mammals were frequent and this was the only association where the brush-tailed possum (Trichosurus vulpeculus) was recorded.

Animal Distribution and Locality.

Table 2 lists the numbers of species identified by capture and observation, in the various localities examined.

TABLE 2

Species Representation by Localities

Locality	Number of Species			
	Mammals	Lizards	Frogs	Total
Whicher Block and Sabina Rd (adjacent to Whicher).	8	11	6	25
St. John's Brook and Cambray	6	4	3	13
Macatee Road and Great West Road	3	5	0	8

The data is Table is unlikely to represent the entire species representation in any one area, but it gives a useful comparison of relative numbers. Whicher Block yielded the greatest variety of animals, and this location remains outstanding even if the mammal species located outside the block but in close proximity to it on Sabina Road are excluded. These species were Setonix brachyurus and Isoodon obesulus.

Species numbers were relatively low in St. John's Brook and Cambray due to prescribed burning in 1973.

Birds.

The 74 species of birds identified in this survey comprised 12 aquatics, 7 species associated with clearings and forest glades, 3 species normally associated with heath or sandplain scrub, and 52 true forest species.

Heath sandplain species were confined to the Kingia suite of soils. The three species were crested bellbird (Oreoica gutturalis), tawny crowned honeyeater (Gliciphila melanops), and white-browed babbler (Pomatostomus superciliosus). Both the tawny crowned honeyeater and the white-browed babbler occur adjacent to or within forest in separate localities

near the south coast. Their occurrence together and in the same locality as the crested bellbird is unique within the jarrah forest zone.

Snakes.

Five species of snake were located. The western tiger snake (Notechis scutatus) and dugite (Demansia nuchalis) were identified in the February 1974 survey. One little whip snake (Denisonia gouldii) was collected on a laterite ridge.

One blind snake (Typhlina australis) and three Muellers snakes (Rhinhoplocephalus bicolor) were collected on the Kingia suite soils. This is the northernmost recorded occurrence of the Muellers snake, which is a species of coastal sand/heath associations.

Fish, Crustaceans and Aquatic Reptiles.

Permanently flowing water courses on the area were Margaret River (covered by the February survey) and St. John's Brook. Species collected from these two rivers are listed in Table 3.

TABLE 3

Fish, Crustaceans and Aquatic Reptiles

Species	Locality	
	St. John's Brook	Margaret River
Fish		
Bostockia porosa	X	
Brachygalaxias nigrostriatus		X
Edelia nittata	X	X
Galaxias occidentalis	X	X
Nantherina balstoni		X
Tandanus bostocki	X	
Crustacean		
Cherax preissii	X	
Reptile		
Chelodina oblonga	X	

DISCUSSION

If museum records and our survey records are combined, a total of 21 mammal species have been recorded within the study area. An additional 5 species have been recorded within 20 km of the boundaries of State Forest. One of

the museum records, the flying fox (Pteropus scapulatus) is a rare vagrant. Another, the woylie (Bettongia penicillata) was not located in either of our surveys. This suggests that the species no longer exists in the area, or is of extremely limited distribution.

The range of mammal species represented in the sunklands is almost identical to that found elsewhere in the jarrah forest.

The range of bird species islikewise typical of jarrah forest associations with the exception of the southern emu wren which is, however, widespread in forest areas to the south and south east of the sunklands, and the 3 heath-scrub species found in association on the Kingia suite of soils.

Lizards species were particularly numerous throughout the area and especially in Whicher Block. A number of the lizard records provided an extension of the previously known range of two species, (Ctenotus catenifer) and Morethia obscura).

Soil/plant associations of the Kingia suite are found at various localities throughout the sunklands. They are generally sizeable units reaching 100 to 200 ha or more in area. One such association was studied on Lawson Road by observation and searching. No trapping was done. The presence of the tawny-crowned honeyeater, crested bellbird, white-browed babbler, and the Muellers snake show this area to be of exceptional scientific interest.

RECOMMENDATIONS

The entire area proposed for pine plantations should be checked by trapping and spotlight survey to determine the status of the Woylie (Bettongia penicillata).

At least one block of forest should be retained in its present state to provide a permanent example of the soil/plant associations represented. This is particularly important for the sandy lower slopes and valleys which are rich in fauna and flora.

Examples of the Kingia soil suite should be retained, each with a peripheral buffer of indigenous forest.

ACKNOWLEDGEMENTS

We are indebted to the West Australian Museum for the identification of 88 specimens, and to West Australian Government Railways for the use of their house at Cambray.

REFERENCES

Schmidt, W. and Mason, M. (1973). The effect of prescribed burning on the fauna of the jarrah forest. Res. Pap. No. 11.

Smith, R. (1951). Soils of Margaret and Lower Blackwood Rivers, W.A. Bulletin No. 262. C.S.I.R.O. Melbourne.

APPENDIX 1

Success of Various Methods of Capture

Method	Captures							
	Mammals		Lizards		Snakes		Frogs	
	No.	%	No.	%	No.	%	No.	%
Pit traps	1	3	16	35			26	81
Break-back traps	7	19	21	46				
Elliot traps	6	17						
Possum traps	9	25	4	8				
Pen traps	10	28						
Hand caught			5	11	3	100	6	19
Shot	3	8						
Totals	36	100	46	100	3	100	32	100

Percent = percentage of total captures within the animal group.

APPENDIX 2

Check Lists

Mammals, Lizards, Snakes, Tortoises, Frogs

I = non-native species C = captured

O = observed M = museum record

Mb = Museum record within 20 km of study area.

Species	Source	Notes on location etc
MAMMALS		
Macropus fuliginosus	O	All localities
M. irma	O	All localities
Setonix brachyurus	C	Swamp, Sabina Road
Bettongia penicillata	M	No recent record
Trichosurus vulpecula	C	St. John's Brook
Cercartetus concinnus	M	
Tarsipes spencerae	C	Whicher
Isoodon obesulus	C	Swamp, Sabina Road
Dasyurus geoffroii	C	February survey
Phascogale tapoatafa	M	
Antechinus flavipes	C	February survey
Sminthopsis murina	C	Whicher
Rattus fuscipes	C	Whicher, Sabina Rd.
R. rattus	I.C	February survey
Hydromys chrysogaster	Mb	
Mus musculus	I.C	All localities
Nyctophilus geoffroyi	Mb	
Chalinobus gouldii	C	Cambray
C. morio	Mb	
Eptisicus pumilis	Mb	
Pipistrellus tasmaniensis	C	Cambray
Pteropus scapulatus	Mb	Rare vagrant
Canis familiaris	Mb	
Vulpes vulpes	I.O	All localities
Oryctolagus cuniculus	I.O	Sparse all localities
Equus caballus	I.O	February survey
Felis cattus	I.C	Whicher
LIZARDS AND GECKOES		
Cryptoblepharus plagiocephalus	C	February survey
Ctenotus catenifer	C	Whicher
C. impar	C	Whicher

APPENDIX 2 cont.

Species	Source	Notes on location etc.
Lizards and Geckoes cont.		
Cryptoblepharus labillardieri	C	Whicher
Egernia carinata	C	Whicher
E. kingii	C	St. John's Brook
E. nitida	C	All localities
E. pulchra	C	Macatee Road
E. pulchra subspecies	C	Macatee Road
Hemieirgis peroni	C	Whicher, Sabina Rd
Lerista distinguenda	C	Whicher
Leiolepisma trilineatum	C	Moist gullies
Lygosama initiale	C	February survey
Morethia obscura	C	Whicher, Sabins Rd. Macatee Rd.
Phyllodactylus marmoratus	C	Whicher
Menetia greyii	C	Macatee Rd
Tiligua luctuosa	C	Whicher, Sabins Rd Macatee Rd
Trachysaurus rugosus	C	All localities
Varanus gouldii	O	St. John's Brook
SNAKES		
Demansia nuchalis	O	February survey
Notechis scutatus	O	February survey
Denisonia gouldii	C	Whicher
Typhlina australis	C	Lawson Rd
Rhinhoplocephalus bicolor	C	Lawson Rd
TORTOISES		
Chelodina oblonga	O	St. John's Brook
FROGS		
Crinia georgiana	C	Whicher, St. John's Brook
C. glauerti	C	Farmland
Helioporus eyrei	C	Whicher
H. inornatus	C	St. John's Brook
Helioporus sp.	C	Whicher
Limnodynastes dorsalis	C	St. John's Brook
Litoria moorei	C	St. John's Brook
Metacrinia nicholleii	C	Whicher
Pseudophryne guentheri	C	Whicher, Sabina Rd

Appendix 3 cont.

Western Warbler (Gerygone fusea)
Broad-tailed thornbill (Acanthiza apicalis)
Western thornbill (A. inornata)
Yellow-tailed thornbill (A. chrysorrhoa)
Spotted scrub wren (Sericornis maculatus)
Weebill (Smicornis brevirostris)
Scarlet robin (Petroica multicolor)
Western yellow robin (Eopsaltria griseogularis)
White-breasted robin (E. georgiana)
Grey fantail (Rhipidura fulignosa)
Willy Wagtail (R. leucophrys)
Golden whistler (Pachycephala pectoralis)
Grey thrush (Colluricincla rufiventris)
Crested bellbird (Oreoica gutturalis)
Black-capped sitella (Neositta pileata)
Rufous tree creeper (Climacteris rufa)
Spotted pardalote (Pardalotus punctatus)
Striated pardalote (P. substriatus)
Silvereye (Zosteraps gouldii)
White-naped honeyeater (Melithreptus lunatus)
Spinebill (Acanthorhyncus superciliosus)
Tawny-crowned honeyeater (Cliciphila melanops)
White-eyed honeyeater (Phylidonyris novaehollandiae)
Red wattle bird (Anthochaera carunculata)
Little Wattle bird (A. chrysoptera)
Red-eared firetail (Zonaeginthus oculatus)
Magpie lark (Grallina cyanoleuca)
Dusky woodswallow (Artamus cyanopterus)
Grey currawong (Strepera versicolor)
Western magpie (Gymnorhina dorsalis)
Raven (Corvus coronoides)

APPENDIX 3

Emu (Dromaius novaehollandiae)
Little grebe (Podiceps novaehollandiae)
Little black cormorant (Phalacrocorax sutcirostris)
Little pied cormorant (P. melanoleucos)
Darter (Anhinga rufa)
White egret (Egretta alba)
White-faced heron (Ardea novaehollandiae)
Brown bittern (Boraurus poiciloptilus)
Mountain duck (Tadorna tadornaides)
Black duck (Anas superciliosa)
Maned goose (Chenonetta jubata)
Musk duck (Biziura lobata)
Whistling eagle (Haliastur sphenurus)
Australian goshawk (Accipiter fasciatus)
Little eagle (Hieroetus morphnoides)
Wedge-tailed eagle (Aquila audax)
Brown hawk (Falco berigora)
Crake spotless (Porzana tabuensis)
Bronzewing pigeon (Phaps chalcoptera)
Brush bronzewing (P. elegans)
White-tailed black cockatoo (Calyptorhyncus baudini)
Red-tailed black cockatoo (C. banksi)
Western rosella (Platycercus icterotis)
Red-capped parrot (Purpureicephalus spurius)
Twentyeight parrot (Barnardius zonarius)
Elegant parrot (Neophema elegans)
Pallid cuckoo (Cuculus pallidus)
Fan-tailed cuckoo (Cacomantis pyrrophanus)
Golden bronze cuckoo (Chrysococcyx lucidus)
Boobook owl (Ninox novaehollandiae)
Tawny frogmouth (Podargus strigoides)
Owlet nightjar (Aegotheles cristatus)
Kookaburra (Dacelo gigas)
Sacred Kingfisher (Halcyon saneta)
Bee-eater (Merops ornatus)
Welcome swallow (Hirundo neoxena)
Tree martin (Petrochelidon nigricans)
Pipit (Anthus novaeseelandiae)
Black-faced cuckoo shrike (Coracina novaehollandiae)
White-browed babbler (Pomatostomus superciliosus)
Splendid wren (Malurus splendens)
Red-winged wren (M. elegans)
Southern emu wren (Stipiturus malachurus)

(iii) FAUNA LIST - SUNKLAND AREA

1. BIRDS

Common Name	Scientific Name
Emu	Dromaius noveahollandiae
Little Grebe	Podiceps noveahollandiae
White-faced Heron	Ardea noveahollandiae
Black Duck	Chenonetta jubata
Musk Duck	Biziura lobata
Whistling Eagle	Haliastur sphenurus
Brown Goshawk	Accipiter fasciatus
Wedge-tailed Eagle	Aquila audax
Crake	Poryara tabuensis
White-tailed Black Cockatoo	Calyptorhynchus baudini
Red-tailed Black Cockatoo	Calyptorhynchus banksi
Western Rosella	Platycercus icterotis
Red-capped Parrot	Purpureicephalus spurius
Twentyeight Parrot	Barnardius zonarius
Elegant Parrot	Neophema elegans
Fan tailed Cuckoo	Cacomantis pyrrophanus
Crested Bellbird	Oreoica gutturalis
Golden Bronze Cuckoo	Chrysococcyx licidus
Boobook Owl	Ninox noveaseelandiae
Tawny Frogmouth	Podargus strigoides
Owlet Nightjar	Aegotheles cristatus
Kookaburra	Dacelo gigas
Sacred Kingfisher	Halcyon sancta
Bee-eater	Merops ornatus
Welcome Swallow	Hirundo neoxena
Tree Martin	Petrochelidon nigricans
Black-faced Cuckoo Shrike	Coracina noveahollandiae
Splenddid Wren	Malurus splendens
Red-winged Wren	Malurus elegans
Southern Emu Wren	Stipiturus malachurus
Western Warbler	Gerygone fusca
Broad-tailed Thornbill	Acanthiza apicalis
Western Thornbill	Acanthiza inornata
Yellow-tailed Thornbill	Acanthiza chrysorrhoa
Spotted scrub Wren	Sericornis maculatus
Weebill	Smicrocornis brevirostris
Scarlet Robin	Petroica multicolor
Yellow Robin	Eopsaltria griseogularis
White Breates Robin	Eopsaltria georgiana
Grey Fantail	Rhipidura fuliginosa
Willy Wagtail	Rhipidura leucophrys
Golden Whistler	Pachycephala pectoralis
Western Shrike Thrush	Collurioincla rifiventris
Black capped Sitella	Neositta pileata
Spotted pardalote	Pardalotus substriatus
Silvereye	Zosterops gouldi
White Naped Honeyeater	Melthreptus lunatus
Spinebill	Acanthorhynchus superciliosus
Tawny Crowned Honeyeater	Gliciphila melanops
White Eyed Honeyeater	Phylidonyris noveahollandiae
Red Wattle Bird	Anthochaera carunculata
Little Wattle Bird	Anthochaera chrysoptera
Magpie Lark	Grallina cyanoleuca
Squeaker	Strepera versicolor
Western Magpie	Gymnorhina dorsalis
Raven	Corvus coronoides
Dusky Wood Swallow	Artamus cyanopterus
Mountain Duck	Tadorna tadornoides
Pipit	Anthus noveaseelandiae

BIRDS cont...

Common Name	Scientific Name
Rufous Tree Creeper	Climacteris rufa
White Egret	Egretta alba
Pallid Cuckoo	Cuculus pallidus
White Browed Babbler	Pomatostomus superciliosus
Bronze Wing Pigeon	Phaps chalcoptera
Little Eagle	Hieraetus morphnoides
Little Pied Cormorant	Phalacrocorax melanoleucos
Little Black Cormorant	Phalacrocorax sulcirostris
Darter	Anhinga rufa
Brown Bittern	Botaurus poiciloptilus
Brown Hawk	Falco berigora
Brush Bronze Wing Pigeon	Phaps elegans
New Holland Honey Eater	Phylidonyris novaehollandiae
Red-eared Firetail Finch	Zonaeginthus oculatus

2. MAMMALS

Grey Kangaroo	Macropus fuliginosus
Black Gloved Wallaby	Macropus irma
Quokka	Setonix brachyurus
Brush-tailed Possum	Trichosurus vulpecula
Ring-tailed Possum	Pseudocheirus occidentalis
Bush Rat	Rattus fuscipes
Honey Possum	Tarsipes spencerae
Mouse Dunnart	Sminthopsis murina
Mardo	Antechinus flavipes
Brush-tailed Phascogale	Phascogale tapoatafa
Western Native Cat	Dasyurinus geoffroyi fortis
Short nosed Bandicoot	Isoodon obesulus
Common Rat	Rattus rattus
House mouse	Mus musculus
Cat	Felis cattus
Fox	Vulpes vulpes
Water Rat	Hydromys chrysogaster
Rabbit	Oryctolagus cuniculus
Bat	Chalinolobus gouldii

3. REPTILES

King Skink	Egernia kingii
Smiths Skink	Egernia carinata
Morning Skink	Egernia luctuosa
	Egernia nitidia
Frys Skink	Egernia pulchra
	Leiolopisma trilineatum
Red Legged Skink	Ctenotus labillardieri
	Hemiergis peronii
	Lerista distinguenda
	Dtenotus impar
Greys Skink	Menetia greyii
Bobtail	Tiliqua rugosa
Racehorse Goanna	Varanus gouldii
Carpet Python	Morelia variegata
Dugite	Demansia nuchalis affinis
Tiger Snake	Notechis scutatus occidentalis
Muellers Snake	Rhinoplocephalus Bicolor
	Phyllodactylus marmoratus
Burrowing Skink	Lygosoma initiale
	Cryptoblepharus plagiocephalus

4.AMPHIBIANS

Common Name	Scientific Name
Green & Gold Tree Frog	Hyla Moorei
Banjo Frog	Limnodynastes dorsalis
	Crinia georgiana
	Pseudophryne quentheri
	Heleioporus Sp.
	Metacrinia nichollsi
	Heleiporus eyrei
	Litoria moorei
	Crinia glaverti
	Heleioporus normatus

5. FISH

	Galaxias occidentalis
	Brachygalaxias nigrostriatus
	Edena vittata
	Nannatherina balstoni

APPENDIX II

(i) List of plant species

(ii) Procedure for site mapping

APPENDIX II

(i) List of plant species known from the Donnybrook Sunkland (G.S.M., 1974)

Where a botanical authority is quoted the identification has been verified by the Western Australian State Herbarium, except for very common species not collected.

X Indicates species used as site Indicators

GENUS	SPECIES AND COLLECTION NUMBER	
AMARANTACEAE		
Ptilotus	manglesii	544
AMARYLLIDACEAE		
Anigozanthus	flavida	214
Conostylis	several species	-
CAESALPINIACEAE		
Labichea	punctata Benth	355
CASUARINACEAE		
Casuarina	drummondiana	424
	fraseriana Miq.	-
COMPOSITAE		
Helichrysum	bracteatum	112
Lagenophora	stipitata Labill	49
CYCADACEAE		
Macrozamia	reidlii C.A. Gardn	-
CYPERACEAE		
Gahnia	preissii Nees.	190
Juncellus	laevigatus	502
Lepidosperma	angustatum	36
Mesomelaena	tetragona X	
Tetrariopsis	octandra	304

GENUS	SPECIES AND COLLECTION NUMBER	
DILLENIACEAE		
Hibbertia	aurea Steud.	330
	Huegelii X	319
	Montana Steud. X	162
	montana (var. minor) X	
	perfoliata Endl.	189
	quadricolor (Domin.) X	256
	racemosa	453
	rhadinopoda F. Muell.	259
	stellaris	503
	sp. nov.	371
	vaginata (Benth) F.Muell.	257
	hypericoides Benth.	453
EPACRIDACEAE		
Andersonia	caerulea	342
	longifolia	497
Astroloma	epacris	449
Conostephium	pendulum	454
Leucopogon	australia R.Br. X	367
	capitellatus D.C. X	2
	corifolius	495
	gilbertii Stchegl.	369
	glabellus R.Br. X	237
	parviflorus	
	pendulus	448
	polymorphus	483
	racemulosus D.C.	
	STRIATUS	479
	verticillatus R.Br. X	
Lysinema	ciliatum R.Br.	261
Sphenotoma	capitatum (R.Br.) Lindl.	404
Styphelia	tenuiflora Lendl. X	262

GENUS	SPECIES AND COLLECTION NUMBER	
EUPHORBIACEAE		
Ricinocarpus	cyanescens	532
	glaucus Endl	328
	tuberculatus Muell.	417
GENTIANACEAE		
Villarsia	albiflora	546
GOODENIACEAE		
Dampiera	linearis	39
	sacculata	322
Goodenia	sp.	48
Leschenaultia	biloba	-
Scaevola	microphylia Benth.	130
	striata R. Br.	1
Velleia	trinervis Labill	320
HALORRHAGACEAE		
Loudonia	aurea	528
IRIDACEAE		
Patersonia	occidentalis R. Br.	
	umbrosa Endl.	323
	xanthina F. Muell.	
LABIATEAE		
Hemiandra	pungens R. Br.	401
Hemigenia	incana	508
	rigida	549

GENUS	SPECIES AND COLLECTION NUMBER	
LAURACEAE		
Cassytha	racemosa	172
LILIACEAE		
Caesia	parviflora	93
Dasypogon	bromeliaefolius R.Br. X	-
	hookerii Drummond X	-
Johnsonia	lupulina R. Br.	300
Kingia	australia R. Br. X	-
Lomandra	sp.	277
Thysanotus	multiflorus R. Br.	-
Xanthorrhea	gracilis Endl. X	-
	preissii Endl. X	-
LOBELIACEAE		
Isotoma	hypocrateriformis	543
LOGANIACEAE		
Logania	vaginalis	8
LORANTHACEAE		
Nuytsia	floribunda Labill	-

GENUS	SPECIES AND COLLECTION NUMBER	
MIMOSACEAE		
Acacia	alata	17
	browniana X	348
	divergens	327
	diptera Lindl. X	344
	drummondii Lindl.	427
	gilbertii Meissn.	422
	mooreana W.V.Fitzg. X	249
	myrtifolia	18
	nervosa	34
	oborata Benth. X	250
	preissiana	347
	stenoptera Benth.	241
MYRTACEAE		
Agonis	flexuosa Schan.	-
	linearifolia Schan. X	273
	parviceps Schan. X	-
Astartea	fascicularis Labill DC	242
Beaufortia	sparsa R. Br. X	272
	squarrosa	-
Callistemon	speciosus	542
Calothamuus	sanguineus Labill.	-
Calytrix	brachyphylla Turcz.	400
	variabilis Lindl.	373
Eremaea	pauciflora	547
Eucalyptus	calophylla R. Br.	
	haematoxylon Maiden	
	marginata SM	
	megacarpa Muell X	428
	patens Benth. X	
	rudis Endl.	

GENUS	SPECIES AND COLLECTION NUMBER	
MYRTACEAE		
Hypocalymma	angustifolium X	399
	cordifolium (Lehm) Schan.	270
	robustum Endl.	396
	strictum Schau.	243
Kunzea	recurva Schau.	236
Leptospermum	crassipes Lehm X	238
	ellipticum Endl. X	332
	firmum	452
Melaleuca	densa	506
	polygaloides	513
	preissiana Schau. X	255
	scabra, var. tuberculata	540
	thymoides Labill. X	254
Verticordia	densiflora Lendl.	374
ORCHIDACEAE		
Orchidaceae	species rarely collected -	
PAPILIONACEAE		
Aotus	villosa	518
Bossiaea	linophylla R. Br.	535
	ornata Meissn. X	227
	pulchella Meissn.	372
Burtonia	conferta DC.	246
	scabra R. Br.	407
Chorizema	glycinifolium Druce.	433
Daviesia	alternifolia Endl.	388
	incrassata Sm. X	268
	pectinata Lindl.	-
	quadrilatera	498

GENUS	SPECIES AND COLLECTION NUMBER	
PAPILIONACEAE		
Dillwynia	cinerascens	482
	uncinata Turcz.	434
Euchilopsis	linearis	-
Gastrolobium	spinosum	-
Gompholobium	aristatum	529
	burtonioides Meisn.	339
	ovatum	499
	polymorphum R. Br.	101
	venustum R. Br.	334
Hovea	chorizemifolia sweet X	29
	elliptica D.C.	-
	trisperma Benth.	210
Jacksonia	horrida DC.	248
Kennedya	coccinea Vent.	69
	stirlingii	510
Mirbelia	dilatata R. Br.	4
Oxylobium	sp.	418
Pultenaea	andrewsii	514
	drummondii X	316
	reticulata Benth. X	360
	skinneri	516
	strobilifera Meissn	365
Sphaerolobium	macranthum Meissn	345
	scabriusculum Meissn	336
Viminaria	juncea	234
PITTOSPORACEAE		
Billardiera	sp. unknown	164

GENUS	SPECIES AND COLLECTION NUMBER	
PODOCARPACEAE		
Podocarpus	drouyniana Muell	-
POLYGALACEAE		
Comesperma	virgatum	545
PROTEACEAE		
Adenanthos	barnigera Lindl. X	-
	meissneri Lehm. X	264
	obovatus Lebill. X	-
Banksia	attenuata R. Br. X	-
	grandis Willd.	-
	illicifolia R. Br. X	466
	quercifolia Meissn.	393
	sphaerocarpa R. Br.	-
Conospermum	acerosum Lindl.	403
	caeruleum	492
	capitatum R. Br.	269
	flexuosum	310
	teretifolium	541
Dryandra	bipinnatifida R. Br.	244
	nivea R. Br.	-
Franklandia	triaristata Benth.	358
Grevillea	brachystylis	329
	brevicuspis Meisn X	353
	manglesioides Meissn.	351
	occidentalis	477
	ornithopoda Meissn.	271
	pulchella X	333
	quercifolia R. Br.	194
	umbellulata	391

GENUS	SPECIES AND COLLECTION NUMBER	
PROTEACEAE		
Hakea	ambigua	311
	bipinnatifida X	119
	ceratophylla (Sm.)R.Br. X	251
	cyclocarpa Lindl.	315
	lasiantha	222
	marginata	481
	ruscifolia Labill	247
	varia R. Br.	380
Isopogon	attenuatus R. Br.	375
	axillaris R. Br.	252
	formosus R. Br.	318
	sphaerocephalus Lindl. X	-
Lambertia	multiflora Lindl.	484
	rariflora Meissn.	420
Petrophile	diversifolia R.Br. X	245
	linearis R. Br. X	338
	serruriae R. Br.	326
	squamata R. Br.	312
Persoonia	elliptica R. Br.	-
	longifolia R. Br. X	-
	saccata R. Br.	415
Stirlingia	latifolia Steud X	-
Strangea	stenocarpoides (F.Muell ex Benth).	253
Synaphaea	favosa R. Br.	309
	preissii	
Xylomelum	occidentale R. Br.	-
RESTIONACEAE		
Anarthria	prolifera R. Br.	324
	scabra	196

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GENUS	SPECIES AND COLLECTION NUMBER	
RESTIONACEAE		
Hypolaena	exsulca R. Br.	37
Leptocarpus	scariosus R. Br.	376
	tenax R. Br.	240
Loxocarya	flexuosa Benth.	325
Lyginia	tenax Labill.	239
Restio	ustulatus Muell.	378
RHAMNACEAE		
Cryptandra	arbutiflora	494
Trymalium	ledifolium	366
RUTACEAE		
Boronia	crenulata	314
	elatior	538
	fastigiata Bartl.	413
	gracilipes	298
	heterophylla	-
	juncea	313
	megastigma F. Muell	-
Crowea	augustifolia Turcz.	406
Eriostemon	nodiflorus Lindl.	390
	spicatus	321
Urocarpus	pallidus	507
SANTALACEAE		
Leptomeria	sp.	

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GENUS	SPECIES AND COLLECTION NUMBER	
STACKHOUSIACEAE		
Stackhousia	huegeli	90
STERCULIACEAE		
Thomasia	grandiflora Lindl. X	331
STYLIDIACEAE		
Stylidium	scandens R. Br.	266
THYMELAECEAE		
Pimelea	rosea	509
	spectabilis (Fisch. & Mey.) Lindl. X	263
	suaveolens	486
TREMANDRACEAE		
Tetratheca	setigera X	185
	viminea	-
VERBENACEAE		
Pityrodia	bartlingii Benth.	
VIOLACEAE		
Hybanthus	floribundus	35
UMBELLIFERAE		
Platysace	compressa (Labill.) Norman	267
Xanthosia	candida	288
	sylvatica	197

(ii) SITE MAPPING

The method adopted has been to gain knowledge of soils and vegetation by moderately intensive ground surveys on two areas having differences in site conditions, with the addition of scattered traverses over a wide area.

Soil types recognized are mapped on aerial photographs, using as a guide soil types and boundaries known from traversing of tracks and widely spaced survey lines. Spacing has varied from about 30 chains to about 80 chains between traverses of one sort or the other. Knowledge of topography/soils and vegetation/soils relationships gained on the more intensive surveys is then used to inter-polate boundaries over the area to be mapped.

Vegetation/Soils Relationship

From the ground surveys, quantitative data on both has been subjected to statistical analysis (Principal Components). As a result of the first such analysis it has been possible to arrange vegetation species into seven groups which can be related to three recognizable site characteristics and a further one not identified. These groups are displayed in Attachment III.

However, vegetation "type" can as yet only be used as a guide to soil type, though time can frequently be saved in the field by avoiding or reducing profile inspection.

Results of another analysis on data from the second survey are still being worked on to try to define better the site characteristics influencing species distribution, and also to produce closer definition of vegetation types. Achievement of this would facilitate classification of site in the field, for both mapping and demarcation purposes.

An assessment of the agreement between soil type and vegetation type on 137 recorded sites has given figures of 60% for an earlier system of assessing vegetation type, and 65% for the current one applied to 25 sites. The approach used was to record whether soil type was "as expected" or "not as expected" on the basis of vegetation type. The more stringent test of predicting soil type and calculating a success rate would produce a lower figure.

Lower storey vegetation of two types can be recognized on photographs, and crown density and height are of aid in interpretation of a further two soil types.

Soil Profile Inspection

Necessary as a supplement to, or alternative to, vegetation classification on field traverses, this has been made less troublesome and time-consuming by adoption of a small diameter core sampler in conjunction with a depth probe. This equipment, however, becomes difficult to use when soil has dried out.

Soil Types

The original classification comprised six types, with a

seventh fore-shadowed, which has since been described. These are briefly defined as follows:-

(1) Lateritic soils - boulders and gravel at surface.

(2) Shallow sandy soils - less than 50 cms. depth over laterite.

(3) Deep (more than 50 cms.) sandy soils of yellowish-brown colour.

(4) Deep sandy soils of greyish colour.

(5) Soils with texture sandy loam or heavier; depth and colour variable.

(6) Soils with very heavy texture, often from surface; gravel-in-clay basement.

(7) Soils of moderately heavy texture and strong colour associated with drainage lines.

Note that the characterizing texture for these types is that found at 60 cms. depth. This was adopted when the statistical analysis showed a better correlation (with vegetation distribution response) than for texture at a lesser depth. This procedure contrasts with that usually adopted where near-surface texture characterizes the soil profile, and could have more relevance to tree site requirements.

More recently the above types have been subdivided in an attempt to obtain more constant agreement between vegetation types and soil types. Two of these new phases for one soil type are recognizable on aerial photographs. This sub-division is defined in Attachment I, "Key to Soil Types".

Reliability of Interpretation on Photographs

Reasonably reliable interpretation, depending mainly on topographic differences, can be done for three soil types out of the seven recognized. These are the laterite and shallow sand over laterite, and the olluvial soils flanking drainage lines. It is known that vravel may occur in the field and be undetected on photograph because of lack of topographic differentiation and unusually poor quality of forest cover. The error of mapping gravel where it does not exist is not thought to occur often; where it does the soil will probably prove to be the shallow sand types, so that the error will not be of great significance.

Soil types of heavy texture are believed to be mapped with fair reliability, but are not separable into the two types recognized.

The remaining two deep sand types can not be separated with any confidence, except that extreme phases of dryness and wetness in grey sands are obvious (this by means of vegetation, as before mentioned). Difference in tone between the two types, probably due to more dense ground vegetation beneath more open canopy on the grey sands, has been observed, but is not known to be consistent.

When aspect and degree of slope were included in a computer analysis of site characteristics, no effect of these upon the ordination of the sites was evident. However, a recent tabular analysis of aspect for Types 3 and 4 only, does suggest a difference in distribution between the yellowish-brown and the grey sands. This has not been tested either on photo-interpretation or in the field.

Because most of the track traversing was done by another officer using a simpler system of classification and slightly different depth criteria, and the information was mostly recorded only by colour code on plans, its value was reduced. Depth limit differences mean that the area of shallow sand shown on plan will have been over-estimated slightly. This may help to counteract under-estimation of laterite areas.

An objective test of reliability has been planned but field checking will not be carried out until the first requirement for soil maps has been met.

Plan Compilation

Boundaries delineated on photographs are transferred to base plans of the "20-chain" topographic series by Drafting Branch personnel using the "Wild" stereoplotter.

Where ground surveys have previously been done the existing plans have been correlated with presently-used soil types and their boundaries used on current plans.

Such plans so used have been:-

(1) 1955 survey; Willcock Group (Hill and van Noort)
(2) 1967 land use survey; Whicher, Molloy, Vasse Groups (McCutcheon)
(3) 1935-37 surveys; Jarrahwood, Cundinup Groups (Helms et.al.)

With the latter survey, such difficulty has been encountered in correlating soil types, for several reasons, that the map produced retains the original soil types and phases. Banded colour to indicate approximate equivalence to current types (in conjunction with an additional key) is used on the plans concerned, but area assessment is on the basis of suitability classes only, for the portions surveyed in 1935-37. Appendix II displays the variations in correlations, and suitability estimates based on profile descriptions recorded in 1937.

Suitability Ratings

These have been assessed, not by consideration of individual areas, but by assuming that all occurrences of a particular soil type will have similar suitability, and assessing this by consideration of the typical profile.

Thus all of Type 1 is classified as unsuitable despite the fact that some limited occurrences of deep gravels with a loamy matrix may well prove suitable. All of Type 2 is classified as doubtful on the grounds of likely moisture stress problems.

Type 7 is classified as suitable; it will frequently be unsuitable for Pinus radiata but suitable for Pinus elliottii. However in practice it will often not be planted because of conservation considerations and because clearing could be a difficulty.

Type 6 has been set up mainly because it is expected to be an extremely difficult site for pines, probably unsuitable without an uneconomic degree of amelioration by mechanical and perhaps chemical means. However in the region so far mapped it is not important.

No difficulties is anticipated with most areas of Type 5; some may need draining, but is classified as suitable at this stage as only ground examination will determine such need.

Type 3 is classified as uniformly suitable, and may prove to be the best site type available.

Type 4 is classified as suitable though the Type 4A may require heavier thinning and more frequent fertilization and Type 4D will require draining.

Areas Plantable - Plan *No's. 159, 156, 155, 154, 176, 173.

Out of a total of 6571 ha of State Forest mapped, the following assessment has been arrived at:-

Suitable	54.0%
Doubtful	5.0%
Unsuitable	41.0%

It should be noted that extensive areas of mainly lateritic soils occur on the strongly dissected portions of river catchments, viz. Ludlow and Sabina Rivers to the north-west, and the St. John Brook and tributaries to the east. These areas contribute to a lower figure for proportion of suitable soil than is to be anticipated for the region south and west of that mapped so far. However, nearer the Blackwood River dissection again reduces the proportion of suitable soils.

The break-down of the area by soil types and by suitability classes is shown in Table I, following.

T A B L E I

Soil Type	Suitable	Doubtful	Unsuitable	Total
1			23041	23041
2		2462		2462
3	7526			7526
4	12853			12853
5	4696			4696
7	2470			2470
Sub Total	27546	2462	23041	53050
1937 Survey	8153	815	3700	12668
TOTAL	35698	3277	26741	65716

Usability of the land suitable for planting has been assessed by exclusion of all portions which are:-

(1) Isolated from other suitable land and less than 40 ha in area by ocular comparison with a sample square or rectangle, or

(2) Connected to other suitable land but forming a strip less than roughly 200 metres in width.

* Identified as "Sunkland Reconnaissance, Pine Site Assessment" File 313/67.

On this basis the percentages of non-usable plantable land on the various plans are 154 - 7.4; 155 - 3.3; 156 - 2.2; 159 - 1.3; 173 - 2.5; 176 - 8.2; overall 4.5 per cent.

Soil Type Evaluation

To assist in evaluation of pine performance on various sites intensive s oil surveys are being carried out on the larger plots in the region. Soil plans are part completed for 9 of the northern plots averaging 6.5 ha each, and one plot has yet to be studied.

Correlation of pine sites with adjoining native vegetation types is to be carried out around plots of all sizes, but as yet only 5 such "ecological" plots have been recorded.

ATTACHMENT I

KEY TO SUNKLANDS SOIL TYPES (FORESTS DEPARTMENT 1974)

			SOIL TYPE NO.
A.		Gravel percentage within 50 cms of surface more than 20%	
	B.	Texture "sand" or "loamy sand"	
		C. Gravel more than 20% within 20 cms of surface	
D.		Gravel within 20 cms of surface more than 60%; massive laterite present -	1b
D.		Gravel within 20 cms of surface; less than 60%; nor massive laterite -	1g
		C. Gravel more than 20% deeper than 20 cms from surface	
D.		Colour range grey or greyish-brown	
	E.	Basement is moderate to heavy gravel	2 Gg
	E.	Basement is massive laterite	2 Gb
D.		Colour range yellowish-brown or brownish-yellow	
	E.	Basement is moderate to heavy gravel	2 Yg
	E.	Basement is massive laterite	2 Yb
	B.	Texture "sandy loam" or heavier	
		C. Gravel more than 20% within 20 cms of surface	1 F
		C. Gravel more than 20% deeper than 20 cms from surface	
D.		Colour range grey, greyish brown, yellowish brown	
	E.	Basement is moderate to heavy gravel	
		F. Texture between gravel not heavier than "clay loam"	5g (shallow phase)
		F. Texture between gravel "sandy clay" and maybe "clay" at surface: colour pale and mottling a feature	6 (shallow phase)
	E.	Basement is massive laterite	
D.		Colour range brownish yellow, strong brown, reddish; usually associated with drainage lines	7 (shallow phase)

			SOIL TYPE NO.
A.		Gravel percentage within 50 cms of surface less than 20%	
	B.	Texture "sand" or "loamy sand"	
		C. Colour range light yellowish brown to brownish yellow	3
		C. Colour range light grey to dark greyish brown	
D.		Profile dry; texture "sand"; colour very light grey	4A
D.		Profile moist but well drained; texture "loamy" sand	4
D.		Profile moist to wet; texture "loamy sand"; organic "coffee-rock" present	4C
D.		Profile poorly drained, or water-gaining site	4D
	C.	Colour strong brown or reddish and associated with drainage line	7
	B.	Texture "sandy loam" or heavier	
,	C.	Colour range, greys, greyish brown, yellowish brown	
D.		Profile shows change of two texture classes between A_2 and B horizons	5D
D.		Texture change down profile is gradual	
	E.	Gravel forms base to profile, with matrix of "sandy clay", which texture may occur at surface; profile colour pale and mottling a feature	6
	E.	If gravel baae, matrix texture not heavier than "clay laom"	5G
	C.	Colour strong brown or reddish; usually associated with a drainage line	7

NOTE:- Characterizing texture (level B in the key) is normally determined at 60 cms depth, unless it is obvious from the profile description that a lesser depth applies. In this case the depth of description will be that immediately above some limiting feature.
Moisture status of greyish sands may be partly inferred from colour (amount and depth of black humus incorporation) and from texture.

ATTACHMENT I I

1937 CORRELATION			BRIEF DESCRIPTION FROM PROFILE DESCRIPTION WHERE AVAILABLE	CORRELATES WITH 1974 TYPE	1974 SUITABILITY ASSESSMENT (Suitable = S, Doubtful = D, Unsuitable = U)	
JARRAHWOOD SOIL GROUPS BASED ON SURFACE INDICATIONS	SURVEY LOCALITY *	TYPE DESCRIPTION				
3A		1	Sand, loamy gravel and scattered lateritic boulders	1b	U	U
	Cu	A1	Sand and heavy gravel with boulders and shallow massive laterite	1b	U	
	Ca	3A	-	-	-	
		3A1	Yellowish-brown sand with heavy gravel, boulders and massive pan.	1b	U	
		3B1	As above but laterite more broken, with pockets of clay-loam.	1b	U	
3B	Cu	A2	Grey- grey-yellow sand with some gravel and scattered boulders.	2Gb	D	D
	Ca	3B	-	-		
3C	J	1A	Sand, light gravel, occasional lateritic boulders, deeper than type 1	1g	U	U
	Ca	3C	-	-	-	
2A	J	3B	G. sandy loam with light gravel becomes yellowish-brown; sandy clay with heavy gravel	5G	S	

2A1	J	3A1	T-G sand becoming CL by 100 cms and gravelly; pan at 125 cms.	5	S	
	Cu	A3	Y-B sandy loam grading to clay over laterite at 75 cms	5G	D	S
		B1	Y sand becoming Y-G sandy clay loam over laterite at 250 cms	3	S	
2B	J	2B	Dark grey, becoming yellowish grey, sand; lat. hardpan at 100 cms	4	S	
	Cu	C4	Y sand over laterite at 103 cms.	3	S	
	Ca	2B	Shallow (37 cms) G to Y-G sand over heavy gravel in loamy matrix.	2Gg	D	S
		2F	Y-G sand increasing to mottled light clay with heavy gravel: 150 cms	4D	S; wet	
	also 2D, 2E1, 2G			-	-	
2B1	Cu	B4	Y-G sand grading to sandy clay by 112cms	3	S	S
2C	J	3C	G to Y-G sand, becoming CL over lat. pan at 130 cms.	4	S	
	Cu	A4	Y to G-Y sand over heavy gravel then laterite at 90 cms.	3	S	
		B2	Y-B sandy loam, texture and gravel increasing to laterite at 90 cms.	5G	D	S

ATTACHMENT II (Cont'd)

2C (cont.)	Ca	2C	-	-	-	S
		2E	-	-	-	
4A	J	3A	Y-B to G-B sandy loam becoming clay loam; pan at 125 cms.	5G	S	
	Cu	B3	R-B sandy loam becoming gravelly by 112 cms.	7	S	
		D1	B-Y to R-B sandy loam grading to sandy clay at 112 cms.	7	S	S
		D2	As above but with laterite at 75 cms	5G	D	
	Ca	4A1 4A2	Types 4 generally are very leached s oils with coffee-rock	4C	S	
4A1	-	-	-	-	-	-
4B	J	4A	G to white sand with org. stain over lat. pan at 190 cms	4C	S; wet	
		4B	GS with B stain at 82 cms, then white; laterite at 200 cms.	4C	S	
	Cu	C2	G sand with org. stains becoming rusty mottled at 240 cms; wet.	4C	S	S
		C5	G to Y-G sand, wet; texture increases at depth; laterite at 200 cms.	4D	S	
	Ca	4B	GS with org. stain at pan at 105 cms.	4C	S	

* J = Jarrahwood Cu = Cundinup Ca = cambray

4C	J	2A	Deep (150 cms) grey sand over lat. hard pan	4	S; wet	S
	Cu	C1	G sand grading to light sandy clay, with gravel; laterite at 90 cms.	4	D	
		C5	See above	4D	S	
	Ca	4C	G sand over Fe/org. pan at 60 cms.	4D	S	

* J = Jarrahwood Cu = Cundinup Ca = Cambray

ATTACHMENT III - SOIL - VEGETATION ASSOCIATION.

	G	F	E	D	C	A
LEUCOPOGON GLABECCUS	×	×	×	×	o	o
BANKSIA ATTENUATA	×	×	×	×	×	
PETROPHILA LINEARIFOLIA	×	×	×	×	×	
ADENANTHOS MEISSNERI	×	×	×	×	o	
DASYPOGON BROMELIAEFOLIUS	×	×	×	×		
HIBBERTIA PACHYRRHIZA	×	×	×	×	o	
MELALEUCA THYMOIDES	×	×	×	o		
HIBBERTIA VAGINATA	×	×	×	×		
AGONIS PARVICEPS	×	o				
ADENANTHOS OBOVATA	×	×	×			o
STIRLINGIA LATIFOLIA	×	×	×	o		o
DAVIESIA INCRASSATA	×	×	×	o	×	×
MESOMELENA TETRAGONA	×	o	×	o	×	×
PUCTANAEA RETICULATA	×	×	×	o		×
BANKSIA LITTORALIS	×	×	×		o	×
HAKEA CERATOPHYLLA	×	×	×		o	×
MELALEUCA PREISSII	×	×	×		o	×
HYPOCALYMMA ANGUSTIFOLIUM	o		×		o	×
DASYPOGON HOOKERII	×	o	o		o	×
LEPTOSPERMUM CRASSIPES	×	×	×		o	×
LEPTOSPERMUM ELLIPTICUM	×	×	o		o	×
XANTHORRHOEA PREISSII	o				o	o
AGONIS LINEARIFOLIA	×	×		o	×	×
EUC. MARGINATA	×	×		×	×	×
EUC. PATENS	×	×		×	×	×
ACACIA BROWNIANA				×	×	×
PULTANAEA DRUMMONDII	o			o	×	×
LEUCOPOGON AUSTRALIS				o	×	×
PIMELIA SPECTABILIS	o			o	×	×
HAKEA LISSOCARPA	o		o	×	×	×
XANTHORRHOEA GRACILIS			o	o	×	×
KINGIA AUSTRALIS	×		×	o	o	×
BORONIA CRENULATA						
ANDERSONIA CAERULEA						
BEAUFORTIA SPARSA						
GREVILLEA PULCHELLA						
ACACIA OBOVATA						
ACACIA DIPTERA						
GREVILLEA BREVICUSPIS						
PETROPHILA DIVERSIFOLIA						
THOMASIA GRANDIFLORA						
HIBBERTIA QUADRICOLOR			×	o	×	×
DAVIESIA PREISSII			×	×	×	×
DAVIESIA PECTINATA		o	×	×	×	×
ACACIA EXPENSA		×	o	o	×	o
TETRATHECA SETIGERA		×	o	×	×	×
LEUCOPOGON VERTICILLATUS		o	×	×	×	×
ADENANTHOS BARBIGERA		o	×			×
HIBBERTIA MONTANA		×	o			×
ISOPOGON SPHAEROCEPHALUS		o	×			×
BOSSIAEA ORNATA		×	×	×	×	×
HOVEA CHORIZEMIFOLIA		×	×	×	×	×
PERSOONIA LONGIFOLIA		×	×			×
LEUCOPOGON CAPITELLATUS		×	×	×	×	×
STYPHELIA TENUIFLORA.		×	×	×	×	×

INDEX

OBLIGATORY

PROBABLE

POSSIBLE

SLIGHT CHANCE

BARRED

APPENDIX 3

Water Sampling Data - Margaret River Catchment

Total dissolved solids mg/litre (Note: Solute nearly all NaCl)

Date:	SAMPLING POINT NUMBER					
	1	12	5	27	13	6
09.11.73	170	139	120		174	170
16.11	182	149	125		175	161
23.11	195	155	124		190	176
30.11	195	152	130		180	169
07.12	189	156	130		184	173
14.12	211	159	131		195	206
21.12	209	170	134		202	186
28.12	223	172	149		202	196
04.01.74	223	192	148		262	198
11.01	246	197	156		Dry	202
18.01	Dry	206	163			206
25.01		Dry	149			202
01.02			149			216
08.02			217			306
15.02			Dry			222
22.02						216
01.03						192
08.03						192
15.03						195
						Dry
10.05.74		227	163		227	
17.05	317	263			263	218
24.05	217	214	148	174	214	196
30.05	176	173	152	192	173	187
07.06	188	162	139	172	162	184
14.06	197	171	139	183	171	189
21.06	197	175	139	187	175	188
28.06	154	130	114	141	130	158
05.07	141	123	108	124	141	142
12.07	123	110	92	90	116	126
19.07.74	92	131	83	80	92	107
26.07	83	79	87	99	108	109
02.08	54	58	64	65	68	65
09.08	89	82	66	81	92	87
16.08	110	97	86	92	105	104
23.08	87	83	67	87	90	83
30.08	109	94	70	99	116	96
07.09	119	92	77	89	107	104
13.09	117	94	75	117	112	106
20.09	133	104	90	116	123	117
27.09	133	112	90	121	133	121
04.10	146	131	87	137	156	132
11.10	163	132	109	139	153	146
18.10	162	134	108	132	161	149
25.10	164	138	121	146	157	159
31.10	168	137	116	149	158	158
08.11	158	136	116	146	158	150

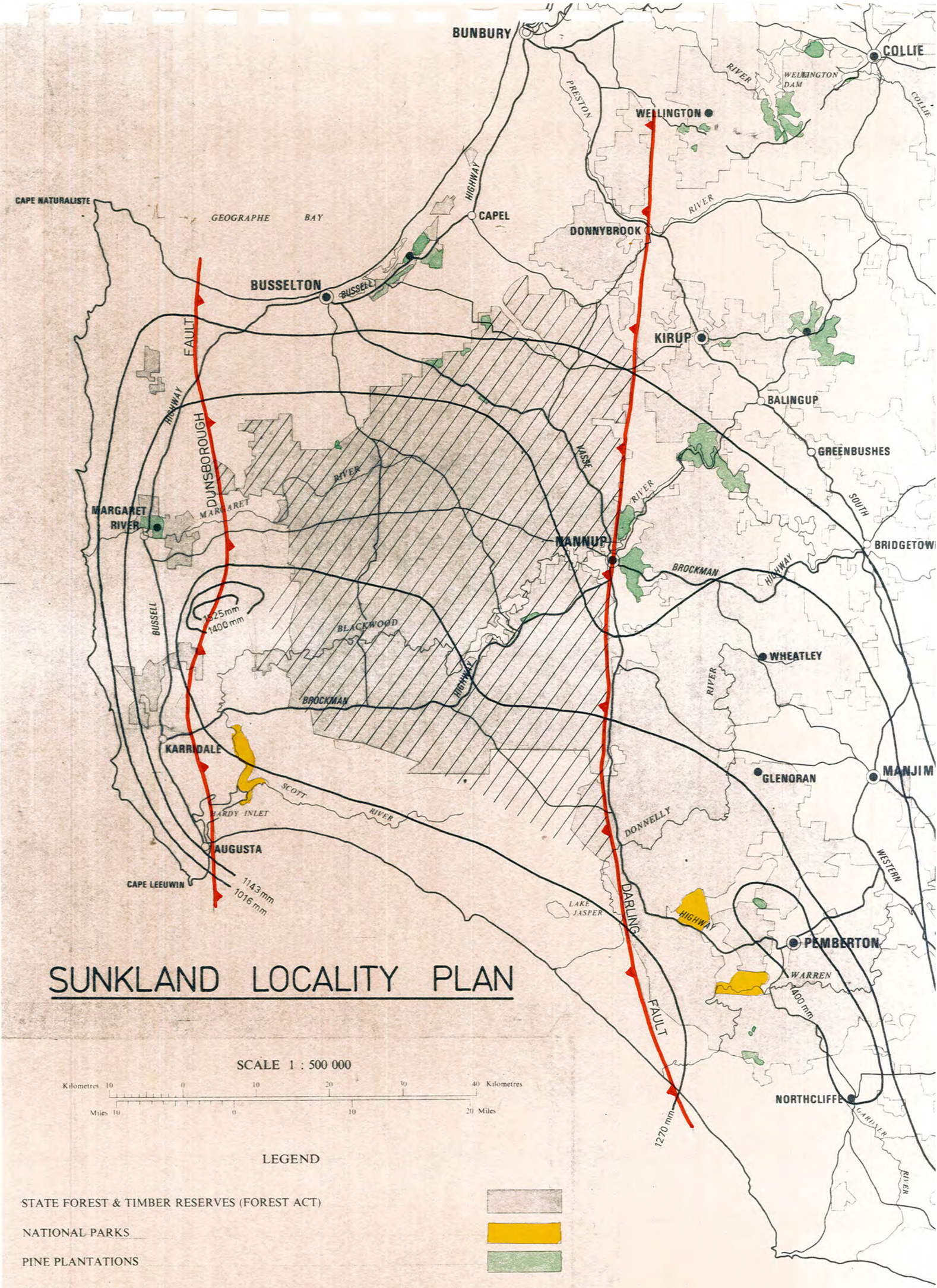
APPENDIX 4

Comparison of Water Quality Data

For Hardwood and Plantation Catchments

Total dissolved solids mg/litre

Date	Uncleared hardwood forest	Pine plantation age 1 & 5 years.
09.11.73	128	91
16.11	134	94
23.11	138	92
30.11	138	90
07.12	142	97
14.12	148	96
21.12	151	Dry
28.12	161	
04.01.74	166	
11.01	Dry	
30.05.74	163	114
07.06	156	111
14.06	154	106
21.06	156	104
28.06	138	95
05.07	126	85
12.07	121	77
19.07	85	67
26.07	90	70
02.08	64	52
09.08	63	50
16.08	70	56
23.08	70	51
30.08	77	50
07.09	77	53
13.09	79	51
20.09	94	62
27.09	97	63
04.10	112	77
11.10	118	83
18.10	117	84
25.10	127	92
31.10	129	91
08.11	126	90



SUNKLAND LOCALITY PLAN

SCALE 1 : 500 000

Kilometres 10 0 10 20 30 40 Kilometres

Miles 10 0 10 20 Miles

LEGEND

STATE FOREST & TIMBER RESERVES (FOREST ACT)

NATIONAL PARKS

PINE PLANTATIONS

RAINFALL ISOHYET ..... 1016 mm

FAULT LINES

"SUNKLAND" AREA

PLAN 1

PLAN 2

MINING CLAIMS

MINING CLAIM

1966

1966

1967

1968

1970

1970

1971

1971

1971

1971

1971

1972

1972

1974

1974

1979

1951, 61, 72

MINING CLAIMS

MINING CLAIM

1966

1966

1968

1972

1971

1974

1967

1970

1971

1974

1951, 61, 72

1971

1970

1971

1971

1972

1971

1974

WELLINGTON

1974

1969

1969 - 70

1969 - 70

BROCKMAN SECTION A

BROCKMAN (PLANTATION)

1970
PLOT No. 9

1967

1971

1972

1969 - 70

1969 - 70

1969 - 70
PLOT No. 8

1974
1971
1969
1969 - 70
1969 - 70
1970
1967
1971
1972
1969 - 70
1969 - 70
1971

1967

1971

1972

1969-70

1969-70

1969-70

SOUTHERN OCEAN

KEY TO SYMBOLS

Forests Dept. Headquarters
Sawmill
Lookout Tower
Survey Reference Tree Theodolite
Survey Reference Tree Compass
Loading Ramp
Permanent Water Supply
Permanent Water Supply Developed

1:126 720

INDEX TO ADJOINING SHEETS

BUSSELTON | KIRUP
AUGUSTA | MANJIMUP
PEMBERTON

STATE FOREST, TIMBER
& FREEHOLD LAND IN
TIMBER RESERVES (LAN
CROWN LAND REQUESTE
STATE FOREST OR TIME

1967

1971

1972

1969-70

1969-70

1969-70
PLOT No. 4

1971
PLOT

VIRGIN
JARRAH
DICKSON

1969-70
PLOT

OCEAN

WHITE POINT

NELSON

INDEX TO ADJOINING SHEETS

BUSSELTON	KIRUP
AUGUSTA	MANJIMUP
	PEMBERTON

R. J. HEGGS
CONSERVATOR OF FORESTS

TENURE PLAN

STATE FOREST, TIMBER & (FOREST ACT)
& FREEHOLD LAND IN NAME OF CONSERVATOR

TIMBER RESERVES (LAND ACT)

CROWN LAND REQUESTED FOR
STATE FOREST OR TIMBER &

RESERVES

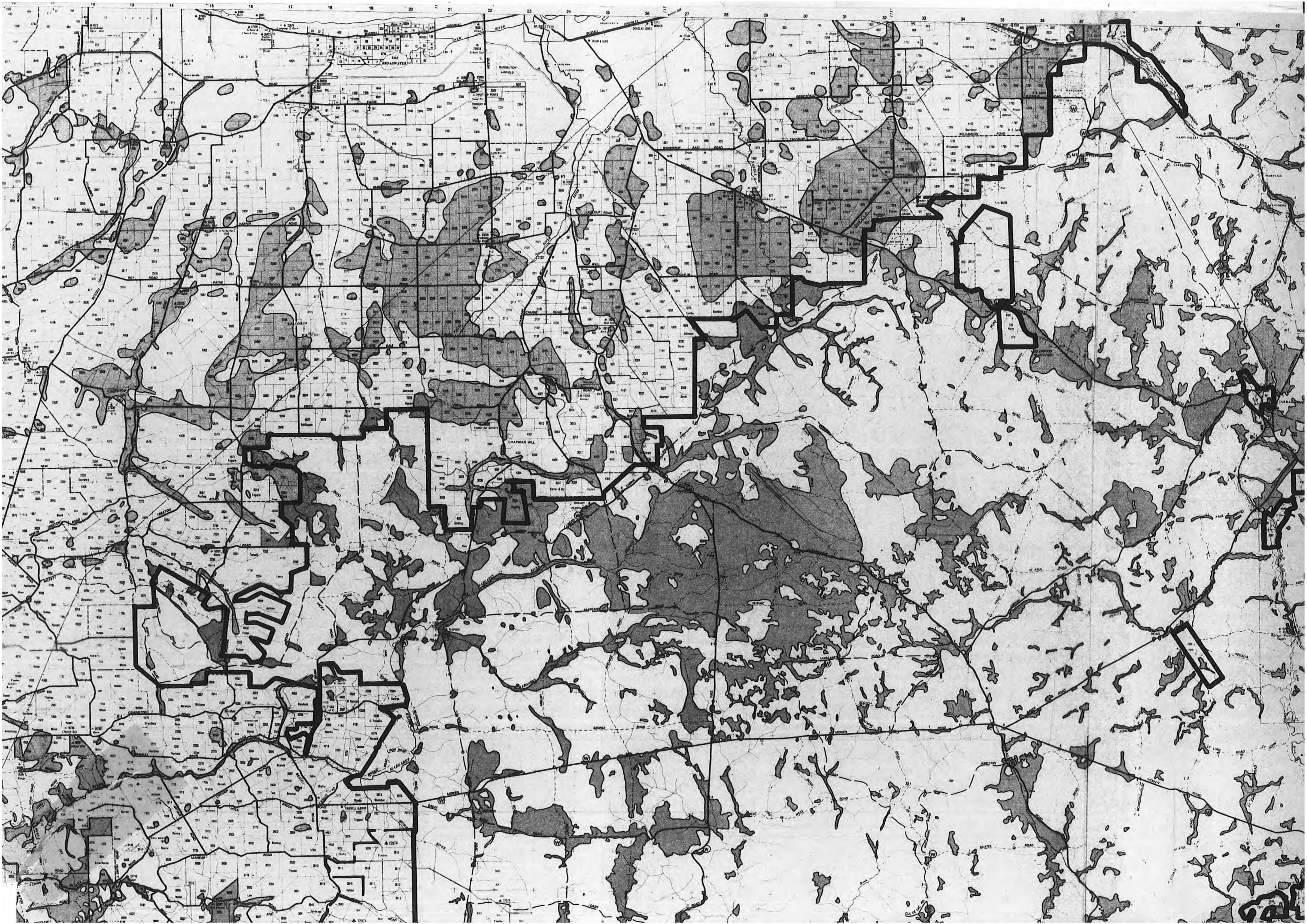
PRIVATE PROPERTY

EXPERIMENTAL PLOTS

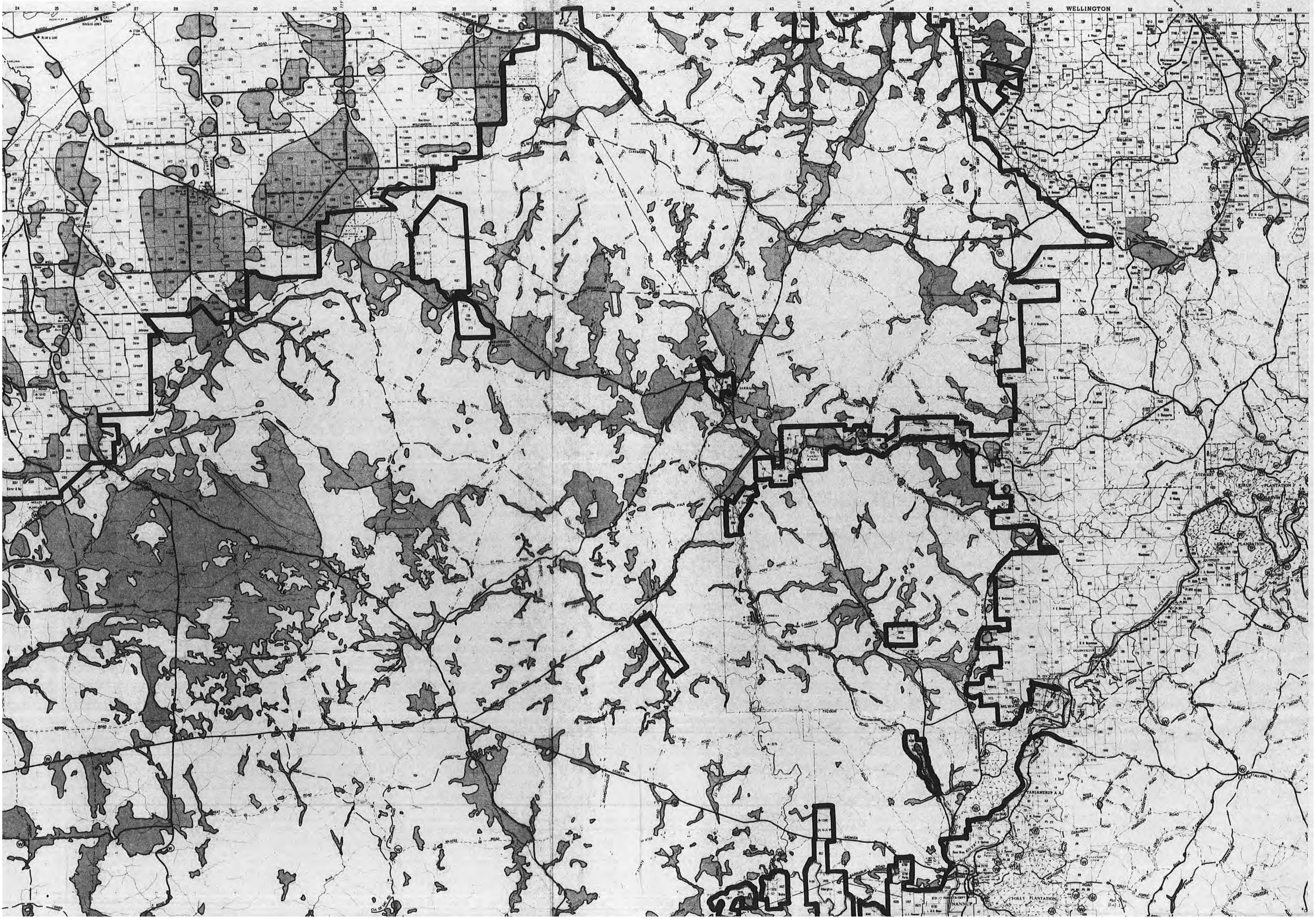
PLAN 2

PLAN 3

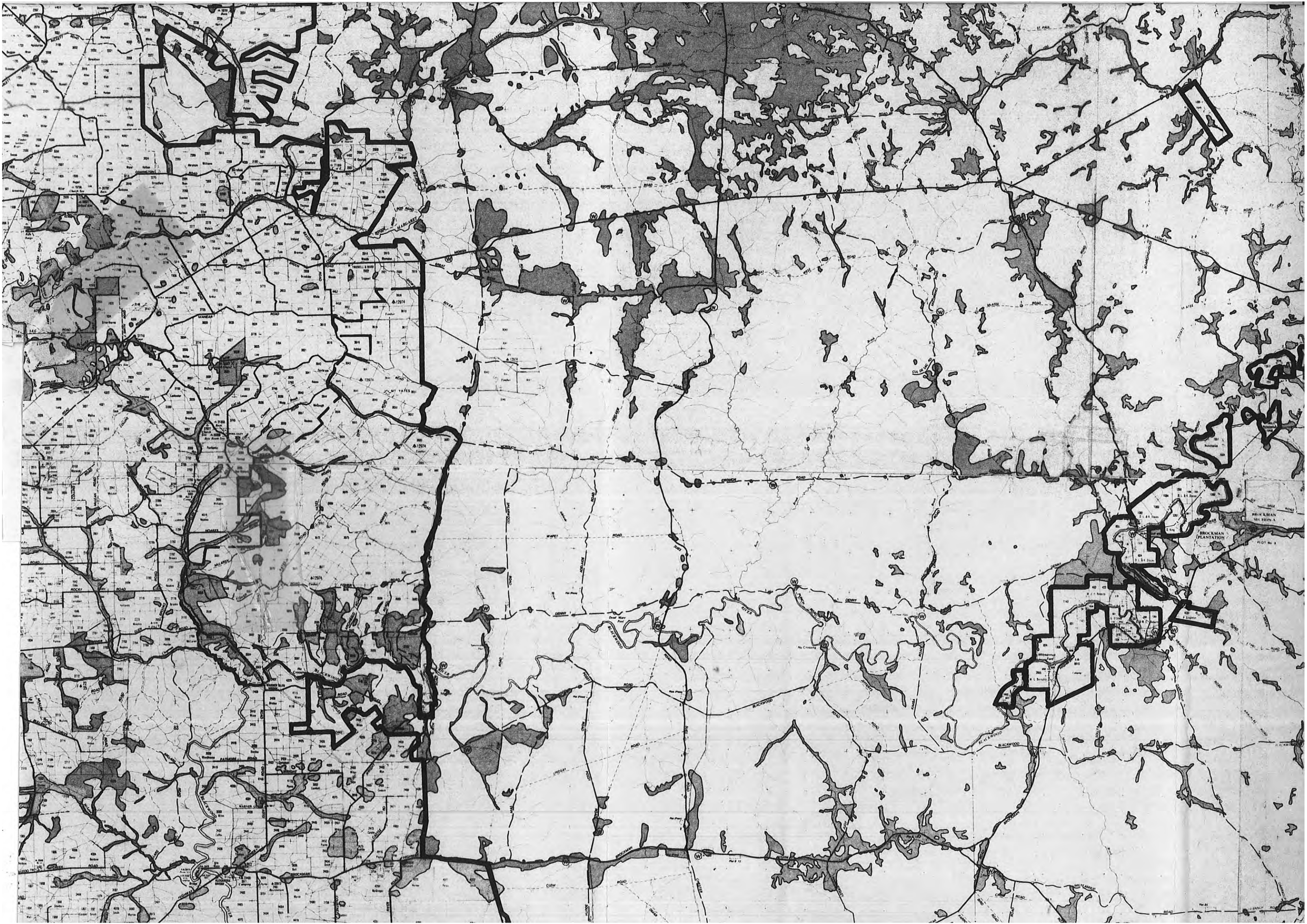
N.B. Plans 4 and 5 are missing

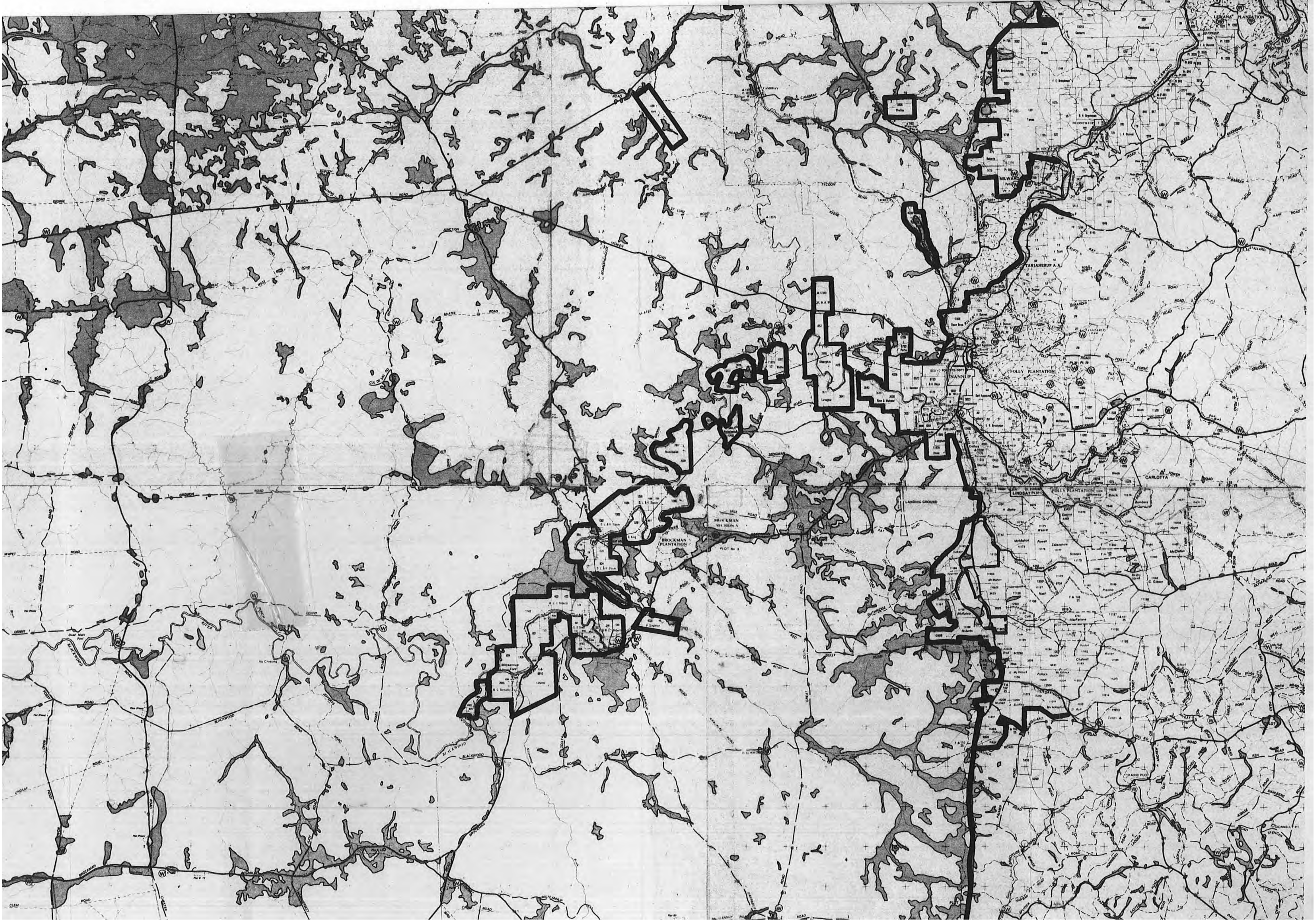


THE BROADWATER
BUSSELTON AIRFIELD
CHAPMAN HILL



WELLINGTON
NANNUP
FOLLY PLANTATION




NANNUP
BROCKMAN PLANTATION
FOLLY PLANTATION
LINDSAY PL
CARLOTTA
LANDING GROUND
MILWARD
TANJANERUP A.A.
BLACKWOOD
MOWEN ROAD
CROUCH ROAD

SOUTHERN OCEAN

SCOTT RIVER

LEDGE POINT

FLINDERS BAY

WHITE POINT

NELSON

KEY TO SYMBOLS

Forests Dept. Headquarters
Sawmill
Lookout Tower
Survey Reference Tree Theodolite
Survey Reference Tree Compass
Loading Ramp
Permanent Water Supply
Permanent Water Supply Developed

1:126720

Kilometres

Miles

R. J. REGGS
CONSERVATOR OF FORESTS
AUGUST 19[illegible]

PROVEN
STATE
& FREE
TIMBER
REQUES

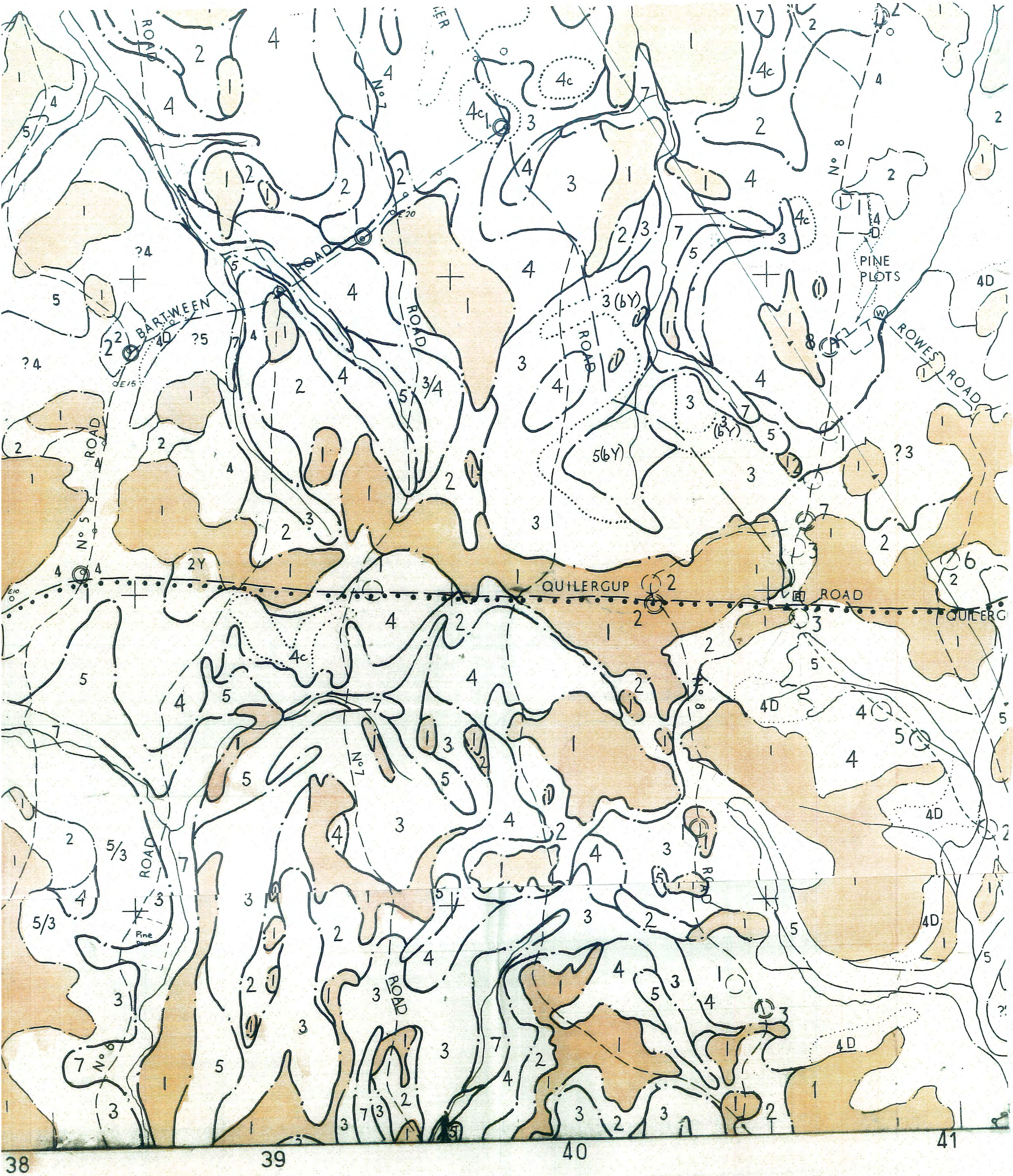
PROVEN AND SUSPECT DIEBACK INFECTIONS 1973

STATE FOREST, TIMBER ⩚ (FORESTS ACT)
& FREEHOLD LAND IN NAME OF CONSERVATOR

TIMBER RESERVES (LAND ACT) & CROWN LAND
REQUESTED FOR STATE FOREST OR TIMBER ⩚

INCIDENCE OF DIEBACK DISEASE

PLAN 3



PLANTABLE SOILS PLAN [EXAMPLE]

Pt. 173/20

SCALE - 1 : 15840

LEGEND -

Unplantable

Plantable

PLAN 6

PLAN NO.7

FOREST RESERVE
RECREATION, CATCHMENT, FLORA

FOREST RESERVE

FOREST RESERVE
RECREATION, CATCHMENT, FLORA

FOREST RESERVE
RECREATION; FLORA; FAUNA

FOREST RESERVE

FOREST RESERVE

RECREATION

MILYEANNUP
BIOLOGICAL RESERVE

FOREST RESERVE
VIRGIN KARRI OUTLIER

FOREST RESERVE

RECREATION

MILYEANNUP
BIOLOGICAL RESERVE

FOREST RESERVE
VIRGIN KARRI OUTLIER

MILYEANNUP
BIOLOGICAL RESERVE

FOREST RESERVE
VIRGIN KARRI OUTLIER

SOUTHERN OCEAN

1:126 720

PLANTATION CELLS (APPROXIMATE)

RESERVES

B. J. BEGGS
CONSERVATOR OF FORESTS
AUGUST 1973

MILYEANNUP
BIOLOGICAL RESERVE

FOREST RESERVE
VIRGIN KARRI OUTLIER

OCEAN

PRELIMINARY BROADSCALE SUNKLAND DEVELOPMENT

PLAN 7

PLANTATION CELLS (APPROXIMATE)

RESERVES

B. J. BEGGS
CONSERVATOR OF FORESTS
AUGUST 1973

WATER SAMPLING POINTS MARGARET RIVER CATCHMENT

SUSSEX LAND DISTRICT

1 : 126720

PROVEN AND SUSPECT DIEBACK INFECTIONS 1973

CATCHMENT BOUNDARY

WATER SAMPLING POINTS

PLAN 8

PLAN NO.9

JARRAHWOOD PLANTATION

9
197mg/l

8
173mg/l

2
180mg/l

15
134mg/l

14
119mg/l

4
210mg/l

3
138mg/l

16
183mg/l

17
138mg/l

10
124mg/l

6
163mg/l

5
118mg/l

11
94mg/l

13
152mg/l

1
166mg/l

12
145mg/l

26
137mg/l

27
127mg/l


9
197mg/l
8
173mg/l
7
149mg/l
24
210mg/l
23
440mg/l
2
80mg/l
15
134mg/l
JARRAHWOOD
PLANTATION
10
124mg/l
14
119mg/l
4
210mg/l
3
138mg/l
16
183mg/l
21
508mg/l
22
580mg/l
6
163mg/l
13
152mg/l
NORTH
11
94mg/l
5
118mg/l
17
138mg/l
25
269mg/l
APPROX. FAULT
DARLING
WELLINGTON


19
170mg/l
18
184mg/l
28
184mg/l
20
421mg/l
27
127mg/l

28
184mg/l

18
184mg/l

19
170mg/l

20
421mg/l

25
269mg/l

KEY TO SYMBOLS

- Forests Dept. Headquarters
- Sawmill
- Lookout Tower
- Survey Reference Tree Theodolite
- Survey Reference Tree Compass
- Loading Ramp
- Permanent Water Supply
- Permanent Water Supply Developed

1:126 720

Kilometres

Miles

B. J. BEGGS
CONSERVATOR OF FORESTS
AUGUST 1973

STR

ST

12
133mg/l

WA

STREAM CATCHMENTS & WATER SAMPLING POINTS

STREAM CATCHMENT BOUNDARY

12
133mg/l WATER SAMPLING POINTS

MEAN TOTAL SOLUBLE SALTS

PLAN 9

B. J. BEGGS
CONSERVATOR OF FORESTS
AUGUST 1971

PLAN NO.10

SEISMIC LINE
POWER ROAD
MARYVALE
MARYVALE ROAD
CLAYMORE
CLAYMORE ROAD
15
222
154
11
217
123
14
227
205
13
261
243
12
221
146
Penguin Rd
Fulmar Rd
Gatter Rd
PETER ROAD
Petrel Rd
Gannet
BARTWEEN
QUILERGUP
10
280
193
9
278
191
8
266
182
7
390
329
17
479
356
Albatross
ROWES ROAD
PINES
Cormorant Rd
16
335
294
Gull Rd
QUILERGUP ROAD
1
278
198ha
2
387
296ha
SHRIKE ROAD
3
476ha
(430ha)
5
382
253ha
20
359
322
HALEY
VASSE
MILL

MARYVALE

MARYVALE

LINE

CLAYMORE

ROAD

ROAD

ROAD

ROAD

GOODWOOD

CLAYMORE

STOCK

ROAD

MORLEY

ROAD

CHARLIE

MORLEY

FORMATION

17

79

56

18

293

222

27

465

365

ROAD

WAGR

Gull Rd

16

335

294

QUILERGUP

QUILERGUP

ROAD

ROAD

GOODWOOD

19

548

433

X ROAD

Pijon Rd

STOCK

534

422

28

338

285 Pt

CHARLIE

317

212

26

BRUSH

ROAD

ROAD

LITTLE

BROOK

28

196

136 Pt

20

359

322

PIT

ROAD

MILL

25

368

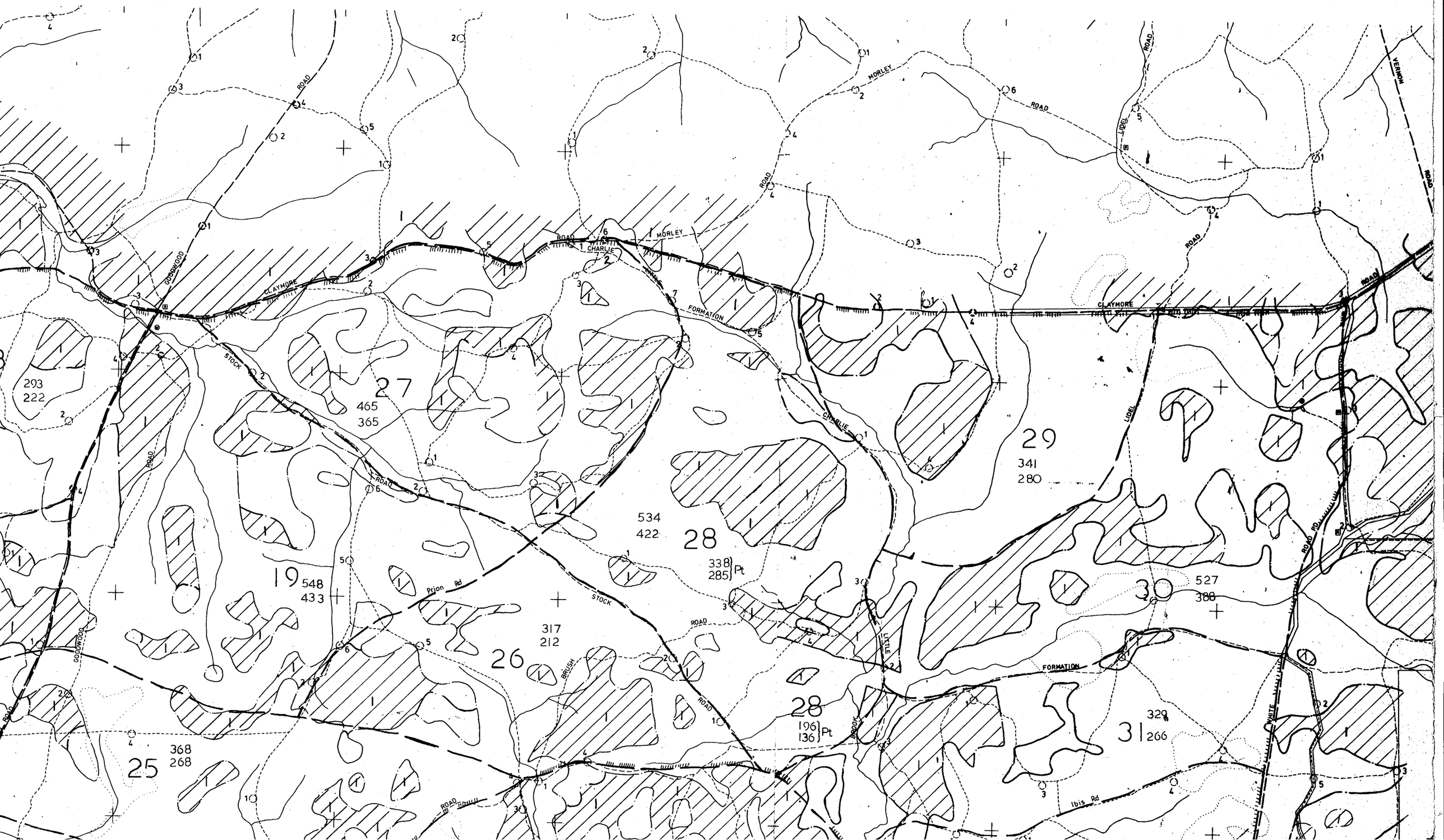
268

21

223

190

ROAD


ROAD
GOODWOOD
CLAYMORE
STOCK
CHARLIE
MORLEY
FORMATION
LIDEL
VERNON
293
222
27
465
365
534
422
28
338
285
Pt
29
341
280
19
548
433
317
212
26
30
527
388
25
368
268
196
136
Pt
31
266
328
Prion Rd
Ibis Rd
BRUSH
BROOK
LITTLE

1
278
198ha
2
387
296ha
3
476ha
(430ha)
4
389
285ha
5
382
253ha
6
358
312ha
20
359
322
21
223
190
23
450
374
223
22
335
294
TIMBER
A 21611
1271
1281
1179
1184
2654
PINES
20m
SHRIKE
ROAD
RESEARCH
HIGHWAY
RD RESERVE UNCLEARED
VASSE
QUILERGUP
ROAD
PIT
MILL
GAFFER
GOBERRANT
Noddy Rd
BROOK
JARRAHWOOD
ST JOSEPH
BARNEY
TERRY
LOG
MAJOR
No 1
No 2
No 3
No 5
No 6
No 8

SUBDIVISION LEGEND

MAJOR ACCESS ROAD — 20m
TRAFFICABLE ROAD ALL VEHICLES — 20m
TRACK — 10m
PLANTING BOUNDARY — 20m
NON TRAFFICABLE BREAK — 20m
WIDTH OF BREAK
PERMANENT WATER
POOR DRAINAGE BOUNDARY INTERNAL

UNCLEARED AREAS ENCLOSED BY TRACK

CREEKS BOUNDED BY TRACK MINIMUM OF 10m RESERVE

1st CLASS ROAD
2nd CLASS ROAD
3rd CLASS ROAD
UNMAINTAINED ROAD
LOADING RAMP
REFERENCE TREE - THEODOLITE
REFERENCE TREE - COMPASS

SCALE 1 : 25000

500 0 1000

20 10 0 20 40

QUILERGUP ROAD
GOODWOOD ROAD
PIT ROAD
MILL ROAD
Prion Rd
STOCK ROAD
BRUSH ROAD
LITTLE BROOK
FORMATION
Ibis Rd
Shrike Rd
OLD ROAD
ASHCROFT
HARRINGTON
Penguin Rd
Noddy Rd
Transperth Rd
Albatross ROAD
BROOK ROAD
HALLEY
HIGHWAY
PINES
PINES
HARRINGTON
STOCK
MARKER
ROAD
ST JOHN
JARRAHWOOD
CUNDINUP ROAD
CUNDINUP ROAD
BROOK
MARKER
ST JOHN
JARRAHWOOD
CUNDINUP ROAD

19 548 433
20 359 322
21 223 190
22 223
23 450 374
24 414 366
25 368 268
26 317 212
28 196 Pt 136 Pt
338 Pt 285 Pt
32
33

A 615
929 C.J.Brown
8235
3485
A 10998
1995 Camarri
1561
1996
12408
11237
11966
8292 S.Camarri
8292 S.Camarri
8293
1281
1179
1184

SCALE 1 : 25000

500 0 1000 2000 Metres

20 10 0 20 40 60 80 100 Chains

TOTAL AREA OF COMPTS. : 12 188 ha
PLANTABLE AREA OF COMPTS. : 9 315 ha

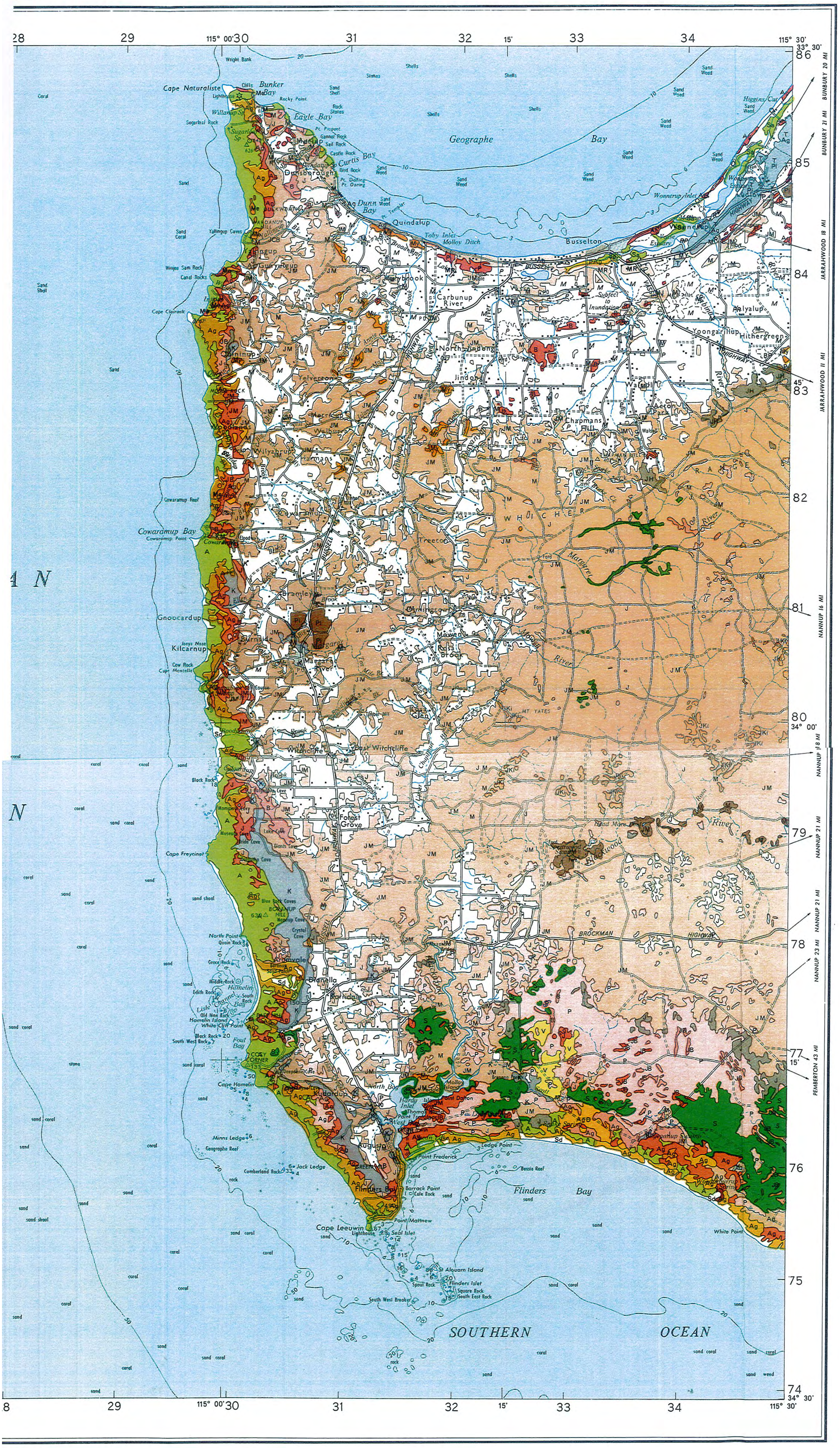
JARRAHWOOD PLANTATION
DETAILED SUBDIVISION PROPOSALS
(SAMPLE ONLY)

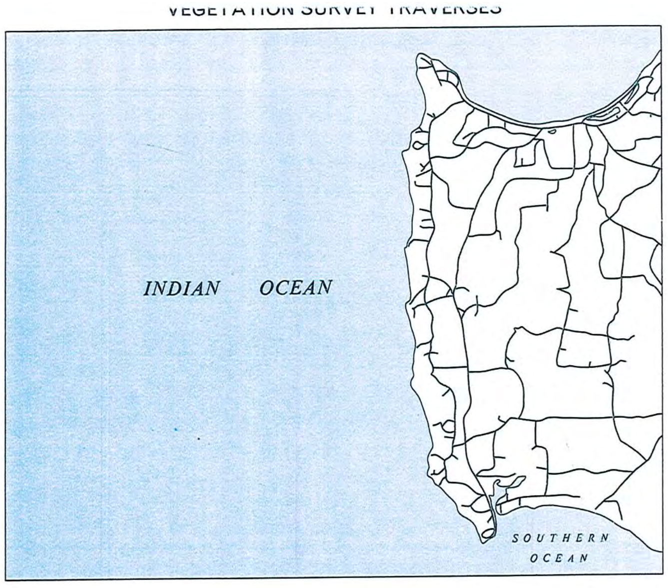
TOTAL AREA OF COMPTS.: 12 188 ha
PLANTABLE AREA OF COMPTS.: 9 315 ha

2000 Metres
80 100 Chains

JARRAHWOOD PLANTATION
DETAILED SUBDIVISION PROPOSALS
(SAMPLE ONLY)

PLAN NO. 10





LEGEND

VEGETATION STRUCTURE

LIFE FORM AND HEIGHT OF TALLEST STRATUM	FORMATION	PROJECTIVE FOLIAGE COVER OF TALLEST STRATUM, PER CENT: 70-100	30-70	10-30	BELOW 10
TREES (Above 30 metres)	High closed forest				
	High open forest				
	High woodland				
	High open woodland				
TREES (10 to 30 metres)	Closed forest				
	Open forest				
	Woodland				
	Open woodland				
TREES (Below 10 metres)	Low closed forest				
	Low open forest				
	Low woodland				
	Low open woodland				
SHRUBS (Above 2 metres)	Closed scrub				
	Open scrub				
	High Shrubland				
	High open shrubland				
SHRUBS (Below 2 metres)	Closed heath				
	Open heath				
	Low shrubland				
	Low open shrubland				
HERBS	Closed herbland				
	Herbland				
	Open herbland				
HUMMOCK GRASSES	Hummock Grassland				
	Open Hummock Grassland				
BARREN	Sand Dunes	Sd			
CLEARED LAND					

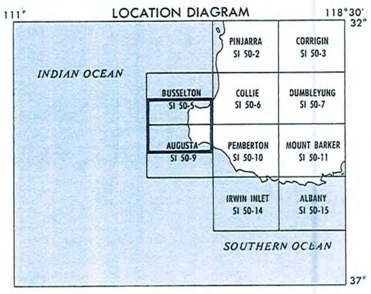
PLANT ASSOCIATIONS

	Acacia decipiens	A
Peppermint	*Agonis flexuosa*	Ag
	Banksia species	B
	Casuarina fraserana	C
	Dryandra sessilis	D
	Eucalyptus haematoxylon	H
Jarrah	*E. marginata*	J
Karri	*E. diversicolor*	K
	Kingia australis	Ki
Marri	*E. calophylla*	M
	Melaleuca species	Me
Myrtaceae		My
	Olearia axillaris	O
Paperbark	*Melaleuca species*	P
Pine Plantations		Pi
Flooded Gum	*E. rudis*	R
Sedgeland		S
Samphire	*Arthrocnemum species*	Sa
Tuart	*E. gomphocephala*	T
	Viminaria juncea	V
Yate	*E. cornuta*	Y

Remnants of plant associations on cleared land are shown in Italics.

Waterhole; water tank; dam: dry lake
Lake; river or stream perennial
Lake; river or stream intermittent
Dam or weir; falls; rapids
Drain or ditch perennial, intermittent
Spring perennial, intermittent, ricefields
Marsh or swamp; mangroves

LOCATION DIAGRAM



15 20 25 Statute Miles
15 20 Nautical Miles
20,000 30,000 Yards
5 20 25 Kilometres

EMANTLE

ON
.63"S LONGITUDE 115°50'26.10"E

NE I (AUSTRALIA SERIES), CLARKE 1858 SPHEROID
OMITTED

Y FOR THE CENTRE OF THE WEST

VEGETATION
BUSSELTON AND AUGUSTA
WESTERN AUSTRALIA