Nature Conservation, Landscape and Recreation values of the Lesueur area

A report to the Environmental Protection Authority from the Department of Conservation and Land Management

Edited by
Andrew A Burbidge, Stephen D. Hopper and Stephen van Leeuwen

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Foreword

This report was prepared by the staff of the Department of Conservation and Land Management in response to a request from the Environmental Protection Authority to collate the available biophysical and landscape information on the Mt Lesueur area.

The report was submitted to the Environmental Protection Authority in August, 1989. It has been published by the Environmental Protection Authority to assist with informed decision-making about future land uses in the area.

The Environmental Protection Authority gratefully acknowledges the work of the Department of Conservation and Land Management and the individuals involved in the preparation of the report.

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EXECUTIVE SUMMARY

1. BACKGROUND

The Lesueur Area of 27 493 ha is near Jurien Bay, some 220 km to the north of Perth. It has long been recognised as an area of outstanding flora conservation values, complex geological features and unusually rugged terrain in the subdued landforms of the northern kwongan region.

Its exceptionally diverse flora of 821 species represents 10 per cent of the State's known flora. Seven species are declared rare and endangered, and several more may warrant similar status. Lesueur is comparable with the Stirling Range and Fitzgerald River National Parks as one of the three most significant areas for flora conservation in southwestern Australia, but it is currently only a collection of unvested reserves and vacant Crown land. It is especially important because it is largely free of dieback disease.

The fauna is diverse, with at least 15 mammal, 124 bird, 48 reptile and 9 frog species. The area is critically important to the survival of hole-nesting birds such as Carnaby's Black Cockatoo, and is rich in birds of the kwongan.

It has been recommended for reservation by botanists, the Australian Academy of Science, the Conservation Through Reserves Committee and the Environmental Protection Authority. These recommendations were endorsed by State Cabinet in 1976 and again in 1983, but the presence of coal deposits at the eastern end of the Lesueur Area has prevented reservation to the present day.

The National Parks and Nature Conservation Authority has recommended that the Lesueur Area be declared a national park.

In 1989, the Environmental Protection Authority (EPA) sought from the Department of Conservation and Land Management (CALM) a detailed evaluation of the nature conservation, landscape and recreation values of the Lesueur Area. This publication is CALM's submission to the EPA.

It should be emphasised that this report only covers technical areas within CALM's responsibility (i.e. nature conservation, landscapes and recreational use in a proposed conservation reserve context). Other Government agencies will address aspects such as mineral resources, energy supply, economic and social issues, hydrology, air pollution, etc., in their own submissions to the EPA.

2. EUROPEAN EXPLORATION

Mount Lesueur was first observed and named from the sea by French explorers on the corvette *Naturaliste* in June 1801. Charles-Alexandre Lesueur was a topographical and natural history artist on the expedition. Europeans first traversed the Lesueur Area in 1839, and a party led by A.C. Gregory ascended Mt Lesueur in 1849. From 1850 onwards, Lesueur was avoided by travellers and pastoralists because of its rugged terrain and the abundance of poisonous plants (*Gastrolobium* spp.). 1850 was also the year that the Lesueur Area was first explored by a botanist, James Drummond, who delighted in finding a rich flora with many plants new to science. Neglected by all but a few bushmen and botanists for 100 years, the Lesueur Area was prominently featured in a Ph.D. study by N.H. Speck written in 1958. Since the early 1970s, the area has been visited by an increasing number of botanists, naturalists and bushwalkers, as well as employees of mining and petroleum exploration companies.

3. DESCRIPTION OF THE LESUEUR AREA

3.1 Geology

Permian to Mesozoic sedimentary rocks are overlain by thin layers of Triassic and Jurassic sandstones in the Lesueur uplands and by Quaternary and Recent sediments on the coastal plain. The ancient sediments have been distorted by a series of roughly north-south trending fault lines, exposing examples of Triassic and Jurassic rocks. Thus the rugged uplands have a variety of interbedded rock types, including sandstones, siltstones, shales and coal. Laterite formed as a fossil soil horizon over undulating land surfaces during the Tertiary and Quaternary. These land surfaces have been eroded leaving lateritic upland residuals, some in the form of flat-topped mesas (e.g. Mt Lesueur, Mt Michaud). The Coastal Belt has a series of dunes of varying ages, some underlain by limestone, and with a chain of salt lakes and freshwater springs parallel to the coast.

3.2 Landforms

A sequence of landforms in the Lesueur Area may be recognised from the coast inland: Quindalup Dunes bounded by a Salt Lake Complex, Spearwood Dunes, Bassendean Dunes bounded by the Gingin Scarp, Peron Slopes, Lesueur Dissected Uplands, Gairdner Dissected Uplands, Banovich Uplands, and Bitter Pool Rises.

3.3 Soils

Soils on the uplands are an extremely complex mixture of siliceous sands, lateritic gravels, yellow duplexes, yellow massive earths and brown mottled cracking clays. The Coastal Belt has yellow and brown siliceous sand, sometimes over aeolinite, with shallow calcareous and gypsiferous soils on the salt lakes.

3.4 Climate

Lesueur has a typically Mediterranean climate of hot, dry summers and cool wet winters, with a moderately reliable rainfall (550 mm at Jurien, 620 mm at Mt Lesueur).

3.5 Drainage

Three major youthful drainage systems have their headwaters in the Lesueur Area - the Hill River (with Munbinea Creek as the major tributary), Cockleshell Gully and Stockyard Gully. In addition, one arm of Coomallo Creek (also a tributary of the Hill River) has mature tributaries arising in the eastern end of the Lesueur. The Lesueur Area protects the upper sections of these catchments in a natural state, allowing them to be used for "bench mark" studies applicable to catchment management issues. Flow in the drainage lines is seasonally intermittent, but permanent water occurs in some pools.

4. VEGETATION

The vegetation of the Lesueur Area is shown to be structurally diverse, consisting mainly of shrublands and woodlands interspersed in a complex mosaic. Even greater complexity is evident when communities are identified on a floristic basis. Major vegetation units are numerous, they form an intricate mosaic, and they show a close relationship to landforms. Moreover, within the one vegetation type studied in greatest detail (heath on lateritic uplands), there are 11 distinct floristic sub-types within the Lesueur Area which are geographically identifiable and can be related to specific geological substrates and soil erosional processes.

The great diversity of communities reflects the complexity of underlying strata and unusually large array of habitats found in the Lesueur Area, particularly in the eastern parts. Detailed mapping by Martinick and Associates (1988) identified a very fine-scale mosaic in the eastern landforms. Some communities in the eastern uplands are not found elsewhere.

5. FLORA

James Drummond in 1850 noted the exceptional richness of the flora, particularly of proteaceous genera and of locally endemic species. Subsequent work this century commencing with C.A. Gardner and N.H. Speck reaffirmed Drummond's observations. A.J.M. Hopkins and E.A. Griffin started a comprehensive study of the flora and vegetation in the late 1970s, providing much of the data on which the present review is based.

The present study supports earlier views on plant diversity in the Lesueur Area. It has 821 taxa of vascular plants, representing approximately 10% of the State's known flora, and a third of the taxa found in the Irwin Botanical District. Moreover, the Lesueur Area has seven species of Declared Rare Flora, nine endemic taxa, 111 regionally endemic taxa, and 81 taxa at their northern or southern limits in the Lesueur Area. The numbers of Declared Rare Flora, endemics and taxa at the end of their geographical ranges are the highest of any area in the Irwin Botanical District. The Lesueur Area has been and will continue to be an important refugium for species from wetter climates.

A rapid replacement of species is notable. Even within the same vegetation type, moving as little as 0.5 km may reduce the number of species in common to less than 40%. When species richness is measured at the scales of landscape unit or within stands, diversity in the Lesueur Area is comparable with that in the Fitzgerald River and Stirling Range National Parks. Lesueur ranks as one of the three most important areas for flora conservation in southern Western Australia.

6. FAUNA

Although not studied in detail, the fauna of the Lesueur Area is known to be rich in species of vertebrates, with 15 indigenous mammal species, 124 bird species, 48 reptile species and 9 frog species. In comparison with other existing conservation reserves in south western Australia, it is richer in species than all except a few, much larger areas.

Among birds, Lesueur is rich in species of the kwongan and species that depend on nest hollows in the wandoo woodlands, e.g. Carnaby's Black Cockatoo and the Regent Parrot. The reptile fauna is particularly rich in geckoes and legless lizards.

Terrestrial and aquatic invertebrates have not been studied in detail. However, the little that is known suggests that it is rich in species, e.g. 104 species of macro-invertebrates were sampled in a brief survey of aquatic sites. Lesueur includes some invertebrate species not known from elsewhere.

7. INTER-RELATIONSHIPS OF PLANTS AND ANIMALS

The Lesueur Area provides an opportunity for essential ecological inter-relationships between plants and animals to continue. Two recent studies highlight relationships between rare plants in the Lesueur Area and the wide-ranging birds on which they are dependent.

Banksia tricuspis is a Declared Rare species endemic to the Lesueur Area. It shows a strong preference for microclimatically favourable sites, and may be a relict species from wetter times. Pollinators, including birds, mammals and insects, are essential for seed set in this outbreeding species. Moth larvae and cockatoos reduce the reproductive success of *Banksia tricuspis* through predation. However, because cockatoos destroy more moth larvae than flower heads, the latter which they damage 'in error', the cockatoos have a positive effect. The ability of *B. tricuspis* to cope with fire is influenced by fire frequency, which influences plant survivorship, and seasonality, which in turn influences seedling recruitment. Management of *B. tricuspis* should ensure that all organisms involved in its inter-relationships are catered for. In the cockatoos' case this is extremely important and will require protection of wandoo woodlands, kwongan and freshwater sources throughout the Lesueur - Coomallo region.

Black Kangaroo Paws (*Macropidia fuliginosa*) are dependent on honeyeaters for pollination and sustain some nectar loss from the introduced honey bee.

The ecological links that exist between these plants and animals in the Lesueur Area highlight the need to not only manage and conserve rare and restricted species but also to conserve the organisms that interact with them. To achieve this, a larger area of native vegetation than that occupied by a rare plant is often required.

8. DIEBACK DISEASES

Phytophthora cinnamomi and other *Phytophthora* species are having a major detrimental effect on the vegetation and associated fauna of many national parks and other conservation reserves in southern Australia. In the northern kwongan, studies on the extent of these plant diseases commenced only recently, but it is known that five types of *Phytophthora* occur there, with *P. cinnamomi* having been found recently near Eneabba. One infection of *Phytophthora citricola* has been found within the Lesueur Area, beside Cockleshell Gully Road.

Dieback disease caused by *Phytophthora* species would have a major impact if introduced because of the suitable climate, the abundance of susceptible plant species and vegetation types and the type of soils present. The probability of introduction of *Phytophthora* is high when extensive use of earth-moving equipment and vehicles takes place in a highly susceptible area, even if high standards of hygiene are maintained. If introduced, the impact of *Phytophthora* could be extensive, because of the high proportion of susceptible vegetation types and plant species.

9. LANDSCAPE VALUES

The Lesueur Area encompasses some of the most attractive countryside to be found in the northern kwongan. The Gairdner Range, with its distinctive mesa landforms, is an area of high scenic appeal. Within the Range, one is confronted by ever-changing vistas of steep breakaways, low hills and gullies with eucalypt woodlands set amongst heath-covered slopes. The heathlands themselves, when viewed more closely, reveal a rich tapestry of plant forms, colours and textures.

10. RECREATION AND EDUCATION VALUES

Recreational and educational values, while not well documented, are nevertheless of major regional importance. Although the Lesueur Area has not been widely promoted and is relatively distant from major population centres, it presently attracts a wide range of recreational use, including nature study, sightseeing, photography, bushwalking, camping and four-wheel driving. Indications are that visitation levels have increased in recent times. This trend is likely to continue, particularly as the area becomes better known. Given adequate protection through reservation and management, the Lesueur Area has the capacity to attract and sustain a much higher level of public use than at present. Opportunities for interpretation of the natural environment are also numerous.

11. STATUS OF CURRENT KNOWLEDGE

The flora and fauna of the northern kwongan are very rich in species and studies on it are inadequate for a detailed analysis of the possible impact of any development on the Lesueur Area. With regard to the flora, more research is needed into local endemics, impacts of dieback disease, cryptogams, regional plant communities, community processes and population biology. Considerable research is required into rehabilitation techniques for many plant groups that cannot be regenerated at present. In the fauna, vertebrate surveys are at present inadequate to understand either the habitat requirements or the minimum area required by most species. Data on terrestrial invertebrates are lacking for most of the area and data on aquatic invertebrates need to be upgraded by conducting surveys throughout the wet season. Because of lack of information this report has not dealt with possible effects on groundwater levels and quality or possible effects on the area's freshwater springs.

12. SIGNIFICANCE OF THE LESUEUR AREA

The Lesueur Area is an area of world, national, State and regional nature conservation significance. It has all the characteristics of an important conservation reserve and is the most important nature conservation area in the northern kwongan. Its major characteristics are uniqueness of many geological, landform and biological attributes, biodiversity, very high nature conservation values, representativeness for more common components of the northern kwongan flora and fauna, and scenic grandeur. Its size is not large for an important conservation reserve and, desirably, it should be larger. There are currently seven national parks and Class A nature reserves in the northern kwongan, totalling only 107 460 ha. The Lesueur Area includes a wider range of ecosystems than any other existing or proposed conservation reserve in the northern kwongan.

Chapter 1

BACKGROUND

by Andrew A. Burbidge

Department of Conservation and Land Management, Western Australian Wildlife Research Centre, P.O. Box 51, Wanneroo, W.A. 6065.

Abstract

The Lesueur Area is an area of 27 493 ha near Jurien Bay some 220 km to the north of Perth. It has long been recognised as an area of outstanding flora conservation values and unusually rugged terrain in the subdued landforms of the northern kwongan region. It has been recommended for reservation by botanists, the Australian Academy of Science, the Conservation Through Reserves Committee and the Environmental Protection Authority (EPA). These recommendations were endorsed by Cabinet in 1976 and again in 1983, but the presence of coal deposits at the eastern end of the Lesueur Area has prevented reservation to the present day.

In 1989 the EPA sought from the Department of Conservation and Land Management (CALM) a detailed evaluation of the nature conservation, landscape and recreation values of the Lesueur Area.

This publication is CALM's submission to the EPA.

1.1 INTRODUCTION

The Lesueur Area is situated about 220 km north of Perth, near the coastal town of Jurien (Figure 1.1). The area around Mount Lesueur has been recommended for reservation for many years because of its very high nature conservation values (Western Australian Sub-Committee of the Australian Academy of Science Committee on National Parks 1965, CTRC 1974).

In 1989, The Environmental Protection Authority requested the Department of Conservation and Land Management to prepare a report on the nature conservation, landscape, recreation and educational values of the Lesueur Area, and this report was prepared in response to that request.

1.2 REGIONAL SETTING

The south west of Western Australia is world famous for the richness, diversity and uniqueness of its native plants and animals.

For an area of low relief and relatively low rainfall, south-western Australia has an exceptional number of species of vascular plants (more than 4 000), many of which are very beautiful. In addition, a very high proportion are found nowhere else in the world - over 80% of the plants of the south west are endemic to the region.

There are three nodes in the south west which are exceptionally rich in plant species (Hopper 1979, George *et al.* 1979) These are:

1. The Fitzgerald River and Barren Ranges area.
2. The Stirling Range.
3. The Lesueur area.

Between these nodes are the farming areas of the wheatbelt. Within the wheatbelt there are sandplains and lateritic areas of high species richness.

While the Stirling Range and Fitzgerald River nodes have considerable overlap of species very few are shared with the Lesueur node.

The botanical significance of these nodes is of international importance. The complex sandplain or heath shrub vegetation, known locally as "kwongan" (an Aboriginal word), has plant species richness unequalled by most other vegetation types in the world, except the fynbos of southern Africa and some tropical rainforests.

The fauna of south-western Australia is also rich in endemic and unusual species (Keast 1981, Heatwole 1987). Among vertebrates the south west harbours numerous relict species, many with no close relatives elsewhere - examples include the Honey Possum, the Western Swamp Tortoise, the Turtle Frog and the Karri Minnow. Among invertebrates the degree of endemism is even higher with many species having co-evolved with the flora, e.g. the strikingly beautiful jewel beetles (Buprestidae).

Two of the three very important nodes mentioned above are protected within secure nature conservation reserves - the Fitzgerald River and Stirling Range National Parks. Over recent decades conservation agencies have worked hard to protect what is left of the wheatbelt vegetation in secure reserves as well. Little opportunity now exists to extend the reserve system in the wheatbelt, where most of the land is privately owned and cleared, except at its arid periphery and in small remnants on private land and in Crown reserves.

While there are conservation reserves in the northern kwongan, for example Nambung National Park, Drovers Cave National Park, Badgingarra National Park, the Beekeepers Reserve and South Eneabba Nature Reserve (Figure 1.1), these reserves do not nearly represent the full range of ecosystems and species that occur in the region. In addition, some are small and, in some cases, they are subject to disturbance, e.g. mineral sand mining in South Eneabba Nature Reserve.

1.3 THE MOUNT LESUEUR AREA

The nature conservation significance of the area near Mount Lesueur has been recognised and extolled for many decades.

Mount Lesueur and Mount Peron were named by the Baudin Expedition in 1801, but expedition members did not land there (see Chapter 2, European Exploration). In 1850 the well-known early botanist James Drummond was the first to collect plants at Lesueur. His letters to Sir Joseph Hooker, Director of Kew Gardens, published by Hooker (Drummond 1853), were the first account of the importance of the Lesueur area for flora conservation.

The Government Botanist, Charles Gardner, published a more detailed account of the area in 1947. In the 1950s, concerned at the effects the rapid alienation of land for farming was having on native flora, Gardner made a series of land-mark recommendations for the protection of important botanical areas. These recommendations resulted in the reservation of several of Western Australia's most valuable national parks and nature reserves, among them Kalbarri National Park, Fitzgerald River National Park, Cape Arid National Park, Jilbadji Nature Reserve and the Beekeepers Flora Reserve. Gardner also recommended the reservation of the Lesueur area but no action was taken, apparently because of the existence of a reserve for "Horse Breeding", dating from the days when horses were needed by the Army. However, the importance of Mt Lesueur itself was recognised at this time by the creation of a reserve for "Educational Purposes (University of Western Australia)" (reserve no. 24275). Another reserve with the same purpose was created at the same time at Mt Benia in the southern Gairdner Range.

The first major review of national parks and nature reserves in Western Australia was by the Australian Academy of Science, which set up a sub-committee in each State. The 1962 report of the Academy (Western Australian Sub-Committee of the Australian Academy of Science Committee on National Parks 1965) stressed the nature conservation importance of the Lesueur area and recommended that it be declared a Class A reserve for a national park.

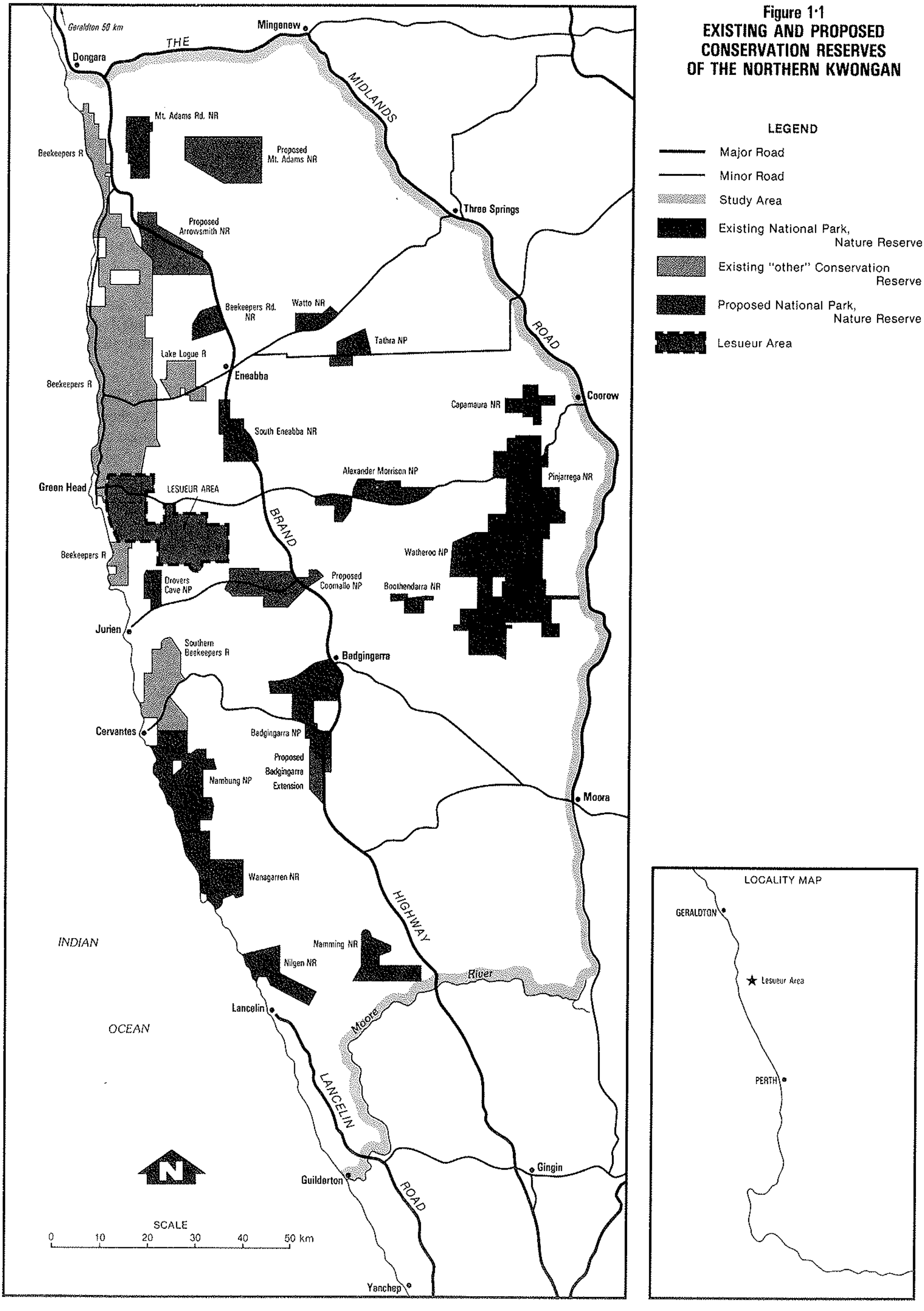
The last major review of nature conservation reserves in Western Australia, that of the Environmental Protection Authority's Conservation Through Reserves Committee (CTRC) in 1974, recommended consolidating several existing reserves and some vacant Crown land in the Lesueur area into a Class A reserve for the conservation of flora and fauna (i.e. a nature reserve). Having summarised the attributes of the Lesueur area, the Committee stated "Thus in 1974 there is an urgent need for consolidation of the Mt. Lesueur Reserves under the control of a single vesting authority and the implementation of a management plan" (p. 5.29).

Following a period of public review, the Environmental Protection Authority (EPA) endorsed the CTRC recommendation and forwarded it to Government. The recommendation was endorsed by State Cabinet on 20 October 1976. However, the recommendation was not implemented because of the objections of the Mines Department, which believed that coal in the area should be available for exploration without hindrance.

In 1982-83 a compromise agreement was achieved whereby the Mines Department agreed to the creation of a Class C reserve on condition that there would be continuing access for mineral and petroleum exploration. This was agreed to by State Cabinet on 16 May 1983 and instructions to create the reserve were passed to the Department of Land Administration. In the ensuing six months the boundaries of the reserve were finalised (the main change being excision of the high recreation value coastal strip, west of the planned coastal highway), but the reserve was not created due to concern regarding the coal deposits.

More recently, the passing of the Conservation and Land Management Act created the new Department of Conservation and Land Management (CALM) that is responsible for both national parks and nature reserves, and a new National Parks and Nature Conservation

Figure 1·1
EXISTING AND PROPOSED CONSERVATION RESERVES OF THE NORTHERN KWONGAN



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Authority (NPNCA) to replace the previous National Parks Authority (responsible for national parks) and the Western Australian Wildlife Authority (responsible for nature reserves). The NPNCA has recommended that the Lesueur Area be declared a national park because of its high landscape and recreational values in addition to its very high nature conservation values.

In February 1988 the Western Australian Government released a new Policy on Exploration and Mining in National Parks and Nature Reserves. Under this Policy, areas recommended for reservation by the EPA and endorsed by State Cabinet, are to be declared national parks and nature reserves, and mining applications are to be dealt with by Parliament following evaluation by the EPA. A Task Force was set up under the Policy to accelerate the declaration of these reserves, including the Lesueur Area. Again, progress in the Task Force was delayed because of concern regarding the coal deposits.

In January 1989 the NPNCA received comprehensive briefings on the nature conservation values of the Lesueur area and on proposals for coal mining for power generation. The Authority concluded that mining should not be permitted within the proposed reserve and that the Government should move immediately to protect the area. These views were transmitted to the Minister for Conservation and Land Management and to the Environmental Protection Authority.

In March 1989 Canning Resources Pty Ltd and The Hill River Power Development Company Pty Ltd submitted a Notice of Intent (NOI) to the EPA under the relevant provisions of the Environmental Protection Act. The NOI stated that the Companies proposed to develop an open-cut mine and power station to supply power to the State Energy Commission of Western Australia. About half of the area proposed to be mined, and the conceptual location of the power station, are within the Lesueur Area. The EPA decided that the proposal should be subject to the highest level of evaluation, and requested that the Company prepare an Environmental Review and Management Plan (ERMP).

In order to provide the basis for thorough evaluation of the proposal the EPA then requested CALM to prepare a report on the nature conservation, recreation, landscape and education values of the Lesueur area.

This report was prepared in response to that request. It should be emphasised that this report only covers technical areas within CALM's responsibility (i.e. nature conservation, landscapes and recreational use in a proposed conservation reserve context). Other Government agencies will address aspects such as mineral resources, energy supply, economic and social issues, hydrology, air pollution, etc., in their own submissions to the EPA.

Chapter 2

EUROPEAN EXPLORATION

by Stephen D. Hopper

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Abstract

Mt Lesueur was first observed and named from the sea by French explorers on the corvette Naturaliste in June 1801. Charles-Alexandre Lesueur was a topographical and natural history artist on the expedition. Europeans first traversed the Lesueur Area in 1839, and a party led by A.C. Gregory ascended Mt Lesueur in 1849. From 1850 onwards, Lesueur was avoided by travellers and pastoralists because of its rugged terrain and the abundance of poisonous plants (Gastrolobium ssp.). 1850 was also the year that the Lesueur Area was first explored by a botanist, James Drummond, who delighted in finding a rich flora with many plants new to science. Neglected by all but a few bushmen and botanists for 100 years, the Lesueur area was prominently featured in a Ph.D. study by N.H. Speck written in 1958. Since the early 1970s, the area has been visited by an increasing number of botanists, naturalists and bushwalkers, as well as employees of mining and petroleum exploration companies.

On June 28 1801 the French corvette *Naturaliste*, under the command of Jacques Felix Emmanuel, Baron Hamelin, sailed north from Rottnest Island to rendezvous at Shark Bay with her sister ship the *Geographe* commanded by exploration leader Captain Nicolas Baudin (Cornell 1974; Marchant 1982). The two ships had been commissioned by the French Government to document the geography and natural history of all parts of the coastline of Australia not documented by Captain James Cook.

The *Naturaliste* sailed close to the coast at what is now Mullaloo, Breton Bay, Lancelin Island and Jurien Bay, after which Captain Hamelin made out to sea to avoid the Abrolhos Islands (Marchant 1982). The expedition named Jurien Bay after Charles Marie, Vicomte Jurien, 1763-1836, a naval administrator. In addition, a flat-topped mesa and a prominent rolling hill to the north were conspicuous from the sea at Jurien and were named Mt Lesueur and Mt Peron respectively.

Mt Lesueur was named after Charles-Alexandre Lesueur, 1778-1846, (Figure 2.1) a trained topographical painter who joined the expedition as a volunteer gunner, but was appointed by Baudin as artist-sketcher when all three, officially-appointed artists left the expedition at Mauritius (Cornell 1974). Lesueur subsequently worked closely with the expedition's naturalist Francois Peron (1775-1810), after whom Mt Peron was named. Lesueur became a skilled naturalist in his own right, with special interests in marine life, travelling to America in 1815 and residing there until 1837 (Bonnemains 1988). He was

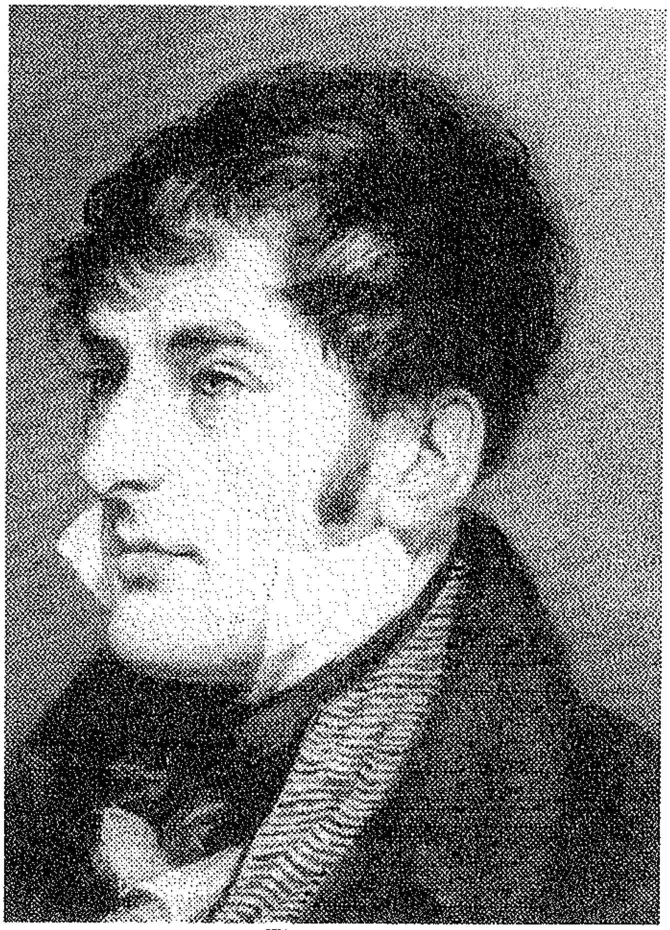


Figure 2.1
Charles-Alexandre Lesueur

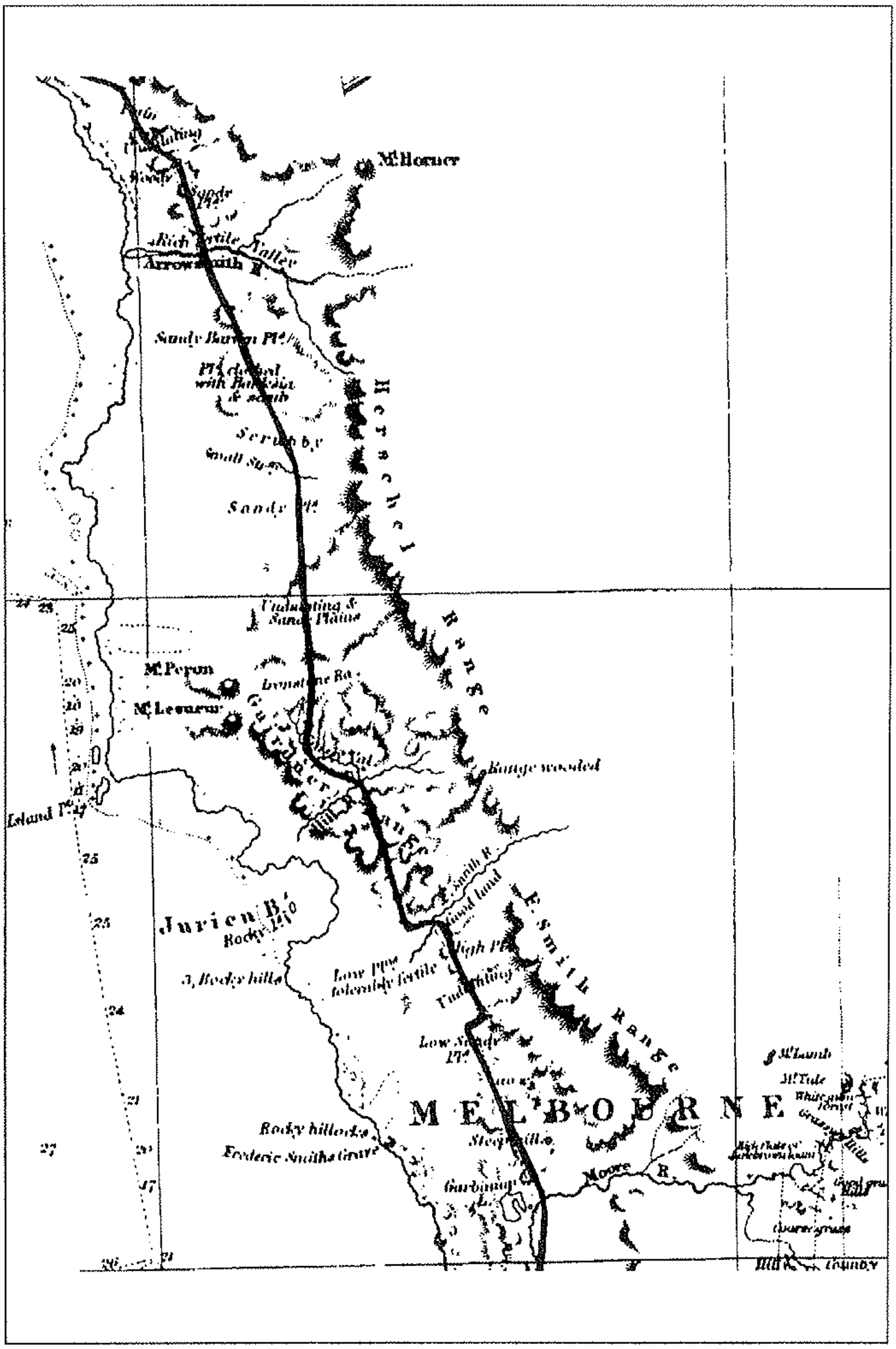


Figure 2.2
Portion of map and chart of the west coast of Western Australia compiled by John Arrowsmith, showing the route traversed through the proposed Lesueur Area by Captain George Grey and party in 1839 (Grey 1841).

appointed Curator of the Museum of Natural History at Le Have in March 1846, just nine months before he died.

Recently, a third prominent hill 1.5 km north-west of Mt Lesueur has been officially named Mt Michaud after Andre Michaud, botanist-gardener on the *Naturaliste* (Cornell 1974).

The first recorded European party to traverse the Mt Lesueur area comprised Captain George Grey and five others (Grey 1841; Figure 2.2). They had been shipwrecked in 1839 near Kalbarri, and walked back to Perth under difficult circumstances and short of food. On April 13, after crossing the Eneabba Plain, they ascended from the north a "red sandstone range... thinly studded with blackboy trees". Grey named the range Gairdner's Range after Gordon Gairdner of the Colonial Office. They camped "in the neighbourhood of a forest", presumably the *E. wandoo* woodlands east of Mt Peron, and were provided by their native companion Kaiber with dry *Macrozamia* nuts for food. Some of the men looked for more, and ate several green nuts which made them violently ill during the night. The next day they travelled south some fourteen miles over "a range of high ironstone hills", before descending a further fourteen miles to the bed of a small river which Grey named the Hill River.

On November 7 1848, A.C. Gregory and party passed "a short distance to the east of Mounts Peron and Lesueur" while returning to Perth from the "Settler's Expedition", in search of pastoral country as far north as the Murchison River (de Burgh 1986). Regarding the Lesueur area, Gregory recorded "The valleys were wooded with red and white gum of large growth, but the hills provided little besides coarse scrub".

Gregory led another party northwards from Perth to the Geraldine mine on the Murchison River in 1849. On November 16, the expedition of men with horses, carts and equipment approached Mt Lesueur from the east and some of the party climbed to the top. The party included mounted policeman Johnston Drummond, son of the colonial botanist James Drummond, who may have noted the richness of the flora as worthy of his father's future attention. Descending Mt Lesueur, the party pitched camp at a spring in a nearby brook (Munbinea Creek). Gregory found exposed coal along the brook in the morning, after which they proceeded northwards beyond the Gairdner Range.

Early in 1850 two groups of the party returned to Perth from Geraldton. Both followed a shorter route than on the northward journey, traversing flatter terrain interspersed with swamps along the east edge of the coastal limestone between Jurien Bay and Mt Lesueur, thence east along the Hill River and south towards Dandaragan.

Pressure for new land from pastoralists with overstocked leases in the York and Toodyay areas finally led to the official opening up of the new Victoria or Champion Bay district for settlement on 1 January 1851 (de Burgh 1986). However, as an emergency measure to counter overstocking and drought in 1850, the Government agreed to stocking the new northern runs prior to leasing. To assist the droving of stock overland to Geraldton, Assistant Surveyors A.C. and H. Gregory were made available as guides. Having previously encountered the difficulties traversing the rugged Mt Lesueur terrain, and noting the abundance of poison plants there, A.C. Gregory and pastoralist L. Burges were firmly of the view that the area was best avoided, a sentiment conveyed in a letter to the Surveyor General from Dandaragan on 13 October 1850:

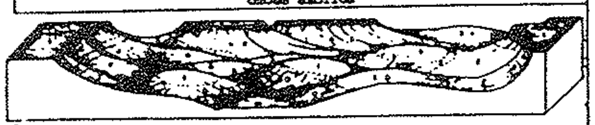
> "On the 28th Mr L. Burges came up with his cattle and on the following day we started to decide the best manner of avoiding the Gairdner Range which is impracticable for carts from the rocky nature of the ground and at the same time abounds with a variety of the poisonous plant which renders it unsuitable for travelling with sheep. The route determined on is about N.N.W. from Dandaragan to the Hill River, to follow that stream bed down to within 7 or 8 miles of the Coast in Lat 30°20', then a northerly course along a chain of lagoons and swampy flats parallel to the coast as far as the Arrowsmith River.
>
> This route by the Hill River is abundantly supplied at this season with water and grass at every ten miles, it involves a detour to the south of the Gairdner range and increases the distance 20 miles but the poisonous plant is so abundant on that part of the range of hills on which Mr Drummond has taken up his licence near Mt Lesueur that stock cannot be driven through it with safety..."

Thus from the outset of pastoral development, the Lesueur Area was regarded as unsuitable and thereby spared from agricultural clearing. Leases were nonetheless granted nearby, with James Drummond Jr taking out 10 000 acres near Munbinea on the Hill River in September 1850, as well as an extensive lease at Dandaragan. These two leases provided convenient bases for James Drummond Snr to pursue botanical exploration.

It is clear from letters written to Sir William Jackson Hooker at Kew in England that Drummond explored Mt Lesueur and environs fairly thoroughly (Drummond 1853). In about March 1850 he went from Toodyay north to Dandaragan with James Jnr (Erickson 1968). They proceeded north-west to investigate leases at the Hill River in the winter, and it is likely that James Drummond Snr explored and collected plants at Mt Lesueur at this time through to September. He

TABLE No. 13 — LESUEUR VEGETATION SYSTEM — AREA 1360 SQUARE MILES

LOCATION & GENERAL DESCRIPTION	An elevated block with lateritic flat tops, wide valleys and undulating hills. It extends from the region of Coomallo to north of Cockleshell Gully and includes most of the Hill River area.
CROSS SECTION	CLIMATE: Rainfall: Annual, 16-25 ins., Winter, 13-17 ins. Break of Season: May 1st. Growing Season: 4.5 - 5 months. Normal Mean Temperature: January (Summer) 73-75°F., July (Winter) 55-57°F. Normal Mean Minimum Temperature: July, 45-48°F. Meyer Ratio, 100-125. Frost Season, May to October, but very few frosts. DRAINAGE: Moderately drained by Hill River and tributaries.



	1 & 2	3 & 4	5	6 & 7	8	9	10
GEOLOGY & GEOMORPHOLOGY	Maturely dissected plateau with wide valleys and undulating sandplain on the divides and underlain by Jurassic sandstones.						
TOPOGRAPHY	Laterite capped flat tops	Gentle slopes	Gentle slopes	Gentle slopes or sandy between hills	Gentle slopes	Gentle slopes	Flats
RELATIVE AREAS	Large	Large	Medium	Small	Small	Medium	Very small
SOILS	1. Laterite 2. Transported Laterite	Sandy Laterite	Very Sandy Laterite	Lesueur Deep Yellow Sands	Lesueur Deep Yellow Sands	Coomallo Clays	Coomallo Clay Loam
VEGETATION	Lateritic Heath *Dryandra* spp. - *Casuarina* spp. Communities	3. Sandplain Heath 4. Mallee-Heath	Sandplain Scrub Heath *Banksia* spp. - *Adenanthos sericea* - *Nuytsia floribunda* Alliance	Low Scrub Forest 6. *Banksia menziesii* - *B. attenuata* 7. *Eucalyptus todtiana* Association	Woodlands *E. calophylla* Association	Temperate Savannah Woodlands *E. wandoo* Alliance	Temperate Savannah Woodlands *E. loxophleba* - *Acacia acuminata* Alliance
DISTRIBUTION OF UNITS	This is a very complex unit and shows but few patterns in distribution. Unit 9 shows a marked linear pattern corresponding to certain bands of soils. Unit 10 small linear patches associated with streamlines in parts of the area.						

Figure 2.3
Topographical figure and table summarising the Lesueur Vegetation system (Speck 1958).

returned to Dandaragan and remained there until October 14, 1850, when he joined Gregory's droving party to Champion Bay (de Burgh 1986). A day after departure, the party split into two, the main body with the stock skirting around the south and west sides of Mt Lesueur as planned. The other party under A.C. Gregory, with J.S. Roe, J. Drummond Jnr, J. Drummond Snr and S.P. Phillips, rode north on the eastern side of the Gairdner Range and onwards to explore the Upper Irwin River area.

Thus, Drummond Snr was able to describe in detail many of the plants of the Mt Lesueur area in his letters to Hooker. Vivid descriptions of Pine Banksia (*Banksia tricuspis*), Lesueur Hakea (*Hakea megalosperma*), Staghorn Bush (*Daviesia epiphyllum*), Gairdner Range Starbush (*Asterolasia drummondii*) and others were provided (Table 5.1).

About a week after the departure of Gregory's October 1850 droving party, Major Logue led another in their footsteps (de Burgh 1986). On a hot late October day, after crossing Cockleshell Gully west of Mt Peron, Logue's party came across and named Diamond of the Desert Spring. It was a small oasis flanked by flooded gums in a limestone hollow surrounded by banksia kwongan. The Spring became an important camp on what soon became a well-travelled stock route.

In October 1855, Walter Padbury and Mounted Constable William Goldwyer (O.I.C. of Dandaragan Police Station) went north from Drummond's Munbinea lease and explored the Cockleshell Gully/Diamond of the Desert Spring area. Within three weeks Padbury took up a 20 000 acre lease at Cockleshell. He also purchased Yatheroo, south of Dandaragan, in the same year. The Cockleshell Gully lease was managed by William Bashford in the 1860s, and then by Padbury's wife's nephew John Grigson from 1869 onwards (de Burgh 1986). The Grigson family is still there today.

The establishment of Padbury's and Drummond's pastoral leases on the major route between Perth and Geraldton meant that the Lesueur Area was thoroughly explored by the end of the 1850s, but neglected thereafter except by keen bushmen and botanists. The Stock Route was officially gazetted in 1889 at the instigation of Alexander Forrest (de Burgh 1986). A reserve for horse breeding in the Mt Peron-Cockleshell Gully area was gazetted in 1913.

Botanical exploration was to lapse for 80 years after James Drummond's pioneering collections. Government Botanist C.A. Gardner first visited Mt Lesueur and Cockleshell Gully in June 1931, and subsequently in June 1935, January 1941 and October 1946 before writing an article extolling the botanical values of the area in the inaugural issue of *The Western Australian Naturalist* (Gardner 1947). N.H. Speck and A.M. Baird examined the flora and vegetation of Mt Lesueur in the 1950s (Speck 1958). In his thesis, Speck proposed a new Lesueur Botanical District because of the distinctive vegetation, landforms and soils of the Lesueur area. He was the first to accurately describe the Lesueur Vegetation System and he strongly urged the creation of a national park.

A summary of the Lesueur Vegetation System was provided in a topographical figure and table (Figure 2.3) and in the following text:

> "The Lesueur Vegetation System (1,260 sq. miles).
>
> This is the exceedingly complex pattern of vegetation, soils and landforms of the Dandaragan Block.... It consists of a laterite capped plateau underlain by Jurassic sediments, dissected to form wide valleys bounded by breakaways, and undulating sandplain.
>
> Its relief, complexity of soils, moderate rainfall and its geographical location give the very great variation in microhabitats that make it a great ecotonal area of the southern forests and woodlands, the northern sand heaths, and the Eremean Savannah Woodland and Mallees.
>
> These factors have all combined to produce one of the richest floristic areas of the State. It is known, from data produced in the final chapter of this paper, that more than 110 species of Proteaceae are to be found in the Mt Lesueur environs. Figures are not available for the complete flora but the number is known to be very great.
>
> Until recent years the area remained inaccessible and almost entirely undeveloped. Although much of this area is not suitable for agricultural development some of the adjacent Hill River country is and this is bringing encroachment and consequent destruction of an extremely rich floristic area. It is gratifying to learn that certain areas have been set aside as national reserves. This is not enough. If our rich heritage is to be preserved, the reserve must enclose all of the various ecological habitats and not only those parts that are useless for agricultural or pastoral development." (Speck 1958, pp 295-6).

Another twenty years elapsed before detailed botanical studies were initiated by A.J.M. Hopkins and E.A. Griffin. It was not until 1985 that the first comprehensive floristic study of Mt Lesueur itself was published. The present paper provides the first published list of the flora and analysis of the vegetation, fauna and landscape of the entire Lesueur Area. It draws upon data acquired by Griffin and Hopkins, as well as other botanists, CALM scientific staff and reports prepared by Martinick and Associates, environmental consultants to CRA. In 1973 the W.A. Museum published results of a fauna survey of part of the Lesueur Area. Additional fauna studies were carried out by staff and students of the Western Australian College of Advanced Education in 1980 and 1981, and consultants to the mining companies commenced fauna studies in 1988.

Since the early 1970s, the area has been visited by an increasing number of botanists, naturalists and bushwalkers, as well as employees of mining and petroleum exploration companies.

Chapter 3

DESCRIPTION OF THE REGION

by E.A. Griffin[A] and Andrew A. Burbidge[B]

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Abstract

Geology and landforms

Permian to Mesozoic sedimentary rocks are overlain by thin layers of Triassic and Jurassic sandstones in the Lesueur uplands and by Quaternary and Recent sediments on the coastal plain. The ancient sediments have been distorted by a series of roughly north-south trending fault lines, exposing examples of Triassic and Jurassic rocks. Thus the rugged uplands have a variety of interbedded rock types, including sandstones, siltstones, shales and coal. Laterite formed as a fossil soil horizon over undulating land surfaces during the Tertiary and Quaternary, which have been eroded leaving lateritic upland residuals, some in the form of flat-topped mesas (e.g. Mt Lesueur, Mt Michaud). The Coastal Belt has a series of dunes of varying ages, some underlain by limestone, and with a chain of salt lakes and freshwater springs parallel to the coast.

A sequence of landforms in the Lesueur Area may be recognised from the coast inland: Quindalup Dunes bounded by a Salt Lake Complex, Spearwood Dunes, Bassendean Dunes bounded by the Gingin Scarp, Peron Slopes, Lesueur Dissected Uplands, Gairdner Dissected Uplands, Banovich Uplands, and Bitter Pool Rises.

Soils

Soils on the uplands are an extremely complex mixture of siliceous sands, lateritic gravels, yellow duplexes, yellow massive earths and brown mottled cracking clays. The Coastal Belt has yellow and brown siliceous sand, sometimes over aeolinite, with shallow calcareous and gypsiferous soils on the salt lakes.

Climate

Lesueur has a typically Mediterranean climate of hot, dry summers and cool wet winters, with a moderately reliable rainfall (550 mm at Jurien, 620 mm at Mt Lesueur).

Drainage

Three major youthful drainage systems have their headwaters in the Lesueur Area - the Hill River (with Munbinea Creek as the major tributary), Cockleshell Gully and Stockyard Gully. In addition, one arm of Coomallo Creek (also a tributary of the Hill River) has mature tributaries arising in the eastern end of the Lesueur. The Lesueur Area protects the upper sections of these catchments in a natural state, allowing them to be used for "bench mark" studies applicable to catchment management issues. Flow in these drainage lines is seasonally intermittent, but permanent water occurs in some pools.

3.1 LAND TENURE

The Lesueur Area straddles the boundary between the Shires of Dandaragan and Coorow. It consists of land with the following tenures (Figure 3.1).

Reserve no. 15018, "Horse Breeding", not vested, excluding the coastal section west of the proposed coastal highway, approx. 15 000 ha.

Part reserve no. 24496, "Protection of Flora" (The "Beekeepers reserve"), not vested, approx. 3 600 ha

Reserve no. 24275, "Educational Purposes (University of Western Australia)", not vested, 789.5 ha.

Reserve no. 1223, "Water and Stopping Place", vested in the Shire of Dandaragan, 259 ha.

Reserve no. 968, "Stopping Place for Travellers", vested in the Shire of Dandaragan, 239 ha.

Part Stock Route (Road no. 301), approx. 1050 ha.

Part reserve no. 35593, "Gravel", vested in the Shire of Dandaragan, 348 ha. Much of this reserve is not required for gravel extraction and a boundary needs to be negotiated.

Reserve no. 35594, "Protection of Flora", not vested, 55.7 ha.

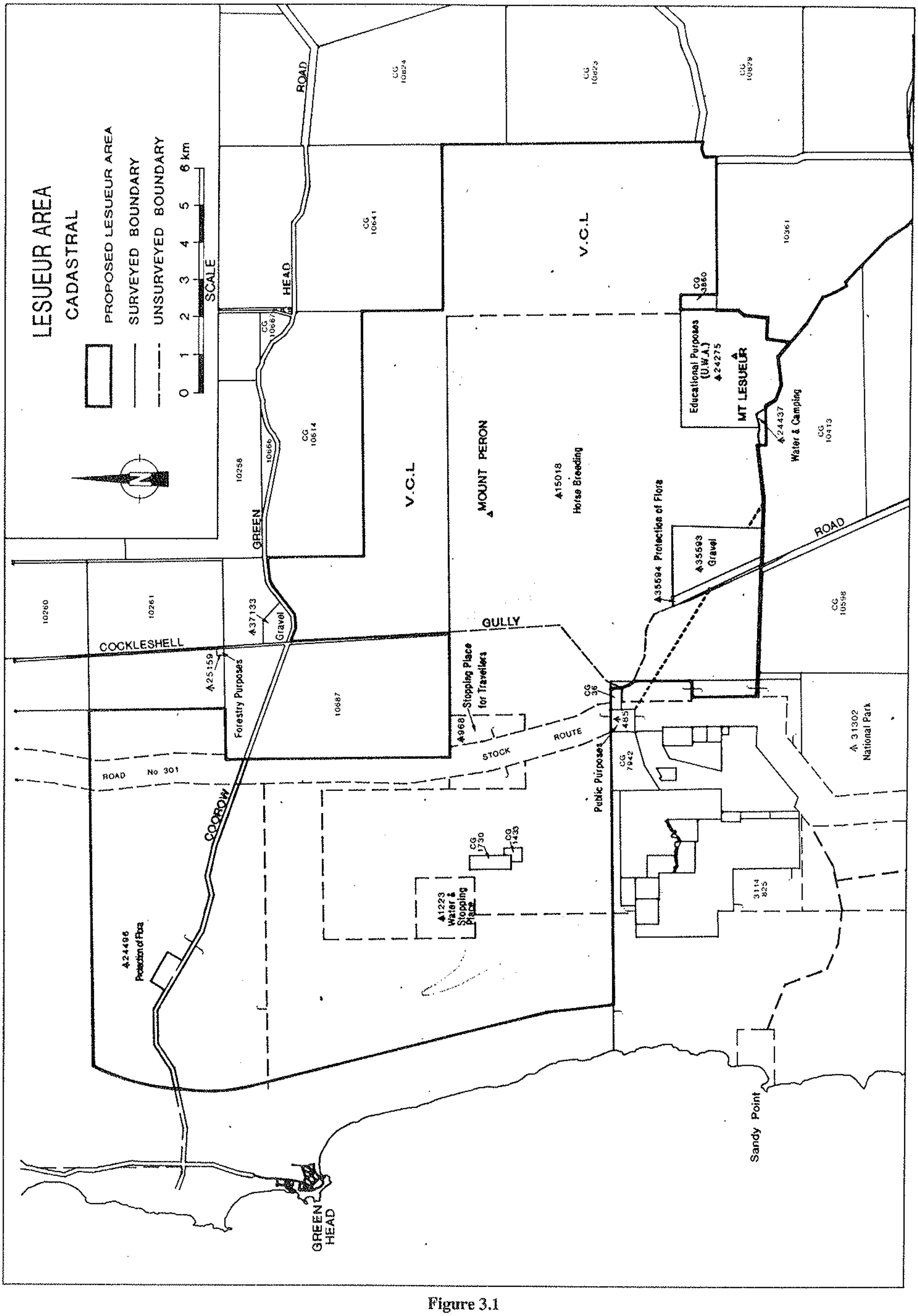


Figure 3.1

Cadastral map of the Lesueur Area

Reserve no. 24437, "Water and Camping", not vested, 22 ha.

Vacant Crown land to the north and east of reserve 15018, approx. 5 400 ha.

Victoria Locations 1433 and 1730, freehold land, 60.7 ha. The owner of this land has agreed to swap it for Crown land outside the Lesueur Area.

Parts of pastoral lease 3114/825 (Cockleshell Gully), 200 ha, (the owner has agreed to swap this land for Crown land outside the Lesueur Area) and vacant Crown land between Victoria location 10598 and pastoral lease 3114/825, 20 ha. This land will connect the Lesueur Area with the small Drovers Cave National Park of 2 680 ha.

The total area of the Lesueur Area is about 27 493 ha.

3.2 GEOLOGY

The Lesueur Area occupies part of the Perth Sedimentary Basin, the geology and geomorphology of which were described by Playford *et al.* (1976). The surface geology of the Hill River 1:250 000 Sheet has been mapped by Lowry (1974). The underlying sediments are Permian to Mesozoic. These ancient sediments have been distorted by a series of roughly north-south trending fault lines and mostly down thrown to the east as much as 2000 m each. Subsequent erosion has exposed examples of most Mesozoic rocks that were laid down in this area. A transect from west to east crosses progressively younger sediments, which are, to varying degrees, weathered or covered by shallow Quaternary deposits.

None of the Permian sediments is exposed in the Lesueur Area, being covered by thin layers of Triassic rocks and Quaternary and Recent sediments of the Coastal Plain. The Beagle Fault, which can be recognized at the surface near Diamond of the Desert Spring, divides the Permian deposits from the Triassic Lesueur Sandstone. The latter, a generally coarse grained sandstone, is exposed in the Lesueur Area, especially on some breakaway slopes south of Mount Peron.

The Lesueur and Peron Faults divide the Lesueur Sandstone from the Jurassic Cockleshell Gully Formation. Both of the latter's Members, the Cattamarra Coal Measures Member and the Eneabba Member, are exposed in the Lesueur Area. A variety of interbedded rock types occur here, varying from sandstones, siltstones and shales to coal. Relatively fresh exposures of all, especially sandstone, are common. Further to the east, the Warradarge Fault separates the Cockleshell Gully Formation from the lower Jurassic portion of the Yarragadee Formation. This mainly sandstone and siltstone Formation is only sparingly exposed in some breakaways, both inside and outside the Lesueur Area.

Laterite, an apparently fossil soil horizon, formed over an undulating but subdued land surface during the Tertiary and Quaternary Periods. The remains of this are to be seen as lateritic upland residuals. Erosion of the intervening areas has contributed towards alluvial, colluvial and swamp deposits. The majority of the sediments in the Lesueur Area are beach or marine deposits. In the Coastal Belt (Figure 3.2) there is a series of dunes of different ages which have undergone varying degrees of leaching since deposition.

3.3 LANDFORMS

Playford *et al.* (1976) recognised two major physiographic regions in the Lesueur Area; the Swan Coastal Plain and the Arrowsmith Region (Figure 3.2). For the Lesueur Area we have divided these two into nine landforms, described here from west to east.

The Swan Coastal Plain has been divided into four units.

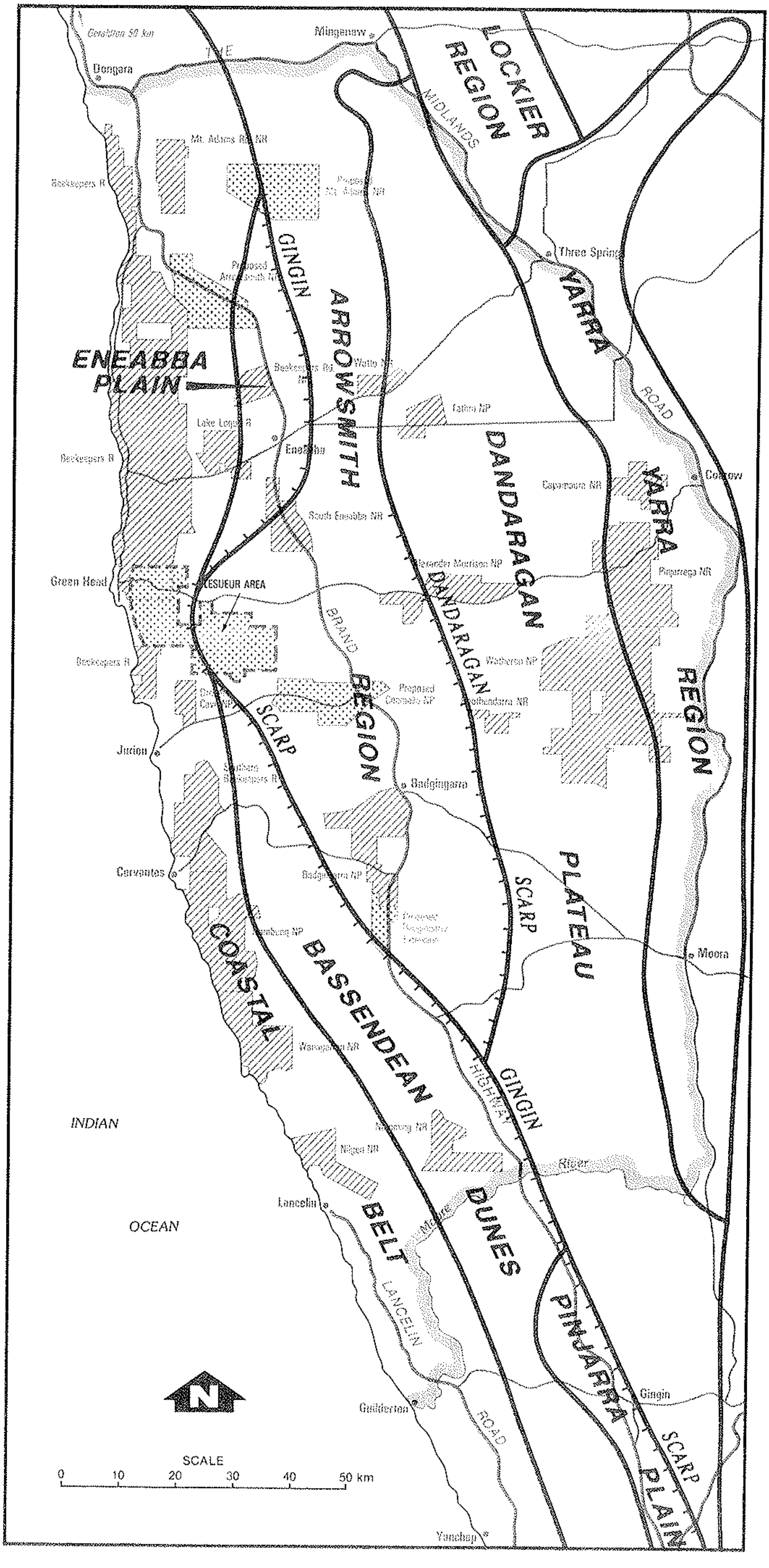
1. The Quindalup Dune System (McArthur and Bettenay 1960), comprises Holocene shorelines and dunes, extending inland for about 2 km. The Quindalup dunes are calcareous and some are mobile.

2. The boundary between the Quindalup and Spearwood Dune Systems is generally marked by a series of lakes, termed here the Salt Lake Complex. These are essentially saline but also include gypsiferous and calcareous deposits. On their eastern margin, freshwater springs and swamps occur.

3. The Spearwood Dune System (McArthur and Bettenay 1960) is carbonate rich, Pleistocene, and probably of marine origin. These dunes have lithified in places, forming Pinnacles or Tombstones (Tamala Limestone) covered by varying thickness of leached, yellow and brown quartz sand. Numerous caves have developed in this Limestone. The most well known (Drover's Cave, Stockyard Gully Cave and Weelawadji Cave) occur in other conservation areas.

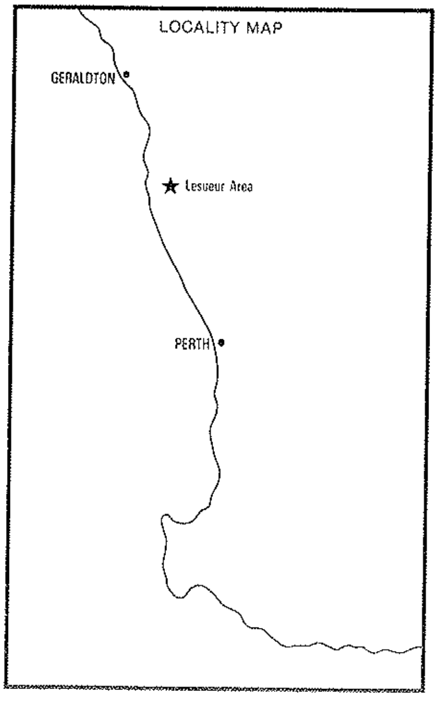
4. The Bassendean Dune System (McArthur and Bettenay 1960) is situated to the east of the Spearwood Dunes. In this area it is very narrow (about 2 km at its widest) and at its northern limit. It is a Pleistocene shoreline deposit and comprises dunes with some small swamps. The Gingin Scarp, a Pleistocene marine erosion feature, has been considerably deflated in this area, and the

Figure 3·2
PHYSIOGRAPHIC REGIONS OF THE NORTHERN KWONGAN
(after Playford et al. 1976)



LEGEND

- Major Road
- Minor Road
- Study Area
- Existing National Park, Nature Reserve
- Existing "other" Conservation Reserve
- Proposed National Park, Nature Reserve
- Lesueur Area
- Physiographic Region Boundary



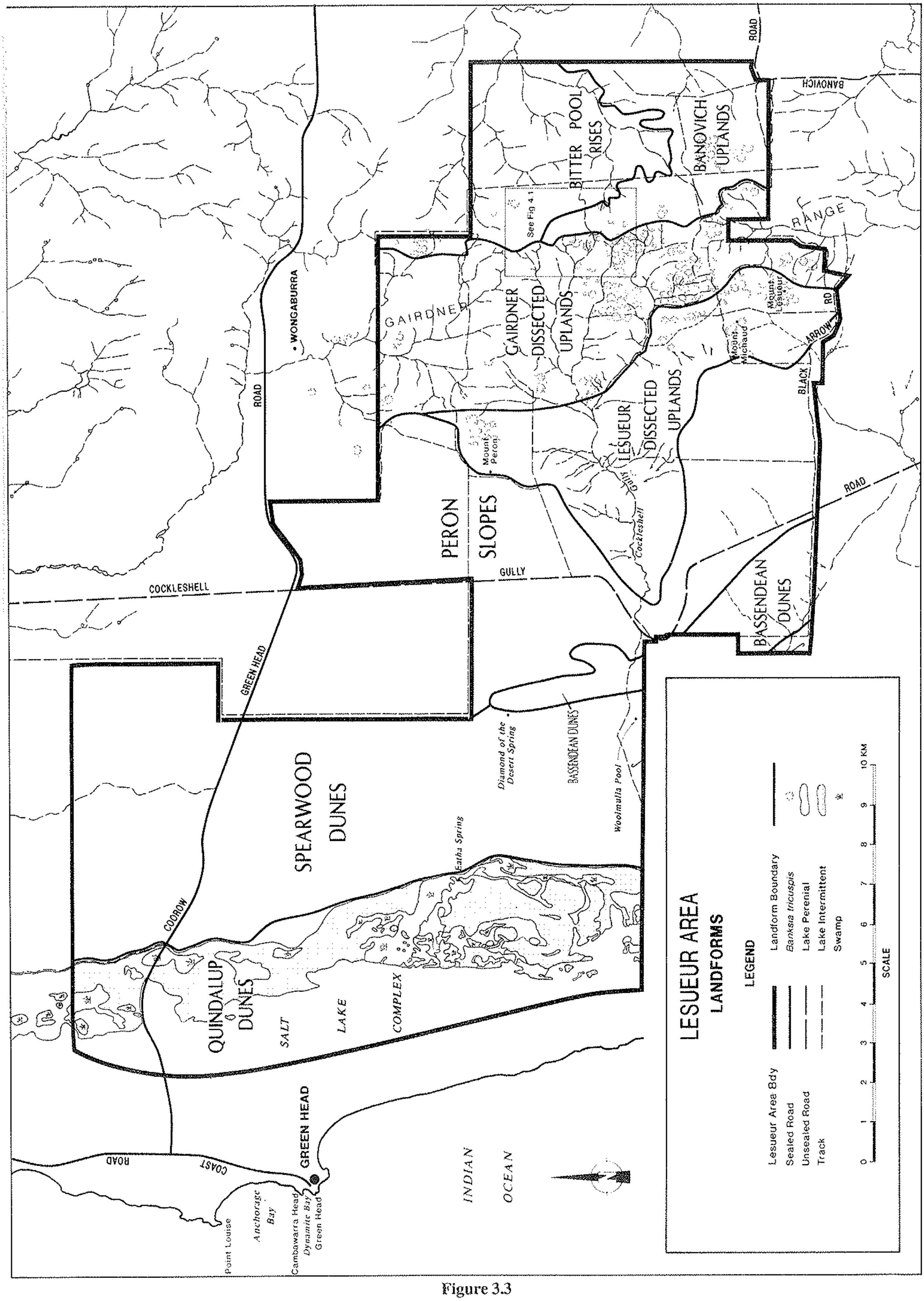


Figure 3.3
Landform map of Lesueur Area

products have contributed to the Bassendean Dune System. In this area dunes development is only slight.

The Arrowsmith Region is separated from the Swan Coastal Plain by the Gingin Scarp. Generally speaking, the Arrowsmith Region is the eroded remnants of the Tertiary land surface. It has residual laterite and sand covered uplands with mainly mature valley forms incised into it. Finkl (1979) described this type of land surface as an Incipient (Lateritic) Etchplain. Several distinct units can be recognized here, relating mostly to the unique local landscapes.

Within the Lesueur Area, the Arrowsmith Region has been divided herein to five units (Figure 3.3). The soil associations of Martinick and Associates (1989a) were used in part as a basis for this division.

5. The Peron Slopes occupy the western slopes of the uplands and include the deflated Gingin Scarp. Exposed are a complex of laterites, sands and colluvium. This is typical of much of the Arrowsmith Region outside the Lesueur Area.

6. The Lesueur Dissected Uplands, which include the prominent breakaway slopes of Cockleshell Gully, lie west of the Peron and Lesueur faults. The sandstones, and occasionally siltsones of the Lesueur Sandstone, are exposed in places. The breakaways here are up to 100 m high and, together with the conspicuous mesas (Mount Lesueur and Mount Michaud), flank the mature, U-shaped Cockleshell Gully.

7. The Gairdner Dissected Uplands are a heavily dissected landscape associated with erosion by Cockleshell Gully and Munbinea Creek. The character of the area owes much to the rapid transition of rock types and the generally steeply dipping sediments. The margins are frequently formed by steep cliff faces and breakaways, and there are prominent hills and ridges of resistant sandstone above the central drainage lines which have been incised into softer sediments. This has created a diverse topography (Figures 3.3 and 3.4). Dissected laterite-capped hills and youthful valleys are a feature of this area. Laterite-capped hills are of limited area in this unit but the Jurassic sandstone, having resisted erosion, forms characteristic breakaways. The uplands are clothed with shallow lateritic gravels and duricrust and have few areas of grey or yellow sand. Most drainage lines are youthful and V-shaped. Upper tributaries are mainly formed by upstream creep. Here, especially, they have exposed Mesozoic sediments.

8. The Banovich Uplands lie to the east of the Gairdner Dissected Uplands and south of the Bitter Pool Rises (Figure 3.3). They consist of old undulating lateritic uplands, including mesas, cuestas, and their slopes. Mature U-shaped valleys with their sandy flanks are prominent.

9. The Bitter Pool Rises are situated to the north of the Banovich Uplands and to the east of the Gairdner Dissected Uplands. They have a gently undulating landscape of low hills and rises. There are few prominent upland areas. Drainage by a mature tributary of Coomallo Creek is sluggish.

3.4 SOILS

The soils of the Lesueur Area will be described in the context of the landforms identified above (Figure 3.3). Sources of information are Northcote *et al.* (1967), who described the soils of south west Australia in very general terms, and E. Bettenay (for Martinick and Associates 1989a) who described the soils of part of the Arrowsmith Region.

1. Quindalup Dune System soils are calcareous sands in the dunes with some acid peaty soils in swales.

2. The Salt Lake Complex includes shallow calcareous and gypsiferous soils over aeolinite.

3. Spearwood Dune System soils are mainly grey, yellow and brown siliceous sand over aeolinite.

4. The Bassendean Dune System has leached siliceous sands with an organically enriched surface layer; a pan may be present near the surface.

5. The Peron Slopes were mapped as Banovich Association by Martinick and Associates (1989a).

6. The Lesueur Dissected Uplands landform was also mapped as Banovich Association by Martinick and Associates (1989a). It has, however, few upland residuals. Consequently the soils are mainly shallow colluvial sands and gravels with some areas of yellow sandy clays over weathered sandstone.

7. The Gairdner Dissected Uplands landform is virtually equivalent to the Gairdner Soil Association.

8. The Banovich Uplands is part of the area mapped as the Banovich Association.

9. The Bitter Pool Rises landform is equivalent to the Bitter Pool Association.

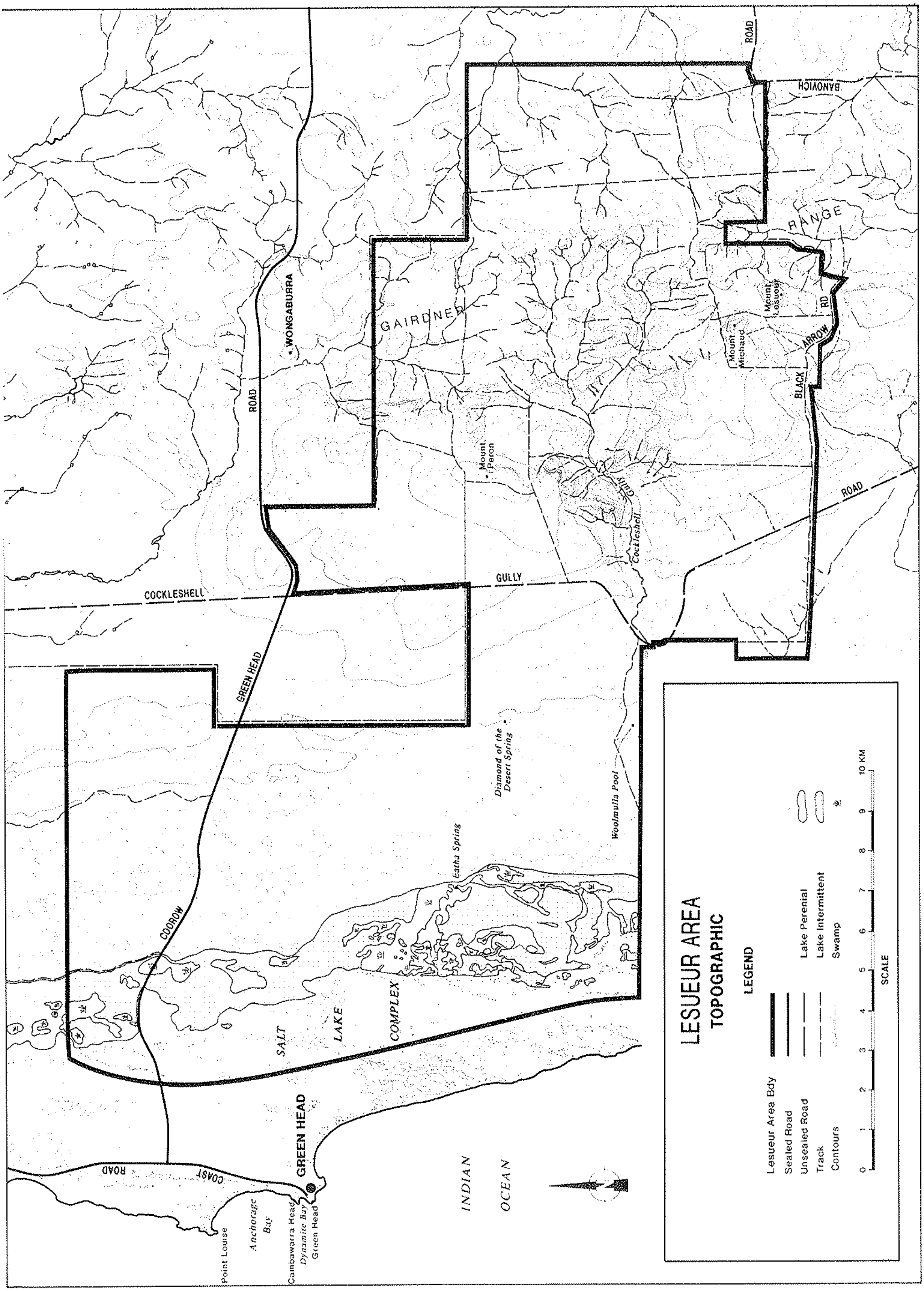


Figure 3.4

Topographic map of Lesueur Area

The following is a brief description of the soil associations of Martinick and Associates. (1989a).

1. The Banovich Association occurs on the old, undulating lateritic uplands, including mesas (such as Mt Lesueur), cuestas, and their slopes. Predominantly it consists of lateritic gravelly soils. Bleached sands with gravel pans are common on the lower margins where colluvial quartz sands have accumulated over lateritic materials. The main depressions and sandy drainage lines have bleached sands with a coloured B horizon. Shallow yellow duplex soils occupy pediments and backslopes.

2. The Bitter Pool Association occurs in the headwaters of Coomallo Creek on a gently undulating landscape. It consists of gravelly, yellow duplex soils on low hills and rises. On lower slopes and in broad drainage lines sink holes and linear gilgais are developed and there is a complex of soils including yellow duplex soils, yellow massive earths and brown, structured cracking clays.

3. Very little of the Coomallo Creek Association occurs within the boundaries of the Lesueur Area. It occurs on a tributary of Coomallo Creek. The landscape is generally subdued with drainage incised into a low lying area with some low north-south trending gravelly or stony ridges. The main soils are hard, yellow duplex soils.

4. The Gairdner Association occurs in a dissected landscape associated with erosion by Cockleshell Gully and Munbinea Creek. The margins are frequently formed by steep cliff faces and breakaways, and there are prominent hills and ridges of resistant sandstone above the incised central drainage lines. Because of this diverse topography, soils also vary considerably in their morphology. Shallow stony brown siliceous sands occur on sandstone ledges and ridges, with shallow ironstone gravelly sands on the upper pediments below breakaways. Some deeper, bleached sands with a coloured B Horizon have accumulated in pockets. In the lower areas there is a complex of soils ranging from duplex soils to yellow massive earths and brown, mottled cracking clays. This complex is associated with sink holes and gilgais, and some tunnel erosion occurs near incised drainage lines. Stones and gravels occur throughout the soils and stone lines are frequently present in the bleached and hard setting zone immediately above the clayey subsoils.

3.5 CLIMATE

The Lesueur Area has a Mediterranean climate of hot, dry summers and cool, wet winters with a moderately reliable rainfall. Climatic data for the district are limited because there are few recording stations.

At Jurien, on the coast about 18 km south west of the Lesueur Area, the annual average rainfall is 550 mm, occurring mostly (57.1%) during June to August. The Gairdner Range appears to have an oreographic effect on rainfall since the annual average at Padbury Farm, on Cockleshell Gully just outside the proposed reserve, is 622 mm (records from 1951 - 1974, Chapman 1977). Isohyets from the Bureau of Meteorology 1968 climatic survey of the region suggest an annual mean rainfall at Mt Lesueur of around 620 mm.

The mean maximum temperature for the hottest month varies from 30.5^{o} near the coast to 32.5^{o}C at the inland edge of the Lesueur Area, while the mean minimum for the coldest month varies from 9^{o} to 10^{o}C. Annual average potential evaporation is about 1780 mm (Froend 1987).

As a consequence of the dissection of the landscape, particularly in the eastern part of the Lesueur Area, there is considerable variation in microclimates. Data in Griffin and Hopkins (1985a) show that the north facing slopes of Mt Lesueur receive more direct sunshine than southern facing slopes. They are therefore drier and do not support the same relict plant populations that are found on southern slopes.

3.6 DRAINAGE

The drainage pattern in the Lesueur Area is intricate and complex. It appears that there have been significant changes in drainage patterns since the Pleistocene. Some of the ancient drainage lines have been truncated, and in some the flow has even been reversed. The youthful patterns are clearly a product of rejuvenation.

Three drainage systems have their headwaters in the Lesueur Area (Figures 3.4 and 3.5). These are the Hill River (with two tributaries), Cockleshell Gully and Stockyard Gully. Cockleshell Gully, Stockyard Gully and Munbinea Creek (a tributary of the Hill River) have similar characteristics. They all have youthful upper tributaries and flow through broad mature valleys which have narrow incised drainage channels. One arm of Coomallo Creek (also a tributary of the Hill River) rises in the area. Unlike the others, the upper tributaries are predominantly mature. Beyond the Lesueur Area the drainage channels are incised. Another similar, but minor, drainage line rises between

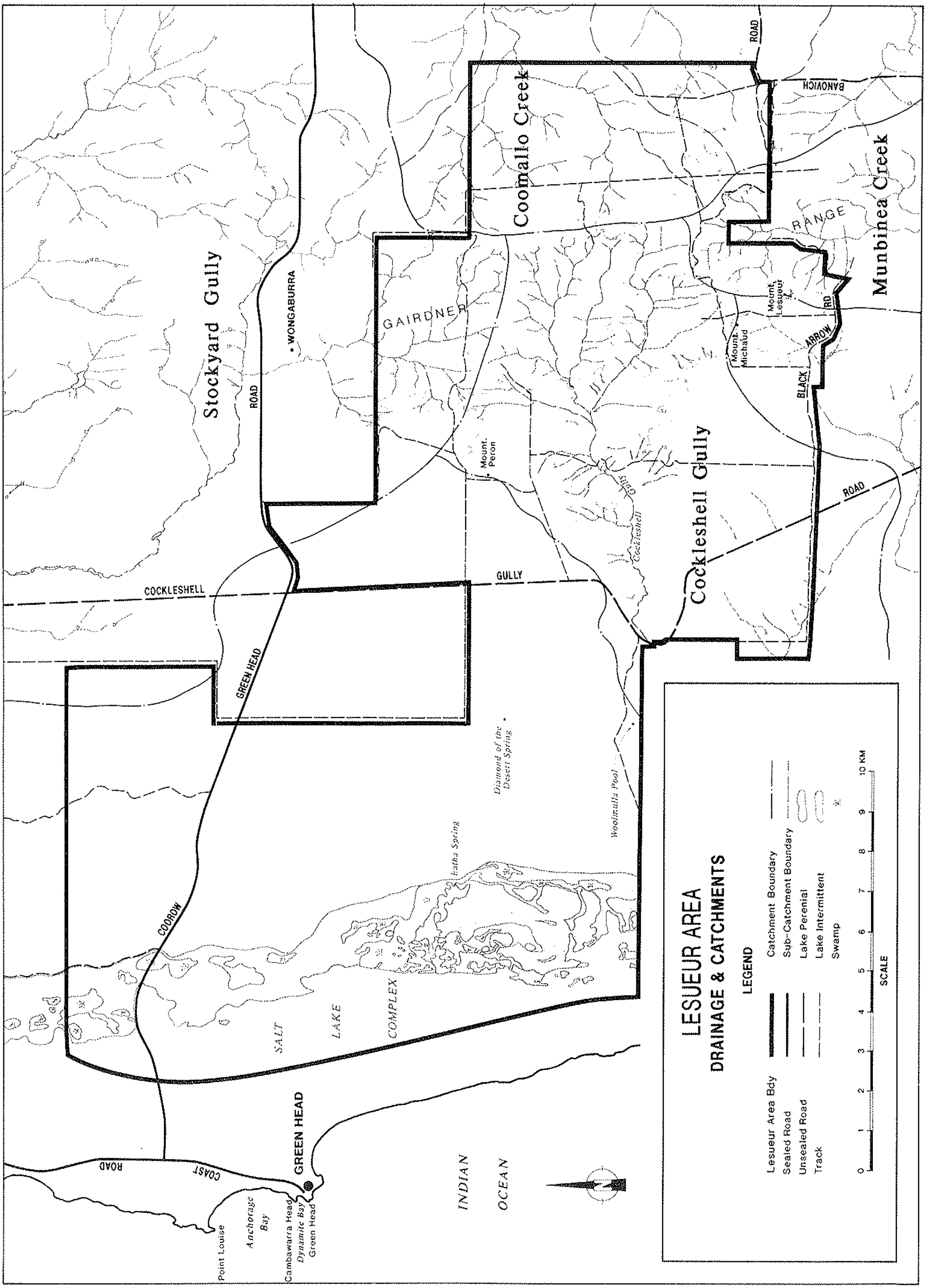


Figure 3.5
Drainage and catchments map of Lesueur Area

A74033-3

Mt Lesueur and Mt Michaud and flows through Bere Bere Spring to the sc uth west.

The flow in these drainage lines is seasonally intermittent. Permanent water occurs in some pools.

An important feature of the Lesueur Area is that it protects the upper portions of four catchments in an undisturbed state. Such protection is valuable in studies of catchment hydrology and management, providing "bench marks" for disturbed or degraded catchments.

Neither Cockleshell Gully nor Stockyard Gully discharge into the sea. The former flows into salt lakes and the latter into a cave (Stockyard Gully Cave) and, it is believed, eventually into the sea via an underground route. The Hill River flows into the sea south of Jurien.

Chapter 4

VEGETATION

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Abstract

The vegetation of the Lesueur Area is shown to be structurally diverse, consisting mainly of shrublands and woodlands interspersed in a complex mosaic. Even greater complexity is evident when communities are identified on a floristic basis. Major vegetation units are numerous, they form an intricate mosaic, and they show a close relationship to landforms. Moreover, within the one vegetation type studied in greatest detail (heath on lateritic uplands), there are 11 distinct floristic sub-types within the Lesueur Area which are geographically identifiable and can be related to specific geological substrates and soil erosional processes.

The great diversity of communities reflects the complexity of underlying strata and unusually large array of habitats found in the Lesueur Area, particularly in the eastern area. Detailed mapping by Martinick and Associates (1988) identified a very fine-scale mosaic in the eastern landforms. Some communities in the eastern uplands are not found elsewhere.

4.1 INTRODUCTION

The vegetation of the Lesueur Area and surrounding areas has been mapped at the scale of 1:250 000 by Beard (1976, 1979). In preparing his maps, Beard used many of the major surface geological boundaries previously recognised by Lowry (1974), thus tacitly recognising the strong influence of geological substrate on vegetation.

At the broad scale used by Beard, the vegetation map of the Lesueur Area is little more than a description of what is growing on each major landform. The vegetation readily can be subdivided further. Blackwell and Griffin (1981) showed that this was possible, even without detailed analyses. However, once the detailed analyses are undertaken, the real complexity of the vegetation becomes obvious.

This Chapter provides a review of existing information about the vegetation of the Lesueur Area in the context of what is known of the vegetation of the region. Vegetation is described firstly in terms of structure, and then in relation to the landforms described in Section 3.3 and illustrated in Figure 3.3. This information is drawn from Beard (1979), Griffin (1982), Martinick and Associates (1988) and unpublished observations of E.A. Griffin.

4.2 VEGETATION STRUCTURE

There is a great variety of structural types in the Lesueur Area. The principal formations are woodlands and shrublands; the area also includes sedgelands and occasional herblands. Taken together, the various shrubland formations are the most extensive. They are often intermingled to form a complex, fine-scale mosaic.

There are significant areas of *Eucalyptus wandoo* Woodland (Low Forest A to Low Woodland A, *sensu* Muir 1977) in Cockleshell Gully. Around the salt lakes *Casuarina obesa* forms Forest. Along drainage lines are small patches of *Melaleuca preissiana* Woodland (Open Low Woodland B) or, occasionally, *Eucalyptus rudis* Woodland. Beneath the woodlands there is a quite variable shrub understorey from Dense Heath A to Low Heath D and Low Sedges. Marri (*Eucalyptus calophylla*) and powderbark wandoo (*Eucalyptus accedens*) occur as Open Low Woodland B (and as emergent trees) in a matrix of shrubs, normally Dense Low Heath C, also with taller shrubs. Illyarrie (*Eucalyptus erythrocorys*) forms small woodland groves on limestone. Other Open Low Woodlands (*Banksia attenuata, B. menziesii* and *Eucalyptus todtiana*) are present on some of the sandy areas. Although an Open Shrub Mallee formation (*Eucalyptus drummondii* Mallee Heath) occurs on some areas of laterite, mallees mainly occur as emergents in areas of Low Heath. Marri often occurs as an Open Tree Mallee.

The shrub-dominated communities are both extensive and variable. As mentioned above, many areas have patches of trees. Taller shrub communities are mainly along drainage lines and in patches in coastal areas, especially near the salt lakes. Shrub dominated drainage lines, however, vary from Dense Heath A (*Melaleuca rhaphiophylla*) to Low Heath C (*Hypocalymma angustifolium* Heath). In other areas, dense shrub-dominated vegetation types vary from Dense Thickets (*Acacia rostellifera*), Dense Heath B (or A) (*Melaleuca* aff. *acerosa* (E.A. Griffin 2436) Heath), to Dense Low Heath C (*Hakea undulata* Heath, *Hakea erinacea* Heath, *Petrophile seminuda* Heath) to Dense Low Heath D (*Petrophile chrysantha* Heath). More open communities include Heath A (*Allocasuarina campestris* Heath), Heath A and B (*Banksia tricuspis* Scrub Heath, *Hakea neurophylla* Heath, *Dryandra sessilis* Heath, *Calothamnus quadrifidus* Heath), Low Heath C and D (Sand Heath, *Eremaea beaufortioides* Heath, Mixed Sand Heath, Lateritic Heath, *Hakea undulata* Heath, *Petrophile chrysantha* Heath, *Hakea erinacea* Heath, *Melaleuca platycalyx* Heath, *Petrophile seminuda* Heath), and a mixture of Low Heath C and Low Sedges (*Ecdeiocolea* Heath).

4.3 MAJOR VEGETATION UNITS

Within the northern kwongan region it has been demonstrated that vegetation is strongly related to soil types (Hnatiuk and Hopkins 1981; Bell and Loneragan 1985; Froend 1987). A similar relationship can be identified in the Lesueur Area and forms the basis of the descriptions given below.

4.31 Quindalup Dunes and Salt Lakes

Two vegetation systems, Guilderton and Cliff Head, are mapped by Beard (1976, 1979) on the sands and associated lacustrine deposits which make up this unit. In the Lesueur Area, the two vegetation systems are very similar in composition. The dunes support low heath, often dominated by *Melaleuca acerosa* and *Acacia lasiocarpa*. The interdunal areas, where there is a shallow layer of sand over the limestone pavement, generally have taller shrubs (e.g. *Acacia rostellifera, Melaleuca cardiophylla* and *M. huegelii*) forming thickets or tall heath.

A feature of these two vegetation systems in the area of the Lesueur Area is the presence of extensive salt lakes. Fringing the lakes are trees, sometimes forming woodlands, mainly of *Casuarina obesa* but also of *Melaleuca lanceolata*. Areas of samphire are prominent on lake margins; in some cases they completely cover the lake bed.

4.32 Spearwood Dunes

The older limestone deposits support Beard's (1976, 1979) Jurien and Illyarrie Systems. These are little different from each other in composition in the Lesueur Area. The vegetation types vary mainly according to the amount of yellow or brown siliceous sand covering the limestone. In places where little sand is present, there is a low heath dominated by *Acacia spathulifolia* and *Jacksonia spinosa*. In this heath, *Dryandra sessilis* is a common emergent, or sometimes the dominant species in which case it forms a tall shrubland. Deeper sands support either a dense low heath dominated by *Banksia leptophylla* and *Calothamnus quadrifidus* or a low woodland of *Banksia prionotes* with a low shrub understorey of *Allocasuarina humilis, Chamelaucium uncinatum, Hibbertia hypericoides* and *Eremaea beaufortioides*, to name a few.

Illyarrie (*Eucalyptus erythrocorys*) forms small woodland groves, but this species occurs mainly north of the Green Head Road. There is usually exposed limestone present in these groves but there is no obvious explanation for the occurrences of the discrete patches of Illyarrie. Areas of alluvium near Cockleshell Gully support *Acacia rostellifera* thickets alone, or such thickets in association with *Eucalyptus rudis* woodlands.

4.33 Bassendean Dunes

This dune system is at its northern limit in the Lesueur Area tapering out just north of Cockleshell Gully. The *Banksia* low woodlands typical of the Bassendean Dunes occupy only a minor portion of the Lesueur Area. Small patches of dense heath occur along an ephemeral drainage line. There are extensive areas of low heath typical of the colluvial sands and gravels of the adjacent Peron Slopes.

4.34 Peron Slopes

Low heath formations dominate the Peron Slopes. *Xanthorrhoea drummondii* indicates the presence of lateritic gravel at or near the surface. In this habitat it is conspicuously taller than other species, but rarely does it or any other species dominate. Shrubs form a low heath about 0.5m tall. Common species include *Allocasuarina humilis, Calothamnus sanguineus, Hakea conchifolia* and *Lambertia multiflora*.

In the sandy areas the heath is up to 1.5 m tall. The dominant species vary, apparently in response to the depth of sand. In shallow sands *Banksia candolleana* is very common. Deeper sands support *Adenanthos cygnorum* and the shrub forms of *Banksia attenuata* and *B. menziesii*. Conspicuous species are *Allocasuarina humilis, Melaleuca scabra, Conospermum* aff.

triplinervium (E.A. Griffin 5262) and *Hibbertia hypericoides.*

4.35 Lesueur Dissected Uplands

This landform has less laterite present than the Peron Slopes. There are two distinct types. The laterite on the upland rim is mostly duricrust whereas the slopes are principally lateritic gravel. They both share many species in common with the Peron Slopes but there are some differences. On the tops of Mt Lesueur and Mt Michaud, *Dryandra sessilis* and *Banksia tricuspis* form Heath up to 2m tall. This formation is quite unusual on laterite in this area. The slopes have a low heath about 0.5m tall. The sands include a similar combination of heath species to the Peron Slopes, but areas of deeper sand support low trees such as *Banksia attenuata, B. menziesii* and *Eucalyptus todtiana*. These areas are mainly near the bottom of Cockleshell Gully surrounding the alluvial deposits into which the current drainage line is incised.

The alluvial deposits around Cockleshell Gully have a clayey profile near to the surface and support a low heath usually dominated by *Verticordia densiflora* and *Calothamnus hirsutus*. Occasionally a few *Banksia grandis* and *Melaleuca preissiana* trees grow with the other banksias at the interzone between the alluvial deposits and the sands.

The drainage channel of Cockleshell Gully is dominated by *Eucalyptus rudis*. In places it forms a low forest but mostly it is a narrow band of trees. The coarse, sandy channels have a distinct flora including *Melaleuca rhaphiophylla, Acacia saligna* and *Jacksonia sternbergiana*.

A distinctive feature of the Lesueur Dissected Uplands is the numerous areas lacking either colluvium or alluvium. Here yellow sandy clays or mottled sandy clays support several vegetation types. These have not been documented but the common ones are heaths of 1-2 m in height dominated by species such as *Hakea neurophylla, Hakea undulata* and *Melaleuca* aff. *acerosa* (E.A. Griffin 2436). Low heaths are dominated by *Petrophile chrysantha* and other species. Such areas have several interesting species including the majority of the known populations of *Andersonia longifolia*, a locally endemic species.

4.36 Gairdner Dissected Uplands

The Gairdner Dissected Uplands landform is an area of varied relief which contains a wide range of vegetation types. The strongly dissected landscape and the narrow bands of different rock types has resulted in a fine-scale mosaic of abruptly changing vegetation. Only a small portion of the area has either Lateritic Heath or Sand Heath as described for the previous landform units. Its predominantly clayey soils support an array of vegetation types unusual in the northern kwongan. These are distinct from each other and are often dominated by a single species. These two features are also unusual for the northern kwongan.

The species which dominate separate heath types on clay or gravelly clay soils include *Calothamnus quadrifidus, Melaleuca platycalyx, Petrophile seminuda* and *Hakea erinacea.* Small patches of heavier clays have *Melaleuca hamulosa* or *M. uncinata* forming taller thickets. Marri (*Eucalyptus calophylla*) is a common species in clayey areas. Here it occurs as scattered trees and occasionally an open woodland. In gravelly soils *Hakea undulata* dominates a heath type while *Petrophile chrysantha* dominates a low heath.

The lateritic gravel in the Gairdner Dissected Uplands appears to be distinct from other laterites because it has a more loamy matrix. Some species relatively common on other laterites are absent or uncommon here, e.g. *Hakea conchifolia, Daviesia pedunculata* and *Dryandra shuttleworthiana*. The Gairdner Dissected Uplands apparently is the only area where *Dryandra fraseri* grows in the Lesueur Area.

The small patches of shallow sandy soil (over clays) may contain *Ecdeiocolea monostachya*, a tussock forming plant, in combination with shrub species. Frequently *Eucalyptus gittinsii*, a mallee, occurs in similar habitats.

This landform has the largest area of *Eucalyptus wandoo* woodlands in the Lesueur Area. These occur as patches often delineated by topography. However, there are places where the boundaries of the wandoo woodlands are clearly associated with changes in rock type. Wandoo appears to be confined to certain, possibly younger soils, especially areas with rejuvenated drainage with steep V-shaped gullies with clayey soil. In these areas *Trymalium floribundum* and *Grevillea thelemanniana* ssp. *delta* form a dense heath or even thicket, one of the several distinct understorey types associated with wandoo. On flatter slopes, different wandoo woodland types have understoreys dominated by *Melaleuca undulata, M. uncinata, Thomasia foliosa* or sometimes *Baeckea camphorosmae.*

The majority of the sandstone exposures in the Lesueur Area occur in this landform. The Lesueur Area contains the only exposures of the Lesueur Sandstone and Cockleshell Gully Formation in the region. Very little laterite remains on this rock type; mostly it has been stripped away leaving bare sandstone on relatively level areas or slopes made up of sandstone gravel. In both cases a distinctive set of vegetation types occurs. *Banksia tricuspis*, sometimes accompanied by

Eucalyptus drummondii, forms a scrub heath on the bare sandstone, a remarkable feat for a small tree to penetrate cracks in the sandstone. Also present with a high degree of constancy and fidelity are *Hakea neurophylla* and *Beaufortia* aff. *bracteosa* (E.A. Griffin 1176). *Actinostrobus acuminatus, Astroloma glaucecsens* and *Isopogon dubius* are common but also occur in other vegetation types. *Hakea neurophylla* is very common on the steeper slopes where it may be completely dominant forming a heath up to 2 m tall. *Banksia tricuspis* does not occur in these areas. However, some species grow almost nowhere else (e.g. *Gastrolobium ilicifolium*).

In some places, shallow sand has accumulated over the sandstone. Here, two species are dominant: *Hakea undulata* in shallow sand and *Melaleuca* aff. *acerosa* (E.A. Griffin 2436) in deeper sand. *Melaleuca* aff. *acerosa* may form, in places, a special type of sand heath with species such as *Eucalyptus todtiana* and *Petrophile macrostachya.*

Distinctive drainage line vegetation types are very limited in area because the lines themselves are so narrow. *Calothamnus quadrifidus* frequently dominates these narrow drainage lines where they pass through clayey areas. Common here are *Alyogyne hakeifolia* and *Viminaria juncea,* especially in the first years following fire. In places where the drainage line is less deeply incised, narrow stands of *Melaleuca hamulosa,* usually fringed by *M. platycalyx* occur. Sandy drainage lines are often dominated by *Melaleuca* aff. *acerosa.* When these are wider, *Melaleuca rhaphiophylla* and even *Eucalyptus rudis* become common.

4.37 Banovich Uplands

The principal vegetation types in the Banovich Uplands are Lateritic Heath and Sand Heath. Both are similar structurally to those described for the Peron Slopes but there are important floristic differences. For example the laterites of the Banovich Uplands are the main area for *Hakea megalosperma* and *Acacia teretifolia*. Several species common to laterite are sparse or absent here (e.g. *Melaleuca trichophylla, Tetratheca confertifolia* and *Conostylis androstemma*).

Some eastern lateritic uplands have a different type of laterite heath. Here there are some areas with clear cover dominance by one or two *Dryandra* species (*D.* aff. *falcata* (E.A. Griffin 3489) and *D. carlinoides.*

The Banovich Uplands landform has a greater number of vegetation types growing on sand than appear to occur on the Peron Slopes. It has extensive areas of *Banksia* woodlands, compared with the very limited areas on the Peron Slopes. (The Lesueur Dissected Uplands have some along Cockleshell Gully and around Mt Lesueur). The sand heath dominated by *Eremaea beaufortioides* is mainly confined to the Banovich Uplands. The only areas of *Hakea obliqua* Heath in the Lesueur Area occur in the south-eastern part of the Banovich Uplands.

There are a number of patches of heavy soil in the Banovich Uplands. These are related to Martinick and Associates' (1989a) Coomallo Soil Association. These areas have patches of low heath, mainly dominated by *Petrophile chrysantha*. Also, there are some small areas of *P. seminuda* and *Hakea erinacea.*

The drainage lines are principally sands overlying a clay pan which is close to the surface. They are filled with sand and are of a type which is poorly represented elsewhere in the Lesueur Area. Typically they support low heath of *Verticordia densiflora* and open woodland of *Melaleuca preissiana*. While similar heaths and woodlands are present elsewhere to a limited extent (e.g. along Cockleshell Gully), here they are best developed here because the drainage lines are shallow.

4.38 Bitter Pool Rises

The north-eastern part of the Lesueur Area has relatively low relief. This is in contrast with the adjacent Gairdner Dissected Uplands. Thus, although the two landforms have many similar substrates supporting vegetation types that are structurally similar, there are important floristic differences between them. The area is not well known, having received little study, partly because of fires which burnt out much of it in 1984 and 1985. Its landform is unique representing a mature U-shaped valley with clayey soils. This is unusual also because it is probably a drainage line which has had its direction of flow reversed in response to the tectonic adjustments in the central part of the Perth Sedimentary Basin.

There are predominantly clayey soils with accompanying species forming vegetation complexes (e.g. *Calothamnus quadrifidus, Petrophile seminuda, Melaleuca platycalyx, M. uncinata, Hakea erinacea* and *Petrophile chrysantha*). Because of the reduced relief, the first three species are relatively more common in this area than in the Gairdner Dissected Uplands. Here are a large number of very clayey pockets ("crab holes") which are distinguished on the ground by the presence of *Melaleuca uncinata* emerging from an area usually dominated by *Calothamnus quadrifidus.* From the air during spring the "crab holes" appear as numerous spots of standing water. Because of the greater dissection in the Gairdner Dissected Uplands, these features are much less abundant there.

Marri also occurs in the Bitter Pool Rises, but is less common here than in the Gairdner Dissected Uplands.

FIG. 4.1

EXAMPLE OF VEGETATION MAP PREPARED BY MARTINICK AND ASSOC (1988)

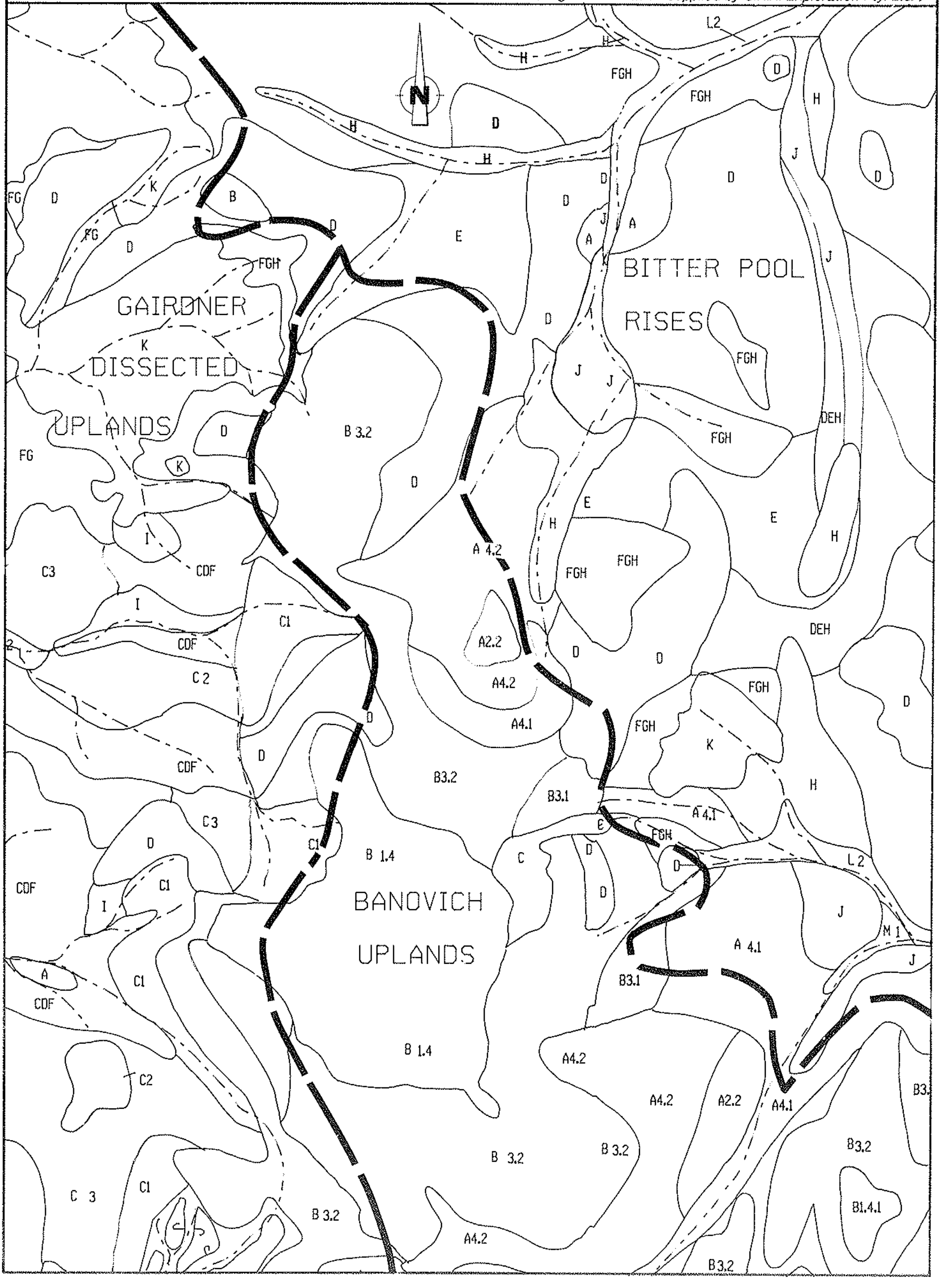
(heavy dashed line)	LANDFORM BOUNDARIES
(solid line)	MAJOR VEGETATION UNITS (eg C)
(dash-dot line)	SUB UNITS (eg B3.1)
FGH	COMPLEXES

Note : For location see Fig. 3.3

0 200 400 600 800 m

SCALE 1:10 000

(Digital Information supplied by C.R.A. Exploration Pty. Ltd.)



Only along the slopes of the slightly incised drainage lines does it occur as trees. In most other areas it is absent or occurs only as a stunted tree-mallee form.

There are several gravelly and lateritic areas which support heath and mallee-heath vegetation types, some of which are absent or uncommon in other parts of the Lesueur Area.

The areas of *Ecdeiocolea* Heath are very limited in the Lesueur Area as a whole. The Bitter Pool Rises landform contains the best examples of this unit (mainly at the boundary with the Banovich Uplands). A particular type of lateritic heath appears only to occur on some of the low rises in this area. The common species *Eucalyptus drummondii* and *Dryandra* aff. *patens* (E.A. Griffin 1507) are not represented on any other lateritic upland in the Lesueur Area (*E. drummondii* does occur on other soil types). The *Dryandra* has very specific habitat requirements, and because few of its patchily distributed populations occur on conservation reserves, this occurrence is significant.

The drainage line communities are mainly on clay. Some drainage lines are broad with no defined channel, especially in their upper reaches. Here there are areas which include heaths of *Melaleuca hamulosa* interspersed with patches of sedges. Although *Melaleuca hamulosa* occurs in other parts of the

Table 4.1

Distribution of major vegetation units within landforms of the proposed Lesueur National Park.

Code#	Name	PS	LDU	Landforms GDU	BU	BPR
A	Sand Heath	A	A	M	A	-
B	Lateritic Heath	A	A	M	A	-
C	Sandstone Heath	-	M	I	-	-
D	Gravel Heath	-	M	M	M	M
E	*Ecdeiocolea* Heath	-	-	M*	-	M
F	*Hakea erinacea* Heath	-	-	I*	-	I*
G	*Melaleuca platycalyx* Heath	-	-	I*	-	I*
H	*Petrophile seminuda* Heath	-	-	I*	M*	I*
I	*Gastrolobium spinosum* Scrub	-	-	-	-	-
J	*Calothamnus quadrifidus* Heath	-	-	I*	M*	I*
K	*Eucalyptus wandoo* Woodland	-	-	I	M	-
L	Clayey Drainage Lines	-	M	I	M	M
M	Sandy Drainage Lines	-	M	-	M	-
X	*Allocasuarina campestris* Heath	-	-	M	-	-

Codes after Martinick and Associates (1988)

Landform Codes

PS Peron Slopes
LDU Lesueur Dissected Uplands
GDU Gairdner Dissected Uplands
BU Banovich Uplands
BPR Bitter Pool Rises

Abundance Codes

A Abundant
I Important
M Minor
* mainly as a complex

Lesueur Area, this particular type of drainage line vegetation only occurs in the Bitter Pool Rises. The eastern part of the drainage patterns in the Lesueur Area are slightly incised. Narrow bands of *Melaleuca rhaphiophylla* and also Marri occur along these eroded slopes.

4.4 DETAILED VEGETATION MAPPING

Vegetation on the Lesueur Dissected Uplands, Gairdner Dissected Uplands, Bitter Pool Rises and Banovich Uplands landforms has been mapped in some detail at the scale of 1:10 000 (Griffin 1982, Martinick and Associates 1988). Initial mapping (Griffin 1982) was based on aerial photographic interpretation. However, since a number of authors (e.g. Hopkins and Hnatiuk 1981) highlighted the very considerable disparity between vegetation units defined on physiognomy and on floristics, the vegetation map was subsequently modified to take into account the results of detailed floristic studies (Martinick and Associates 1988).

Fourteen major units were identified. An additional 24 subunits were also recognised. Broadly speaking these units reflect landform and geological characteristics. Beard (1979) had earlier recognized that the vegetation of the Cockleshell Gully Formation (mainly woodlands and heath with scattered trees) was clearly different from that on the Lesueur Sandstone (heath and scrub heath).

Even at the scale of 1:10 000, mapping of the detail recognisable on the ground was difficult. Often it was not possible to draw meaningful boundaries; the vegetation types occurred in such a fine-scale mosaic that mapping could only indicate the presence of a complex of vegetation types. Some 28 complexes were recognised in the area by Martinick and Associates (1988).

Figure 4.1 is a sample of the vegetation map produced by Martinick and Associates (1988). This illustrates some of the heterogeneity of the vegetation: the 5.5 square kilometre area shown contains 13 of the major units of vegetation, as well as 12 subunits and five complexes. The complexity shown on the map is a reflection of the extremely fine mosaic of the soil (and geological substrate) in the Lesueur Area generally. Included in the figure are segments of the three main landforms on which the vegetation was mapped in detail. Even a quick examination reveals that the landforms have quite different assemblages of vegetation.

Table 4.1 provides an analysis of the relative abundance of the major vegetation units in each landform. However, Martinick and Associates (1988) recognised that many of the major units were extremely variable; this Table, therefore, is only indicative.

Sand Heaths and Lateritic Heaths are abundant on the Peron Slopes, Lesueur Dissected Uplands, and the Banovich Uplands. Sandstone Heath occurs predominantly on the Gairdner Dissected Uplands and to a lesser extent on the Lesueur Dissected Uplands. Gravel Heath is present to a minor degree on all units except for the Peron Slopes. Although *Ecdeiocolea* Heath is present on both the Gairdner Dissected Uplands and the Bitter Pool Rises, it appears to be more abundant in the latter area. *Hakea erinacea* Heath, *Melaleuca platycalyx* Heath and *Petrophile seminuda* Heath occur in complexes, with and without *Calothamnus quadrifidus* Heath, principally in the Gairdner Dissected Uplands and the Bitter Pool Rises. *Eucalyptus wandoo* Woodlands are common in the Gairdner Dissected Uplands, the landform on which most stands are found. Drainage line units are mainly found in the Gairdner Dissected Uplands and the Bitter Pool Rises. Clayey drainage units are mostly confined to both of these landforms whereas sandy units are more common in the Lesueur Dissected Uplands, and the Banovich Uplands. *Allocasuarina campestris* Heath is found as a minor component of the vegetation of the Gairdner Dissected Uplands.

The area that has been mapped in detail contains a number of vegetation units of special interest. Small areas of heath dominated by *Dryandra* aff. *patens* (E.A. Griffin 1507) occur within major unit B, lateritic heath (rarely within D, gravel heath) in the northern part of the area. The dominant species, *Dryandra* aff. *patens*, is undescribed and occurs patchily throughout its limited range in the district. It is poorly represented in conservation reserves.

Particularly fine stands of *Eucalyptus wandoo* with *Trymalium floribundum* as an understorey dominant occur on steep slopes of some V-shaped valleys with highly oxidised carbonaceous sedimentary rocks outcropping to the north-north-east of Mount Lesueur.

The *Calothamnus quadrifidus* heath (unit J) on the Bitter Pool rises landform differs from that occurring elsewhere, although this has not been documented in detail. On this landform, the *Calothamnus* heath is associated with the poorly-drained, heavy soils with sink holes and gilgais.

Where the heath dominated by *Ecdeiocolea monostachya* (unit E) occurs on the Bitter Pool Rises landform, it too is associated with heavy soil substrates. These contrast markedly with those found on the Gairdner Dissected Uplands landform, where the substrates are comparatively more sandy. Elsewhere in

Table 4.2

Relationship between floristic groups and landforms, geological units and erosional modifications in lateritic heath uplands (Data from Griffin and Hopkins unpubl.).

Group No*	Code+	Landform Unit	Geological Unit	Erosional Modification
I	B1.1	LDU	LS	H
II	B1.2	PS,LDU	LS	
III	B1.42	BU	CGF	
IV	B1.3	BU	YF	
V	B1.41	LDU,GDU,BU	LS,CGF	M
VI		PS,LDU	LS	
VII	B2.2	GDU	CGF	
VIII		?BU	YF	M
IX		?BU	YF	
X	C1	GDU	CGF	V
XI	B2.1	BPS	CGF	M

* Group No. from Griffin and Hopkins (unpublished) - see Figure 4.3.

\+ Code from Martinick and Associates (1988)

Landform Unit (this Publication)

PS	Peron Slopes
LDU	Lesueur Dissected Uplands
GDU	Gairdner Dissected Uplands
BU	Banovich Uplands
BPR	Bitter Pool Rises

Geological Unit (Lowry 1974)

LS	Lesueur Sandstone
CSG	Cockleshell Gully Formation
YF	Yarragadee Formation

Erosional Modification

V	Very Highly Stripped
H	Highly Modified
M	Moderately Modified

south western Australia, *Ecdeiocolea* heath typically occurs on yellow, sandy soils.

Drainage line vegetation (units L and M) is an important feature of the area mapped in comparison with areas to the west. Sandy substrates support particularly fine stands of *Melaleuca preissiana*, while the broad, clayey flats have *Melaleuca hamulosa* and some associated open sedgelands. The prominence of the *Melaleuca* units is largely a reflection of the diverse drainage pattern in the area east of the Lesueur and Peron faults.

4.5 DETAILED FLORISTIC STUDIES

Since 1979 over 400 permanent quadrats have been established in the eastern portion of the Lesueur Area and as far as Mt Benia and the Brand Highway for the purposes of detailed study of soil/plant relationships. Data from these quadrats have been analysed to provide an objective framework for the small scale vegetation map of Martinick and Associates (1988). Subsets of the data have also been examined (see Hopkins and Griffin 1984; Griffin and Hopkins 1985a).

When detailed floristic analyses involve several distinct vegetation types, soil and landform have usually been identified as the major factors in discriminating between vegetation types (e.g. Hnatiuk and Hopkins 1981; Bell and Loneragan 1985; Martinick and

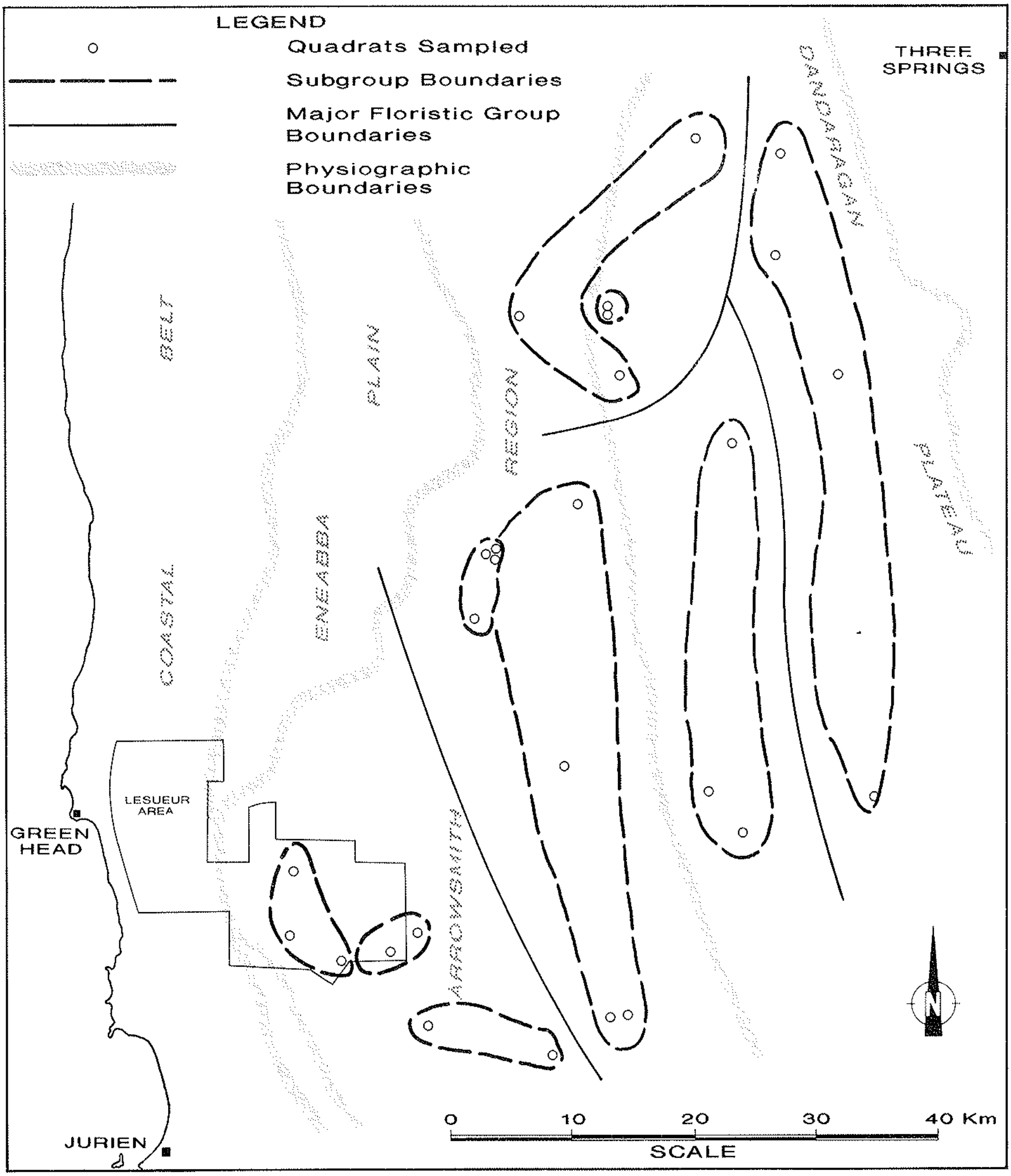


Figure 4.2
Regional variation in floristic composition of lateritic uplands in the Jurien-Eneabba area (from Griffin *et al.* 1983) shown on base map of physiographic regions (Playford *et al.* 1976).

Table 4.3

Diversity measures for selected vegetation types and subtypes in the proposed Lesueur National Park.

Vegetation Type	No.of Quads.	-Beta (a)*	Homo. (b)*
All sites[1]	226	9.19	0.17
Laterite - all[2]	142	3.57	0.59
Laterite - GI[2]	18	1.33	1.10
Laterite - GII[2]	29	1.52	1.24
Sand - all[1]	48	4.69	0.47
Sand - A2.1[1]	14	2.34	0.40
Sandstone - all[1]	20	2.88	0.43
Sandstone - C2[1]	7	1.51	0.57
Gravel - all[1]	48	4.63	0.48
Gravel - D5[1]	25	3.55	0.41
Wandoo[1]	12	3.73	0.19

Original data from: [1]Martinick and Associates (1988); and [2]Griffin and Hopkins (unpublished).

(a)* Beta (between stand) Diversity (Whittaker 1972)

(b)* Homotoneity (a statistic measuring homogeneity. For Homotoneous vegetation this value should equal about 1.0; Westhoff and van der Maarel 1973)

Associates 1988; Froend 1987). Few studies have investigated floristic variation within a single vegetation type, especially within this region. Beard (1976) commented on the variation in the floristic composition of *Banksia* woodlands on his Bassendean System. Two recent unpublished, detailed studies have confirmed Beard's impressions (J.Dodd pers. comm.; Griffin *et al.* in litt.). The latter showed that the *Banksia* woodlands of the eastern part of the Lesueur Area were significantly different from near sites sampled on the Hill River and in the Badgingarra National Park. More detailed study is required to understand what factors are responsible for this variation and at what scale regional variation can be identified.

The only vegetation type where such regional variation has been investigated in any detail is Lateritic Heath growing on uplands (Griffin *et al.* 1983). This study, between Jurien and Three Springs, demonstrated a clear regional basis underlying the variation in its floristic composition (Figure 4.2). These authors believed that water stress (as measured by potential evapotranspiration) might be the factor responsible. However, there was a clear recognition of the potential role of landform and substrate differences in controlling plant species distribution patterns at the regional level. Recent observations of distribution patterns of *Dryandra* (Griffin unpublished) have highlighted a correlation with geological factors.

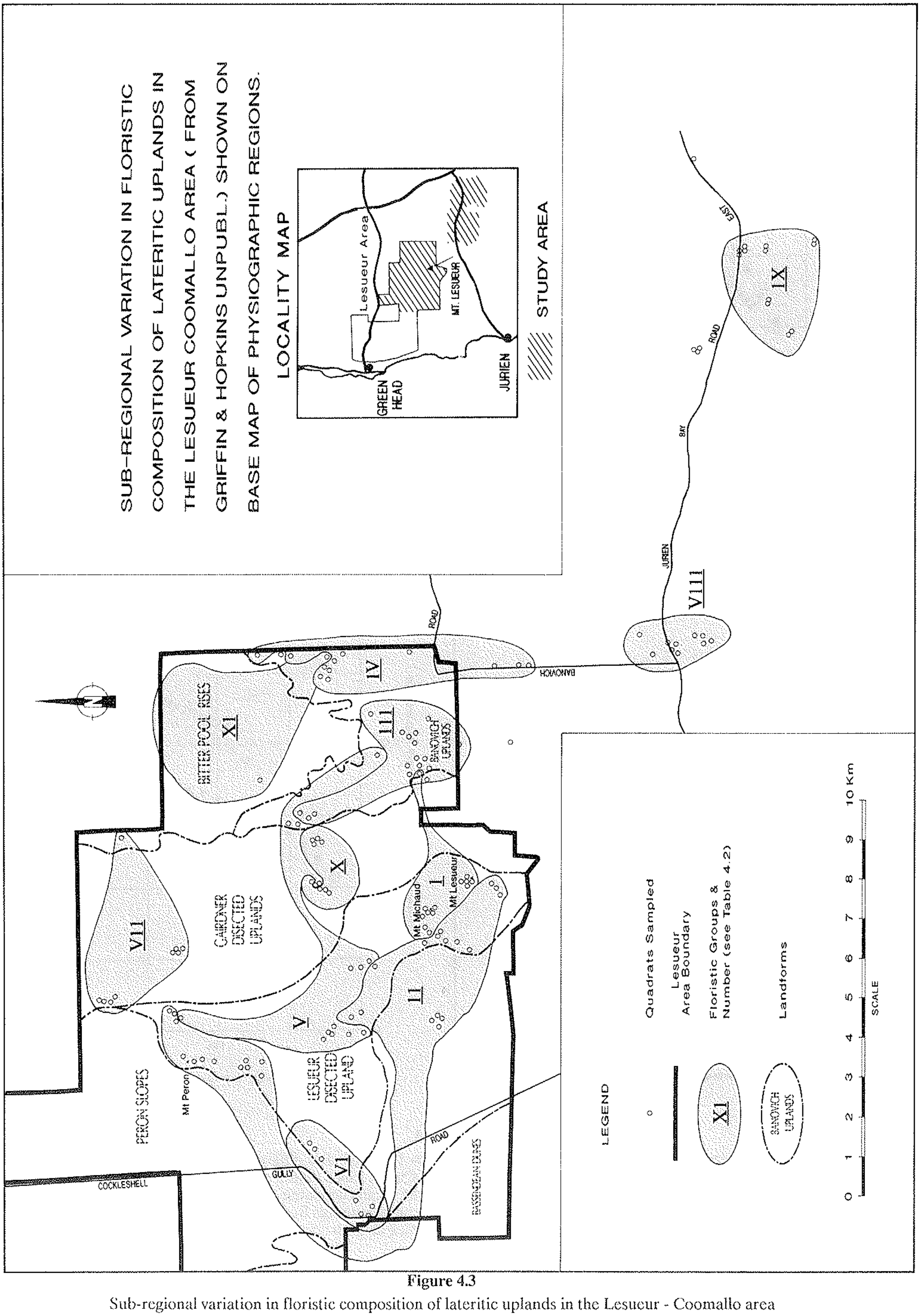


Figure 4.3

Sub-regional variation in floristic composition of lateritic uplands in the Lesueur - Coomallo area

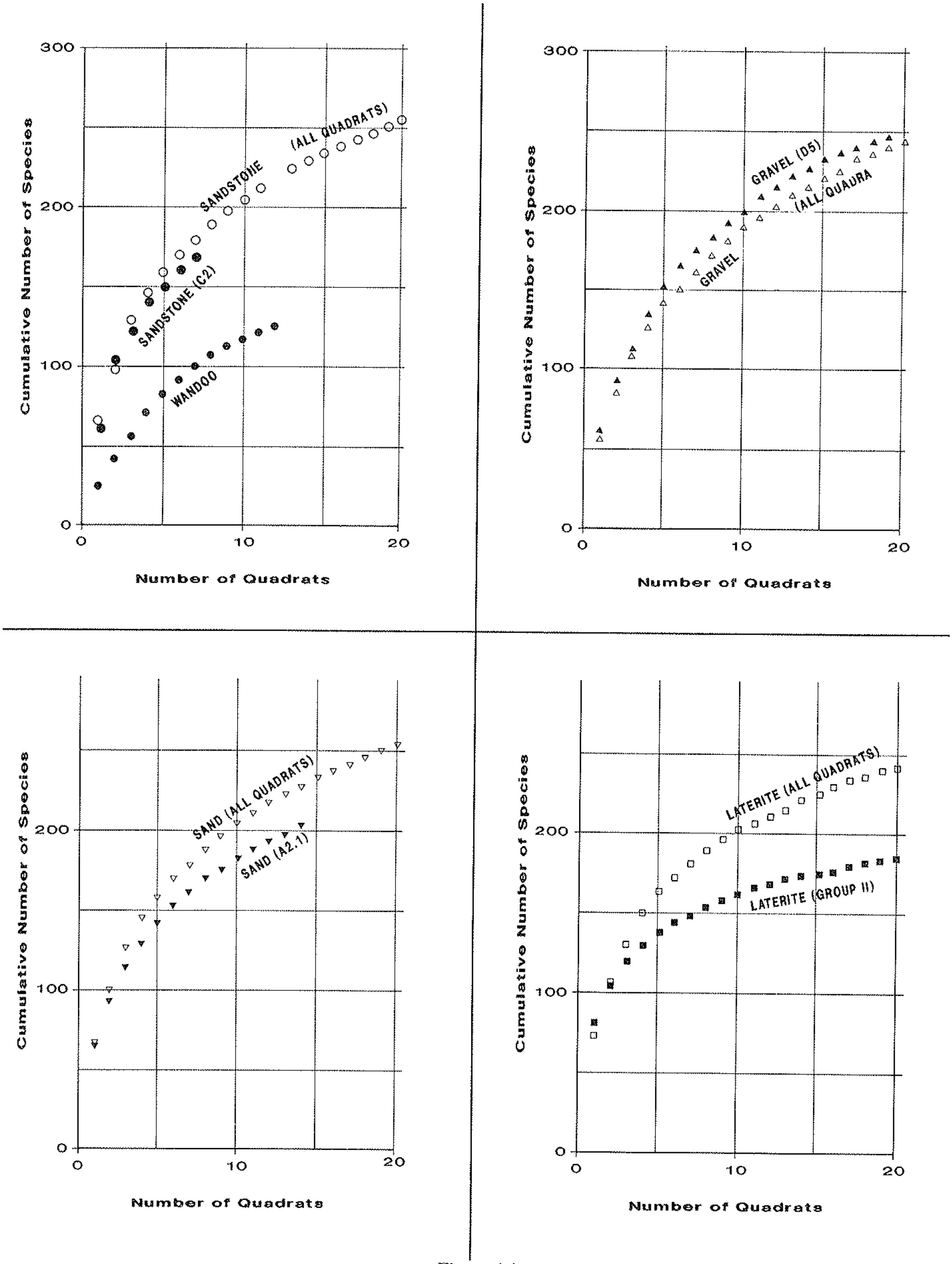


Figure 4.4

Species diversity of vegetation types. Curves indicate how the number of different species encountered increases as the number of quadrats sampled increases. Curves which flatten out quickly, indicate data sets which are more homogenous. Each data point is the mean cumulative number of species of 20 combinations of randomly selected quadrats: [Data on laterite sets from Griffin and Hopkins (unpublished), remainder from Martinick and Associates (1988)].

Detailed sampling of Lateritic Heath in the Lesueur Area and areas as far east as the Brand Highway was carried out to investigate the role of geology on soil formation and vegetation patterns at a finer scale. Figure 4.3 illustrates the results of this study: 11 groups of sites, 10 heath on laterite and one on sandstone, were recognised using multivariate ordination and classification programs as detailed in Martinick and Associates (1988).

There was an exact correspondence between eight of the 11 groups in this study and eight recognised by Martinick and Associates (1988; cf. Table 4.2). All three new groups recognised herein were not sampled by Martinick and Associates (1988). The pattern of distribution of the 11 groups is best explained in terms of geological substrate and erosional modification. As an example, differences in substrate make it possible to distinguish between Group II (laterite on sandstone), Group VII (laterite on siltstone) and Group XI (laterite on claystone) (Table 4.2).

Several stages of the erosional processes involved in stripping laterite are represented. A sequence of Group II, Group V, Group I and Group X reflects the relatively unmodified upland on the one hand (Group II), to bare sandstone from which the laterite has been completely stripped (Group X), on the other.

The significance of this study is that distinct types of Lateritic Heath on uplands can be identified and related reasonably well to the landforms in the Lesueur Area.

It is not yet possible to establish whether other vegetation types vary in similar ways. The distribution patterns of certain species suggest that this could be the case.

Comparing diversity measures is another way of establishing how likely this is. Table 4.3 and Figure 4.4 demonstrate that all of the major vegetation types examined in this way are at least as heterogeneous as laterite heath. More or less homogenous subtypes of lateritic vegetation were able to be established after detailed analyses. But the analyses by Martinick and Associates (1988) have not defined homogenous subtypes of the other major vegetation types. This disparity suggests that basic subtypes of most vegetation types could be identified if more detailed analyses and studies were undertaken.

It is important therefore to appreciate that although the map produced by Martinick and Associates (1988) (e.g. Figure 4.1) is complex, it is actually a simplification of an obviously more complex vegetation.

Chapter 5

FLORA

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Abstract

James Drummond in 1850 noted the exceptional richness of the flora, particularly of proteaceous genera and of locally endemic species. Subsequent work this century commencing with C.A. Gardner and N.H. Speck reaffirmed Drummond's observations. A.J.M. Hopkins and E.A. Griffin started a comprehensive study of the flora and vegetation in the late 1970s, providing much of the data on which the present review is based.

The present study supports earlier views on plant diversity in the Lesueur Area. It has 821 taxa of vascular plants, representing approximately 10% of the State's known flora, and a third of the taxa found in the Irwin Botanical District. Moreover, the Lesueur Area has seven species of Declared Rare Flora, nine endemic taxa, 111 regionally endemic taxa, and 81 taxa at their northern or southern limits. The numbers of Declared Rare Flora, endemics and taxa at the end of their geographical ranges are the highest of any area in the Irwin Botanical District. The Lesueur Area has been and will continue to be an important refugium for species from wetter climates.

A rapid replacement of species is notable. Even within the same vegetation type, moving as little as 0.5 km may reduce the number of species in common to less than 40%. When species richness is measured at the scales of landscape unit or within stands, diversity in the Lesueur Area is comparable with that in the Fitzgerald River and Stirling Range National Parks. The Lesueur Area ranks as one of the three most important areas for flora conservation in southern Western Australia.

5.1 INTRODUCTION

The Eneabba - Mt Lesueur area has long been recognised as an extremely rich area for flowering plants (Drummond 1853; Gardner 1947; Speck 1958). However, this richness has not been comprehensively documented until recently, and the lack of comparative data from other sites in south-western Australia has hampered appreciation of the northern kwongan flora's exceptional richness.

This chapter provides a brief historical review of the acquisition of floristic knowledge on Lesueur, and then discusses the floristic list, endemism and species of special conservation value.

5.2 BOTANICAL HISTORY

Apart from records of "blackboy trees", *Macrozamia*, *Eucalyptus calophylla*, *E. wandoo* and "a variety of the poison plant" (presumably *Gastrolobium bidens* and *G. oxyloboides*) in the journals of explorers Grey (1841) and A.C. Gregory (de Burgh 1986), Drummond (1853) provided the first botanical account of the Lesueur flora in a published letter to Sir William Jackson Hooker in Kew. The account was based on collections made in the winter and spring of 1850. Drummond's enthusiasm for the flora of the northern kwongan was evident. He had observed and collected so much of interest that only plants of special note were mentioned:

"Having lately travelled from the Moore River to the Murchison (Lat. 27.5 South) and taken excursions to the east and west of Dandaragan, I send you some account of the plants I met with, promising that I shall principally confine my observations to plants which I suppose to belong to new, or to species of such known genera as may be interesting to botanists for their rarity, to florists for the beauty of their blossoms, or to the public generally as characteristic of the country...".

In this context, plants from the Lesueur Area were mentioned more than 20 times in the letter. Drummond's brief descriptions were sufficiently diagnostic for most plants to enable their current names to be ascribed with reasonable certainty (Table 5.1). Species of Proteaceae figured prominently among the Lesueur plants mentioned. Drummond clearly had a keen eye for both the commonplace and rare plants.

Table 5.1
Descriptions of plants from the proposed Lesueur National Park in Drummond's (1853) published letter to Hooker arising from collections made in 1850.

Alyogyne ?huegelii

"The first new species (of *Hybiscus*) I met with in the deep rocky gully which runs into "Cockleshell Plains", this species grows 2' high with trifid deeply indented leaves, the divisions linear and indented at their edges. The flowers are rose coloured, marked with deep crimson spots at the base of the petals; this beautiful species grows also in the Valley of the Lakes and at Champion Bay, where it was first found by Lieutenant Elliot, the officer in command of the troops there; the plant is known by the name of Elliot's Hibiscus."

Asterolasia drummondii

"The Natural Order Rutaceae, is not common in the country passed over, but I met with two plants which I suppose belong to the new genera; one is a small shrub, about 2 feet high, with round heavy leaves about half an inch diameter; the flowers have no calyx. They consist of 5 petals which expand in a star like form; they are of a greyish-green colour outside and pure white inside; they soon fall off and leave only the 2 celled capsule; the cells are placed opposite, with lengthened recurved points; they each contain a single seed. This plant grows sparingly by the side of a watercourse on the east side of Mount Lesueur."

Banksia candolleana

"The sandplains to the west of Dandaragan and those to the east and west of Hill River produce a curious *Banksia*; it grows in broad patches with stems creeping underground and leaves from a foot to a foot and a half in length, and about 0.75" in breadth pinnatifid; the lobes are beautifully nerved, the stems grow about 2' high and terminate in flowers; the flowers are the size and form of *B. dryandroides* but the follicles are larger than they are in any described species. Most of the branches die after perfecting their seeds, and their place is supplied by fresh shoots from the stems underground; only some of the stronger branches throw out shoots, which again terminate in flowers, when they also perish and others take their place; this species is one of importance to the natives who congregate in numbers to feed upon the honey of its flowers which they call "Mangite", a name they give to the flowers of *B. grandis* and various other species."

Banksia elegans

"In travelling to the north (from the Hill River), the next *Banksia* which makes its appearance near the road (i.e. the old stock route between Perth and Geraldton) is a remarkable species with globe shaped flowers of a metallic green colour; the leaves are pinnate and resemble in length and breadth those of *B. prionotes*. The remains of the flowers fall off, leaving the follicles exposed; they are verrucose, the warts formed of a white wax like substance. This species was first shown to me by Mr Henry Gregory, but I afterwards met with it in many places in the Valley of the Lakes; it grows to be a small tree with a small trunk a foot or 18" in diameter."

Banksia tricuspis

"The flat summit of Mount Lesueur and other hills of Gairdner's Range, produce a remarkable *Banksia*, that has, when growing, a considerable resemblance to a Scotch Fir; the leaves are about 3" long, very narrow, the edges entire and rolled back, they end in three very minute teeth; the flowers bear a considerable resemblance to those of *B. verticillata*, and they are followed by similar seed vessels."

Daviesia epiphyllum

"A very curious *Daviesia* with broad plank-like leaves repeatedly branched in the form of a stag's horn, grows on Mt Lesueur and other hills of Gairdner's Range; the flowers were past in September; the seed vessels found on the plant were like those of *Daviesia*, but larger than they usually occur in the genus."

Drosera menziesii

"I found another very remarkable species, agreeing with *D. macranthum* in size, climbing habit and the form of its leaves, but having smaller and deeper rose coloured flowers, and instead of glands, the flower stalks and sepals are covered with long grey hairs; this plant grows in a swamp near the Yandyait springs, where the roots were under water when I found it; it also appears near the base of Mount Lesueur. This species and the following differ remarkably from other droseras in their roots, which are naked white bulbs growing two together as in some orchidaceous plants; that is a new bulb forms by the side of the flowering one, destined to flower the following season."

Drosera ?gigantea

"The other double rooted species alluded to appears on the banks of all the rivers and brooks from the Hill often growing on their banks with its roots under water when the plants is in flower, but only in situations where ..."

Cont'd...

Eucalyptus erythrocorys

"... a beautiful yellow flowered *Eucalyptus* grows on the limestone hills to the west of the Valley of the Lakes; it grows to a tree from 20 - 30 feet high, the leaves resemble those of a Red Gum, they are hispid on the young shoots, glabrous on the flowering branches, they are always opposite in vigorous growth. Sometimes alternate on old stunted trees, the cups are of a bright scarlet colour, and have a verrucose appearance; when the capsule expands in a quadrangular form, the angles carry with them the stamens in 4 divisions. The seed vessels are nearly as large as those of the Red Gum. The scarlet cups, fine yellow flowers and opposite shining leaves of this tree make it one of the finest species of the genus."

Grevillea

"A new *Grevillea* of the *Manglesia* section, grows near the first spring on the Hill River, on the same hill with the *Adenanthos*-like *Isopogon*, its leaves in the barren branches are round, strongly nerved with large teeth between the nerves. The leaves in the flowering branches are deeply trifid with narrow pungent divisions, its flowers are of the same character as the other species of this section of the genus."

Hakea neurophylla

"I found a fine red flowered species, with leaves resembling *H. loranthifolia* in shape, but they are larger and the veins different; it grows abundantly on the east side of Mount Lesueur, near the top."

Hakea megalosperma

"The flat summit of Mount Lesueur produces sparingly another remarkable *Hakea*; the leaves are glabrous, with very entire edges, broadly spathulate; the seed vessels are about 2" long and 1.5" in breadth and only 1.5" in thickness; the flowers I have not seen."

Hypocalymma xanthopetalum

" ... of *Hypocalymma*, a yellow coloured species, growing from 18" to 2' in height, with leaves about an inch long and a quarter of an inch wide, first makes its appearance on the sandplain and ironstone hills near Dandaragan and I saw it in abundance in similar situations as far to the north as Mount Lesueur; it produces an abundance of fine yellow flowers in the axils of the leaves."

Hypocalymma angustifolium

"A narrow leaved plant like *H. angustifolium*, but growing sparingly near the Diamond Spring, ..."

Isopogon linearis

"The ironstone hills to the north of Dandaragan, and most of the hills of Gairdner's Range, produce (but very sparingly) a new *Isopogon*, with linear leaves; it grows about a foot high, and bears large rose-coloured heads of flowers; this species resembles *I. latifolius* in its flowers but the foliage is altogether different."

Petrophile inconspicua

"On the same hills (i.e. Dandaragan - Gairdner Range), I found another new species of *Isopogon* near *I. asper* of Mr Brown, but it differs from it in the following characters:- *I. asper* has unbranched stems, the new species has numerous branches; *I. asper* has smooth anther tubes, in the new species they are covered with white hairs; the scales also which surround the flowers are hairy and bent inwards, in *I. asper* the scales which surround the flowers have glabrous recurved points."

Isopogon adenanthoides

"An ironstone hill to the west of the river near the first spring on the Hill, yields (sparingly) a very curious *Isopogon*, in habit and foliage so like *Adenanthos sericea* that when not in flower it may be easily passed over for that plant."

Isopogon tridens

"I also met with a new trifid-leaved *Isopogon* with much broader leaves; it is a rare plant, and seen only in one spot, on the great sandplain to the north of the Diamond Spring."

Lambertia multiflora

"The ironstone hills to the west of Dandaragan and as far to the north as Gairdner's Range extends produce a fine red flowered *Lambertia*, nearly answering to Mr Brown's description of *L. formosa* but without the recurved margins to the leaves; this species bears its flowers in clusters of seven; when not in flower it is so like *L. multiflora* I cannot tell one from the other by their leaves."

Pileanthus filifolius

"Of Labillardiere's genus *Pileanthus* I gathered two species ... The first is a species with large purple flowers growing in corymbs, not unlike a purple Sweet William. This species grows on the limestone hills to the north of the Spring Diamond of the Desert, ..."

Verticordia argentea

"A new lilac flowered *Verticordia* with glaucous, heartshaped, indented leaves, with several unbranched stems from the same root, which terminate in small corymbs of flowers, appears sparingly about 9 miles to the north of the Hill River, and also near the base of Mount Lesueur;"

Some of Drummond's collections from Lesueur were used as Type specimens by Carl Meissner, Professor of Botany at Basle in Switzerland, for formal descriptions of new taxa published in 1855, e.g. *Banksia tricuspis* (Table 5.2). Type specimens and the localities from which they were collected are of great importance in modern botany as a means of ensuring the validity and stability of names of plants. The Lesueur Area has had several such Type specimens collected from it (Table 5.2).

Diels (1906) did not visit the Lesueur Area. He mentioned Mt Lesueur only when reviewing Drummond's collecting trips. However, Diels noted the richness and high endemism of his Irwin Botanical District (i.e. the northern kwongan), in which 811 species were known at the time. Of this total, Diels estimated that 37% were endemic, the highest level of endemism then known for any botanical district in the State.

Diels and Pritzel collected in the Dandaragan area in 1901, and subsequently named *Acacia forrestiana* from hills to the west of Dandaragan (possibly Mt Misery). This wattle is now a Declared Rare Flora species known only from the Type area and Lesueur Area.

Gardner (1947) provided a narrative of his botanical explorations in the Lesueur Area based on trips in June 1935, January 1941 and October 1946. He was able to relocate all the species found by Drummond except *Asterolasia drummondii*, as well as discover a new species of *Xanthosia, X. tomentosa*, and collect but not recognise as new the type specimen of *Diploloena ferruginea* (Table 5.2). Returning again in August 1949, Gardner and party finally found Drummond's *Asterolasia* as well (Perry 1971).

N.H. Speck undertook a Ph.D. research program in the 1950s at the University of Western Australia, and paid special attention to the area in the immediate vicinity of Mt Lesueur. Speck's (1958) thesis highlighted the importance of Lesueur vegetation and flora (Figure 2.3), and provided quantitative substantiation of Drummond's observation that the Lesueur Area was especially rich in species of the Proteaceae (Figure 5.1a). Speck made a substantial number of plant collections in the Lesueur Area additional to the Proteaceae, including the Type of *Conostylis crassinerva* (Table 5.2). Because of the large size of his study area (the Irwin Botanical District), Speck was unable to compile a complete inventory of the flora of Mt Lesueur.

The Lesueur Area was visited sporadically by botanists over the next two decades, but it was not until the late 1970s that the comprehensive floristic and vegetation studies by A.J.M. Hopkins and E.A. Griffin were initiated. Preliminary summaries of data were provided by George *et al.* (1979), Hopkins *et al.* (1983) and Hopkins and Griffin (1984). Detailed data on the flora and vegetation of Mt Lesueur itself were presented by Griffin and Hopkins (1985a). The present publication provides the first full list and analysis of the flora of the whole Lesueur Area

5.23 Methods

The species list (Appendix 1) was compiled from a variety of sources. It was based primarily on a list commenced in 1979 by Griffin and Hopkins (unpublished) and added to by Martinick and Associates (1988), and on miscellaneous observations made by a variety of people including E.A. Griffin, S. van Leeuwen, A.P. Brown, S.D. Hopper, G.J. Keighery, D.J. Coates and A.S. George. Additional species were added to the list from the records of the Western Australian Herbarium during the assessment of the geographic distribution of species in the Irwin Botanical District.

For an assessment of regionally endemic species and Declared Rare Flora we have updated the list of Griffin (1981). Additional information has come from recently published taxonomic revisions, herbarium records and from personal communication with botanists. This gave a list of taxa confined or substantially confined to the northern kwongan between the Moore and Irwin Rivers, west of the Midlands Highway. Only one species of Declared Rare Flora (*Thelymitra stellata*) is more wide-ranging than the study area. All the rest are endemic to the northern kwongan. The distribution of each taxon on the list was mapped on a 1:1 000 000 base using localities obtained from specimens at the Western Australian Herbarium and from sight records from reliable observers (e.g. CALM records for Declared Rare Flora, Banksia Atlas records (Taylor and Hopper 1988), observations on *Dryandra* by E.A. Griffin, *Conostylis* and *Eucalyptus* by S.D. Hopper, *Stylidium* by A.H. Burbidge, *Eremaea* by D.J. Coates, *Verticordia* by A.S. George and members of the *Verticordia* Study Group, and *Beaufortia* by A.A. Burbidge).

The following data were then derived from each map:

- Maximum geographic range scored as:

1 less than 50 km (very geographically restricted)

2 50-160 km (geographically restricted)

3 more than 160 km (widespread regional endemic)

Table 5.2.
Plant taxa described from Type specimens collected in the proposed Lesueur National Park.

Taxon, author, place of publication (date)	Collector	Locality	Date of type collection
Asterolasia drummondii Paul G. Wilson, Nuytsia 6:8 (1987)	J. Drummond	n.l.*	1850
Banksia tricuspis Meissner, Hooker's J. Bot. Kew Gard. Misc. 7:119 (1855)	J. Drummond	n.l.	1850
Banksia micrantha A.S. George, Nuytsia 3:422-426 (1981)	A.S. George	5 km W of Mt Lesueur	27 March 1979
Conostylis crassinerva J.Green, Proc Linn. Soc. New South Wales 85:361 (1961)	N.H. Speck	Mt Lesueur	n.d.**
Conostylis latens Hopper, Fl. Australia 45:461 (1987)	S.D. Hopper	Mt Michaud	21 Sept. 1982
Diplolaena ferruginea, Paul G. Wilson, Nuytsia 1:198 (1971)	C.A. Gardner	Mt Lesueur	16 Oct. 1946
Eucalyptus lateritica Brooker & Hopper, Nuytsia 5:346-351 (1986)	S.D. Hopper	Mt Michaud	2 April 1982
Genetyllis (= Darwinia) helichrysoides Meissner, J. Linn. Soc. 1:37 (1857)	J. Drummond	n.l.	1850
Haemodorum venosum T. Macfarlane, Fl. Australia 45:464 (1987)	E.A. Griffin	Mt Peron	17 Oct. 1984
Hakea megalosperma Meissner, Hooker's J.Bot Kew Gard. Misc. 7:17 (1855)	J. Drummond	n.l	1850
Hakea neurophylla Meissner, Hooker's J.Bot Kew Gard. Misc. 7:17 (1855)	J. Drummond	n.l	1850
Isopogon tridens F. Muell., Fragm. Phyt. Austral. 6:239 (1868)	J. Drummond	Diamond of the Desert Spring	1850
Leucopogon plumuliflorus F. Muell., Fragm. Phyt. Austral. 6:29-30 (1867)	J. Drummond	n.l.	1850
Walteranthus erectus G.J. Keighery, Bot. Jahb. Syst. 106:110-112 (1985)	G.J. Keighery	2-3 km S of Green Head	n.d.
Xanthosia tomentosa A.S. George, J. & Proc. Roy. Soc. Western Australia (1967)	A.S. George	2 miles N of Cockleshell Gully	Sept. 1966

*n.l. = no locality given on Type specimen
**n.d. = no date given on Type specimen

Table 5.3
Total number of species in the major families and major genera in the proposed Lesueur National Park and other areas. Percentages are of totals in each area.

	Lesueur	Irwin District	Eneabba	Eneabba laterites	Stirling Range	Fitzgerald River	Tutanning	Wongan Hills
Total area (km^2)	275	39656	20	**	1157	2428	21	18
Total species	821	2153*	429	317	1262	1748	663	405
Total genera	268	524	162	125	355	433	258	196
Total families	76	120	50	38	90	91	77	76
Families								
Proteaceae	99 (12%)	146	71 (17%)	61 (19%)	133 (11%)	130 (7%)	56 (8%)	38 (9%)
Myrtaceae	93 (11%)	257	55 (13%)	37 (12%)	128 (11%)	222 (13%)	55 (8%)	61 (15%)
Papilionaceae	57 (7%)	149	27 (6%)	30 (9%)	110 (9%)	134 (8%)	44 (7%)	13 (3%)
Orchidaceae	56 (7%)	67	9 (2%)	4 (1%)	61 (5%)	86 (5%)	42 (6%)	18 (4%)
Liliaceae	47 (6%)	88	31 (7%)	19 (6%)	40 (3%)	48 (3%)	36 (5%)	11 (3%)
Asteraceae	46 (6%)	141	11 (3%)	3 (1%)	69 (6%)	108 (6%)	62 (9%)	41 (10%)
Cyperaceae	35 (4%)	45	30 (7%)	17 (5%)	44 (4%)	97 (6%)	34 (5%)	5 (1%)
Mimosaceae	33 (4%)	92	7 (2%)	12 (4%)	30 (2%)	79 (5%)	19 (3%)	31 (8%)
Goodeniaceae	30 (4%)	96	16 (4%)	10 (3%)	31 (3%)	54 (3%)	26 (4%)	13 (3%)
Haemodoraceae	29 (4%)	68	16 (4%)	8 (3%)	17 (1%)	15 (1%)	9 (1%)	2 (0%)
Epacridaceae	26 (3%)	43	19 (4%)	15 (5%)	62 (5%)	89 (5%)	21 (3%)	6 (1%)
Stylidiaceae	25 (3%)	48	15 (3%)	10 (3%)	32 (3%)	30 (2%)	28 (4%)	10 (2%)
Restionaceae	19 (2%)	15	19 (2%)	7 (2%)	26 (2%)	26 (1%)	11 (2%)	2 (0%)
Poaceae	19 (2%)	84	11 (3%)	1 (0%)	45 (4%)	66 (4%)	32 (5%)	7 (2%)
Dilleniaceae	15 (2%)	15	6 (1%)	10 (3%)	12 (1%)	21 (1%)	8 (1%)	7 (2%)
Apiaceae	15 (2%)	25	6 (1%)	7 (2%)	23 (2%)	27 (2%)	13 (2%)	6 (1%)
Droseraceae	12 (1%)	25	13 (3%)	7 (2%)	14 (1%)	15 (1%)	10 (2%)	9 (2%)
Rutaceae	11 (1%)	30	7 (3%)	7 (2%)	16 (1%)	37 (2%)	5 (0%)	6 (1%)
Genera								
Acacia	33 (4%)	89	7 (2%)	12 (4%)	30 (2%)	79 (5%)	19 (3%)	31 (8%)
Stylidium	22 (3%)	44	15 (3%)	9 (3%)	29 (2%)	26 (1%)	24 (4%)	8 (2%)
Hakea	21 (3%)	38	16 (4%)	17 (5%)	20 (2%)	34 (2%)	12 (2%)	9 (2%)
Melaleuca	20 (3%)	43	7 (2%)	5 (2%)	24 (2%)	66 (4%)	12 (2%)	15 (4%)
Eucalyptus	16 (2%)	52	7 (2%)	2 (1%)	28 (2%)	50 (3%)	12 (2%)	18 (4%)
Schoenus	15 (2%)	15	8 (2%)	4 (1%)	14 (1%)	31 (2%)	11 (2%)	1 (0%)

Table 5.3 *(cont'd)*

	Lesueur	Irwin District	Eneabba	Eneabba laterites	Stirling Range	Fitzgerald River	Tutanning	Wongan Hills
Hibbertia	15 (2%)	15	6 (1%)	10 (3%)	12 (1%)	21 (1%)	8 (1%)	7 (2%)
Caladenia	14 (2%)	25	1 (0%)	0 (0%)	30 (2%)	29 (2%)	18 (3%)	8 (2%)
Thysanotus	13 (2%)	16	11 (3%)	8 (3%)	12 (1%)	11 (1%)	7 (1%)	2 (0%)
Banksia	13 (2%)	27	10 (2%)	4 (1%)	20 (2%)	16 (1%)	3 (0%)	2 (0%)
Dryandra	13 (2%)	19	9 (2%)	15 (5%)	24 (2%)	14 (1%)	11 (2%)	6 (1%)
Petrophile	13 (2%)	18	8 (2%)	9 (3%)	14 (1%)	9 (1%)	9 (1%)	4 (1%)
Daviesia	13 (2%)	21	9 (2%)	12 (4%)	15 (1%)	19 (1%)	8 (1%)	4 (1%)
Conostylis	12 (2%)	35	11 (3%)	5 (2%)	6 (0%)	10 (1%)	3 (0%)	1 (0%)
Drosera	12 (2%)	25	13 (3%)	6 (2%)	14 (1%)	15 (1%)	10 (2%)	9 (2%)
Grevillea	12 (2%)	na	9 (2%)	2 (1%)	10 (1%)	17 (1%)	5 (1%)	9 (2%)
Leucopogon	11 (2%)	29	10 (2%)	8 (3%)	34 (3%)	54 (3%)	10 (2%)	2 (0%)
Verticordia	11 (1%)	26	10 (2%)	4 (1%)	8 (1%)	21 (1%)	7 (1%)	6 (1%)
Scaevola	9 (1%)	20	5 (1%)	2 (1%)	3 (0%)	11 (1%)	1 (0%)	3 (1%)
Isopogon	9 (1%)	9	3 (1%)	5 (2%)	12 (1%)	8 (0%)	4 (1%)	2 (0%)
Jacksonia	9 (1%)	19	4 (1%)	3 (1%)	9 (1%)	14 (1%)	8 (1%)	2 (0%)
Astroloma	9 (1%)	7	5 (1%)	4 (1%)	8 (1%)	9 (1%)	6 (1%)	3 (1%)
Aliens	24 (3%)	nd	4 (1%)	1 (0%)	74 (6%)	104 (6%)	43 (6%)	6 (1%)

nd - not determined
na - not available
** - not a contiguous area
* - does not include Grevillea

Sources of data: Irwin: R.J. Hnatiuk, (pers. comm.); Eneabba: Hnatiuk and Hopkins (1981); Eneabba laterites: Griffin et al. (1983); Stirling Range: G.J. Keighery (unpubl.); Fitzgerald River: Chapman & Newbey (1987); Tutanning: A.J.M. Hopkins (unpubl.); Wongan Hills: Kenneally (1977)

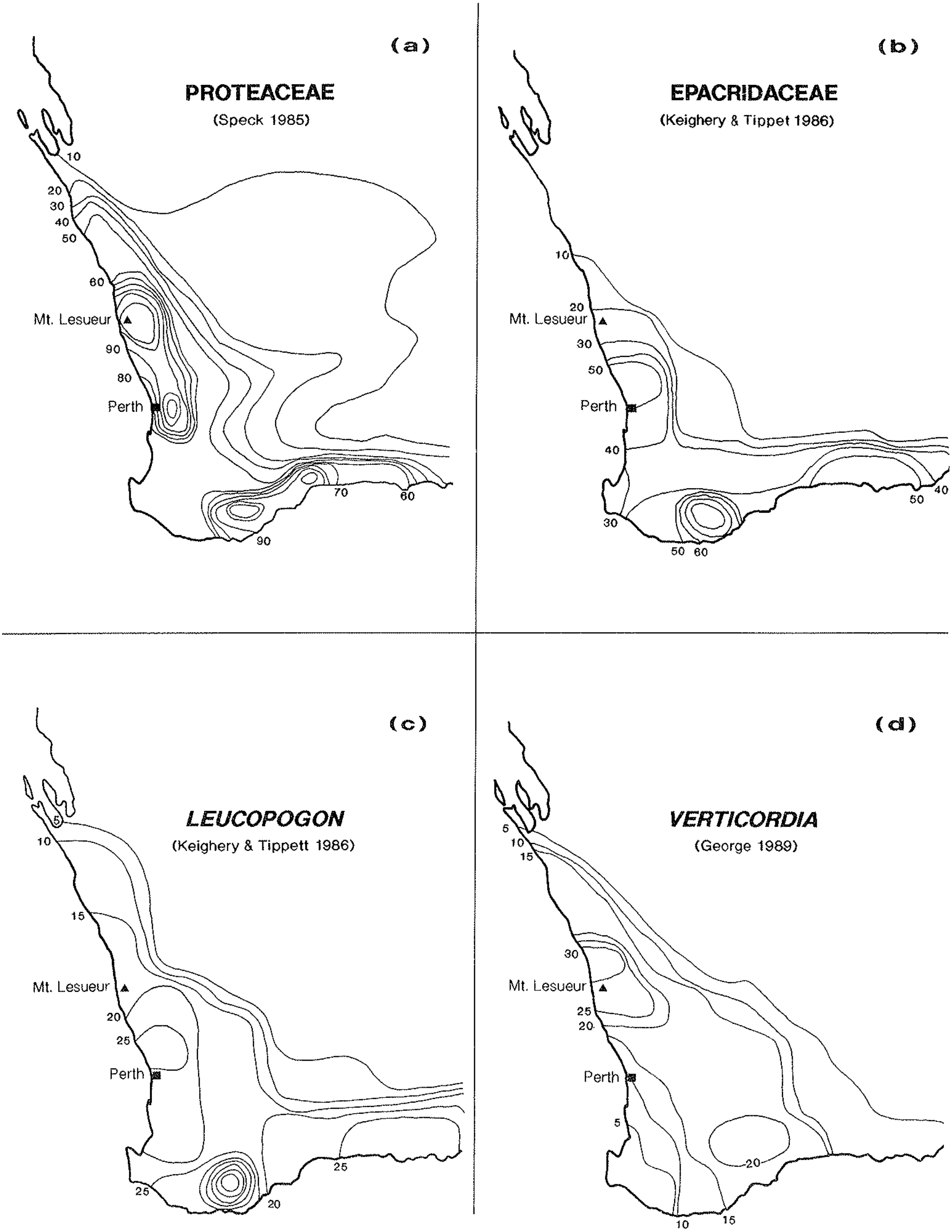


Figure 5.1

Isoflor maps of (a) Proteaceae, (b) Epacridaceae, (c) *Leucopogon* and (d) *Verticordia*

- Presence in the physiographic regions of Playford *et al.* (1976; Figure 3.2).

In addition, for endemics recorded in the Lesueur Area, their presence was noted in three main geomorphic sectors:

- coastal plain (Quindalup, Spearwood and Bassendean Dunes)
- western uplands (Peron Slopes, Lesueur and Gairdner Dissected Uplands)
- eastern uplands (Banovich Uplands and Bitter Pool Rises)

For these species, additional data recorded were:

- total number of known populations
- number of populations on existing conservation reserves (i.e. excluding the Lesueur Area)
- number of populations in the Lesueur Area
- number of populations in the eastern uplands.

Species were categorised as to:

- whether or not the taxon was declared as Rare Flora under the Wildlife Conservation Act,
- whether it was formally described or undescribed, and
- whether or not it was included on CALM's Reserve Flora List for taxa which have been or are being considered for gazettal as Declared Rare Flora. These taxa require further survey for addition to the Schedule, or have been adequately surveyed and are not considered to be under threat but require monitoring to ensure that they do not become so (Hopper, van Leeuwen and Brown in prep.).

The schedule of Declared Rare Flora is reviewed annually, and taxa (not including hybrids) may be added to the schedule if they satisfy the following criteria:

- the taxon (species, subspecies, variety) is well-defined, readily identified and represented by a voucher specimen in a State or National Herbarium;
- the taxon has been searched for thoroughly in the wild by competent botanists during the past five years, according to guidelines approved by the Executive Director of CALM;
- such searches have established that the plant in the wild is either *rare* (less than a few thousand adult plants exist in the wild), *in danger of extinction* (the taxon is in serious risk of disappearing from the wild state within one or two decades if present land use and other causal factors continue to operate), or *deemed to be threatened and in need of special protection* (the taxon is not presently in danger of extinction but is at risk over a longer period through continued depletion, or largely occurs on sites likely to experience changes in land use which would threaten its survival in the wild).

Five priorities have been assigned to taxa on CALM's Reserve List according to the following criteria.

Priority one: high priority species which are known from only one or a few localities on lands under threat, e.g. road verges, urban areas, active mineral leases, grazing by feral animals, etc. These species are under consideration for declaration but urgently require further survey.

Priority two: high priority species known from one or a few localities on land not under immediate threat, e.g. nature reserves, national parks, vacant Crown land, water reserves etc. These species are under consideration for declaration but are in need of urgent further survey.

Priority three: known from several localities, some of which are on lands not under immediate threat. These species are under consideration for declaration but are in need of further survey.

Priority four: taxa presumed extinct, (i.e. which have not been collected or reliably observed over the past 50 years, or whose total known wild population has been destroyed more recently.)

Priority five: taxa for high priority monitoring (i.e. which are considered to have been adequately surveyed and not endangered or in need of special protection, but could be if present circumstances change. These species are usually represented on reserves.)

Species in categories 1 to 3 are considered "poorly known".

The distribution of endemics in the study area was summarised by counting the number of taxa in all 10' latitude x 10' longitude grid squares. Using computer generated contouring on distributions partitioned in a 10 km grid, separate isoflor maps showing patterns of species richness were compiled for the three categories of maximum geographic range, for Declared Rare Flora, and for all regional endemics.

A number of species have been recorded at Lesueur as being at the limit of their geographic range (e.g. Griffin and Hopkins 1985a). That study only considered the flora of Mt Lesueur. The distribution of species considered most likely (on the basis of extensive field surveys in the northern kwongan) at either their northern or southern limits was assessed by comparison with the records of the Western Australian Herbarium. Species were categorised as being:

- at the northern limit of a more or less continuous distribution
- at the northern limit with a disjunct distribution
- at the southern limit of a more or less continuous distribution
- at the southern limit with a disjunct distribution.

5.4 SPECIES RICHNESS

The total number of flowering plant taxa (species, subspecies and varieties) in the Lesueur Area presently stands at 821 (Table 5.3, Appendix 1), approximately 10% of the State's known flora (Green 1985), and a third of the taxa in the Irwin Botanical District (R. Hnatiuk pers. comm.).

The 821 taxa belong in 268 genera and 76 families. Undescribed taxa represent 5.5% (45) of the total. Alien species are relatively poorly represented (24 species) and only occur in limited areas. Typical of kwongan, the families Proteaceae, Myrtaceae and Papilionaceae are the richest in species (Table 5.3). Genera with the most species are *Acacia* (33 species), *Stylidium* (22), *Hakea* (21) and *Melaleuca* (20) (Table 5.3).

The vascular flora of the Lesueur Area is large in absolute terms and also when considered in relation to other important nature conservation areas (Table 5.3). Both the Stirling Range National Park and the Fitzgerald River National Park have greater numbers of species. However, they are also very much larger in size and have been studied much more intensively by botanists.

The richness of the Lesueur Area at the landscape unit scale, or gamma diversity, can be attributed to a number of factors, foremost of which must be the wealth of habitats present. In particular, the dissected area between the Lesueur and Warradarge Faults (i.e. the Gairdner Dissected Uplands, Banovich Uplands and Bitter Pool Rises) with its varied topography and range of geological substrates appears to contribute much to the total species complement. In the context of the relatively subdued topography of the northern kwongan, the relief in the Lesueur Area is outstanding. This relief can be regarded as indicative of high habitat diversity.

Only gamma diversity of the similar South African Cape fynbos vegetation (Kruger and Taylor 1979) is higher than for kwongan of south-western Australia (Lamont *et al.* 1984). This is attributed to the greater relief of the Cape.

At smaller scales, the kwongan of the Lesueur Area is also notable. Quadrats of 100 m^2 have been sampled throughout the Lesueur Area. Hopkins and Griffin (1984) reported that the Lesueur lateritic uplands were on average richer than others in the Jurien to Eneabba area studied by Griffin *et al.* (1983). Kwongan on laterite in the central Wheatbelt (Brown and Hopkins 1983) is only about 40% to 60% as rich as that in the Lesueur Area.

While superficially uniform in structure, the vegetation of the Lesueur Area is floristically heterogeneous. There is a rapid geographical replacement of species, even on the same vegetation type. Adjacent quadrats on laterite may have as few as 60% of species in common (Hopkins and Griffin 1984; Figure 5.2). Moving as little as 0.5 km within the same vegetation type (e.g. laterite) can reduce this to less than 40%. When sites on different soils are compared, the floristic differences become even more marked. This floristic variation or beta diversity is a feature of the kwongan vegetation generally, but it appears to be pronounced in the Lesueur Area.

A study of species/area relationships conducted on the top of Mt Lesueur itself revealed that over half the species occurring in any quadrat are likely to be relatively uncommon or sparse; that is they occur at very low population densities (Hopkins and Griffin 1984). This feature has much to do with the low dominance of species which allows them to persist at low densities.

The high species richness values reported for kwongan, particularly in the nodes of richness at Mt Lesueur and the Stirling Range - Fitzgerald River area (George *et al.* 1979) has prompted some writers to suggest a comparison of species diversity with tropical rainforest vegetation (e.g. Lamont *et al.* 1977). When samples of 1000 m^2 or less are compared, the kwongan is certainly the richer of the two vegetation types. At scales of 1 to 2 hectares, the rainforests are generally richer (Lamont *et al.* 1984). At the scale of landscape units the comparisons have not been made in detail but it seems that richness values might be similar.

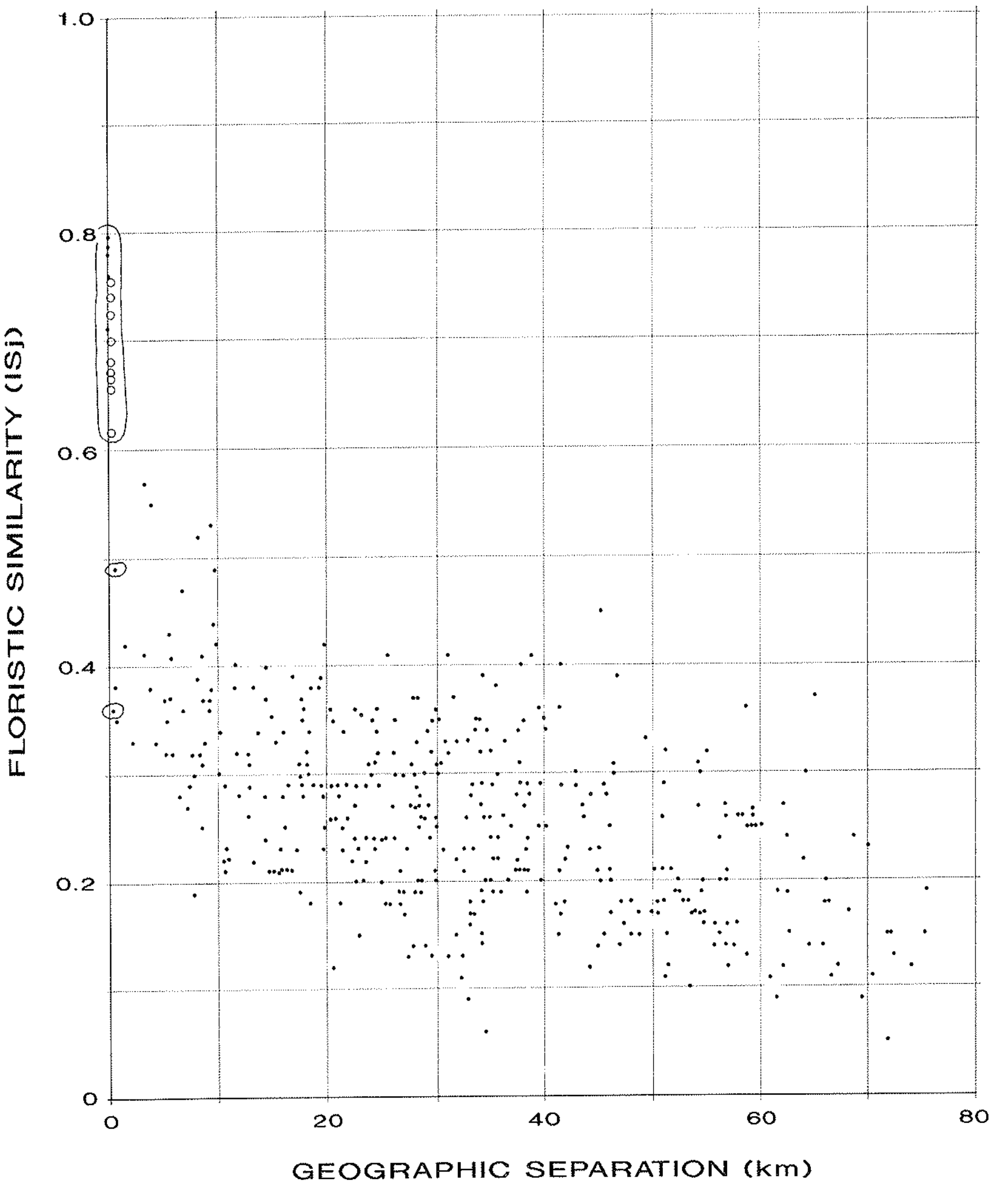


Figure 5.2

Relationship between floristic similarity (Jaccard coefficient) and geographic separation of lateritic upland heath quadrats, from Griffin *et al.* (1983) and Griffin and Hopkins, unpublished data from Mt Lesueur. Within-stand comparisons are ringed.

Currently the International Union for Biological Sciences is examining a proposal to establish a programme of international collaborative research on Biodiversity. One of the propositions encapsulated in this proposal is that studies of the dynamics of species in kwongan will provide insights into processes operating in rainforests. The Lesueur Area is the likely site for these studies.

5.5 BIOGEOGRAPHY OF SELECTED FAMILIES AND GENERA

The Lesueur Area is especially important for many famililies and genera. For example Speck (1958) plotted known distributions based on herbarium collections of 426 members of the family Proteaceae on a map of south-western Australia. The map was subdivided by 45 km^2 grid squares, the number of taxa present in each grid square was counted and lines (isoflors) drawn to join grid squares of equal species richness.

The resultant map (Figure 5.1a) showed two areas of high species richness: the Stirling Range-Fitzgerald River National Park southern kwongan area, and a second node in the northern kwongan centred on the Mt Lesueur-Eneabba area. The intervening, high rainfall, forested country between these two nodes of species richness had relatively few species of Proteaceae, as did the eastern wheatbelt and arid zone beyond. This pattern had been noted but not quantified in earlier works by Diels (1906) and Gardner (1944), and was also discussed by Burbidge (1960) and Marchant (1973).

In contrast, Hopper and Maslin's (1978) study of *Acacia* indicated that Lesueur was peripheral to the main south-western belt of species richness between Moora and Ravensthorpe, a pattern that held in subsequent research on updated data a decade later (Hnatiuk and Maslin 1988).

Suprisingly for the northern kwongan, therefore, *Acacia* was the genus with the most species in the Lesueur Area (33; Table 5.3). Although the coastal physiographic regions contributed some species (six confined to them), the eastern area (the Arrowsmith Region) still has more species than any other genus present. *Melaleuca, Eucalyptus,* and *Caladenia* are similarly richer in the Lesueur Area than at Eneabba, an area more typical of the northern kwongan.

Hopper (1979) showed that *Eucalyptus* and the Rutaceae were relatively poor in species in the northern kwongan, each displaying greatest richness in the southern kwongan and mallee. Other genera, however, are clearly concentrated in the northern kwongan, as George *et al.* (1979) and George (1989) demonstrated for *Verticordia* (Figure 5.1d).

Over the past ten years, many other genera and families have been mapped in this way (Hopper 1979; Rye 1980; Keighery 1984; Morrison 1987; Coates pers. comm.; e.g. Epacridaceae and *Leucopogon*, Figure 5.1). Such studies highlight the importance of Lesueur as a major potential conservation reserve for diverse genera of plants in the region. For instance, Lesueur genera now known to be richest in species in the northern kwongan include: *Astroloma, Conostylis, Eremaea, Haemodorum, Hypocalymma, Lechenaultia, Leptocarpus, Patersonia, Schoenus, Scholtzia* and *Verticordia.*

In addition, a number of genera have a bimodal pattern of species richness, with peaks in both the northern and the southern kwongan (e.g. *Andersonia, Anigozanthos, Banksia, Beaufortia, Calothamnus, Calytrix, Conospermum, Darwinia, Dryandra, Gompholobium, Grevillea, Hakea, Isopogon, Jacksonia, Leptospermum, Petrophile, Phebalium, Regelia, Restio, Thelymitra* and *Thysanotus*). A few are concentrated in the northern kwongan and the adjacent wheatbelt (e.g. *Gastrolobium, Micromyrtus, Thryptomene*). Some are rich in an extensive arc from the northern kwongan through the wheatbelt to the southern kwongan (e.g. *Baeckea, Melaleuca, Acacia*).

Most of the genera mentioned above are in the Lesueur Area, many in greater number of species than for any other northern kwongan conservation reserve (Appendix 1).

Mapping of genera in more detail than that available from herbarium records has occurred in some instances. The recently published *Banksia Atlas* (Taylor and Hopper 1988) is an example where sight records of many volunteer contributors have been used to gain a better understanding of exact distributions. This approach has facilitated the recognition of new localised taxa and has substantiated the biogeographical patterns derived from herbarium records. For instance, in the case of the Lesueur Area, observations that *Banksia tricuspis* is almost entirely confined to the Gairdner Range, and that *B. ilicifolia, B. grandis* and *B. littoralis* are at the northern limit of their ranges have been verified by many observers.

A number of other prominent northern kwongan genera have been surveyed thoroughly by botanists interested in taxonomy, evolution or biogeography, e.g. *Conostylis* (Hopper 1978; Hopper *et al.* 1987), *Verticordia* (George 1989), *Dryandra* (Griffin 1985) and *Eucalyptus* (Brooker 1972; Brooker and Blaxell 1978; Brooker and Hopper 1986). Biogeographical patterns elucidated for these genera similarly are well substantiated.

Accurate mapping of this kind has yet to be undertaken for the majority of species of the northern kwongan. From a different perspective, however, a few areas in the south west have been studied intensively (Table 5.3). This enables a quantitative comparison of the species richness of families and genera in Lesueur with that in some other well known areas. These studies confirm Speck's (1958) observation that the northern and southern kwongan are both richer in Proteaceae than the wheatbelt. Myrtaceae is relatively high in all areas while Papilionaceae and Epacridaceae (Figure 5.1b) appear to be higher in the southern kwongan. Haemodoraceae are richer in the northern kwongan. Typically, kwongan, especially in the north, is poorer than the wheatbelt in Asteraceae and Orchidaceae. Suprisingly the Lesueur Area is much richer in both these families than the kwongan of Eneabba. This is probably due to the greater habitat diversity in the Lesueur Area and especially to the significant areas of clay soils.

Over one third of the species noted for the Irwin Botanical District occur in the Lesueur Area (Table 5.3). Certain families are proportionally much better represented at Lesueur. Almost all the Irwin Restionaceae and Dilleniaceae and well over half the Proteaceae, Orchidaceae, Cyperaceae, Epacridaceae, and Apiaceae occur in the Lesueur Area. Several genera are very well represented, for example *Schoenus, Thysanotus, Hibbertia, Dryandra, Petrophile, Isopogon* and *Astroloma*.

Sympatry (or co-occurrence of species of the same genus) is a factor contributing to the high species richness of some genera. Particularly on laterite, *Hakea* and *Dryandra* are commonly represented by as many as five species in one stand. Other genera with significant sympatry include *Stylidium, Schoenus, Hibbertia, Banksia, Daviesia, Conostylis* and *Leucopogon*. Although rich in species, *Acacia, Melaleuca* and *Eucalyptus* have only low levels of sympatric occurrence. These three genera contrast with most others in the northern kwongan in being represented in a wide range of soil types. The richness of these genera in particular reflects the great diversity of vegetation and soils in the Lesueur Area.

5.6 SPECIES RICHNESS OF VEGETATION TYPES

George *et al.*(1979) documented the richness of some of the kwongan of southwestern Australia and showed that the samples richest in species (as measured in an area of 500 m^2) were concentrated in the reputed nodes of richness (Stirling Range - Fitzgerald River area and the Lesueur - Eneabba area). Although their single sample from Mt Lesueur was not as rich as those at Eneabba, many subsequent samples demonstrated that the Lesueur Area contains vegetation types with richness equal to the richest reported in southwestern Australia (Hopkins and Griffin 1984).

Table 5.4 shows just how diverse most vegetation types in this area are. Most have over 80 species per 100 m^2 quadrat, and this may increase by as many as 10 species just after a fire. (This is richer than in Martinick and Associates' (1988) data because detailed monitoring in the fire regeneration study found plants not obvious to those workers).

The richest areas are on sandstones and some lateritic soils. Suprisingly, some of the vegetation types on clayey soil (*Petrophile seminuda* Heath and *Melaleuca platycalyx* Heath) are also very rich. Their richness is due mainly to the relatively high number of annual species present.

Because of the great turnover of species as mentioned in Section 5.4, the richness of a vegetation type is several times that of an individual 100 m^2 quadrat (Figure 4.4). How great an increase depends partly on how precisely the vegetation type is defined. Figure 4.4 shows that all the major heath vegetation types (on sand, gravel, sandstone and laterite) are very similar in richness at this level. Detailed comparison of the richness of vegetation subtypes is not possible and must await their precise definition (cf Section 4.15.).

A distinct relationship between soil type and species richness was recognised by George *et al.* (1979). Sandy soils associated with laterite were richer in species than deep sand for example. Hopkins and Hnatiuk (1981) and Froend (1987) found that ecotonal areas between the extremes of laterite and deep sand were richer than other types examined. Table 5.4 supports this view. Lateritic Slope Heath was at least 10% richer than either Lateritic Heath or Sand Heath.

5.7 ENDEMISM

Although many authors have discussed northern kwongan endemism in general reviews (e.g. Drummond 1853; Diels 1906; Gardner 1944; Burbidge 1960; Marchant 1973; Hopper 1979; George *et al.* 1979; Hopkins *et al.* 1983; Lamont *et al.* 1984; Hopper and Muir 1984), the first detailed analysis of endemism was by Griffin (1981). On the basis of herbarium and literature records and field observations, Griffin identified and mapped herbarium records of 84 geographically restricted taxa confined to the northern kwongan between the Moore and Irwin Rivers. He listed only formally described taxa, but noted that an

Table 5.4

Mean species richness sampled in 100m² quadrats for all species and for annual species alone before and one year after fire within different vegetation types (Vegetation codes and names from Martinick and Associates 1988).

Code	Vegetation Type Name	No of Quads	Pre-fire All	Pre-fire Annual	Post-fire All	Post-fire Annual
K	*Eucalyptus wandoo* Woodland	3	36.0	9.3	40.6	12.3
F	*Hakea erinacea* Heath	1	66.0	14.0	70.0	16.0
E	*Ecdeiocolea* Heath	1	68.0	11.0	72.0	14.0
D	Gravel Heath	6	76.0	4.3	84.4	7.8
B2	Laterite Heath 2	2	80.0	3.5	87.5	7.5
A	Sand Heath	6	82.5	4.8	91.5	10.2
J1	*Calothamnus quadrifidus* Heath	1	83.0	25.0	92.0	31.0
B1	Laterite Heath 1	8	86.6	0.9	92.4	3.4
G	*Melaleuca platycalyx* Heath	1	87.0	23.0	92.0	27.0
H	*Petrophile seminuda* Heath	3	91.6	27.0	103.0	28.0
B3	Laterite Slope Heath	4	95.3	4.0	101.8	3.9
C	Sandstone Heath	3	103.7	1.0	112.0	3.7

additional 66 apparently undescribed taxa were known from the Eneabba-Mt Lesueur area and most of these were probably geographically restricted as well.

Over the past eight years, Griffin's surmise on undescribed taxa has been substantiated. Many northern kwongan endemics have been described recently, and many more still await formal description (e.g. 45 taxa in the Lesueur Area are undescribed).

A total of 259 taxa, including 92 undescribed (36%), are currently known to be regional endemics and/or Declared Rare Flora of the northern kwongan between the Moore and Irwin Rivers west of the Midlands Highway (Appendix 2). Of the 259, 117 (45%) are Very Geographically Restricted with a known range of less than 50km. A similar number (114) are Geographically Restricted with a range of between 50 and 160km. The other 28 (11%) have ranges greater than 160km.

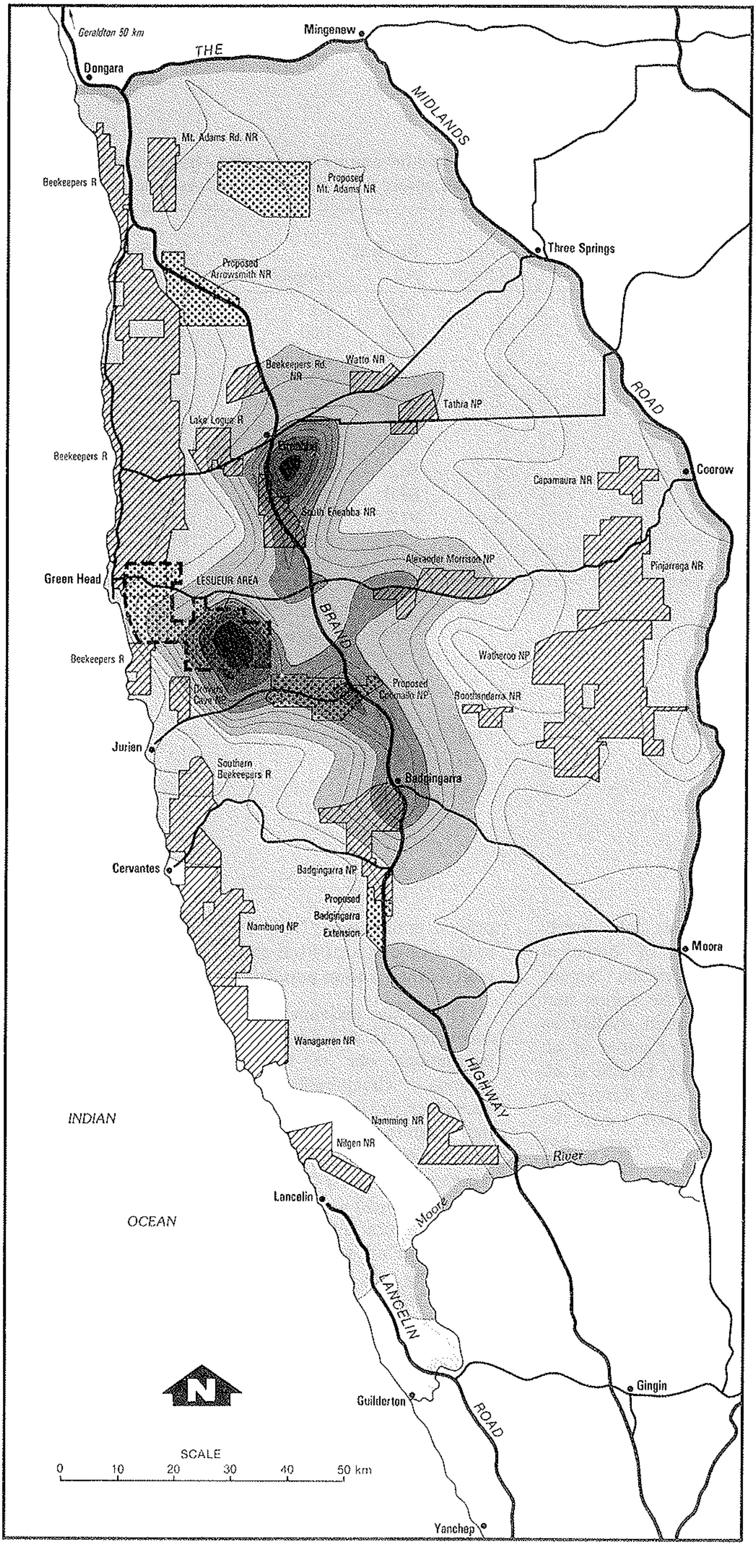
The majority of these regional endemics occur in the Arrowsmith Physiographic Region with its lateritic uplands and sandy plains, (190 (78%) out of 243 (data excluding *Verticordia* which is undergoing taxonomic revision)). The Coastal Belt and the Bassendean Dunes each had only 12% and 14% respectively of the regional endemics even though they occupy a similar combined area to the Arrowsmith Region. Similarly, the Dandaragan Plateau (39%) and the Yarra Yarra Region (25%) had only moderate proportions of the regional endemics. On a unit area basis, the small Eneabba Plain was the richest in endemics, with an average of 10 taxa per 100km². The Arrowsmith Region had 3 per 100 km² and the others about 1 (Table 5.5).

The regional endemics are concentrated in the Lesueur Area, which has 111 (43%) of the 259 taxa. Moreover, the 10' x 10' grid cell covering the eastern part (Gairdner Dissected Uplands, Banovich Uplands and Bitter Pool Rises) contains 104 of these endemics. The second richest cell with 82 taxa was immediately to the north covering the species-rich Eneabba Plain. Mt Lesueur and the southern part of the Gairdner Range were in the third richest cell (78), while the Peron Slopes were in the fourth richest cell with 77 taxa. Numbers of endemics per cell declined with distance from Mt Lesueur and the Eneabba Plain. There is a minor node of richness (37 taxa) in the Cataby area.

Computer-generated isoflors of these data derived from species numbers within 10 km x 10 km grid cells provide a graphic demonstration of the concentration of regional endemics in the Lesueur Area (Figure 5.3). There is a secondary node of richness just south of Eneabba, with moderately rich "ridges" trailing south-east from Lesueur down Brand Highway to Badgingarra, and east of Brand Highway towards Alexander Morrison National Park. A minor node is found near Cataby.

It is important to note that the summit of the node in the Lesueur Area is considerably smaller than the 10 km grid from which the isoflors were derived (Figure 5.3, cf. scale bar). The precision implied by the narrow peak is an artefact of the contouring algorithm used. However, it can be said with certainty that the eastern uplands of the Lesueur Area overall have the richest concentration of regional endemics in the northern kwongan between the Moore and Irwin Rivers.

Figure 5·3
ISOFLOR MAP OF 259 REGIONAL TAXA OF THE NORTHERN KWONGAN



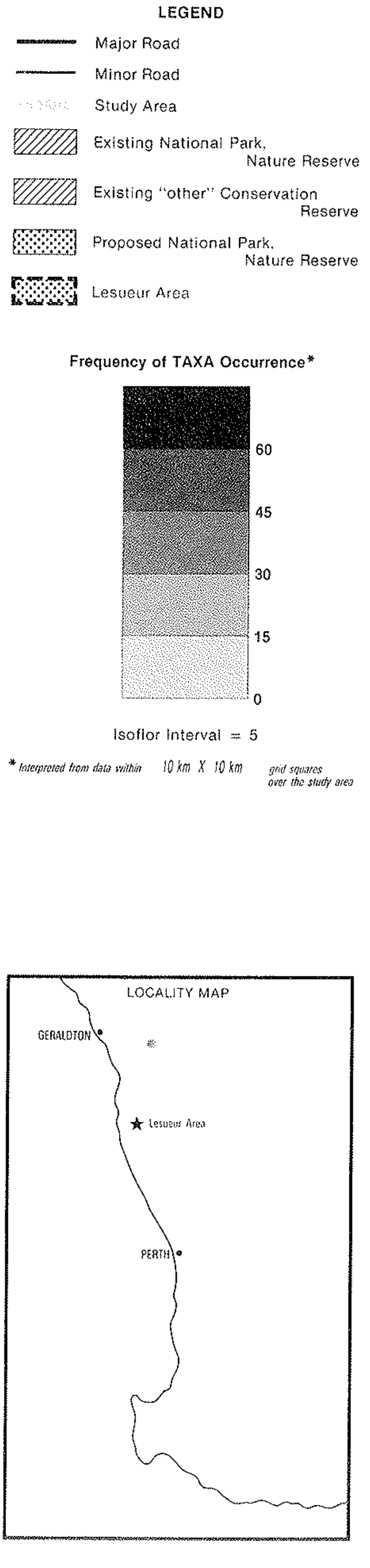


Table 5.4

Mean species richness sampled in 100m^2 quadrats for all species and for annual species alone before and one year after fire within different vegetation types (Vegetation codes and names from Martinick and Associates 1988).

Code	Vegetation Type Name	No of Quads	Pre-fire All	Pre-fire Annual	Post-fire All	Post-fire Annual
K	*Eucalyptus wandoo* Woodland	3	36.0	9.3	40.6	12.3
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B2	Laterite Heath 2	2	80.0	3.5	87.5	7.5
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J1	*Calothamnus quadrifidus* Heath	1	83.0	25.0	92.0	31.0
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G	*Melaleuca platycalyx* Heath	1	87.0	23.0	92.0	27.0
H	*Petrophile seminuda* Heath	3	91.6	27.0	103.0	28.0
B3	Laterite Slope Heath	4	95.3	4.0	101.8	3.9
C	Sandstone Heath	3	103.7	1.0	112.0	3.7

While some of the detail in Figures 5.3-5.7 may reflect imbalances in the intensity of botanical collecting, places such as South Eneabba Nature Reserve, lateritic uplands throughout the region and the verges of Brand Highway have been studied as intensively as the Lesueur Area (e.g. Lamont *et al.* 1977, 1984; Hnatiuk and Hopkins 1981; Griffin *et al.* 1982, 1983). Moreover, species of Declared Rare Flora have been searched for throughout their ranges by many workers, and this intensity of survey has reinforced the view that the general pattern in Figure 5.3 is real.

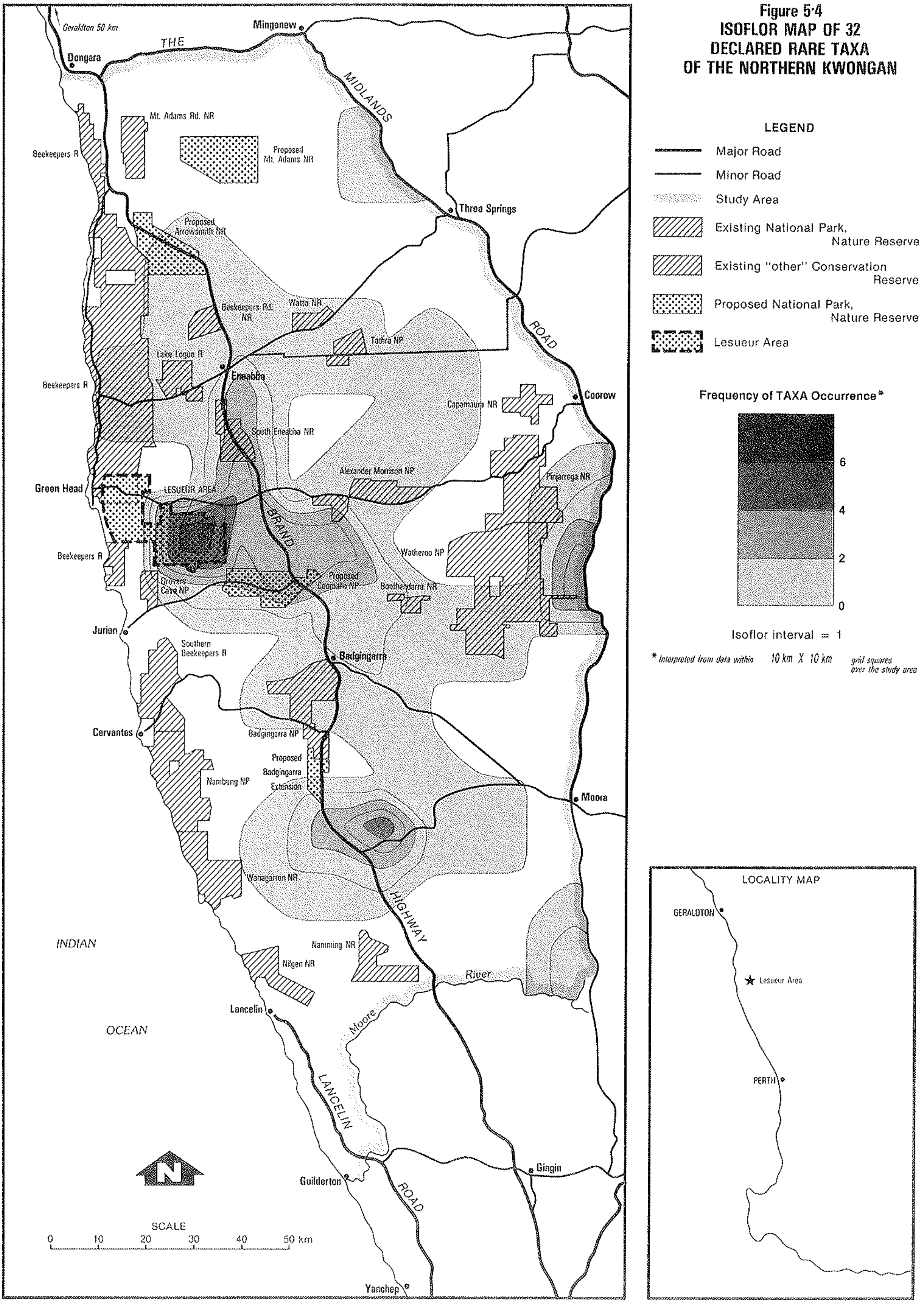
The pattern in Figure 5.3 is repeated with only minor variations when the endemics are divided into Declared Rare Flora (Figure 5.4), Very Geographically Restricted taxa (Figure 5.5), Geographically Restricted taxa (Figure 5.6), and widespread regional endemics (Figure 5.7).

The precise distribution of most regional endemics within the Lesueur Area is only sparingly known. On present information (Table 5.6), nine taxa are endemic to the Lesueur Area itself and a further 25 have 50% or more of their known populations in the area.

Of the nine endemic (Table 5.6), *Hypocalymma* aff. *ericifolium* (E.A. Griffin 1972) has two known populations, one of which occurs in the eastern uplands. Comparable figures for *Eucalyptus* aff. *haematoxylon* (E.A. Griffin 2451) are 7 overall with 3 in the eastern uplands, *Persoonia rudis*, *Grevillea thelemanniana* spp. *delta* and *Gompholobium* aff. *polymorphum* (E.A. Griffin 2304) each have 3 (1 in the eastern uplands) and *Leucopogon plumuliflorus* has 6 (1 in the eastern uplands). None of the two known populations of *Andersonia longifolia*, 5 of *Phebocarya pilosissima* ssp. *teretifolia* nor the one of *Restio* sp. (Briggs 7473 and Johnson) are known to occur in the eastern uplands.

There are 26 very geographically restricted taxa (maximum range 50 km) that occur in the eastern uplands. Twenty of these 26 taxa are not known on

Figure 5·4
ISOFLOR MAP OF 32
DECLARED RARE TAXA
OF THE NORTHERN KWONGAN



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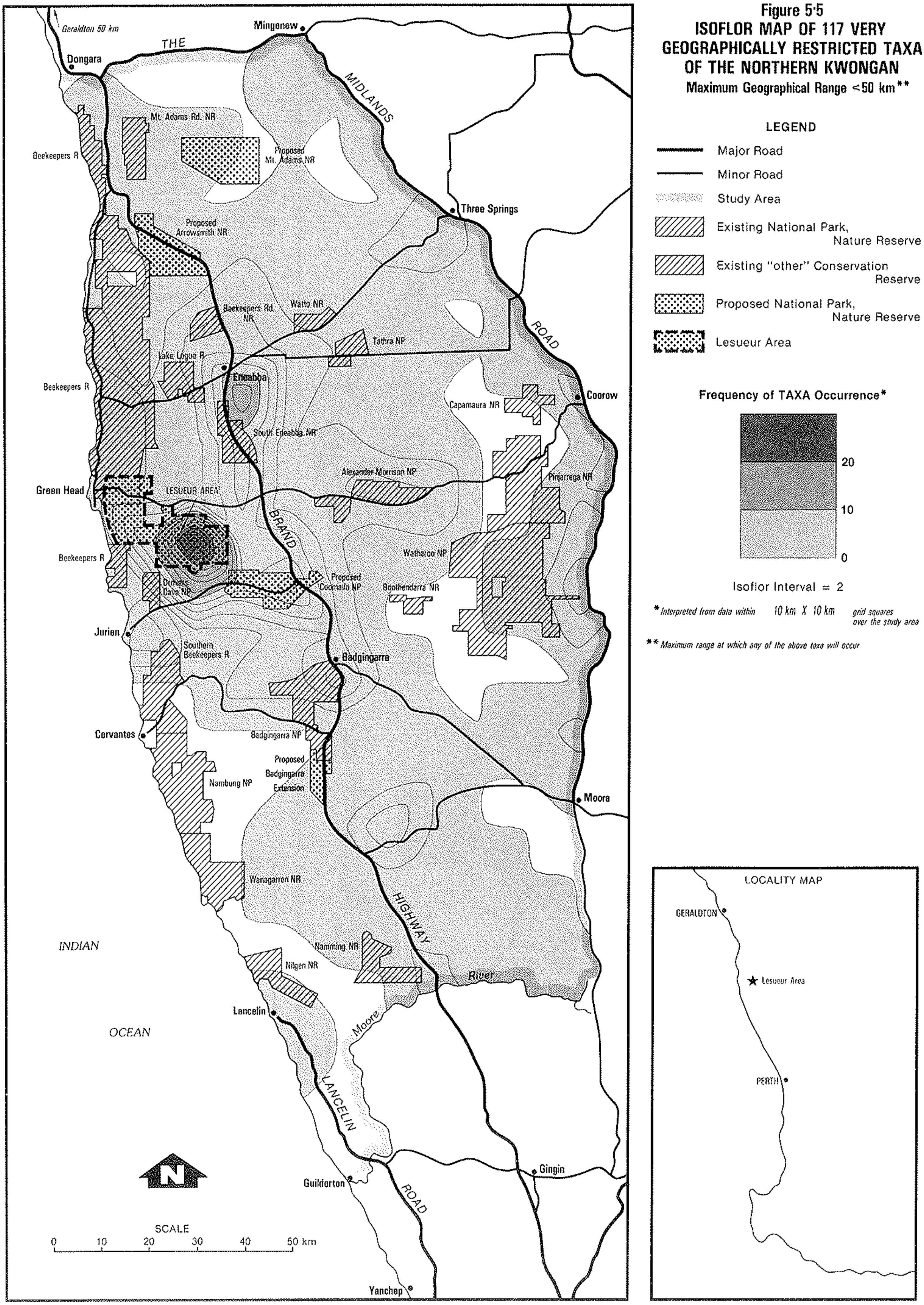
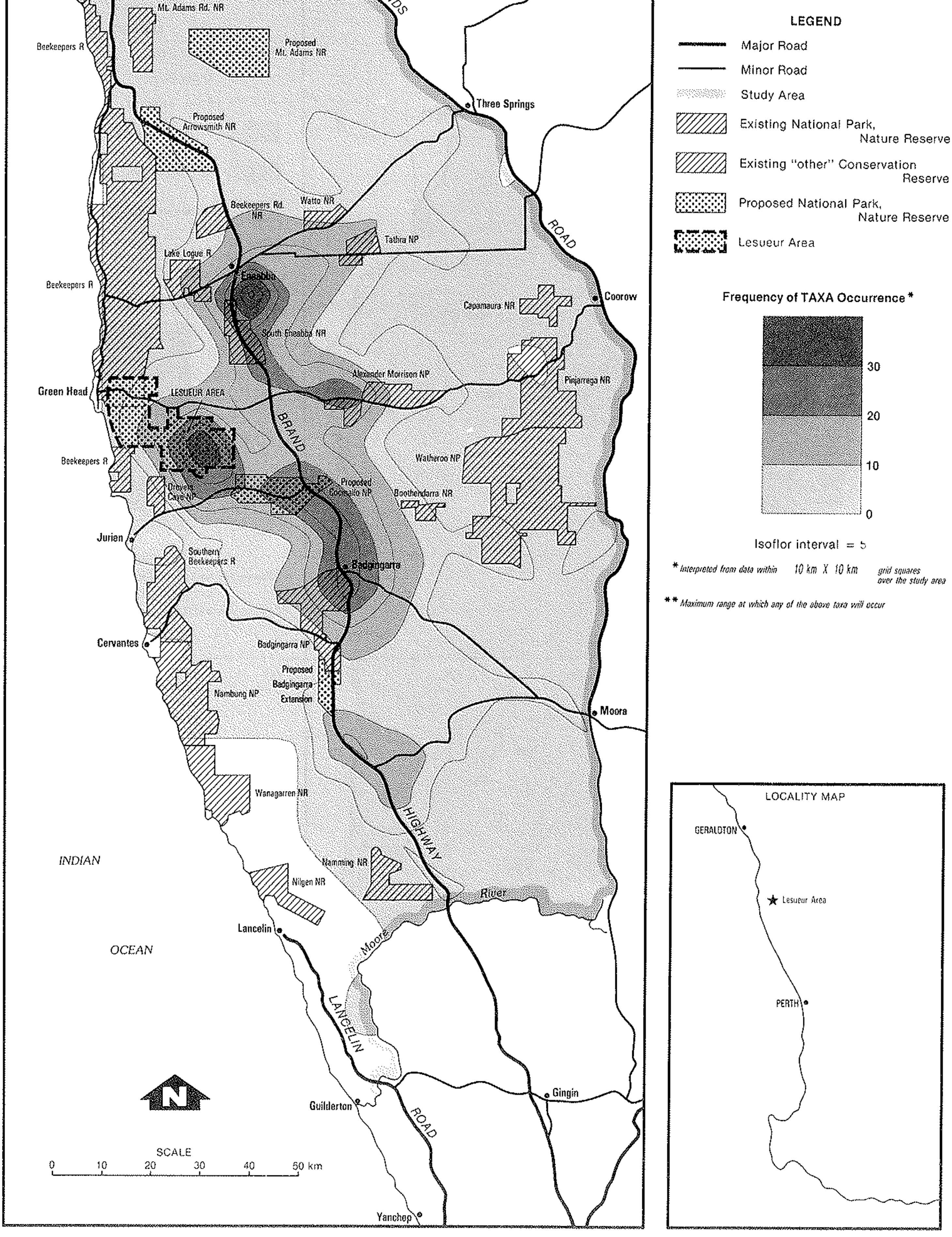


Figure 5·5
ISOFLOR MAP OF 117 VERY GEOGRAPHICALLY RESTRICTED TAXA OF THE NORTHERN KWONGAN
Maximum Geographical Range <50 km**

Figure 5·6
ISOFLOR MAP OF 114 GEOGRAPHICALLY RESTRICTED TAXA OF THE NORTHERN KWONGAN
Maximum Geographical Range 50–160 km**



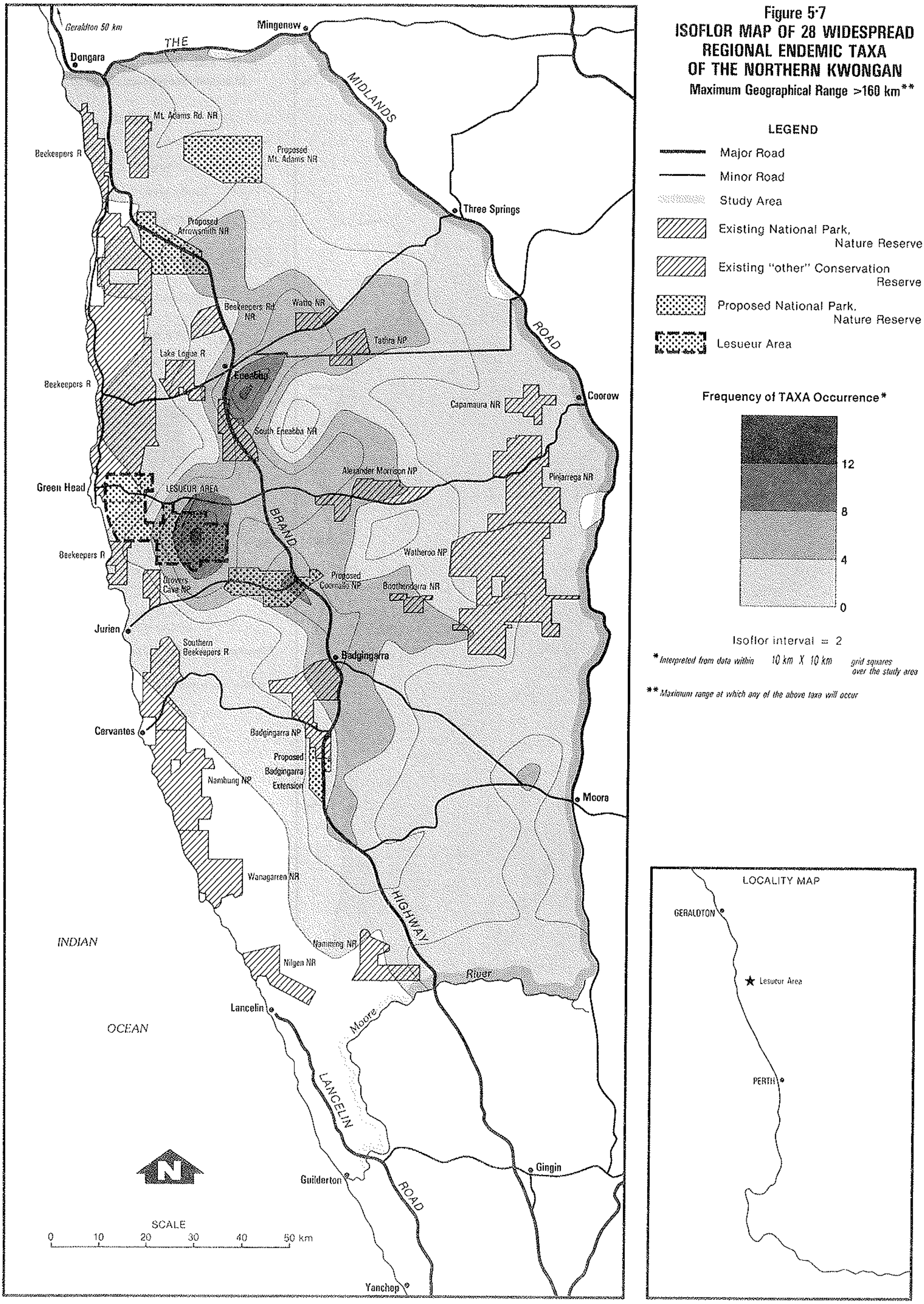


Figure 5·7
ISOFLOR MAP OF 28 WIDESPREAD REGIONAL ENDEMIC TAXA OF THE NORTHERN KWONGAN
Maximum Geographical Range >160 km**

Table 5.6

Statistics on the 111 regional endemics and Declared Rare Flora occurring in the Lesueur Area (A, per centage of known populations in the Lesueur Area ; B, per centage of known populations in the eastern uplands of the Lesueur Area; C, per centage of known populations occurring within conservation reserves; D, number of known populations mapped separately at 1: 1000 000 scale.) Data extracted from herbarium records. * indicates no data available,

Taxon	A	B	C	D
Andersonia longifolia	100	0	0	2
Eucalyptus aff. *haematoxylon* (E.A. Griffin 2481)	100	43	0	7
Gompholobium aff. *polymorphum* (E.A. Griffin 2306)	100	33	0	3
Grevillea thelemanniana ssp. *delta*	100	0	0	2
Hypocalymma aff. *ericifolium* (E.A. Griffin 1972)	100	50	0	2
Leucopogon plumuliflorus	100	16	0	6
Persoonia rudis	100	33	0	3
Phlebocarya pilosissima ssp. *teretifolia*	100	100	0	5
Restio sp. (Briggs 7473 & Johnson)	100	0	0	1
Banksia tricuspis	90	64	0	72
Asterolasia drummondii	88	50	0	8
Stylidium aeonioides	83	17	16	6
Acacia forrestiana	80	40	0	5
Hakea neurophylla	80	20	0	10
Darwinia helichrysoides	78	11	0	9
Thysanotus vernalis	75	25	0	4
Eucalyptus suberea	73	27	0	11
Hypocalymma xanthopetalum var. nov. (C.A. Gardner 9096)	67	0	0	3
Thysanotus anceps	67	0	0	3
Xanthosia tomentosa	67	13	0	15
Hakea auriculata var. *spathulata*	66	33	0	3
Patersonia argyrea	66	33	0	3
Thysanotus sp. (E.A. Griffin 2511)	66	33	0	3
Acacia retrorsa	63	13	12	8
Hakea erinacea var. *longiflora*	63	13	12	8
Eucalyptus lateritica	62	23	0	13
Hakea megalosperma	54	36	10	11
Acacia aff. *myrtifolia* (R.J. Cranfield 33)	50	17	0	6
Daviesia sp. (M.D. Crisp 5429)	50	0	0	8
Daviesia epiphyllum	50	25	0	4
Goodenia xanthotricha	50	0	0	2
Grevillea acrobotrya ssp. *uniforma*	50	17	0	6
Tetratheca remota	50	0	0	2
Trymalium aff. *wichurae* (E.A. Griffin 2234)	50	25	0	4
Grevillea olivacea	44	0	44	9
Acacia plicata	43	29	0	7
Restionaceae Genus aff. *Ecdeiocolea* (E.A. Griffin 2157)	43	14	28	7
Daviesia sp. (M.D. Crisp 6213)	40	20	20	5
Haemodorum loratum	40	20	0	5
Hakea conchifolia	40	20	20	5
Restio sp. (Briggs 6293)	40	20	20	5
Strangea cynanchocarpa	39	13	9	23
Comesperma acerosum	38	13	12	8

cont'd ...

Taxon	A	B	C	D
Hemigenia curvifolia	38	13	0	8
Thelymitra variegata var. *apiculata*	38	25	0	8
Acacia volubilis	36	9	0	11
Darwinia sanguinea	36	5	18	22
Acacia epacantha	33	8	0	12
Banksia micrantha	33	6	18	33
Guichenotia sp. (E.A. Griffin 858)	33	0	16	6
Tricoryne sp. (E.A. Griffin 1451)	33	0	0	3
Conospermum crassinervum	32	0	16	19
Oxylobium reticulatum var. *gracile*	32	16	16	6
Diplolaena ferruginea	31	6	6	16
Macropidia fuliginosa	31	6	6	16
Petrophile inconspicua	31	4	17	23
Thelymitra stellata	30	30	0	10
Astroloma sp. (E.A. Griffin 1022)	28	14	14	7
Eucalyptus wandoo ssp. (M.I.H. Brooker 9885 & C. Souness)	27	9	0	11
Gastrolobium bidens	27	7	0	30
Hakea flabellifolia	27	9	27	11
Lepidobolus sp. (E.A. Griffin 2093)	27	9	0	11
Dasypogon obliquifolius	25	12	25	8
Loxocarya sp. (B. Briggs 7481)	25	0	0	4
Phlebocarya filifolia	23	8	23	13
Darwinia neildiana	21	3	15	39
Petrophile chrysantha	21	4	17	24
Astroloma microdonta	20	0	20	20
Stylidium inversiflorum	20	0	20	10
Walteranthus erectus	20	0	40	5
Astroloma sp. (N. Marchant s.n.)	17	0	0	6
Hensmania stoniella	17	0	0	6
Olax scalariformis	17	0	17	6
Conospermum nervosum	16	3	22	32
Allocasuarina grevilleoides	15	7	15	13
Dryandra tridentata	15	0	15	13
Isopogon adenanthoides	15	4	0	26
Dryandra sclerophylla	14	3	22	35
Dryandra tortifolia	14	14	14	7
Lasiopetalum drummondii	14	0	38	21
Lasiopetalum lineare	14	0	42	7
Alexgeorgea subterranea	13	0	13	15
Allocasuarina ramosissima	12	6	0	17
Conostylis aculeata ssp. *breviflora*	12	3	15	33
Banksia grossa	11	5	11	57
Banksia elegans	10	0	10	10
Conostylis angustifolia	10	0	0	20
Dryandra aff. *patens* (E.A.Griffin 1507)	9	9	18	22
Conostylis crassinervia ssp. *absens*	8	2	18	48
Cryptandra humilis	8	0	38	13
Eriostemon pinoides	8	0	15	13
Haemodorum venosum	8	0	8	13
Hybanthus aff. *floribundus* (E.A. Griffin s.n.)	8	0	10	12

cont'd ...

Taxon	A	B	C	D
Isopogon tridens	8	0	33	12
Phlebocarya pilosissima ssp. *pilosissima*	8	0	15	13
Beaufortia aff. *bracteosa* (E.A. Griffin 1176)	7	3	29	27
Beaufortia bicolor	7	7	28	14
Stylidium aff. *repens* (A.S. George 2341)	7	0	9	30
Stylidium maitlandianum	7	7	20	15
Banksia chamaephyton	6	6	19	31
Caladenia crebra	6	0	56	16
Conostylis canteriata	5	0	5	42
Conostylis crassinerva ssp. *crassinerva*	5	0	23	22
Conostylis neocymosa	5	0	5	20
Grevillea rudis	5	0	26	19
Dryandra nana	4	0	7	28
Darwinia speciosa	3	0	23	30
Dryandra aff. falcata (sp 9) (E.A. Griffin 3489)	2	2	20	50
Dryandra shuttleworthiana	2	1	8	118
Dryandra carlinoides	1	1	10	89
Verticordia grandis	*	*	*	*

current conservation resrves. These taxa, their total number of known mappable populations (at 1:1 000 000 scale) and the percentage of these populations on current conservation reserves are:

Species	Total number mappable pop.	% on cons. res.
Acacia retrorsa	8	12
Banksia tricuspis	12	0
Darwinia helichrysoides	9	0
Daviesia sp. (M.D. Crisp 6213)	5	20
Daviesia epiphyllum	4	0
Daviesia sp. * (M.D. Crisp 5429)	8	0
Dryandra sclerophylla	35	22
Eucalyptus aff. *haematoxylon*	7	0
Eucalyptus lateritica	13	7
Eucalyptus suberea	11	0
Genus nova aff. *Ecdeiocolea* E.A. Griffin 2157	7	28
Gompholobium aff. *polymorphum* (E.A. Griffin 2304)	3	0
Grevillea acrobotrya ssp. *uniforma*	6	0
Grevillea thelemanniana ssp. *delta*	2	0
Hakea erinacea var. *longiflora*	8	12
Hakea neurophylla	10	0
Hypocalymma aff. *ericifolium*	2	0
Leucopogon plumuliflorus	6	0
Patersonia argyrea	3	0
Persoonia rudis	3	0
Phlebocarys pilosissima ssp. *teretifolia*	5	0
Stylidium aeonioides	6	16
Tetratheca remota	2	0
Thysanotus aff. *sparteus*	3	0
Thysanotus vernalis	4	0
Xanthosia tomentosa	15	0

Eight taxa have been found only in the eastern upland area. These taxa, their total number of known populations and the per cent on existing conservation reserves are:

Banksia chamaephyton - 31, 19%
Beaufortia bicolor - 14, 28%
Dryandra aff. *falcata* (E.A. Griffin 3459) - 50, 20%
Dryandra aff. *patens* (E.A. Griffin 1507)- 22, 18%
Dryandra carlinoides - 89, 10%
Dryandra tortifolia - 7, 14%
Phlebocarya pilosissima ssp. *pilosissima* - 13, 15%
Stylidium maitlandianum - 15, 20%

All are represented elsewhere on conservation reserves, although *Dryandra* aff. *patens* (E.A. Griffin 1507) only sparingly.

From mainly Herbarium information an attempt was made to identify in which of three broad physiographic units within Lesueur the regional endemics occurred (i.e coastal (Quindalup, Spearwood and Bassendean landforms), western uplands (Peron Slopes, Lesueur Dissected Uplands and Gairdner Dissected Uplands) and eastern uplands (Banovich Uplands and Bitter Pool Rises). Very few (4) of the species occurred in the coastal areas (Appendix 2). Most (65) occurred in both the western and the eastern uplands. A significant number (42) occurred in only one or other of the uplands (34 in the western uplands, 8 in the eastern uplands).

5.8 DECLARED RARE FLORA

There are 32 taxa of Declared Rare Flora (DRF) in the northern kwongan, seven (22%) of which are known to occur in the Lesueur Area (Figure 5.8; Table 5.7). The Lesueur - Eneabba area contains the greatest concentration of declared taxa in the region (Figure 5.4).

The number of known DRF in the Lesueur Area is likely to rise given that 54 additional taxa in the area are on CALM's Reserve List for urgent further survey to assess their need for declaration.

The seven Lesueur species of DRF vary from large conspicuous shrubs (*Banksia tricuspis, Eucalyptus lateritica, E. suberea*) through small shrubs (*Hakea megalosperma, Acacia forrestiana*) to a shrublet (*Asterolasia drummondii*) and a sun orchid (*Thelymitra stellata*). The latter two are only conspicuous during their brief flowering seasons.

The Lesueur Area contains 97% of the known individuals of *Banksia tricuspis*, 90% of *Hakea megalosperma*, 89% of *Acacia forrestiana*, 68% of *Eucalyptus suberea*, 62% of *Eucalyptus lateritica*, 53% of *Asterolasia drummondii* and 22% of *Thelymitra stellata* (Table 5.7). On average 43% of the total number of known individuals, and 67% of the individuals within the Lesueur Area occur in the eastern uplands (i.e. in the Gairdner Dissected Uplands, Banovich Uplands and the Bitter Pool Rises).

No populations of *Banksia tricuspis, Acacia forrestiana, Eucalyptus suberea, E. lateritica* and *Thelymitra stellata* are known on secure conservation reserves at present, and only small populations of *Asterolasia drummondii* and *Hakea megalosperma* occur on nature reserves elsewhere. The declaration of the Lesueur Area as a conservation reserve is therefore essential to afford protection to these species of DRF.

A study of isozyme variation in *Eucalyptus lateritica* and *E. suberea* (Moran and Hopper 1987) showed that both had an unusually high proportion of localised alleles for eucalypts. Also, *E. lateritica* had greater average variation within populations than *E. suberea*, and both rare species showed relatively little divergence between populations (i.e. 13% of the total genetic variation sampled for both species). Further study of these taxa is needed, as only two populations of *E. lateritica* and three of *E. suberea* were investigated. Indeed, with the exception of *Banksia tricuspis* (see Chapter 7), the genetics, population biology and recruitment of all of Lesueur's DRF have yet to be investigated in detail. This will be essential for future management of these threatened taxa.

5.9 POORLY KNOWN TAXA AND OTHER PLANTS ON CALM'S RESERVE LIST

There are 155 northern kwongan taxa currently on CALM's Reserve List, and 58 (37%) have been recorded in the Lesueur Area (Table 5.8). Of the 58, 20 are Priority 1 species in urgent need of further survey, and 16 of these are very geographically restricted with a known range of less than 50 km.

Sixteen of the 58 in the Lesueur Area are Priority 2, while 18 are Priority 3. One (*Platysace dissecta*) is presumed extinct, and six have been adequately surveyed and appear secure but require monitoring to ensure that they do not become threatened (i.e. *Eucalyptus exilis, Grevillea olivacea, Hakea neurophylla, Macropidia fuliginosa, Stylidium inversiflorum* and *Thelymitra variegata* var. *apiculata*).

On the basis of the narrowness of their geographic range, the number of known populations and reservation status, a priority order for urgent further survey has been developed for 48 of the 58 taxa on the reserve list that occur in the Lesueur Area (Table 5.9). Mapping of these plants is considered the top priority for future work aimed at documenting the flora conservation values of the Lesueur Area.

5.10 SPECIES AT THEIR NORTHERN OR SOUTHERN LIMIT

Populations at the limits of a species' range are often subjected to unusual selective pressures in marginal habitats. They may, as a consequence, diverge genetically from mainstream populations. For example, Moran and Hopper (1987, unpublished) found that the isolated populations of jarrah in the Lesueur Area were distinct in their isozyme frequencies from a northern forest stand. Brooker and Hopper (unpublished) found that seedlings from Lesueur were slower growing than forest seedlings. It is well known that jarrah at Lesueur is a stunted mallee unlike the forest tree from further south. Thus, jarrah populations at Lesueur are

Table 5.7

Number of Declared Rare Flora populations and individuals in the Lesueur Area.

	Total		In Lesueur Area	
	No. Pop	No. Plants	No. Pop	No. Plants
Acacia forrestiana				
number	5	920	4	820
% total populations	-	-	80.0	89.1
Asterolasia drummondii				
number	11	3213	9	1713
% total populations	-	-	81.5	53.3
Banksia tricuspis				
number	72	19031	65	18940
% total populations	-	-	90.3	97.2
Eucalyptus lateritica				
number	13	260	8	160
% total populations	-	-	61.5	61.5
Eucalyptus suberea				
number	11	220	8	150
% total populations	-	-	72.7	68.2
Hakea megalosperma				
number	11	1274	6	1150
% total populations	-	-	54.5	90.3
Thelymitra stellata				
number	11	51	4	11
% total populations	-	-	36.4	21.5
MEAN				
% TOTAL POPULATIONS	-	-	68.1	68.7
(± SE)			17.1	24.5

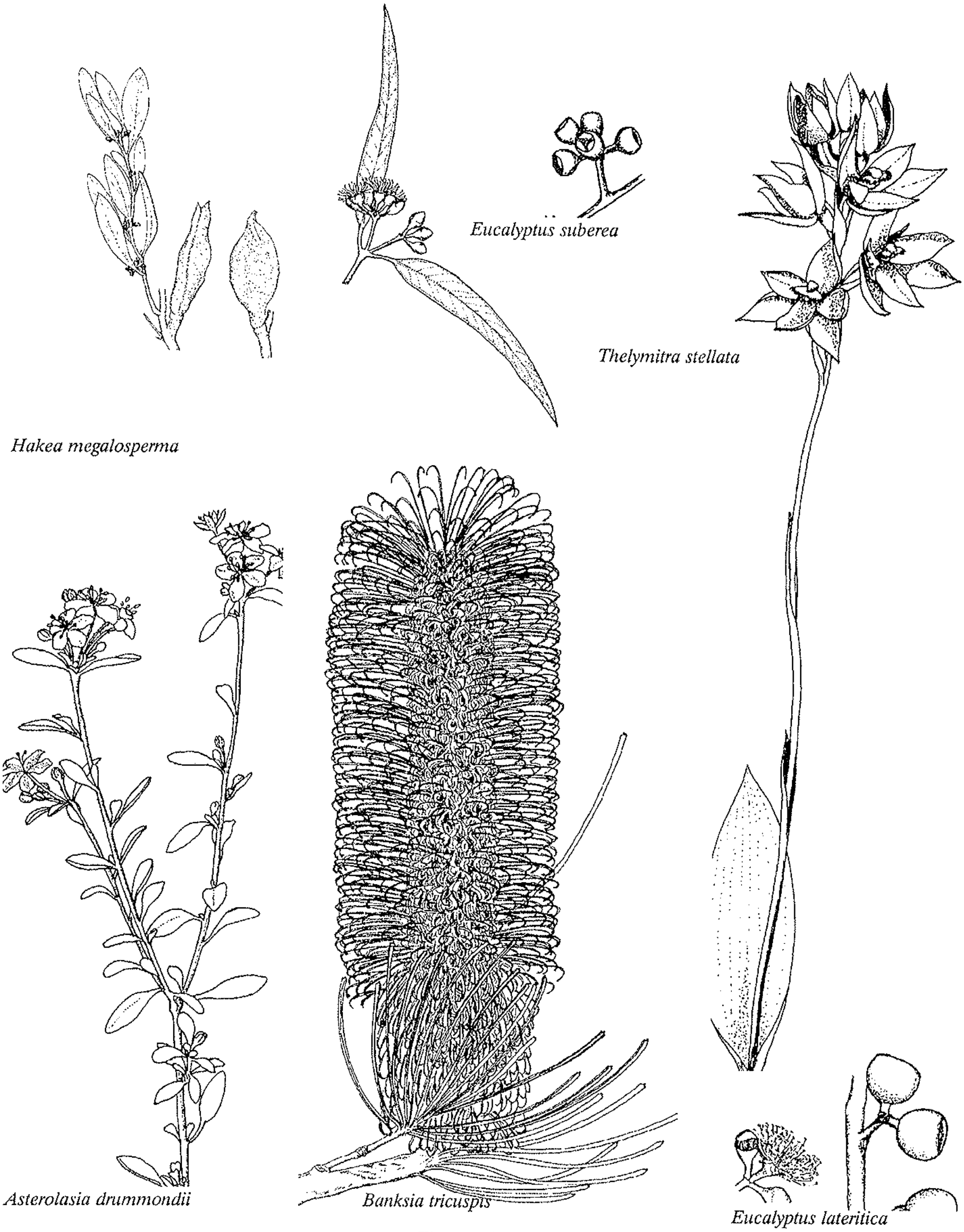


Figure 5.8.
Six of the seven species of Declared Rare Flora found in the Lesueur Area. *Acacia forrestiana* is not illustrated.
(Drawn by Susan Patrick)

Table 5.8
Regional endemic taxa in the proposed Lesueur National Park and the northern kwongan as a whole giving total numbers within different geographical range classes for taxa of Declared Rare Flora, taxa listed on CALM's Reserve Flora List (priorities 1-5) or for taxa not so listed.

Taxon Code	In Proposed National Park maximum geographical range			Total*	
	< 50km	50-160km	> 160km	LNP	IDB
Declared Rare Flora	3	3	1	7	32
CALM reserve list priorities					
1	16	2	2	20	63
2	7	9	0	16	50
3	3	11	4	18	32
4	0	0	0	0	1
5	4	1	1	6	9
Not on DRF or Reserve Lists	2	35	7	44	72

*LNP - proposed Lesueur National Park

- IBD Irwin Botanical District

genetically differentiated from forest stands in a number of attributes, and may be important in the future if breeding of this major timber tree is required to enhance disease resistance or other qualities.

In this context, Lesueur is of special conservation significance as an exceptionally high number of plants reach their northern or southern limit in the area. Griffin and Hopkins (1985a) reported 25 species at the northern limit of their distribution at Mt Lesueur. It is now known that the area contains a much larger number of these species (81, Appendix 1). This represents about 10% of the total known flora of the Lesueur Area.

Species at the northern limit of a continuous distribution are from a wide range of families: *Actinostrobus pyramidalis* (Cupressaceae), *Thysanotus glaucus* (Liliaceae *sens. lat.*), *Banksia grandis* (Proteaceae) and *Daviesia longifolia* (Papilionaceae), to mention a few. There are many species which have disjunct distributions with the nearest populations outside the Lesueur Area 50 km or more away (Table 5.10). Disjunct species also are from a wide range of families and genera and include *Thysanotus anceps, Isopogon asper, Acacia obovata, Chorizema ilicifolium, Boronia crassifolium, Eucalyptus marginata, E. exilis, Polypompholyx multifida, Goodenia fasciculata, Stylidium pycnostachyum*, and *Trichocline spathulata*.

Only two of the species at their northern limit are confined to the coastal plain (*Logania vaginalis* and *Leucopogon australis*). Most occur in the Arrowsmith Region of the Lesueur Area in both the western uplands (Peron Slopes, Lesueur Dissected Uplands and Gairdner Dissected Uplands) and eastern uplands (Banovich Uplands and Bitter Pool Rises). Slightly more of these species were found in the western than in the eastern uplands. Both had significant numbers of species present in only one or the other (28 only in the western and 10 only in the eastern uplands).

Although it was not possible to compile a breakdown of their distribution by vegetation types, species at their northern and southern limit clearly are represented in a variety of types including lateritic uplands (*Boronia crassifolia* and *Acacia drummondii*), sandy soils (*Dasypogon obliquifolius* and *Olearia*

Table 5.9

Priorities for urgent further survey of poorly known plants recorded within the Lesueur Area.

Taxon	No. of known populations	CALM Reserve list code
VERY GEOGRAPHICALLY RESTRICTED (<50 km)		
Restio sp. (Briggs 7473 & Johnson)	1	1
Andersonia longifolia	2	1
Goodenia xanthotricha	2	1
Grevillea thelemanniana ssp. *delta*	2	1
Hypocalymma aff. *ericifolium* (E.A. Griffin 1972)	2	1
Gompholobium aff. *polymorphum* (E.A. Griffin 2306)	3	1
Patersonia argyrea	3	1
Persoonia rudis	3	1
Tetratheca remota	3	1
Phlebocarya pilosissima ssp. *teretifolia*	5	1
Leucopogon plumuliflorus	6	1
Eucalyptus aff. *haematoxylon* (E.A. Griffin 2481)	7	1
Daviesia sp. (M.D. Crisp 5429)	8	1
Hakea erinacea var. *longiflora*	8	1
Darwinia helichrysoides	9	1
Xanthosia tomentosa	15	1
Hypocalymma xanthopetalum var. nov. (C.A. Gardner 9096)	3	2
Thysanotus sp. (E.A. Griffin 2511)	3	2
Thysanotus vernalis	4	2
Daviesia sp. (M.D. Crisp 6213)	5	2
Grevillea acrobotrya ssp. *uniforma*	6	2
Stylidium aeonioides	6	2
Acacia retrorsa	8	2
Daviesia epiphyllum	4	3
Walteranthus erectus	5	3
Restionaceae Genus aff. *Ecdeiocolea* (E.A. Griffin 2157)	7	3
GEOGRAPHICALLY RESTRICTED (50-160 km)		
Hakea auriculata var. *spathulata*	3	1
Hemigenia curvifolia	8	1
Tricoryne sp. (J.S. Beard 1901)	3	2
Loxocarya sp. (B. Briggs 7481)	4	2
Acacia aff. *myrtifolia* (R.J. Cranfield 33)	6	2
Astroloma sp. (N. Marchant s.n.)	6	2
Guichenotia sp. (E.A. Griffin 858)	6	2
Hensmannia stoniella	6	2
Oxylobium reticulatum var. *gracile*	6	2
Acacia plicata	7	2
Astroloma sp. (E.A. Griffin 1022)	7	2

cont'd ...

Taxon	No. of known populations	CALM reserve list code
Dryandra tortifolia	7	3
Lasiopetalum lineare	7	3
Comesperma acerosum	8	3
Acacia volubilis	11	3
Lepidobolus sp. (E.A. Griffin 2093)	11	3
Isopogon tridens	12	3
Allocasuarina grevilleoides	13	3
Phlebocarya filifolia	13	3
Phlebocarya pilosissima ssp. *pilosissima*	13	3
Beaufortia bicolor	14	3
Stylidium maitlandianum	15	3

paucidentata), wandoo woodlands (*Trymalium floribundum* and *Chorizema ilicifolium*), clayey soils (*Drosera microphylla* and *Utricularia menziesii*), and drainage lines (*Banksia littoralis* and *Hakea varia*). An interesting feature is that they represent a range of lifeforms from annuals, geophytes, shrubs and trees.

Only five species are at their southern limit and none of these is considered to be disjunct. Most of these occur in the coastal units.

Because of the presence at Lesueur of many species at their northern limit, especially disjunct species such as jarrah, Hopkins *et al.* (1983) highlighted the value of the Lesueur Area as a refugium. Jarrah, for example, occurs in relatively favourable sites (south facing slopes) and does not survive in more exposed areas. Churchill (1968) proposed that jarrah had a much wider distribution in the past when the climate was wetter. For such species the Lesueur Area has important evolutionary significance. An understanding of the habitat requirements of such species will better equip managers to plan for, and perhaps even counter, any adverse impacts on the conservation of plant species in southwestern Australia that might result from climatic changes associated with predicted global warming.

5.11 RELICTUAL SPECIES

Griffin and Hopkins (1985) noted a number of species at Mt Lesueur which appear to have no close relatives and may be relicts from past periods when the Lesueur Area had a more mesic climate. These included local endemics (*Darwinia sanguinea, Hakea megalosperma, Hakea neurophylla*), species with disjunct distributions (*Hakea marginata, Isopogon sphaerocephalus*) and others (*Isopogon linearis*). Very little of this type of assessment has been done and undoubtedly many more species could be similarly classified.

As a carefully studied example, Brooker and Hopper (1986) recently described Cork Mallee (*Eucalyptus suberea*) and noted it had no close relatives. Subsequently, Ladiges *et al.* (1987) established that in a cladistic analysis, *E. suberea* was indeed an isolated taxon that presumably arose early in the evolution of the Western Australian monocalypt eucalypts (well before jarrah and its allies and before common distinctive mallees such as *E. preissiana, E. sepulcralis, E. pendens, E. johnsoniana, E. todtiana, E. lateritica, E. buprestium* and *E. insularis*). The taxonomic distinctiveness of *E. suberea* was formally recognized when Chippendale (1988) named the new monotypic series *Eucalyptus* ser. *Subereae*.

Ladiges *et al.* (1987) argued for a Tertiary origin for species such as *E. suberea*. If correct, the species may well have been around when much of south-western Australia was covered by subtropical rainforest (Hopper 1979). It has persisted at Lesueur presumably because a somewhat mesic refugium was provided in the breakaway upland systems as the region became progressively drier during the late Tertiary and Quaternary. During this long persistence, populations of *E. suberea* appear to have declined in genetic variation relative to that seen in much younger species such as *E. lateritica* (Moran and Hopper 1987).

Studies of this kind will no doubt reveal many more aspects to the evolutionary history of the flora of the Lesueur Area, and reinforce its value as a future refugium for species from more mesic climates and times.

5.12 CHROMOSOME STUDIES

The Lesueur Area features prominently in the most comprehensive survey of chromosome variation completed on a northern kwongan plant, that of Coates and James (1979) and Coates (1980) on *Stylidium crossocephalum*. Cockleshell Gully constituted a barrier to different localised chromosome races (D and E) to the north and south along the Peron Slopes and Coastal Plain (Figure 5.9). The dissected uplands of Lesueur constituted another barrier, isolating race C to the east from Cockleshell races D and E. Moreover, the distribution of micro B chromosomes also responded to these barriers (Coates 1980).

A complex evolution of chromosome races is thus evident within the confines of the Lesueur Area in this species. This striking example highlights another aspect of the richness of the flora, at the genetic level within morphologically defined species. Clearly, it would be unwise to assume that different populations of the same morpho-species in the Lesueur Area have the same genetic, evolutionary and ecological attributes. Careful studies like that on *Stylidium crossocephalum* are needed to resolve genetic variation within species. This is an essential prerequisite in certain groups if genetic management, relocation, and revegetation are required for endangered populations (Hopper and Coates 1989).

Table 5.10
Statistics on the distribution within the Lesueur Area of taxa at their Northern and Southern Limits.

Distribution	Northern Limit		Southern Limit	Total
Code	Continuous	Disjunct	Continuous	
1	2	0	4	6
2	14	13	1	28
3	6	4	0	10
2 and 3	21	16	0	35
Total	43	33	5	81

Distribution codes:

1 Coastal

2 Central Uplands Peron Slopes
Lesueur Dissected Uplands
Gairdner Dissected Uplands

3 Eastern Uplands Banovich Uplands
Bitter Pool Rises

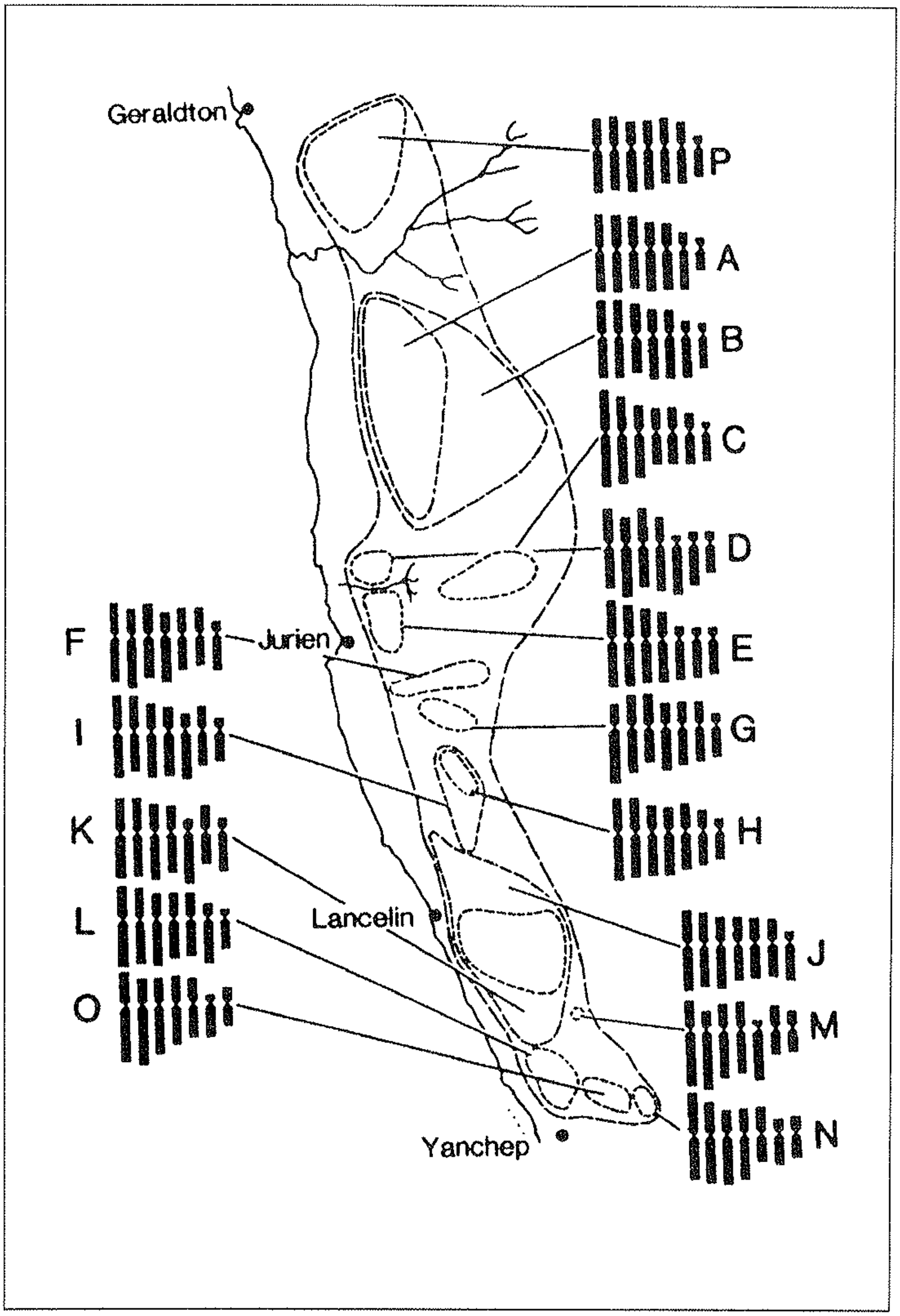


Figure 5.9
Chromosome races in *Stylidium crossocephalum* (from Coates and James 1979).

Chapter 6

FAUNA

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Abstract

Although not studied in detail, the fauna of the Lesueur Area is known to be rich in species of vertebrates, with 15 indigenous mammal species, 124 bird species, 48 reptile species and 9 frog species. In comparison with other existing conservation reserves in south western Australia, it is richer in species than all except a few, much larger areas.

Among birds, Lesueur is rich in species of the kwongan and species that depend on nest hollows in the wandoo woodlands, e.g. Carnaby's Black Cockatoo and the Regent Parrot. The reptile fauna is particularly rich in geckoes and legless lizards.

Terrestrial and aquatic invertebrates have not been studied in detail. However, the little that is known suggests that it is rich in species, e.g. 104 species of macro-invertebrates were sampled in a brief survey of aquatic sites. Lesueur includes some species of invertebrates not known from elsewhere.

6.1 INTRODUCTION

The fauna of the Lesueur Area has not been studied in detail. The only published biological surveys are of a vertebrate survey of the western parts of the Area by the Western Australian Museum in 1973 and 1974 (Chapman *et al.* 1977) and an ecological study of the heathlands of the Leeman area (actually within the north western part of the Lesueur Area) by the W.A. College of Advanced Education, Claremont Campus, in September of 1981 and 1982 (Foulds and McMillan no date). Neither of these surveys included an examination of the Bitter Pool Rises and Banovich Uplands landscape units to the east of Mount Lesueur. Some additional data are available from unpublished studies by consultants commissioned by the mining Companies exploring the coal deposits in and adjacent to the Lesueur Area and from other studies on specific species.

6.2 VERTEBRATES

6.21 Mammals

Taxonomy follows Strahan (1983) and more recent taxonomic research. Data are from Chapman and Kitchener (1977), the Western Australian Museum mammal register, Foulds and McMillan (n.d.), observations by E.A. Griffin (personal communication), observations and trapping by S. van Leeuwen (personal communication), Lynam (1987) and an unpublished draft report (incomplete, dated April 1989) by Martinick and Associates, being prepared for Canning Resources Pty Ltd (Martinick and Associates 1989b). Bats were sampled only by the Museum survey.

Table 6.1 lists the mammals recorded from the Lesueur Area, and their recorded distribution by landform (see Chapter 3).

The taxonomy of the *Sminthopsis murina* species complex is not clear and the records of both *Sminthopsis griseoventer* and *S. dolichura* at Lesueur require further investigation. However, it is quite possible that both occur there.

Fifteen species of indigenous mammals have been recorded. None of the species recorded has been declared "rare or likely to become extinct" or "in need of special protection" under the Wildlife Conservation Act, and none has restricted distributions.

The Lesueur Area contains almost all the extant indigenous mammals that could be expected in this region and has an important part to play in their conservation. The bat fauna is under-sampled. Based on known distributions, species that may be present in the Lesueur Area include *Tadarida australis*, *Mormopterus planiceps* and *Nyctophilus major*.

Eleven species of native mammals (excluding bats) have been recorded in the Lesueur Area. Comparative figures for other existing and proposed conservation reserves are given in Table 12.2. Lesueur has more species recorded than most reserves in the south west. Only Dryandra and Dragon Rocks, with rich

Table 6.1
Mammals of the proposed Lesueur National Park, showing distribution according to landform.

INDIGENOUS SPECIES

Echidna, *Tachyglossus aculeatus*, common in uplands.

Grey-bellied Dunnart, *Sminthopsis griseoventer*, Peron Slopes, Gairdner Dissected Uplands, Bitter Pool Rises, Banovich Uplands.

White-bellied Dunnart, *Sminthopsis dolichura,* trapped by Lynam (1987) 1 to 2 km north west of Mount Peron in heath on grey-white sand (Peron Slopes).

Fat-tailed Dunnart, *Sminthopsis crassicaudata*, in samphire in Salt Lake Complex, Bassendean Dunes, Banovich Uplands.

White-tailed Dunnart, *Sminthopsis granulipes*, trapped by W.A.Museum in Bassendean and Spearwood Dunes, trapped by Lynam (1987) 1 to 2 km north west of Mount Peron in heath on grey-white sand (Peron Slopes).

Honey Possum, *Tarsipes rostratus*, very common, Spearwood Dunes, Peron Slopes, Lesueur Dissected Uplands, Gairdner Dissected Uplands, Bitter Pool Rises, Banovich Uplands.

Brush Wallaby, *Macropus irma*, uncommon throughout.

Western Grey Kangaroo, *Macropus fuliginosus*, common throughout.

Euro, *Macropus robustus*, uncommon throughout.

Gould's Wattled Bat, *Chalinolobus gouldii,* recorded in Spearwood Dunes, probably widespread.

Chocolate Bat, *Chalinolobus morio*, in uplands, roosts in caves.

King River Eptesicus, *Eptesicus regulus,* recorded in marri woodland along Cockleshell Gully.

Lesser Long-eared Bat, *Nyctophilus geoffroyi,* recorded in Quindalup Dunes, probably more widespread.

Ash-grey Mouse, *Pseudomys albocinereus*, sandy soils, Lesueur Dissected Uplands, Peron Slopes, Gairdner Dissected Uplands, Banovich Uplands, Bitter Pool Rises.

Southern Bush Rat, *Rattus fuscipes*, common throughout.

INTRODUCED SPECIES

European Rabbit, *Oryctolagus cuniculus,* common near edges of proposed reserve, few in bushland areas.

Dog, *Canis familiaris*, dingoes recorded occasionally, wild dogs also observed.

Red Fox, *Vulpes vulpes,* common throughout.

Feral Cat, *Felis catus*, common throughout.

Feral Pig, *Sus scrofa*, scarce.

Horse, *Equus caballus*, formerly common, now scarce.

Cattle, *Bos taurus*, formerly uncommon, now absent.

House Mouse, *Mus musculus,* common throughout.

woodlands, and the large, diverse Fitzgerald River National Park have more species.

Of particular interest is the occurrence of three (possibly four) species of *Sminthopsis* (Dunnarts) at Lesueur. *Sminthopsis granulipes* has a restricted range in the south west of Western Australia, and in the northern kwongan is restricted to an area bounded by Moora, Three Springs, Eneabba, Lesueur and Badgingarra. Honey Possums, which are endemic to the south west of Western Australia, are abundant within the Lesueur Area; more so than in any existing nature conservation reserves, except those on the south coast.

One important feature of the Lesueur Area is the occurrence of recent fossil mammal deposits in nearby caves. Chapman and Kitchener (1977) list 18 of the species recorded in the cave deposits as probably present in the district prior to European settlement and a further six species recorded during their survey that are not represented in the caves, but which were probably present (the cave fauna is thought to have been accumulated by owls). Only six of the 18 were recorded during the 1973-4 survey and one additional species, the dingo, since. Some of the locally extinct species, such as Woylie *Bettongia penicillata*, Chuditch *Dasyurus geoffroii*, Mardo *Antechinus flavipes*, Dibbler *Parantechinus apicalis*, Quenda *Isoodon obesulus*, Western Mouse *Pseudomys occidentalis* and Heath Rat *P. shortridgei*, still occur in other parts of the south west and could be reintroduced if foxes and cats could be controlled, suitable fire regimes maintained and the area kept free of *Phytophthora*.

Eight introduced mammal species have been recorded. In common with most of Western Australia, house mice, cats and foxes are abundant. Horses were once common, much of the area having been reserved for "Horse Breeding" early in the century to provide mounts for the army. Today, few remain. Fortunately they seem to have had little long-term deleterious effects on the vegetation. The other introduced species are not common.

6.22 Birds

Taxonomy and vernacular names follow Blakers *et al.* (1984). Data are from Dell and Johnstone (1977), Foulds and McMillan (n.d.), observations by E.A. Griffin (personal communication), observations by S. van Leeuwen (personal communication), Department of Conservation and Land Management files, and an unpublished draft report (incomplete, dated April 1989) by Martinick and Associates (1989b) being prepared for Canning Resources Pty Ltd.

Bird species that have been recorded in the Lesueur Area are listed in Table 6.2 Estimates of status follow Dell and Johnstone (1977) and are listed as scarce, uncommon, moderately common or common. Presence in the different landforms (see Chapter 3) is given where known.

Records of the Brush Bronzewing *Phaps elegans* and the Letter-winged Kite *Elanus scriptus* by Foulds and McMillan require confirmation and are not included above. Brush Bronzewings were recorded by Burbidge and Boscacci (1989) at the Southern Beekeepers Reserve.

The Lesueur Area has a very rich bird fauna with 122 indigenous and two introduced species having been recorded. This is partly due to the wide range of habitats present, which vary from saltlakes and freshwater springs through kwongan and mallee to woodlands and hills. However, it is also due to the relatively large area of bushland and its relatively undisturbed condition.

With 124 species, Lesueur compares favourably with other existing and proposed conservation reserves in the south west (Table 12.2). Only the large and diverse Fitzgerald River and Kalbarri National Parks have more species recorded and they include coastline as well as wetlands. Dell and Johnstone (1977) recorded an additional 30 species of coastal birds during their survey of the Lesueur Area.

The Lesueur Area is particularly rich in bird species of the kwongan. These include honeyeaters, thornbills, fairy-wrens, Southern Emu-wren, White-browed Scrub-wren, and Calamanthus. It is probably the only place where four species of Fairy-wrens (*Malurus*) occur together in the same kwongan formations.

Carnaby's Black Cockatoo is the largest cockatoo found in the region. It has declined considerably in both abundance and range since European settlement because of clearing of its habitat (Saunders 1986), and is on the Department of Conservation and Land Management's Reserve List under its Policy on Endangered Fauna. Species on the reserve list are reviewed at least every three years for possible declaration as "Endangered Fauna" under The Wildlife Conservation Act. Carnaby's Cockatoo is still declining in range and abundance, and will doubtless be declared "endangered" if habitat loss continues. The species depends on both the heathlands and the woodlands, the former for food and the latter for nest sites and shelter. It also requires access to free water. Nesting occurs only in nest hollows of particular dimensions and at Lesueur these are generally confined to *Eucalyptus wandoo* woodlands (Saunders 1979, 1980, 1982; Saunders and Ingram 1987). In the Lesueur - Eneabba area, there are only a few pockets of woodland that satisfy the requirements for successful breeding, and the woodland to the east of Lesueur is one of the four most important. Cockatoos can remain in an area for many years after they cease breeding, because they are long-lived; thus the effects of habitat alteration can be delayed.

Carnaby's Black Cockatoo demonstrates both the importance of the Lesueur Area itself and its importance as one part of a regional system of conservation reserves in conserving a declining species (Hopkins and Saunders 1987). It also demonstrates the interdependence of species in ecosystems (see Chapter 7).

Other hollow-nesting species that depend on the wandoo woodlands are the Long-billed Corella (Saunders 1977, 1979), Galah, Regent Parrot (now an uncommon species), Western Rosella, Port Lincoln Ringneck, Barn Owl, Boobook Owl and Australian Owlet-nightjar.

Lesueur species at or near their northern range limit on the mainland include Western Rosella, Restless Flycatcher, Southern Emu-wren, Shy Hylacola, Little Wattlebird, Spotted Pardalote and Dusky Woodswallow. The Western Thornbill, Scarlet Robin and Western Spinebill have been recorded sparingly

Table 6.2
Birds of the proposed Lesueur National Park, their abundance and distribution according to landform.

Emu, *Dromaius novaehollandiae*, scarce throughout.

Pacific Heron, *Ardea pacifica*, scarce, Salt Lake Complex.

White-faced Heron, *Ardea novaehollandiae*, uncommon, Salt Lake Complex and freshwater areas.

Great Egret, *Egretta alba,* scarce, Salt Lake Complex.

Black Swan, *Cygnus atratus,* moderately common, Salt Lake Complex.

Australian Shelduck, *Tadorna tadornoides,* common, Salt Lakes Complex and freshwater areas.

Pacific Black Duck, *Anas superciliosa*, moderately common, saltlakes and freshwater.

Grey Teal, *Anas gibberifrons*, common on saltlakes, uncommon on freshwater.

Maned Duck, *Chenonetta jubata*, scarce, Salt Lake Complex, Eatha Spring.

Osprey, *Pandion haliaetus*, scarce, Salt Lake Complex.

Black-shouldered Kite, *Elanus notatus,* scarce throughout.

Whistling Kite, *Haliastur sphenurus,* uncommon throughout.

Brown Goshawk, *Accipiter fasciatus,* scarce throughout, nesting recorded in marri Eucalyptus calophylla 2 km south east of Mt Peron.

Collared Sparrowhawk, *Accipiter cirrhocephalus*, scarce throughout.

Wedge-tailed Eagle, *Aquila audax,* moderately common, mainly in dissected uplands.

Little Eagle, *Hieraaetus morphnoides*, scarce throughout.

Spotted Harrier, *Circus assimilis,* uncommon, mainly in kwongan.

Marsh Harrier, *Circus aeruginosus,* uncommon, Salt Lake Complex.

Peregrine Falcon, *Falco peregrinus,* scarce, Salt Lake Complex.

Australian Hobby, *Falco longipennis,* scarce, Salt Lake Complex, woodlands.

Brown Falcon, *Falco berigora,* moderately common throughout.

Australian Kestrel, *Falco cenchroides,* moderately common throughout.

Mallee Fowl, *Leipoa ocellata,* kwongan, probably locally extinct.

Stubble Quail, *Coturnix novaezealandiae,* scarce, Salt Lake Complex.

Little Button-quail, *Turnix velox,* moderately common, open areas.

Australian Crake, *Porzana fluminea,* scarce, Salt Lake Complex, Eatha Spring.

Black-tailed Native-hen, *Gallinula ventralis,* scarce, Salt Lake Complex.

Eurasian Coot, *Fulica atra*, scarce, Salt Lake Complex.

Australian Bustard, *Ardeotis australis,* varies from scarce to common from year to year.

Pied Oystercatcher, *Haematopus longirostris,* scarce, Salt Lake Complex.

Banded Lapwing, *Vanellus tricolor,* uncommon, Salt Lake Complex, open areas, also on adjacent farms.

Hooded Plover, *Charadrius rubricollis,* scarce, on saltlakes.

Red-capped Plover, *Charadrius ruficapillus,* common, on saltlakes.

Black-fronted Plover, *Charadrius melanops,* scarce, saltlakes and temporary freshwater lakes.

Black-winged Stilt, *Himantopus himantopus,* uncommon, saltlakes and freshwater lakes.

Banded Stilt, *Cladorhynchus leucocephalus,* uncommon, saltlakes and freshwater lakes.

Greenshank, *Tringa nebularia*, uncommon, on saltlakes.

Sharp-tailed Sandpiper, *Calidris acuminata*, uncommon, freshwater areas.

Red-necked Stint, *Calidris ruficollis*, moderately common on saltlakes and freshwater lakes.

Silver Gull, *Larus novaehollandiae,* uncommon, on saltlakes.

Whiskered Tern, *Chlidonias hybrida,* occasional visitor to Salt Lake Complex.

Feral Pigeon, *Columbia livia*, scarce, in woodlands.

Cont'd...

Birds of the proposed Lesueur National Park, their abundance and distribution according to landform.

Common Bronzewing, *Phaps chalcoptera*, scarce, Cockleshell Gully and Salt Lake Complex.

Crested Pigeon, *Ocyphaps lophotes*, scarce throughout.

Red-tailed Black-Cockatoo, *Calyptorhynchus magnificus*, scarce, woodlands.

Carnaby's Cockatoo, *Calyptorhynchus funereus latirostris*, common, breeds in woodlands.

Galah, *Cacatua roseicapilla,* moderately common, breeds in woodlands.

Long-billed Corella, *Cacatua pastinator butleri,* common, breeds in woodlands.

Little Corella, *Cacatua sanguinea,* moderately common, woodlands.

Regent Parrot, *Polytelis anthopeplus,* uncommon throughout, breeds in woodlands.

Western Rosella, *Platycercus icterotis,* scarce, woodlands.

Port Lincoln Ringneck, *Barnardius zonarius,* moderately common throughout, breeds in woodlands.

Pallid Cuckoo, *Cuculus pallidus,* common throughout.

Horsfield's Bronze-Cuckoo, *Chrysococcyx basalis,* uncommon, kwongan and woodlands.

Shining Bronze-Cuckoo, *Chrysococcyx lucidus,* uncommon in the woodlands of the dissected uplands.

Southern Boobook, *Ninox novaeseelandiae,* uncommon, breeds in woodlands, feeds widely.

Barn Owl, *Tyto alba,* scarce, breeds in woodlands, feeds widely.

Tawny Frogmouth, *Podargus strigoides,* common throughout.

Australian Owlet-nightjar, *Aegotheles cristatus*, scarce, breeds in woodlands, feeds widely.

Spotted Nightjar, *Caprimulgus guttatus,* scarce throughout.

Fork-tailed Swift, *Apus pacificus,* occasional visitor.

Laughing Kookaburra, *Dacelo novaeguineae,* uncommon in woodlands.

Sacred Kingfisher, *Halcyon sancta,* uncommon throughout.

Rainbow Bee-eater, *Merops ornatus,* uncommon, kwongan and woodlands.

White-backed Swallow, *Cheramoeca leucosternum,* moderately common, kwongan.

Welcome Swallow, *Hirundo neoxena,* common throughout.

Tree Martin, *Cecropis nigricans,* moderately common, breeds in woodlands.

Richard's Pipit, *Anthus novaeseelandiae,* moderately common, Salt Lake Complex, open areas, also on adjacent farms.

Black-faced Cuckoo-shrike, *Coracina novaehollandiae,* common in kwongan and woodlands.

White-winged Triller, *Lalage sueurii,* common throughout.

Scarlet Robin, *Petroica multicolor,* uncommon, kwongan and woodlands.

Red-capped Robin, *Petroica goodenovii,* moderately common, Salt Lake Complex, kwongan, scrub and woodlands.

Hooded Robin, *Melanodryas cucullata,* uncommon, Salt Lake Complex.

White-breasted Robin, *Eopsaltria georgiana*, moderately common, thickets in kwongan, Salt Lake Complex.

Jacky Winter, *Microeca leucophaea,* common, kwongan.

Golden Whistler, *Pachycephala pectoralis,* uncommon, kwongan and woodlands.

Rufous Whistler, *Pachycephala rufiventris,* common throughout

Grey Shrike-thrush, *Colluricincla harmonica,* uncommon throughout.

Crested Bellbird, *Oreoica gutturalis,* common in kwongan, also in woodlands.

Restless Flycatcher, *Myiagra inquieta,* scarce, location not recorded.

Grey Fantail, *Rhipidura fuliginosa,* common, widespread.

Willie Wagtail, *Rhipidura leucophrys,* common throughout.

White-browed Babbler, *Pomatostomus superciliosus,* scarce throughout.

Cont'd...

Birds of the proposed Lesueur National Park, their abundance and distribution according to landform.

Little Grassbird, *Megalurus gramineus,* uncommon, edge of saltlakes and freshwater areas.

Brown Songlark, *Cinclorhamphus cruralis,* moderately common, open areas.

Splendid Fairy-wren, *Malurus splendens,* common in kwongan.

Variegated Fairy-wren, *Malurus lamberti,* common in dense vegetation along creeks.

Blue-breasted Fairy-wren, *Malurus pulcherrimus,* scarce in kwongan.

White-winged Fairy-wren, *Malurus leucopterus,* common, kwongan and Salt Lake Complex.

Southern Emu-wren, *Stipiturus malachurus,* common in kwongan.

White-browed Scrubwren, *Sericornis frontalis,* common, kwongan and scrub.

Shy Hylacola, *Sericornis cautus,* scarce, recorded just outside proposed national park, in mixed sand heath.

Calamanthus, *Sericornis fuliginosus,* common in kwongan.

Weebill, *Smicrornis brevirostris,* common, woodlands.

Western Gerygone, *Gerygone fusca,* uncommon, in woodlands.

Inland Thornbill, *Acanthiza apicalis,* common, woodlands and kwongan.

Western Thornbill, *Acanthiza inornata,* uncommon, kwongan.

Yellow-rumped Thornbill, *Acanthiza chrysorrhoa,* common, Salt Lake Complex, wandoo woodlands.

Varied Sittella, *Daphoenositta chrysoptera,* uncommon.

Red Wattlebird, *Anthochaera carunculata,* uncommon throughout.

Little Wattlebird, *Anthochaera chrysoptera,* common throughout.

Spiny-cheeked Honeyeater, *Acanthagenys rufogularis,* scarce, kwongan.

Yellow-throated Miner, *Manorina flavigula,* scarce, kwongan and woodlands.

Singing Honeyeater, *Lichenostomus virescens,* common throughout.

Brown-headed Honeyeater, *Melithreptus brevirostis,* scarce, woodlands.

Brown Honeyeater, *Lichmera indistincta,* common throughout.

White-cheeked Honeyeater, *Phylidonyris niger,* common throughout.

Tawny-crowned Honeyeater, *Phylidonyris melanops,* common in kwongan.

Western Spinebill, *Acanthorhynchus superciliosus,* moderately common, thickets in kwongan.

Pied Honeyeater, *Certhionyx variegatus,* single record.

White-fronted Chat, *Ephthianura albifrons,* uncommon, Salt Lake Complex.

Mistletoe-bird, *Dicaeum hirundinaceum,* uncommon, mainly in woodlands.

Spotted Pardalote, *Pardalotus punctatus,* scarce.

Striated Pardalote, *Pardalotus striatus,* uncommon, mainly in woodlands.

Silvereye, *Zosterops lateralis,* common throughout.

Australian Magpie-lark, *Grallina cyanoleuca,* scarce, Salt Lake Complex.

Black-faced Woodswallow, *Artamus cinereus,* moderately common throughout.

Dusky Woodswallow, *Artamus cyanopterus,* scarce throughout.

Grey Butcher-bird, *Cracticus torquatus,* common throughout.

Pied Butcher-bird, *Cracticus nigrogularis,* scarce, woodlands.

Australian Magpie, *Gymnorhina tibicen,* uncommon, Salt Lake Complex.

Grey Currawong, *Strepera versicolor,* scarce, woodlands.

Australian Raven, *Corvus coronoides,* moderately common throughout.

Little Crow, *Corvus bennetti,* scarce, passage migrant.

further north, but the Lesueur Area is probably their northern limit under most circumstances. This comparatively large list reflects the biological importance of the Lesueur Area, its value as a refuge and its value in studies of factors that limit distribution. Species at their southern limit include Variegated Fairy-wren and Pied Honeyeater.

White-breasted Robins are typical of thickets along watercourses in karri and jarrah forest. However, there is an isolated population in the northern kwongan centred on the Lesueur Area. Here it inhabits thickets in the kwongan, particularly near the coast.

The saltlakes are important summer refuges for several species of waterbirds, including Australian Shelduck (or Mountain Duck), Grey Teal and Banded Stilt. They are also used by resident and migratory wading birds (including species covered by the Japan - Australia and China - Australia Migratory Birds Agreements) as feeding places. The freshwater springs flowing into the saltlakes are especially important, since they provide drinking and feeding places for species that cannot survive on salt water alone, such as Pacific Black Duck and Australian Crake and other species that utilise the salt lakes for food. They also are important breeding places for species that require dense rushes or reeds, e.g. crakes and Little Grassbird.

6.23 Reptiles

Taxonomy follows that of the Western Australian Museum [see Wilson and Knowles (1988) for a recent treatment of lizards and snakes]. Data are from Dell and Chapman (1977), the Western Australian Museum reptile register, Foulds and McMillan (n.d.) and an unpublished draft report (incomplete, dated April 1989) by Martinick and Associates (1989b) being prepared for Canning Resources Pty Ltd.

Reptiles known from the Lesueur Area are listed in Table 6.3, together with the landforms from which they have been recorded. This table should be interpreted with caution because:

i) Trapping and searching effort has not been the same in all landforms. The Museum and WACAE surveys did not examine the two eastern landforms (Banovich Uplands and Bitter Pool Rises) and the Museum survey predated the use of modern pitfall trapping methods, while the Martinick and Associates (1989b) survey is restricted to three landforms (Gairdner Dissected Uplands, Banovich Uplands and Bitter Pool Rises). In addition, the Museum survey was carried out in late autumn and late spring, while the data available from the Martinick survey are restricted to spring and early summer.

ii) The landforms from Peron Slopes eastwards are very complex, containing numerous soil and vegetation units.

iii) Few data are available on micro-habitat.

Foulds and McMillan (n.d.) recorded *Pseudonaja affinis*, the Dugite, from the Lesueur Area, but did not lodge a specimen in the Museum. This record needs confirmation. The common *Pseudonaja* in this area is the Gwardar, *P. nuchalis*. If dugites do occur in this area they are at the northern limit of their distribution.

Forty-eight reptile species have been recorded in (or immediately adjacent to) the Lesueur Area and the continuing additions to the 1974 Museum list suggest that further species await discovery.

The reptile fauna of the Lesueur Area is a rich one; it has more species than any existing conservation reserve in the south west of the State, except the much larger and more northern Kalbarri National Park (Table 12.2). The Lesueur Area is particularly rich in geckoes (9 species) and legless lizards (6 species). It is the only place where three species of the *Diplodactylus vittatus* group (*granariensis*, *ornatus* and *polyophthalmus*) occur together, and it provides an opportunity for evolutionary and ecological studies in this group.

Some idea of the reptile species richness of this area of the State, and the value of the Lesueur Area in conserving it, can be gauged by listing species recorded in similar habitats nearby, but not in the Lesueur Area (data from W.A. Museum reptile register). These are: *Diplodactylus michaelseni*, *Aprasia repens*, *Ctenotus catenifer*, *C. gemmula*, *C. schomburgkii*, *L. lineopunctulata*, *Aspidites ramsayi*, *Morelia spilota imbricata*, *Notechis scutatus*, *Rhinoplocephalus nigriceps*, *Vermicella bertholdi*, *V. bimaculata*, *V. calonotus* (declared endangered under the Wildlife Conservation Act), and V. *fasciolata*. It can be seen that only 14 additional species have been recorded in nearby, comparable areas of the northern kwongan and that the Lesueur Area is both species-rich and important in the conservation of the reptiles of the district.

The Woma *Aspidites ramsayi* (a python) has declined drastically in the south west (Smith 1981) and the south western population is now near extinction. It has been declared in need of special protection under the Wildlife Conservation Act. The south west sandplain population is thought to be a different taxon from that of the central deserts (L.A. Smith personal communication) and is thought to have become threatened with extinction mainly because of clearing and fragmentation of its habitat. The only recent records in the northern kwongan are from near

Table 6.3
Reptiles of the proposed Lesueur National Park, showing recorded distribution according to landforms.

	QD	SLC	SD	BD	PS	LDU	GDU	BU	BPR
Agamidae Dragon Lizards									
Ctenophorus maculatus maculatus					X	X			
Pogona minor minor	X		X	X	X	X	X	X	X
Tympanocryptis adelaidensis adelaidensis			X	X	X	X	X	X	X
Gekkonidae Geckoes									
Crenadactylus ocellatus ocellatus			X				X	X	X
Diplodactylus alboguttatus					X		X		
Diplodactylus granariensis granariensis						X	X		
Diplodactylus ornatus					X	X			
Diplodactylus polyopthalmus				X	X	X		X	
Diplodactylus spinigerus spinigerus	X	X	X	X	X	X	X	X	X
Gehyra variegata	X	X	X			X			
Phyllodactylus marmoratus marmoratus		X	X			X			
Underwoodisaurus millii		X	X				X	X	
Pygopodidae Legless Lizards									
Aclys concinna concinna	X			X		X	X	X	
Delma fraseri		X			X		X	X	X
Delma grayii							X	X	X
Lialis burtonis					X		X	X	
Pletholax gracilis	X							X	
Pygopus lepidopodus lepidopodus		X	X		X	X	X	X	X
Scincidae Skinks									
Cryptoblepharus plagiocephalus		X				X	X		
Ctenotus fallens			X		X	X	X	X	X
Ctenotus impar						X	X		
Ctenotus lesueurii			X					X	
Ctenotus pantherinus pantherinus					X		X	X	X
Egernia kingii			X						

Cont'd...

	QD	SLC	SD	BD	PS	LDU	GDU	BU	BPR
Egernia multiscutata bos			X		X	X	X		
Egernia napoleonis				X					
Lerista christinae							X?		
Lerista distinguenda							X	X	
Lerista elegans			X		X				
Lerista planiventralis decora			X*						
Lerista praepedita			X*						
Menetia greyii			*X*				*X*	*X*	*X*
Morethia lineoocellata			X			X		X	X
Morethia obscura					X	X	X	X	
Omolepida branchialis		X							
Tiliqua occipitalis			X						
Tiliqua rugosa rugosa	X	X	X		X		X	X	X
<u>Varanidae</u>									
Varanus gouldii								X	X
Varanus tristis tristis		X				X		X	
<u>Boidae</u> Pythons									
Morelia stimsoni stimsoni		X					X		
<u>Elapidae</u> Frontfanged Snakes									
Demansia psammophis reticulata			X*						
Notechis curtus		X		X	X			X	
Pseudonaja nuchalis							X		
Pseudechis australis					X*				
Rhinoplocephalus gouldii							X	X	X
Vermicella littoralis			X						
Vermicella bimaculatus					X*				
<u>Typhlopidae</u> Blind Snakes									
Ramphotyphlops australis	X#		X#			X	X		

*Recorded from just outside proposed Lesueur National Park, likely to occur on similar landforms within it.

#species uncertain

QD - Quindalup Dunes; SLC - Salt Lake Complex; SD - Spearwood Dunes; BD - Bassendean Dunes; PS - Peron Slopes; LDU - Lesueur Dissected Uplands; GDU - Gairdner Dissected; BU - Banovich Uplands; BPR - Bitter Pool Rises Uplands

Badgingarra and Yandanooka in the 1960s and from near Gunyidi in 1989. There is a reasonable possibility that this endangered species occurs in the Lesueur Area, one of the largest areas of its habitat that remains.

Taxa of limited geographic range that occur in the Lesueur Area include *Tympanocryptis adelaidensis adelaidensis*, *Diplodactylus alboguttatus*, *Aclys concinna concinna*, *Delma grayii*, *Ctenotus lesueurii* and *Lerista christinae*. The last of these has a very restricted range in the Badgingarra - Lesueur - Eneabba area, and is known from only one conservation reserve - Badgingarra National Park. It also occurs on Rottnest Island. *Lerista christinae* is currently declared as endangered fauna under the Wildlife Conservation Act. However, its status has now become better understood and it is proposed to transfer it to the Reserve List.

Three species, *Ctenophorus maculatus*, *Lerista planiventralis* and *Vermicella littoralis* occur at or near the southern limit of their geographic range, and two, *Egernia napoleonis* and *Ctenotus impar*, are at or near their northern limit. The main range of *Diplodactylus polyophthalmus* is from the Stirling Range to the Darling Range; the population in the Lesueur Area is a disjunct one.

Many species are widely distributed in the Lesueur Area. However, some are known only from one or a few landforms. These include *Diplodactylus alboguttatus* (Peron Slopes and Gairdner Dissected Uplands), *D. ornatus* (Peron Slopes and Lesueur Dissected Uplands), *Pletholax gracilis* (Quindalup Dunes and Banovich Uplands), *Ctenotus impar* (Lesueur Dissected Uplands and Gairdner Dissected Uplands), *C. lesueurii* (Spearwood Dunes and Banovich Uplands), *Egernia napoleonis* (Peron Slopes), *Lerista christinae* (Gairdner Dissected Uplands), *L. distinguenda* (Gairdner Dissected Uplands and Banovich Uplands), *L. planiventralis* (Spearwood Dunes), *L. praepedita* (Spearwood Dunes), *Tiliqua occipitalis* (Spearwood Dunes), *Varanus gouldii* (Banovich Uplands and Bitter Pool Rises) and *Morelia stimsoni* (Salt Lake Complex and Gairdner Dissected Uplands). Some of these species may be more widespread in the Lesueur Area than current data indicate, but some may be restricted to special habitats. *Egernia napoleonis*, for example, is at the northern edge of its range and would be expected to be limited to particular habitats. *Lerista christinae* is a northern kwongan endemic with a restricted distribution (except for an isolated population on Rottnest Island) and could also be restricted in its habitat use.

6.24 Amphibians

Taxonomy follows Tyler *et al.* (1984). Data are from Dell and Chapman (1977), Foulds and McMillan (n.d.), the Western Australian Museum register and an unpublished draft report (incomplete, dated April 1989) by Martinick and Associates (1989b) being prepared for Canning Resources Pty Ltd.

Frogs known from the Lesueur Area are listed in Table 6.4, together with data on the landforms from which they have been recorded. As mentioned above (Reptiles), data on landform distribution should be interpreted with caution.

The frog fauna known from the Lesueur Area is not rich in species and is typical of that of the northern kwongan. No known Lesueur species are rare or geographically restricted. The Lesueur Area is near the northern limit of the range of *Heleioporus eyrei*, and *Ranidella pseudinsignifera* occurs as an isolated population at the northern end of its range.

6.3 INVERTEBRATES

6.31 Terrestrial invertebrates

The only published study on the invertebrate fauna of the Lesueur Area is that of the W.A. College of Advanced Education in 1980 and 1981 (Foulds and McMillan n.d.). They worked along the Coorow - Green Head Road, within the Quindalup Dunes, Salt Lake Complex, Spearwood Dunes and Peron Slopes landscape units and recorded 463 species of invertebrates during two brief surveys. Twenty-nine species of jewel beetles were found, four in Quindalup Dunes, 10 in the Salt Lake Complex, 17 in Spearwood Dunes and 15 in Peron Slopes.

Foulds and McMillan concluded that "..this study clearly demonstrates that a rich flora provides a rich invertebrate fauna in heathland habitats" and "The importance of the insect fauna in the Leeman area is twofold. They form an important part of the food web, providing food for arthropods such as spiders, centipedes and scorpions as well as predatory insects (eg. Dragonflies and Mantids). Frogs, many lizards and birds are also dependent on insects for food. Secondly they are essential for the pollination of many plants, in particular the Leguminosae, Orchidaceae and Stylidiaceae." (p.33).

Comparative data on the invertebrates of other areas of the Lesueur Area or other areas of the northern kwongan are not available.

Table 6.4
Frogs of the proposed Mount Lesueur National Park, showing recorded distribution according to landforms.

	QD	SLC	SD	BD	PS	LDU	GDU	BU	BPR
Hylidae Tree Frogs									
Litoria moorei		X							
Leptodactylidae Leptodactylid Frogs									
Myobatrachus gouldii								X	
Ranidella pseudinsignifera		X					X	X	X
Heleioporus albopunctatus		X				X	X	X	X
Heleioporus eyrei			X				X	X	X
Heleioporus psammophilus								X	X
Limnodynastes dorsalis		X			X		X	X	X
Neobatrachus pelobatoides		X	X				X	X	
Pseudophryne guentheri		X					X	X	X

QD - Quindalup Dunes; SLC - Salt Lake Complex; SD - Spearwood Dunes; BD - Bassendean Dunes; PS - Peron Slopes; LDU - Lesueur Dissected Uplands; GDU - Gairdner Dissected; BU - Banovich Uplands; BPR - Bitter Pool Rises Uplands

The little that is known of the invertebrates of the northern kwongan suggests that there are many species restricted to it. Examples include:

1. The undescribed thynnid wasp that pollinates the Arrowsmith Spider Orchid *Caladenia crebra*. The Arrowsmith Spider Orchid can only be pollinated by this wasp, an example of the very close relationship between some insects and some plants. The orchid has evolved a pheromone and an appearance that deceive the wasp into believing that it is mating with a female of its species (Stoutamire 1983). The orchid's distribution extends northwards from Cervantes and the Lesueur Area to near Morawa.

2. The terrestrial mollusc *Bothriembryon perobesus* which is restricted to the northern kwongan (W.A. Museum, personal communication).

3. The native bee *Leioproctus tomentosus*, which is restricted to flowers of *Conospermum crassinervium* (occurs in the Lesueur Area, distributed from near Eneabba to near Gingin) (W.A. Museum, personal communication).

4. Other insects of restricted distribution, such as the undescribed lycaenid butterfly *Ogyris* sp., the skipper butterfly *Croitana croites*, and the weevils *Catasarcus nepheloides*, *C. optimus* and *C. pallescens* (W.A. Museum, personal communication).

These examples support the contention that there are many close associations between the large number of endemic plants of the northern kwongan and insects and other invertebrates, and that there are likely to be many invertebrate species unique to the area. The Lesueur Area doubtless provides an important sanctuary for many of these species.

6.32 Aquatic invertebrates

The only data available on aquatic invertebrates are from a brief October 1988 survey carried out by Streamtec Ecological Consultants (1988) for Martinick and Associates. The survey was restricted to 11 sites in the eastern section of the Lesueur Area in the vicinity of the proposed coal mine and was conducted at a time when almost all streams had ceased flowing with most reduced to a series of pools, or in extreme cases, to one pool. Cockleshell Gully was dry and was not sampled.

Streamtec recorded a total of 104 macro-invertebrate taxa during their study, Species richness at the 11 sites varied from 15 to 38 species. The most diverse group was the Coleoptera, principally the Dytiscidae (water beetles), with 36 species from four families. The Chironomidae (midges) comprised a combination of lotic (stream) and lentic (pool) species. Three species found have not been recorded previously and are probably new to science. Evidence of the presence of Koonacs (*Cherax plebejus*) was obtained. This south west endemic is threatened by both habitat destruction (including salination) and by competition from the introduced yabbie (*C. destructor*).

Streamtec concluded that the aquatic fauna, as sampled, was a contracted lentic community with elements of lotic species. The lotic species present were typical of streams of the northern jarrah forest. They considered many of the lentic species present to be cosmopolitan as they rapidly colonise suitable wetlands and as such have limited use in characterizing the nature of the aquatic ecosystems of the area. Streamtec strongly recommended further sampling during late winter.

This brief study of the streams in part of the Lesueur Area produced a surprisingly high number of macro-invertebrate species - 104. Lakes like Thomsons and Forrestdale, near Perth, have lists of about 70 species, each from regular sampling, and the list for all jarrah forest streams contains about 260 species (S. Halse personal communication). The very large proportion of predators in the Lesueur sample is indicative of systems that are drying up and is a warning that it is not a typical fauna that was sampled. Clearly, a proper assessment of the biological significance of the Lesueur streams requires sampling in all seasons, including summer (after heavy rainfall).

Chapter 7

INTER-RELATIONSHIPS OF PLANTS AND ANIMALS

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Abstract

The Lesueur Area provides an opportunity for essential ecological inter-relationships between plants and animals to continue. Two recent studies highlight relationships between rare plants in the Lesueur Area and the wide-ranging birds that are dependent upon them.

Banksia tricuspis is a Declared Rare species endemic to the Lesueur Area. It shows a strong preference for microclimatically favourable sites and may be a relict species from wetter times. Pollinators, including birds, mammals and insects are essential for seed set in this outbreeding species. Moth larvae and cockatoos reduce the reproductive success of B. tricuspis through predation. However, because cockatoos destroy more moth larvae than flower heads, the latter of which they damage 'in error', the cockatoos have a positive effect. The ability of B. tricuspis to cope with fire is influenced by fire frequency, which effects plant survivorship, and seasonality which influences seedling recruitment. Management of B. tricuspis should ensure that all organisms involved in its inter-relationships are catered for. In the cockatoos' case this is extremely important and will require protection of wandoo woodlands, kwongan and fresh water sources throughout the Lesueur - Coomallo region.

Black Kangaroo Paws (Macropidia fuliginosa) are dependent on honeyeaters for pollination and sustain some nectar loss from honey bee activity.

The ecological links that exist between these plants and animals in the Lesueur Area highlight the need to not only manage and conserve rare and restricted species but also to conserve the organisms that interact with them. To achieve this a larger area of native vegetation than that occupied by a rare plant is often required.

One of the most important attributes of the Lesueur Area is that by its size it affords an opportunity for ecological processes to continue. Provided surrounding native vegetation remains uncleared, this may happen even for organisms that require large areas to survive. Such organisms include Black Cockatoos and nomadic honeyeaters. In this section two recent studies are discussed that highlight relationships between rare plants in the Lesueur Area and the wide-ranging birds that are dependent upon them.

The findings of these studies emphasize that plant and animal species do not exist in isolation. All species are dependent on complex inter-relationships with other species in their ecosystems. Much more work on these inter-relationships is needed to give a clear picture of the web of life in the Lesueur Area.

7.1 *BANKSIA TRICUSPIS*: BIOLOGY, INTERACTIONS AND MANAGEMENT

Seven species of Declared Rare Flora occur within the Lesueur Area. One of them is the Pine Banksia, *Banksia tricuspis*. This section will describe aspects of the biology and ecology of the species, with emphasis on its relationship with other species. Considerations relevant to the development of a management plan for this species are then discussed.

B. tricuspis is a lignotuberous, emergent shrub or tree up to 4 m tall that has an irregular, gnarled form. The foliage is distinctly conifer-like, the bark wrinkled and grey, and the orange-yellow inflorescences cylindrical. Anthesis occurs in a downwards direction and the styles are hooked with a terminally located stigma. Flowering commences in March, peaks in May-July and extends through to September. Plants produce on average 6.9 ± 1.1 (SE) inflorescences per

Table 7.1.
Distribution of *Banksia tricuspis* populations and individuals by the landform units represented within the proposed Lesueur National Park.

Landform	Number (%) of populations	individuals
Lesueur Dissected Uplands	9 (12.5)	3608 (18.9)
Gairdner Dissected Uplands	38 (52.7)	13924 (73.2)
Bitter Pool Rises	2 (2.8)	55 (0.3)
Banovich Uplands	16 (22.2)	1178 (6.2)
Total	**65 (90.2)**	**18765 (98.6)**

Table 7.2.
Summary of effects of pollination and predation constraints on the reproductive success of *Banksia tricuspis* (inflorescences through to cones).

Sequence of events	Mean number of inflorescences per plant	Percentage of inflorescences remaining
number per plant	6.9 ± 1.1 (SE)	100.0
4.4% of inflorescences not pollinated	6.6	95.6
2% of inflorescences predated by nectar-foraging ringnecks	6.4	92.7
69% of inflorescences predated by moth larvae and cockatoos	2.6	37.7
12% of inflorescences predated by cockatoos 'in error'	2.2	31.9

year (Table 7.2) but this may vary from 0-45. The woody fruits and seeds mature within six months of flowering and are green initially, turning grey with age. Cone production per plant varies from 0-15 per year with a mean of 2.2 ± 0.1 (Lamont and van Leeuwen 1988).

The species is placed within the Section *Oncostylis* Series *Spicigerae* of the genus *Banksia* (George 1981). This group is characterised by having cylindrical inflorescences, hooked styles and a descending pattern of floral opening. There are eight species within this Series, six endemic to south western Australia and two occurring in eastern Australia. *B. tricuspis* is distantly allied to *B. verticillata*, *B. seminuda* and *B. littoralis* but is distinguished from them by its narrow tricuspate leaves which have revolute margins.

7.11 Distribution and habitat.

B. tricuspis is endemic to the Gairdner Range, growing most abundantly in the headwaters of Cockleshell Gully between Mt Lesueur and Mt Peron. The species has a geographic range of 13 km north-south and 8.5 km east-west (Figure 3.3). It is the second most geographically restricted *Banksia*, eclipsed only by the recently discovered narrow endemic *B. epica* (Taylor and Hopper 1988).

A total of 72 populations representing about 19 031 individuals have been identified with the smallest and largest population containing 1 and 4 150 plants respectively. All but seven populations are confined to the Lesueur Area. The remaining seven are on private property.

Populations are located on four of the five landforms recognized for the Gairdner Range (Table 7.1, Figure 3.3), but the species is most abundant on the Gairdner Dissected Uplands.

The distribution of the species appears to be determined by edaphic and microclimatic influences. It is found growing on hill tops, breakaways, scree slopes and gullies, which are comprised of a lateritic or sandstone bedrock overlain by a gravelly skeletal soil. In a few rare instances individuals have also been located growing in the deep grey sands on the valley floors.

The species shows a strong preference for southerly slopes and other sites, such as mesa tops and gullies. It has been argued by Griffin and Hopkins (1985a) that such sites are microclimatically favourable, offering a more mesic environment than found elsewhere at Lesueur. These sites provide refugial habitats for relictual species and those at the limits of otherwise more mesic distributions. Evidence supporting this argument is provided by the preference for southerly sites by the relictual species *Hakea megalosperma* and the disjunct outliers of *Eucalyptus marginata*.

The preference of *B. tricuspis* for microclimatically favourable sites along with several character-states that are considered to be primitive (George 1981) suggest that it is a relictual species. George (1981) speculated that the Section *Oncostylis* evolved early in the evolution of the genus, before the onset of aridity and the edaphic changes associated with the formation of the Nullarbor Plain. The Series in which *B. tricuspis* is a member, the *Spicigerae*, is considered the oldest within the Section, as is evident by the presence of two species from the Series in eastern Australia.

7.12 Pollination Ecology

B. tricuspis requires pollinators to effect seed set (van Leeuwen 1985). It is not apomictic and its protandrous flowers prevent selfing in the absence of pollinators. It is pollinated by a number of different animals.

The most important pollinator groups are the vertebrates, namely birds and marsupials. A number of bird species, all honeyeaters, and the honey possum have been observed foraging on *B. tricuspis* inflorescences and all were found to carry pollen (van Leeuwen 1985). Birds seen at inflorescences from the most active observed foragers to the least, include the Brown Honeyeater (*Lichmera indistincta*), Tawny-crowned Honeyeater (*Phylidonyris melanops*), White-cheeked Honeyeater (*P. nigra*), the Western Spinebill (*Acanthorhynchus superciliosus*), the Western Silvereye (*Zosterops lateralis*), and the Pied Honeyeater (*Certhionyx variegatus*) .

The levels of pollination success achieved by vertebrate pollinators, when measured in terms of the numbers of seeds produced, is significantly higher than those achieved by invertebrates (62% of open seed set versus 38%). The difference between the two vertebrate pollinator types in achieving seed set is not significant (van Leeuwen, unpublished data). Of the invertebrates, the most important appear to be thynnid wasps and the introduced honey bee (van Leeuwen 1985).

Ants are also regularly observed visiting inflorescences but are too small to effect pollination. Rather, they play an important role in suppressing predators of inflorescences, particularly the larvae of moths. Survivorship of inflorescences which have been experimentally manipulated to exclude ants is zero (van Leeuwen 1985).

All pollinator groups frequently move from plant to plant while foraging. Such behaviour would promote outbreeding pollination events. This is especially so in the vertebrates which are extremely mobile. The mean and maximum observed foraging bout distances for honeyeaters are 7.6 m and 75 m, and for the honey possum are 9 m and 59 m respectively.

7.13 Breeding System.

Pollen-ovule ratios and multilocus outcrossing estimates based on isozyme electrophoresis indicate that this species is facultatively xenogamous, i.e. mainly outbreeding, but selfing does occur (S. van Leeuwen and D. Coates, unpublished data). Multilocus outcrossing estimates of the breeding system indicated that the levels of outcrossing within a population is on average 70-75%. However, in the case of a population consisting of one individual isolated from its nearest neighbour by 800 m, the level of outcrossing was calculated to be as low as 35% (van Leeuwen, unpublished data).

7.14 Biotic Constraints on Reproductive Success.

Apart from spatial, resource and genetic constraints which may operate to limit the reproductive success of *B. tricuspis*, there are several external constraints. Pollination success is one of these constraints. On average, 4.4% of inflorescences per plant are not successfully pollinated. However, this value may vary from 0-8.9% (van Leeuwen, unpublished data).

External constraints have the most significant effect on the reproductive success of *B. tricuspis* and are mainly manifested as predation on inflorescences, cones and seeds. The most significant constraints on the reproductive success of the species occur as a result of floral predation by the Port Lincoln Ringneck, *Barnardius zonarius*, the larvae of the moth *Arthrophora diadela* and Carnaby's Black Cockatoo, *Calyptorhynchus funereus latirostris*. Predation of an inflorescence by any of these agents results in the failure of an inflorescence to set seed.

Ringnecks attack inflorescences by removing all the perianth parts except the bracts, ovaries and nectaries that are attached to the rachis. The nectaries continue to produce nectar, which is harvested by the ringnecks over subsequent days. Ringnecks attack a mean of 2% of the inflorescences on plants (Table 7.2), but this varies from 0-15%.

Larvae of the moth *A. diadela* have the largest impact on the reproductive success of *Banksia tricuspis*. The moth larvae enter the rachis via the bracts and commence burrowing throughout the length of the rachis. When ready to pupate, the larvae exit via the bracts. The mean number of larvae present in an inflorescence is four, but can vary from 1-11 individuals. Larvae can damage 0-100% of the inflorescences produced by a plant. Most plants sustain 90-100% damage. However, the mean value for such predation is 59.3±29.7%. The mean value is lower than the modal value because larval predation increases as the number of inflorescences produced by a plant increases. Larval-predated plants have significantly more inflorescences (8.1±2.2) than those not affected (2.1±0.5, $p < 0.001$ by t-test) (Lamont and van Leeuwen 1988).

Carnaby's Black Cockatoo, the final floral predator, accidentally destroys inflorescences in its search for the larvae of *A. diadela*. The cockatoo has the ability to predict with reasonable accuracy which inflorescences have larvae present. It attacks about 89% of all larval-bearing inflorescences, while only 42% of those without larva are attacked ($p < 0.001$ by X^2 test). The little corella, *Cacatua sanguinea*, has also been observed predating the larvae of *A. diadela* on rare occasions.

As is the case for moth larvae, predation by cockatoos increases significantly as the number of inflorescences on a plant increases. The mean number of inflorescences on damaged plants is 9.6±7.8, compared with 3.0±1.4 on those plants which are not damaged ($p < 0.001$ by t-test) (Lamont and van Leeuwen 1988). This preferential visitation to plants with the most inflorescences increases the cockatoos' chance of locating the larvae, which are also relatively more abundant on these plants.

The overall effect of these three agents on floral predation is a significant reduction in the reproductive success of the *Banksia*, to a level where cones with follicles is only 31.9% of the original number of inflorescences (Table 7.2). The net effect of predation by cockatoos is positive because they destroy more moth predated inflorescences than they damage inflorescences 'in error' (Lamont and van Leeuwen 1988).

Predation of seeds by beetle larva of the family Cleridae is another constraint operating to limit the reproductive success of the *Banksia*. Such predation is only minimal, the effect being a 15% reduction in the number of seeds present in the canopy-stored seed crop over a four year period. Without the destructive effects of birds and the larvae of moths and beetles, the canopy seed store of *B. tricuspis* would be about four times greater.

7.15 Fire Ecology.

B. tricuspis is a fire tolerant species that has the ability to resprout from both the lignotuber and epicormic buds. However, young plants are susceptible to fire. A major proportion of the Lesueur Area was burnt in 1985, which resulted in the death of 27 of the 41 known 18-year-old plants (van Leeuwen 1985). Mortality rate also increased in adult plants immediately after the fire from 0.005% pre-fire to 0.1% in the year immediately after the fire. Hence, during the pre-fire period and up to one year after, the net change to the overall population of *B. tricuspis* has been a decrease by about 66 individuals (n = 19 031 plants, van Leeuwen, unpublished data).

The extent to which a plant retains its seed within the canopy over time is a measure of its degree of serotiny. Species that release their seeds once mature are nonserotinous while those that retain their seed indefinitely are highly serotinous. Seed release in highly serotinous species only occurs after the death of the plant or branch supporting the fruit. Death of plants and branches occurs after events such as fire.

B. tricuspis is weakly serotinous, beginning to release its seeds once mature and continuing to do so until, at four years post flowering, all the seeds have been released. However, seedling recruitment has not been recorded in between fire periods. Recruitment of individuals appears to occur only after the habitat has been burnt and the highest levels of seedling recruitment occur after summer-early autumn fires. Seedling recruitment is considerable after such events because the time lag between follicle rupture and the onset of suitable conditions for seed release from the cone, for germination and for seedling growth are minimal. This reduces the amount of time that seeds are exposed to predators and to extreme surface soil temperatures, both of which significantly reduce seed viability. It also maximises the length of the growing season available to seedlings.

Several years after a fire the initial increase in population size resulting from the influx of seedlings becomes negligible. Seedling mortality is mainly induced by summer drought stress. Field observations indicate that as few as 0.4% of the seedlings in a seedling population pool of 550 survive to be five years old (van Leeuwen unpublished data).

Seedling recruitment and survivorship may also be enhanced by minimal competition from other plant species, especially in the immediate post-fire period. Comparison of seedling survivorship *in situ* with different levels of competition, i.e. natural heathland versus cleared tracks, indicates that seedling survival is highest on the tracks. Five years after initial recruitment, 54% of the seedlings on the track site were surviving, while only 0.4% of those in ten natural heathland sites survived (van Leeuwen, unpublished data).

7.16 Management implications.

The main considerations in a management program designed for *B. tricuspis* should be to ensure the maintenance of existing populations, if not to endeavour to increase their size. Such a management program should ensure that:

1. pollinators remain abundant in the Lesueur Area,
2. a viable population of Carnaby's Black Cockatoo is maintained,
3. fire regimes are prescribed to minimize mortality and maximise recruitment, and
4. dieback disease is not introduced into the Lesueur Area.

It is obvious that it is necessary to maintain viable populations of the pollinating agents within the Lesueur Area. Without such animals, *B. tricuspis* is unable to produce seed and therefore will lose the ability to recruit new individuals into the population when conditions become suitable.

Similarly, it is extremely important to maintain viable populations of Carnaby's Black Cockatoo within the Lesueur Area. Carnaby's Black Cockatoo is a declining species that will require special management in its own right. It is declining in number as the vegetation associations in which the birds forage and nest are cleared for agriculture. It has already become locally extinct in a number of wheatbelt localities (Saunders and Ingram 1987). Foraging mainly occurs in heathland vegetation communities (Saunders 1980), which have abundant fruits and seeds of proteaceous and myrtaceous species, the main food sources. Nesting occurs in *Eucalyptus wandoo* woodlands where there are numerous, suitably-sized nesting hollows. Such sites are usually close to free water, which is essential to nesting and summer-roosting birds. It is also necessary for the nest sites to be close to the food resources so that adult birds can find enough food for nestlings without travelling great distances (Hopkins and Saunders 1987).

The Lesueur Area currently fulfills all the requirements of Carnaby's Black Cockatoo, including suitable woodlands with nesting hollows along water courses, rich heathland communities for foraging and short flight distances from nest sites to foraging sites and free water. The Lesueur Area has been identified as a major breeding and summer roosting site for Carnaby's Black Cockatoo (Hopkins and Saunders 1987).

Management of Carnaby's Black Cockatoo and the places it utilizes within the Lesueur Area must not be considered in isolation. If remnant native vegetation outside the Lesueur Area is dramatically reduced through clearing then increased pressure will be placed on those resources within it. Such pressures will come from displaced populations of Carnaby's Black Cockatoo and other species such as the Galah (*C. roseicapilla*) and Long-billed Corella (*C. pastinator pastinator*). Saunders *et al.* (1985) have demonstrated that the Galah and the Long-billed Corella are already increasing in abundance in the Lesueur Area. Both species will compete with Carnaby's Black Cockatoo for nest hollows and may reduce their numbers in the absence of appropriate management.

If Carnaby's Black Cockatoo became locally extinct or numbers were severely reduced through clearing and/or competition for food, nesting and water resources, this may further reduce the seed reserves of *B. tricuspis*. Such a reduction may occur as a result of the substantial increase in the number of *A. diadela* larvae reaching adulthood and therefore, the amount of predation on *B. tricuspis* inflorescences.

The most desirable fire management program for *B. tricuspis* should prescribe a regime of early autumn burns at intervals of no less than 25 years. Bell *et al.* (1985) suggests a burning interval at 25-50 years for the northern kwongan. Such a regime would ensure that burning occurred at an optimum time for the release and germination of seeds and establishment of seedlings, at an intensity that would cause follicles to rupture and at an interval that should not adversely effect seedlings recruited after the last fire.

The Lesueur Area is currently free from dieback disease and any management plan should aim to maintain this situation. The susceptibility of *B. tricuspis* to the disease has not been determined but information available for other south western Australian species in the same Series indicate that it may be moderately to highly susceptible (McCredie *et al.* 1985). Two of its closest allies, *B. seminuda* and *B. verticillata*, have been demonstrated to have 42% and 54% mortality during a 395 day trial. A more detailed discussion of the susceptibility of the Lesueur plants to dieback is provided in Section 8.4 and 8.5.

The management plan for the Lesueur Area should not be designed and implemented in isolation but should be formulated in a regional context. The management plan should not only consider *B. tricuspis*, but all the other species which occur within its bounds, particularly those which are rare, endangered, restricted or disjunct outliers.

The close ecological link between *B. tricuspis* and Carnaby's Black Cockatoo highlights the fact that conservation of rare, highly localised species requires more than just protecting and managing the known populations of the rare plant. A larger area supporting a viable population of Carnaby's Black Cockatoo is essential for the long-term persistence of *B. tricuspis*.

7.2 BLACK KANGAROO PAWS

The Black Kangaroo Paw, *Macropidia fuliginosa*, has a limited distribution in the northern kwongan (Hopper 1978) and is well represented within the Lesueur Area. It has specific habitat requirements, favouring well-drained lateritic slopes and breakaways and is rarely found in valleys except where sands are thin and overlie laterite. Apart from being a conspicuous and attractive plant in the kwongan, the species is a favourite food for kangaroos.

The pollination ecology of Black Kangaroo Paws has been studied by Brown (1988) on the slopes of Mt Michaud and at another site to the east. She found that Black Kangaroo Paws were exclusively pollinated by honeyeaters, particularly the Tawny-crowned Honeyeater (*Phylidonyris melanops*) and the Singing Honeyeater (*Lichenostomus virescens*). Honey bees (*Apis mellifera*) visited the flowers, but did not effect pollination, robbing the flowers of their nectar. The Kangaroo Paws' flower shape and biology is highly adapted to honeyeater pollination. Morphological changes in flower structure and orientation on the stem are used as cues to encourage visits by honeyeaters when nectar is produced, and maximum nectar production coincides with pollen release and maximum stigma receptivity.

In order to maintain Black Kangaroo Paws in the Lesueur Area it is necessary to maintain viable populations of honeyeaters and keep honey bee numbers at a low level.

Chapter 8

DIEBACK DISEASE AND OTHER PHYTOPHTHORA SPECIES IN THE NORTHERN KWONGAN

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Abstract

Phytophthora cinnamomi and other Phytophthora species are having a major detrimental effect on the vegetation and associated fauna of many national parks and other conservation reserves in southern Australia. In the northern kwongan studies on the extent of these plant diseases commenced only recently, but it is known that five types of Phytophthora occur there, with P. cinnamomi having recently been found near Eneabba. One infection of Phytophthora citricola has been found within the Lesueur Area, beside Cockleshell Gully Road.

Dieback disease caused by Phytophthora species would have a major impact if introduced because of the suitable climate, the abundance of susceptible plant species and vegetation types and the type of soils present. The probability of introduction of Phytophthora is high when extensive use of earth-moving equipment and vehicles takes place in a highly susceptible area, even if high standards of hygiene are maintained. If introduced, the impact of Phytophthora could be extensive, because of the high proportion of susceptible vegetation types and plant species.

8.1 BACKGROUND

Over the past 25 years, a devastating epidemic has swept through the indigenous vegetation of many national parks and reserves in southern Australia (Newhook and Podger 1972). The epidemic is caused by *Phytophthora cinnamomi*, an introduced, soil-borne fungus. In Western Australia, *P. cinnamomi* (known locally as jarrah dieback disease) kills more than 150 native species (J.T. Tippett unpublished); world-wide it has been recovered from over 900 plant species (Zentmyer 1980). Recently, in this State, several other taxa of *Phytophthora*, namely *P. citricola*, *P. megasperma* var. *megasperma*, *P. megasperma* var. *sojae*, *P. drechsleri*, *P. cryptogea* (A2) and *P. nicotianae* var. *parasitica*, have been recovered from dying plants in diseased patches of native vegetation (M.S. Stukely and T.C.J. Hill unpublished).

Detailed studies have shown the impact of *P. cinnamomi* to have been particularly severe in four national parks, two in Victoria and two in Western Australia. In Victoria, dry sclerophyll forest and shrubs in the Brisbane Ranges and dry sclerophyll woodlands, heaths and swamps at Wilsons Promontory have been badly affected (Dawson *et al.* 1985; Weste and Law 1972). In Western Australia, the disease is widespread in the Stirling Range and Cape Le Grand National Parks, where it is dramatically changing the composition of jarrah and banksia woodlands, banksia shrublands, thickets and mallee and scrub heaths (R. Wills unpublished; G.J. Keighery unpublished).

In these four parks, the development of the disease, from incipient infection to infestation, has taken only two decades. Introduction and intensification of the disease has been, in each case, directly attributable to the disturbance of the area caused by the construction of roads, tracks and firebreaks and their subsequent use. In the Brisbane Ranges, the disease appeared in 1961, after the gravelling of the major road system (Dawson *et al.* 1985). Its distribution increased dramatically in the following decade, rising from 1% of the area of the park in 1971 to 31% in 1980-81 (Dawson and Weste 1985). Roadworks and subsequent infection of drainage lines were identified as the main vectors of the disease. At Wilsons Promontory, the fungus was probably brought in to the park on fire control equipment in 1962, infecting vegetation at the junction of two firebreaks (Weste and Law 1972). In 1968, gravel from the infected area was used to repair the main access road; by 1972 the disease was well entrenched in several areas of the park. In Western Australia, the construction and gravelling of major roads and fire breaks in the Stirling Range and at Cape Le Grand in the '60s and '70s similarly established the disease in each park. Both are now severely affected.

Table 8.1

Plants, which occur on the Swan Coastal Plain or in the Lesueur area, that are susceptible to infection by Phytophthora species.

Plant Species	Pathogen[2] Pc	Pmm	Pcit	Pd	Pms
Acacia huegelii[1]	**[3]				
Adenanthos cygnorum	*	**	*		
Adenanthos obovata[1]	**				
Allocasuarina fraseriana	*				
Allocasuarina humilis	*				
Andersonia heterophylla	**				
Andersonia lehmanniana	*				
Aotus ericoides[1]	*				
Astroloma sp.	*				
Astroloma xerophyllum	**				
Banksia attenuata	**	**	**	**	
Banksia grandis	*	**			
Banksia ilicifolia	**	**		**	
Banksia laricina	**				
Banksia littoralis[1]	*				
Banksia menziesii	**	*	**	*	
Banksia prionotes		**	**		**
Banksia sphaerocarpa?	*				
Banksia telmatiaea	**				
Beaufortia elegans	**				
Bossiaea eriocarpa[1]	**				
Burtonia conferta[1]	**				
Calothamnus villosus	*		**		
Calytrix flavescens[1]	**				
Calytrix sp.	*				
Conospermum stoechadis	*	*	**		
Conospermum triplinervium	**				
Conostephium pendulum	**				
Dampiera alata[1]	*				
Dampiera linearis[1]	**				
Dasypogon bromeliifolius[1]	*				
Daviesia incrassata[1]	*				
Dryandra nivea[1]	*				
Dryandra sp.		*			
Eremaea pauciflora	**				
Eremaea sp. (large star fruit)		**			
Eucalyptus marginata[1]	*				
Eucalyptus todtiana	*				
Hibbertia acerosa[1]	**				
Hibbertia hypericoides	*				
Hibbertia subvaginata	**	*			

Cont'd...

Plant Species	Pathogen[2]				
	Pc	Pmm	Pcit	Pd	Pms
Hypocalymma robustum[1]	**				
Isopogon buxifolius		**			
Jacksonia eremodendron			**		
Jacksonia floribunda	**				
Lasiopetalum floribundum[1]	**				
Leptospermum ellipticum[1]	*				
Leucopogon australis[1]	**				
Leucopogon conostephioides	**	**		**	
Leucopogon lasiostachyus[1]	**				
Leucopogon polymorphus	*				
Leucopogon propinquus	*				
Lomandra sp.[1]	**				
Lysinema ciliatum	*				
Macrozamia riedlei	*				
Melaleuca scabra	**				
Patersonia occidentalis	*	*			
Petophile drummondii	**				
Petrophile linearis	*	*			
Petrophile striata[1]	*				
Phlebocarya ciliata		**			
Scholtzia involucrata	**	**			
Stirlingia latifolia	*		**		
Thomasia grandiflora[1]	**				
Thryptomene saxicola	*				
Verticordia densiflora[1]	**				
Verticordia huegelii[1]	**				
Verticordia nitens	**				
Xanthorrhoea gracilis[1]	*				
Xanthorrhoea preissii	*	*			
Xylomelum occidentale[1]	*				

[1]Data from Podger (1968). Unless confirmed by direct root plating, only those species that were rated as severely affected by the disease were included in the table.

2Pc = Phytophthora cinnamomi, Pmm = Phytophthora megasperma var. megasperma, Pcit = Phytophthora citricola, Pd = Phytophthora drechsleri, Pms = Phytophthora megasperma var. sojae.

3* = susceptibility determined from visual symptoms, ** = susceptibility confirmed by recovery of the fungus from infected plants (direct root plating).

8.2 *PHYTOPHTHORA* SPECIES NORTH OF PERTH

In May 1989, *Phytophthora cinnamomi* was recovered from dying vegetation near Eneabba. This is the only known outbreak of *P. cinnamomi* north of the Moore River, a distance of over 150 km. The Lesueur Area is situated 20 km to the south of the diseased site. Four other *Phytophthora* taxa are also known to occur in the northern kwongan. Current knowledge of the distribution and impact of each species is outlined below.

8.21 *Phytophthora cinnamomi*

Phytophthora cinnamomi is widely distributed in, and is a major threat to the banksia woodlands that surround Perth (Shearer and Hill 1989). It destroys the structure and diversity of the woodland, killing most of the overstorey and shrub layer in affected areas. Species that have been recorded as susceptible to *P. cinnamomi* on the Swan Coastal Plain and the Lesueur area are listed in Table 8.1. *Phytophthora cinnamomi* causes greatest impact among species that belong to the families Proteaceae, Epacridaceae, Myrtaceae, Dilleniaceae, Papilionaceae and Xanthorrhoeaceae. The other *Phytophthora* species attack the same suite of plant families.

The incidence of *P. cinnamomi* infections decreases north of Wanneroo. Only one infection has so far been discovered in the Moore River National Park. At this site, the geographically restricted *Banksia laricina* is being killed.

On the Woodada access road, 5 km west of Eneabba, *P. cinnamomi* has been recovered from a site situated on the wide flood plain of the Eneabba Creek. *Phytophthora cinnamomi* A2 has been isolated from the roots of *Banksia menziesii*, *Banksia telmatiaea* (culture identified by R. Hart), *Conospermum triplinervium* and *Petrophile drummondii*. Another *Phytophthora* species (possibly *P. drechsleri*) has been recovered at the same site, from a dying *Calothamnus hirsutus*. Other affected species include *Stirlingia latifolia*, *Astroloma* sp., *Allocasuarina humilis*, *Verticordia densiflora* and *Thryptomene saxicola*. The mortality rate among susceptible species is moderate to low at present. However, the pattern in similar sites in the region indicated the likeleyhood of an increase in impact following inundation and re-infection of the banks and flood plain each winter. The downstream course of Eneabba Creek, which flows for another 6 km through Lake Logue Reserve before emptying into Lake Logue, must already be infected.

8.22 Other *Phytophthora* species

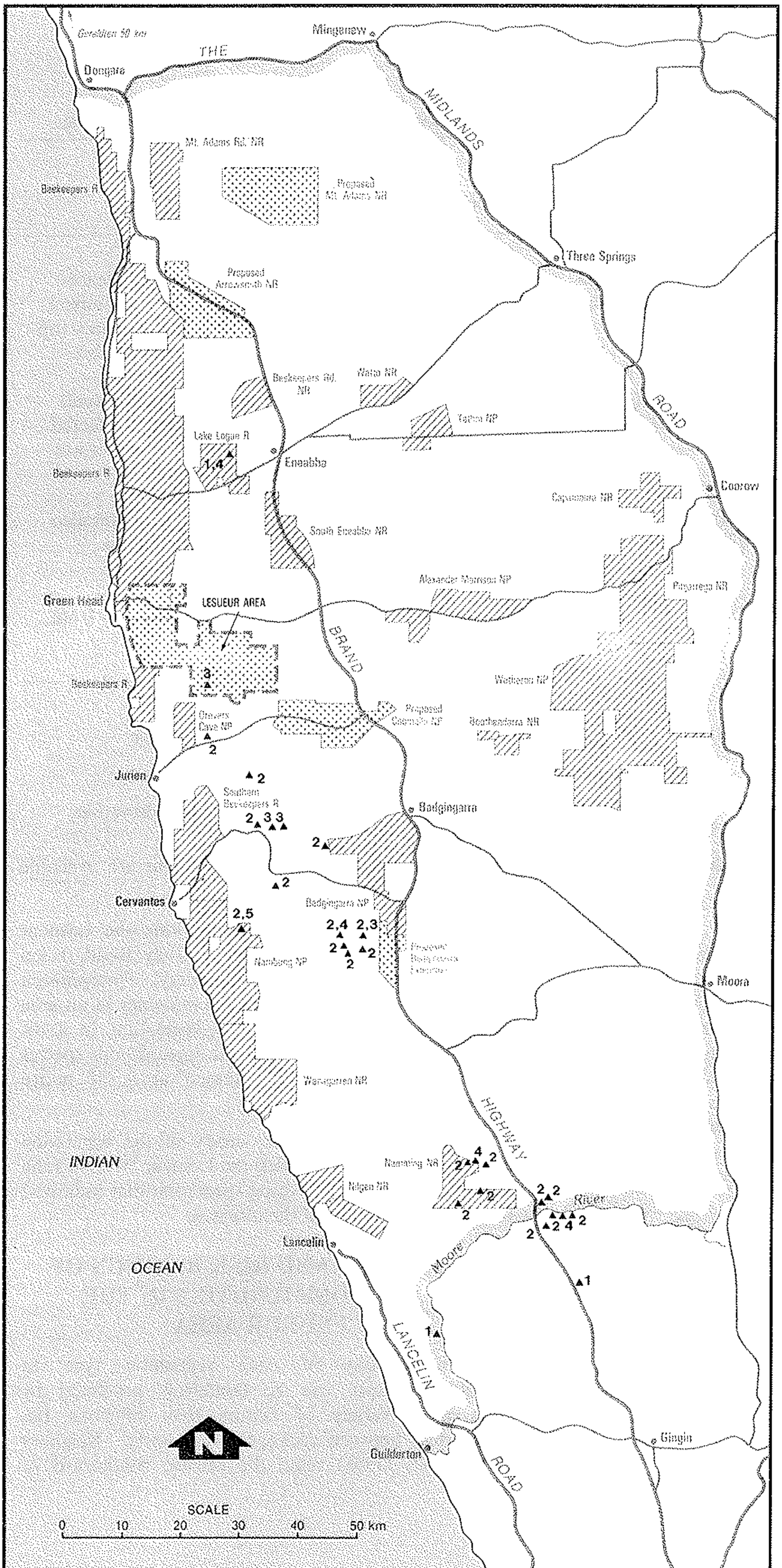
Current knowledge of the distribution and impact of other *Phytophthora* species in the northern sandplains is summarised in Table 8.2, (species killed are listed in Table 8.1; see Figure 8.1 for location of infections):

Seasonally wet conditions clearly assisted the establishment and impact of all *Phytophthora* species (including *Phytophthora cinnamomi*) at every infection north of Moore River. Sites were low lying and prone to flooding, bordering drainage lines or receiving off-road drainage. At two roadside sites, disease symptoms only appeared after modification of the road verge and resultant ponding of water.

The consistent association of disease with sites prone to seasonally wet conditions cannot be assumed to indicate that the disease will, in future, be confined only to these areas. These sites carry a high risk of infection and so would be expected to be the first to be contaminated. Without knowledge of the age of the infections, the fate of surrounding vegetation can not be predicted. *Phytophthora cinnamomi* in the Moore River National Park also appeared initially in a high risk location (along a creek line), and is now encroaching upon, and destroying, the surrounding banksia woodland. A similar sequence of establishment and expansion was evident in a series of aerial photographs of a large diseased site at Gnangara (Shearer and Hill 1989). *Phytophthora cinnamomi*, associated initially with a strawberry farm before 1942, had, by 1953, contaminated a nearby complex of ephemeral swamps. Subsequent photographs, taken at decade intervals, show the disease fronts slowly (1.1 m/yr), but steadily, advancing upslope into freely drained woodland, killing all banksias and most shrub species in the process.

Little information is available on the comparative virulence of each species against indigenous hosts. Hill (unpublished data) compared lesion lengths produced by three *Phytophthora* species, *P. cinnamomi* (IMI 264384), *P. citricola* (IMI 329667, isolated from *Banksia prionotes* at Badgingarra) and *P. megasperma* var. *megasperma* (IMI 329668, isolated from *Banksia attenuata* at Regans Ford), inoculated into stems of *B. attenuata*. Fifteen stems were wound-inoculated in early September, each with all three isolates at separate points along the stem, and harvested forty two days later. Mean total lesion lengths, for *P. cinnamomi*, *P. citricola* and *P. megasperma* var. *megasperma* were 30.2_a, 25.8_a and 19.1_b cm respectively (dissimilar letters indicate a significant difference between results, $P < 0.05$). *Phytophthora cinnamomi* also grew significantly faster than several other *Phytophthora* species, including *P. citricola*, and *P. megasperma* var.

Figure 8·1
PHYTOPHTHORA SPECIES NORTH OF GUILDERTON



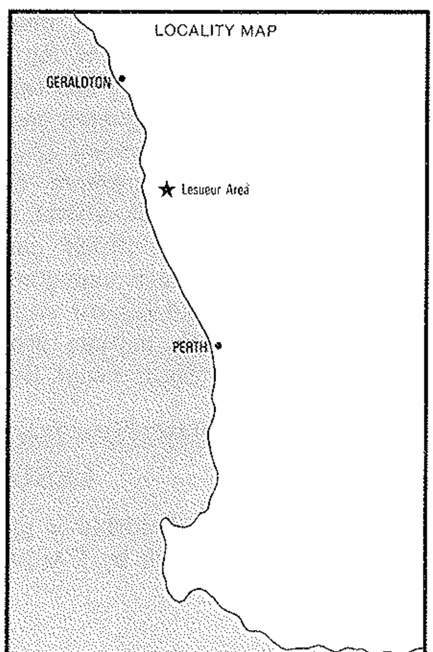


Table 8.2

Distribution and impact of *Phytophthora* species (except *P. cinnamomi*) north of Moore River National Park.

Pathogen	No.[1]	Physiographic regions[2]	Topography[3]	Vegetation Types Affected[4]	Impact
Phytophthora megasperma var. *megasperma*	15	BD, DP(s)	RV(sw), D (sw), DL, F	BLW, BLW(os), SH, LH	Initially only scattered deaths. With succesive winters, impact increases, esp. in overstorey (up to 100%).Single deaths also.
P. citricola	5	BD, DP(s)	RV(sw), D(sw) BLW,	BLW(oh), XH	Single roadside deaths. Small foci with most species affected. Scattered deaths in winter wet depressions.
P. drechsleri	3-4	BD, DP(s), EP?	RV(sw), D (sw), DL	BLW, BLW (os)	Only recovered from sites also infected by other species. Recovered from 3 spp.
P. megasperma var. *sojae*	1	BD	F	LH	Not known. Isolated only from *Banksia prionotes.*

[1]Number of occurrences.

[2]After Playford et al. 1976. BD = Bassendean Dunes, DP(s) = scarp region of the Dandaragan Plateau, EP = Eneabba Plain

[3]RV(sw) = seasonally wet road verges, D(sw) = seasonally wet depressions, DL = drainage lines, F = flood plains·

[4]BLW = banksia low woodland, BLW(os) = open banksia low woodland over sedges, BLW(oh) = open banksia low woodland over heath, SH = scrub heath, LH = low heath, XH = Xanthorrhoea heath (structural classification following Muir 1977).

sojae, in inoculated stems of *Banksia grandis*, though no such disparity occurred in stems of *Eucalyptus marginata* (Shearer *et al.* 1988).

Further variation exists between *Phytophthora* species regarding the types of survival spores they produce and in their tolerance of temperature extremes. *Phytophthora citricola*, *P. megasperma* var. *megasperma* and *P. megasperma* var. *sojae* readily produce thick-walled, desiccation-resistant oospores (sexual spores). On the other hand, *Phytophthora cinnamomi* and *P. drechsleri* only produce oospores when both mating types are present. Only one mating type of *P. cinnamomi* (A2) is prevalent in Western Australia. *Phytophthora cinnamomi* does, however, form an asexual survival spore: the chlamydospore. *Phytophthora drechsleri* possesses an unusually high tolerance to high temperature. A *P. drechsleri* isolate from the Badgingarra area grew well at 35°C, 4°C higher than the maxima recorded for *P. cinnamomi* and *P. citricola* (Shearer *et al.* 1987).

8.3 *PHYTOPHTHORA* SPECIES AT LESUEUR

Few data are available on plant diseases in the Lesueur Area. Research by CALM in the northern kwongan commenced only in 1987, and few data are available from other sources.

There is one known infection within the Lesueur Area. This is beside Cockleshell Gully Road, 1 km north of the Area's southern boundary. *Phytophthora citricola* was isolated from *Banksia prionotes* in an area of otherwise apparently healthy vegetation in 1988. South of Jurien Bay Road several *Phytophthora* species have been isolated from diseased areas of native vegetation.

A visual reconnaissance survey of the vegetation along roads and tracks within the Lesueur Area in June 1989 did not reveal any dying vegetation that indicated the possible presence of the diseases.

8.4 HAZARD AND RISK RATINGS OF PLANT COMMUMITIES IN THE LESUEUR AREA

The susceptibility of each vegetation type to *Phytophthora* spp. can be tentatively predicted by assessing a variety of factors that influence the relationship between pathogens and hosts. Keighery and Tippett (1986) rated the disease risk/hazard of south coast vegetation types by giving each a disease risk/hazard score, based on the following queries:

1. Climate. Warm, moist conditions for part of the year?
2. High concentration of susceptible species present?
3. Are susceptible species the dominants in the community?
4. Is the risk of infection high? (amount of human use, and position in the landscape)
5. Do conditions favour the spread of the fungi?
6. Do soil characteristics suggest that conditions are favourable for the fungi?

The risk rating of a vegetation type predicts the ease with which it could become infected, and is determined mainly by its position in the landscape, its soil type and its proximity to roads and drainage lines. Risk rating is covered in point four of the above list. The other five questions address the hazard rating of the community, which reflects the likely impact of disease on the vegetation.

In a high priority nature conservation area, such as the Lesueur Area, the risk rating of a plant community becomes somewhat meaningless, as the only acceptable risk, for long term management of the Area, is no risk at all. For this reason, the risk and hazard ratings have been separated. Hazard ratings will be scored out of five; the higher the score, the more acute the likely impact. Risk will be given a subjective rating of low, medium or high.

Some comments on the hazard rating categories are given below:

Climate. The Lesueur Area receives virtually the same amount of annual rainfall, around 600 mm, as the severely diseased Stirling Range National Park, though it has drier summers (Figure 8.2). Most rain falls between May and September, a time when temperatures are comparable with late spring and early autumn at Stirling Range. In the jarrah forest, Shearer and Shea (1987) recorded the highest recoveries of *P. cinnamomi* from surface soil in mid- and late-winter, from both upland and lowland sites.

Another strong indicator of suitable climatic conditions for the fungi in the Lesueur Area is the presence of "outlying populations of species from mesic environments to the south" which "may reflect an amelioration of the general climate" (Hopkins and Griffin 1984). Overall, the relatively warm conditions in the area during winter provide a five month window for establishment and activity of *Phytophthora* spp.

The harsh summer conditions in the area will, however, not preclude survival of the fungi in the soil. At Gnangara, *P. cinnamomi* survived in 63% and 14% of colonised pine plugs buried for one and two years respectively. Plugs were buried at a depth of 0.3 m in banksia woodland growing on Bassendean sand. Survival rate of the fungus was even greater in plugs buried at 1.3 m, easing from 100% to 88% over the same period. Soil moisture in summer dropped to 0.6% of dry soil weight at 0.3 m (T.C.J. Hill, unpublished data).

The region also occasionally receives heavy rain in summer. In February of 1986, for example, Jurien received 164 mm; in 1976, 93 mm; and in 1970, 90 mm. If Greenhouse Effect predictions are correct, cyclonic influences and summer rainfall will increase in both frequency and intensity, thereby increasing the potential dieback hazard.

Abundance of susceptible species. The abundance of susceptible species in a plant community is, possibly, the most important factor in determining its hazard rating. Jarrah forest, banksia woodlands, banksia shrublands, proteaceous thickets, scrub heath and heath, all of which contain an abundance of susceptible species, are the most severely affected communities in south-western Australia. When the community is dominated by susceptible species, conditions for the fungus can become so favourable that it can virtually uncouple itself from the edaphic environment, and spread by growing within roots of susceptible plants; infecting new hosts at points of root to root contact. The Bell Track infection in the Fitzgerald River National Park appears to be operating in this manner, devastating *Banksia baxteri*/*Lambertia inermis* shrubland growing in deep sand, at a site that receives only 390 mm of annual rainfall.

Soil and Topography. Soil profile and topography are closely related. In the uplands of the Lesueur Area, soils on steep slopes are usually skeletal and impeding, the impeded drainage assisting the rapid, lateral spread of zoospores, but this characteristic would, however, also hinder the establishment of the fungus because the soil would dry quickly. Colluvial accumulation on lower slopes builds either poorly-drained loams and clay soils or deep, well-drained, siliceous sands. The latter, because of their low fertility, are often dominated by highly susceptible proteaceous species. Soils on uplands tend to be moderately impeding due to the presence of duricrust near the surface, but their small gradients do not promote lateral sub-surface flow.

Susceptible Vegetation Types. Table 8.3 gives the hazard and risk ratings of major plant communities in the Lesueur Area. The eastern sector of the Area contains many vegetation types with high hazard ratings. By contrast, the western (coastal plain) sector contains only one potentially threatened community: banksia low woodland on Bassendean Dunes. This vegetation type occurs only as a small intrusion between the Peron Slopes and Spearwood Dunes landforms.

The hazard ratings of five eastern sector vegetation types (of Martinick and Associates 1988) were scored as very high (4-5 to 5). They are:

C - *Hakea neurophylla/Banksia tricuspis* heath
D - *Petrophile chrysantha* heath
H - *Petrophile seminuda* heath
M1 - *Verticordia densiflora* heath
X - *Allocasuarina campestris* Thicket

These communities are characteristically dominated (often with 50-100% foliage cover) by susceptible species, as well as containing a high concentration of associated susceptible elements. *P. cinnamomi* would probably completely destroy the present structure and significantly reduce the diversity of these communities. Complete or localised extinction of some plant species is also likely. Importantly, these vegetation types occur on a wide range of positions in the landscape, including uplands, slopes, low rises, middle to lower slopes, lower slopes, drainage lines and depressions. As in the Stirling Range, position in the landscape does not confer immunity to the disease. If *P. cinnamomi*, or any other *Phytophthora* species, is introduced, its impact would not simply be confined to low-lying, water-gaining sites.

Six other heath associations (types A,B,E,F,G and J) were rated between 3 and 4. Types A and B, the sand and lateritic heaths, contain a wide variety of sub-types; some significantly more vulnerable than others by virtue of the presence of one or more susceptible dominants. The likely impact of disease in these moderate to high hazard types is not possible to predict, though the low-lying, medium to high risk E,F,G and J associations would inevitably harbour the disease and consequently incur some level of damage.

Experience in other parts of south-western Australia, as well as in parts of south-eastern Australia, suggests that there is a high probability of introduction of *Phytophthora* spp. when extensive use of earth-moving equipment or vehicles takes place in a highly susceptible area.

The recent construction of numerous exploratory roads and drilling tracks by the mining companies was carried out under strict dieback hygiene controls. However, the opening up of large, previously inaccessible areas to both two-wheel drive and four-wheel drive vehicles presents an unacceptable hygiene risk to the Lesueur Area, and is, of course, disturbingly reminiscent of other case histories. There are no hygiene controls on the use of the area by private vehicles.

8.5 POSSIBLE IMPACT OF *PHYTOPHTHORA* IF INTRODUCED

The Bitter Pool Rises unit contains the greatest abundance of high hazard vegetation types in the Lesueur Area, with significant expanses of types D, H and M1, as well as DEH and FGH mosaics. The Gairdner Dissected Uplands unit also contains large areas of highly susceptible heaths, particularly types D, H, DFH, DFG, FGH and AE. Banovich Uplands contain fewer of the highly susceptible vegetation units. However, amongst the widespread lateritic and sand heaths are sub-types of moderate to high susceptibility. The highly susceptible types D and M1 occur in places.

Of the seven Declared Rare flora species in the Lesueur Area, at least one, *Banksia tricuspis*, would be seriously threatened if dieback was introduced. It occurs in C1 and B1.1 vegetation sub-types, both of which were scored as high to very high hazard. Localised extinction is possible. *Hakea megalosperma*, though probably susceptible to *P. cinnamomi*, occurs in less susceptible, lateritic heath communities.

Based on current Herbarium information and field studies, nine plants are entirely restricted to the Lesueur Area. Of these, five belong to susceptible genera (or in the case of *Eucalyptus*, informal sub-genera). A further 24 species have between 50% and 100% of known populations confined to the Lesueur Area. Fourteen of these belong to susceptible genera (Table 5.6).

Of the 111 geographically restricted and/or rare species listed in Appendix 2 that occur in the Lesueur Area, 60 belong to susceptible genera.

Outlying occurrences of several species, particularly *E. marginata*, may also be at risk.

Overall, dieback diseases have the potential to cause major degradation of the nature conservation values of the Lesueur Area if the area is not protected, properly quarantined and managed. Stirling Range National Park provides a warning of the problems that could occur (R. Wills pers. comm.).

Table 8.3

Hazard and risk ratings of major plant communities in the proposed LesueurArea. A hazard rating of 4 to 5 indicates high to very high disease hazard.

Vegetation Type	Hazard (0-5)	Risk (Low-High)	Comments
Eastern Sector[1]			
A (Sand heath)	3-4	Low	types A1,A2.1,A2.2 probably higher hazard than others
B (Lateritic heath)	3-4	Low-Medium	types B1.1,B1.3,B3.1 probably higher hazard than others
C (*H. neurophylla* heath)	4-5	Low-Medium	
D (*P. chrysantha* heath)	4-5	Low-Medium	
E (*Ecdeiocolea* heath)	4	Medium-High	
F (*H. erinacea* heath)	4	Medium	
G (*M. platycalyx* heath)	3-4	Medium	
H (*P. seminuda* heath)	4-5	Medium-High	
I (*G. spinosum* scrub)	3	Low-Medium	
J (*C. quadrifidus* heath)	4	High	
K (*E. wandoo* woodland)	2	Low	
L (heath)	3	High	
M1 (*V. densiflora* heath)	5	High	type M2: low hazard
SUB-TYPE X (*A. campestris* thicket)	4-5	High	
Western Sector[2] (west of Peron Slopes)			
$b_{1/2}L_i$ (Banksia low woodland)	4	Low-Medium	
x_9SZc (heterogeneous scrub-heath)	3	Low	
$x_6SZc/e_{44}Lp$ (Illyarrie scrub-heath)	2-3	Low	
$a_{26}m_4Zc/a_{23}m_3Sc$ (coastal thicket)	1	Low	

1 = Vegetation classification of Martinick and Associates(1989d)

2 = Vegetation classification of Beard (1976)

Chapter 9

LANDSCAPE VALUES

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Abstract

In terms of landscape values, the Lesueur Area encompasses some of the most attractive countryside to be found in the northern kwongan. The Gairdner Range, with its distinctive mesa landforms, is an area of high scenic appeal. Within the Range, one is confronted by ever-changing vistas of steep breakaways, low hills and gullies with eucalypt woodlands set amongst heath-covered slopes. The heathlands themselves, when viewed more closely, reveal a rich tapestry of plant forms, colours and textures.

9.1 INTRODUCTION

Western Australians have in recent times demonstrated an increasing concern over the quality and appearance of the visual environment. This is perhaps a reflection of the growing interest in the community in national and global environmental issues as well as the accelerating rate of environmental change which is occurring locally. Whatever the reasons, public interest in land planning decisions and management operations is on the increase and in many instances it is at least partially linked to how sensitively changes to the landscape have been accommodated and managed.

Many land uses and management practices can and often do significantly change the character of the landscape. Such uses and practices, while they may be scientifically or technically correct, do not always result in visually attractive landscapes. Where operations are not carefully planned and executed, the result can be long term or permanent degradation of the visual resource. In many instances, it is this very loss of scenic quality associated with environmental change that is most apparent to the public and which results in criticism of land-use activities. Often this can be avoided through sensitive planning and management of the visual resource.

Landscape or visual resource management as it is frequently termed is concerned with the conservation and management of land, vegetation and water resources in ways that either maintain or improve the visual quality of the environment. The prime goal of landscape management is to ensure that all uses and activities are planned and implemented so as to complement rather than detract from the inherent visual qualities of the environments in which they occur. As such, landscape management is a positive and integral component in the land use planning and management process. It should not be regarded as a cosmetic exercise in which the results of careless land use planning and development are hidden from view or superficially treated to make them more palatable to the viewing public.

9.2 THE BASIS FOR LANDSCAPE MANAGEMENT ON PUBLIC LANDS MANAGED BY CALM

Landscape management is based on the premise that the visual quality of any landscape is a resource in its own right which can be assessed and managed in much the same way as other resource values such as fauna, flora, water, timber and recreation. As used in this context, the term landscape refers to the appearance or visual quality of an area as determined by its geology, soils, landforms, vegetation, water features and land use history.

Managing this visual resource is dependent on the knowledge and assessment of the landscape itself as well as a thorough understanding of proposed land use(s). After the various landscape elements have been identified and assessed, it is possible to evaluate how particular management alternatives will effect the appearance of any landscape and to develop subsequently appropriate landscape prescriptions compatible with other resource management objectives.

In the past two years, the Department of Conservation and Land Management (CALM) has adopted a systematic approach to compiling an inventory and assessing landscape values based on systems now operating in other Australian States and overseas. Referred to as the Visual Resource

Table 9.1.

Northern Kwongan Landscape Character Type

Scenic Quality	Landform	Vegetation	Waterform	Land Use
GENERAL DESCRIPTION	*Broad, flat to undulating sandplain ranging in elevation from 30-250 metres (highest in the eastern section) with pronounced escarpments and low ranges (up to 300 metres); some areas of exposed limestone and sandstone outcropping	*Coastal heathlands and scattered banksia/eucalypt woodland; extensive agricultural pastoral clearing throughout much of the type	*Numerous small streams and intermittent creeks; some larger streams and rivers which drain from east to west across the coastal plain; numerous wetland areas, primarily in the southern portion of the type.	*Combination of reserves and vacant Crown land supporting native vegetation with extensive freehold land supporting grazing and grain growing.
HIGH	*High rounded hills with steep slopes, mesa topped ranges and escarpments to 300 metres in elevation with sharp breakaways. *Steep sided gorges and strongly dissected valleys.	*Areas of high plant diversity (structural and/or species richness) which display distinctive textural and colour patterns. *Pockets or bands of vegetation which become focal points due to relative height, position in landscape, isolation or colour contrast..	*Larger wetlands, river pools and other permanent water features. *Steep sided gorges or valleys associated with major river drainages	*Large expanses free of human disturbance or developments such as roads/firebreaks and where edge contrasts are not evident. *Spot developments which are in harmony with naturally established forms, lines, colours and textures.
MODERATE	*Gently undulating plains and rounded hills similar in gradient to surrounding landforms and which are not visually distinctive or prominent.	*Some structural and seasonal colour patterns evident in vegetation, but lacking in uniqueness or distinction relative to surrounding vegetation. *Gradual transition between heathland and woodland communities.	*Seasonal wetlands, intermittent streams and creeklines.	*Pastoral/agricultural landscapes in which clearings, firebreaks, roads and other human imposed developments borrow significantly from natural patterns; some discordant visual impacts apparent.
LOW	*Expansive plains with little or no dissection and with limited topographic features of specific visual interest.	*Extensive areas/vistas of similar vegetation cover with little or no structural diversity or colour/texture changes.	*Waterforms absent.	*Developments in which the form, line, colour and texture of introduced elements contrast markedly with natural features.

Management (VRM) system, this approach enables scenic values to be described, evaluated, compared and mapped with a minimum amount of subjectivity (Leonard and Hammond 1984; Williamson and Calder 1979). To date, landscape values in the Department's Southern Forest Region and several National Parks throughout the State have been classified and mapped using this system.

9.3 REGIONAL LANDSCAPE CONTEXT

The significance and importance of the Lesueur Area as a landscape resource can only be appropriately evaluated by first placing the area in a broader, regional context. The identification and description of what are termed Landscape Character Types is central to the methodology employed by CALM in assessing visual resource values.

All landscapes have differing physical characteristics and hence visual qualities. These are a result of the effect which geologic, hydrologic and other natural processes as well as climate and land use have on landform and landcover patterns. In simple terms, a Landscape Character Type represents a broad-scale area of common distinguishing visual characteristics as identified by these elements.

Thus for the purpose of this assessment, it has been necessary to extend the classification into a region in which the visual resource has yet to be extensively surveyed, assessed and mapped. Consequently, the information contained in this report is of a preliminary nature and will require further field and office assessments to verify.

Two landscape character types have been identified in the area which is bounded by the Lesueur Area. The first is what has been tentatively labelled as the Northern Kwongan Landscape Character Type. This type covers the bulk of the reserve including Mt Lesueur and the other nearby peaks, slopes and drainages of the Gairdner Range. In addition, the seaward portion of the proposed reserve extends into a separate Coastal Landscape Character Type.

Delineation of each of these types has been based on a brief field assessment of the physical landscape and its overall visual appearance. For each type, descriptive criteria termed "frames of reference" have been established to help in assessing the scenic quality components which exist. While all landscapes have some value, some are of greater scenic attraction and importance than others. To assess such differences, CALM's Visual Resource Management System recognizes three classes of relative scenic quality - High, Moderate and Low. The description of these three classes for various landscape components - landform, vegetation, waterform and land use - is outlined in Tables 9.1 and 9.2.

The landscape encompassed by the Lesueur Area is of major regional significance and importance. The Gairdner Range, which includes Mt Lesueur, Mt Michaud and Mt Peron, contains some of the highest and most scenically attractive landforms within the Northern Kwongan Landscape Character Type. The first two of these peaks, with their distinctive tableland or mesa shapes, are visible on the skyline up to 15km away from various vantage points along the Jurien and Coorow-Green Head Roads and the Brand Highway. Only the Morseby Range north and east of Geraldton contains topography of comparable scenic appeal.

West of the Gairdner Range and Peron Fault, the Lesueur Area extends seawards across a broad, relatively flat sandplain to the coast. Here a line of outer reefs and small islands and an extensive chain of salt lakes which parallel the coastline provide added visual interest to an otherwise unspectacular seascape.

In terms of vegetation, much of the sandplain and uplifted lateritic range is dominated by low heath. This land cover is remarkably uniform in height and therefore displays little structural diversity when viewed from a distance. Nevertheless, the heathlands impart an attractive texture to the landscape and provide a distinctive contrast to the cleared grazing lands which border the areas proposed for reservation.

The real visual appeal of the heathland communities, however, is at a microscale. Closer inspection reveals a myriad of plant forms, colours and textures of incredible richness. This diversity is particularly evident during the winter and spring months, when a large proportion of the more than 800 species which are found in the Lesueur Area are in flower.

Amongst the dissected landforms of the Gairdner Range, the vegetation displays more structural diversity. Here, pockets of wandoo and marri woodland are scattered across many of the lower hillsides and along the valleys, adding considerably to the scenic appeal of this escarpment. A brief description of the more distinctive visual attributes and values of these landforms follows.

9.4 LANDSCAPE DESCRIPTION AND ASSESSMENT

The Lesueur Area contains a number of distinct and mappable landforms. Three of these, the Quindalup, Spearwood and Bassendean Dunes, combine to form the Coastal Landscape Character Type (LCT). Another five landforms, referred to as the Peron Slopes,

Table 9.2

Coastal Landscape Character Type

Scenic Quality	Landform	Vegetation	Waterform	Land Use
GENERAL DESCRIPTION	*Coastal Landforms include extensive sand beaches, dunes (both consolidated and mobile), offshore reefs, stacks and islands, high cliffs, headlands and coastal gorges.	*Range of vegetation communities including dune grasses, coastal heathlands, woodlands and mangrove thickets.	*Indian Ocean, numerous streams and rivers, extensive embayments and tidal estuaries.	*Several urban centres and numerous smaller coastal towns; some squatter settlements and scattered shacks; various recreation access points, some with developed areas and facilities.
HIGH	*Cliffs and headlands. *All islands, stacks, offshore sandbars and reefs. *Rock features, caves, faultlines, obviously banded sedimentary rocks. *Irregular coastline edges often emphasised by distinctive rock outcropping bays, inlets, and sand deposition patterns. *Primary dunes which display areas of active weathering, steep slopes and/or sandblown edges.	*Windshaped, gnarled or dwarfed vegetation unusual in form, colour or texture. *Single tree, shrubs or patches of vegetation which become focal points due to isolation or position in relation to rocks or water. *Strongly defined patterns of woodland, dune vegetation Melaleuca scrub, mangrove thickets and/or barren rock.	*All estuaries, inlets, lakes and swamps. *Unusual ocean shoreline motion as eddies due to islands, reefs, surf zones and shoreline configuration.	*Long stretches of coastal landscape free of human development and disturbance. *Spot developments which are in harmony with naturally existing forms, lines, colours and textures.
MODERATE	*Expanses of beach of uniform width and colour without rock outcroppings or local features. *Regular coast edges without bays, inlets, promotories, stacks or cliffs.	*Predominantly heath or beach grasses with some variation in colour, texture or pattern. *Some contrast caused by different colours.	*Uniform ocean shoreline and motion characteristics with little diversity.	*Coastal areas in which human-imposed developments/disturbance s borrow significantly from natural landscape patterns; some discordant visual impacts apparent.
LOW	*Expanses of uniform (indistinctly dissected) landform.	*Extensive areas of similar vegetation such as heath or beach grass, with very limited variation in colour or texture.	*Water, where present rates no lower than moderate in this LCT.	

*Highly developed or disturbed areas with little or no vegetation cover.
*Townsite, housing, harbour and other developments in which form line, colour and texture of introduced elements contrast markedly with natural features.

Lesueur and Gairdner Dissected Uplands, Banovich Uplands and Bitter Pools Rises, make up the Northern Kwongan LCT. These landform units are referred to in describing the visual resources of the Lesueur Area.

9.41 Coastal Landscape Character Type

The portion of the coast adjacent to the Lesueur Area boundaries is of Moderate Scenic Quality (refer to Table 9.2 for descriptive criteria). Along the coastline, the Quindalup Dune system appears as a series of low (10-25 metre high), sparsely vegetated sandhills. Many of these appear poorly consolidated and there are several large expanses of mobile dunes.

Immediately east of the foredunes, a chain of salt lakes and swamps extend in a north-south direction parallel to the beach front. These water bodies are a prominent and attractive coastal feature, particularly when viewed from the Upper Peron Slopes along Cockleshell Gully Road or from on top of the Range. To the west, the seascape is enhanced by the wave break over the reef, rock stacks and small islands which are situated within a few kilometres of the coast. Collectively, these features provide visual diversity to the landscape in the form of edge and colour contrast.

Towards the east of the coastal plain, the Spearwood Dunes and a narrow band of Bassendean Dunes gradually rise to join the lower slopes of Mt Peron and the Gairdner Range. Cockleshell Gully, which traverses the coastal plain to the south of the Lesueur Area represents the only significant drainage within this viewshed.

Development within the Coastal LCT is primarily restricted to the Jurien and Green Head townsites and the major access roads which service these centres. In addition, there are numerous squatter shacks sprawled among the dunes north of Green Head. Adjoining the proposed reserve some freehold land has been cleared for grazing and there are several farms situated along Cockleshell Gully Road. While some of these developments are visually intrusive, they do not dominate or significantly detract from the natural character of the coastal landscape between Jurien and Green Head. The squatter shacks north of Jurien are an obvious visual blight, particularly when viewed at close range, but many of these structures are partly hidden from view and are not evident from within the Lesueur Area.

9.42 Northern Kwongan Landscape Character Type

When viewed from the coast, the Gairdner Range appears as an elongated ridge which rises above the flat coastal plain. This western flank of the Range comprises the Peron Slopes, a gradual incline with relatively little dissection apart from Cockleshell Gully. Covered in kwongan with emergent "forests" of scattered blackboys, these slopes are of Low to Moderate Scenic Quality.

Cockleshell Gully Road, which dissects this landform unit in a north-south direction, affords panoramic views over the coastal plain. East from this road, several narrow sand tracks and fire breaks lead to the summit of the escarpment and the dissected uplands beyond. Some of these tracks cut directly across the contour, visually scaring these largely unblemished slopes.

Immediately east of the escarpment, the landscape dramatically unfolds, revealing numerous hills, valleys and breakaways to the east and north. These are the Lesueur and Gairdner Dissected Uplands (Figure 3.3), the central core of the Gairdner Range and a landscape of High Scenic Quality. Further to the east and north, portions of the Banovich Uplands and Bitter Pool Rises as well as other more distant landforms, some up to 25 km away, are clearly visible. To the west, views of the coastline and Indian Ocean complete this superlative panorama.

Once on top of the escarpment, one can look down upon a large basin partially enclosed by the steep eastern flanks of Mt Peron, Mt Michaud and Mt Lesueur and by the Lesueur Fault further east. Cockleshell Gully, which arises on the eastern side of the Range, passes through this depression. The basin floor is in fact quite undulating, consisting of a maze of low hills, ridges, breakaways and shallow valleys. Some of the steeper slopes and breakaways have exposed outcrops of sandstone and extensive pockets and bands of eucalypt woodland scattered across the heath-covered slopes and valleys.

From the eastern edge of the Range, the distinctive tabletop forms of Mt Lesueur and Mt Michaud are particularly prominent, while Mt Peron dominates the northwestern skyline. One is also afforded a spectacular enframed ocean view across the dissected uplands, where Cockleshell Gully cuts through the Peron Slopes.

This is, in summary, an area of high scenic appeal owing to the diversity of landforms and vegetation associations and the textural and colour patterns associated with these. In virtually every direction, one is confronted by an everchanging landscape of steep breakaways, low hills and gullies with sculptural eucalypt woodlands set amongst the heath-covered ranges. The only negative visual intrusion on this otherwise pristine landscape is the network of firebreaks and access tracks which crisscross the

Ranges. While many are reasonably located, others are situated on steep slopes and extend across prominent viewsheds, partially spoiling what would otherwise be outstanding views.

East of the Lesueur and Gairdner Uplands, the landscape broadens out into a series of low undulating hills, flats and broad valleys. Topographic relief is more pronounced to the south, gradually decreasing further northwards. This is the area referred to as the Banovich Uplands and Bitter Pool Rises, a zone of Moderate Scenic Quality.

The eastern section of the Lesueur Area is covered with kwongan with emergent blackboys and scattered, stunted eucalypts. Sweeping views are available to the north, east and south across a mosaic of pasture lands and heath-covered hills while to the west, the eastern margin of the Gairdner Range forms a visual enclosure. Apart from some adjoining and more distant agricultural clearing, the only human visual intrusions on this landscape are several tracks, firebreaks, cleared mining drill rig sites, fencelines and a small number of scattered farm structures.

Chapter 10

RECREATION AND EDUCATION VALUES

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Abstract

Recreational and educational values, while not well documented, are nevertheless of major regional importance. Although the Lesueur Area has not been widely promoted and is relatively distant from major population centres, it presently attracts a wide range of recreational use, including nature study, sightseeing, photography, bushwalking, camping and four-wheel driving. Indications are that visitation levels have increased in recent times. This trend is likely to continue, particularly as the area becomes better known. Given adequate protection through reservation and management, the Lesueur Area has the capacity to attract and sustain a much higher level of public use than at present. Opportunities for interpretation of the natural environment are also numerous.

10.1 INTRODUCTION

The Department of Conservation and Land Management (CALM) has a statutory responsibility to ensure that recreational opportunities and educational values are sensitively managed and promoted on the public lands and waters entrusted to it. This is reflected in the Department's enabling legislation and its Strategic Plan which includes among its five primary management objectives the following:

> Recreation : To facilitate the public enjoyment of the natural attributes of public lands and reserved waters in a manner that does not compromise conservation and other management objectives.
>
> Knowledge : To seek a better understanding of the natural environment and to promote awareness and appreciation of its values.

Achievement of these two objectives is dependent on the reservation of adequate natural areas capable of attracting and sustaining public use. Once reserved, it is imperative that these areas are carefully managed so as to protect them from inappropriate activities or excessive use.

Presently some 17 million hectares of land or approximately 6.5% of Western Australia have been gazetted as National Parks, Nature Reserves, State Forest or given similar reserve status. Of this total, nearly 10 million hectares has been specifically reserved for the conservation of fauna and flora, with the remaining 7 million available for a range of other uses including recreation.

Apart from the more obvious commercial values associated with water, timber, fauna and flora, CALM lands are also of immeasurable economic and social value for community recreation, tourism, education and scientific study. It is sometimes argued that reserving land in National Parks or other reserves reduces their commercial value and utility. On the contrary, the opposite is more often the case. Western Australia in recent years has begun to reap the enormous financial benefits which its natural environments provide in terms of attracting recreation and tourism dollars and generating foreign exchange on a large scale. Providing visitor activities and pressures are carefully planned and managed, the resultant economic and social benefits and the natural values on which they are dependent can be maintained indefinitely.

10.2 REGIONAL CONTEXT

The Lesueur Area is arguably the most significant area within southwestern Australia recommended for reservation but yet to be gazetted. If created, this park would complement a number of other northern kwongan reserves that include Alexander Morrison, Badgingarra, Drovers Cave, Kalbarri, Nambung, Tathra and Watheroo National Parks.

The majority of existing northern kwongan reserves have some documentation of conservation values, but their value and use for public recreation and educational purposes is not well established. The two exceptions are Kalbarri and Nambung National Parks, which contain land and/or water features of high scenic appeal and visitor interest. The Lesueur Area is similar to these latter two parks in that its diverse landscapes hold considerable recreational appeal for a range of users and activities.

10.3 POTENTIAL VALUE AND USE FOR RECREATION AND EDUCATION

The potential value and use of the Lesueur Area for recreational and educational purposes is difficult to gauge accurately, as little information on current use levels is available. It is known, however, that the area is:

- visited by wildflower groups and individuals interested in nature study and photography.

- frequently visited by 4WD clubs who have, in recent years, conducted a number of excursions through the Gairdner Range.

- used by Scout and Venturer groups as well as other groups and individuals for bushwalking, camping and related activities.

In previous years, the Gairdner Range has also been used for Army manoeuvres as well as activities such as pig hunting. The level of wilderness camping also appears to be substantial, judging by the remains of numerous campfires evident in the woodland areas situated throughout the Range. Thus while the area is a considerable distance from large population centres and has not been actively promoted, it is nevertheless receiving a considerable degree of visitor use.

Perhaps the best indication of the potential level of recreational use the Lesueur Area could satisfy comes from some recent visitor survey figures generated for Nambung National Park 35 km to the south. In 1984, the number of visitors at Nambung was 50 000 decreasing to 41 000 visitors in 1985. During 1986/87, a major road reconstruction programme was carried out to improve access to the Pinnacles Desert. At the same time, coastal and inland recreation areas were upgraded and educational and interpretative facilities provided. The following year (1987), visitor numbers to Nambung rose to 105 000, a 2.5 fold increase over the 1985 figure (Haynes 1988).

Much of this increase can be attributed to commercial tourist interests. Prior to 1984 only one coach company operated tours to Nambung. By 1986, 23 different companies were operating within the Park with one company alone conducting three tours daily seven days a week. It is also worth noting that the net economic value of this increase in visitor numbers has been calculated to be in the order of $9 million/annum, based on the "travel cost method" and 1987 visitor numbers. This represents a significant financial contribution to the regional and State economy.

Equally important in the Nambung example, the increase in visitation has not had any apparent detrimental impacts on Park values. To quote the survey report, ... "The results with respect to conservation have been pleasing. People are staying on marked access tracks, both the new access and the circuit track within the Pinnacles area. Despite the increase in numbers there has been no appreciable rise in vandalism or irresponsible behaviour."

In the case of Lesueur, the recreational "drawing power" of the Gairdner Range is not known. Certainly the appreciable landscape and conservation values, if sensibly promoted, interpreted and managed, can be expected to generate a substantial increase in sightseeing, bushwalking, compiling, nature study and similar activities. The recently completed small boat harbour and launching facility near Jurien is also likely to lead to increased visitor use and fishing activity along this section of the coast. This in turn could place increased visitor pressure on the inland areas, including the Lesueur Area.

The Lesueur Area is also rich in terms of its educational and interpretation potential. Apart from the wealth of plant species, the heath and woodland communities support a diverse range of birds, many of which are readily observable due to the open nature of the countryside. The Gairdner Ranges also afford excellent opportunities for studying and interpreting geological features, including a variety of exposed sediments which have been extensively faulted. The cultural history and use of the area, both Aboriginal and European, is likewise worthy of interpretation.

In summary, the Lesueur Area has obvious but as yet unrealised potential to attract a far greater level of public use than at present. Given appropriate management controls and input, the Gairdner Range is capable of offering a diverse range of recreational and educational opportunities without diminishing the area's considerable conservation values.

Chapter 11

STATUS OF CURRENT KNOWLEDGE

by Andrew A. Burbidge and Stephen D. Hopper

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Abstract

The flora and fauna of the northern kwongan are very rich in species and the limited number of studies on it are inadequate for a detailed analysis of the possible impact of any development on the Lesueur Area. With regard to the flora, more research is needed into local endemics, impacts of dieback disease, cryptogams, regional plant communities, community processes and population biology. Considerable research is required into rehabilitation techniques for many plant groups that cannot be regenerated at present. In the fauna, vertebrate surveys are at present inadequate to understand either the habitat requirements or the minimum area required by most species. Data on terrestrial invertebrates are lacking for most of the Lesueur Area and data on aquatic invertebrates need to be upgraded by conducting surveys throughout the wet season. Because of lack of information this report has not dealt with possible effects of any development on groundwater levels and quality, or possible effects on the area's freshwater springs.

11.1 INTRODUCTION

It is important to consider the amount of data available on the Lesueur Area when evaluating the possible impact of any development on it.

Detailed studies of the flora and vegetation commenced only in 1979. While the amount of effort has been greater in this area than is the case for a some other areas in the south west of Western Australia, it is by no means adequate for an accurate assessment of impact. The kwongan vegetation of the northern sandplains is one of the most complex and species-rich in the world; the number of species of vascular plants per unit area being eclipsed only by the fynbos vegetation of southern Africa and some tropical rainforests.

11.2 FLORA

Knowledge of the flora of the surrounding region is even more deficient - the high number of poorly known plant species on the list of Lesueur flora is as much an indication of the lack of detailed knowledge of the district's flora as it is of the richness of the Lesueur Area itself.

There are five areas where knowledge of the flora needs considerable improvement to enable a reasonable assessment of the effects of any development.

11.21 Local endemics

There are 145 known geographically restricted regional endemics in the northern sandplains between the Moore and Irwin Rivers whose distribution and abundance are so poorly known that a reasonable assessment of their conservation status is not possible. Current information indicates that 54 of these 145 occur in the Lesueur Area (Table 5.8). Of these 54, 26 have a known geographical range of less than 50 km, and do not occur on any conservation reserves. Nine taxa are entirely confined to the Lesueur Area, and a further 25 have 50-80% of their known populations so confined (Table 5.6).

11.22 Cryptogamic flora

No study of bryophytes (mosses and liverworts) or thallophytes (algae, fungi and lichens) has been undertaken in the Lesueur Area. Comprehensive collections and appropriate taxonomic research will be required to develop a reasonable inventory and to determine what plant communities, soils and landforms are occupied by cryptogamic taxa.

A knowledge of cryptogams may be essential to the success of revegetation of disturbed areas. The Western Australian kwongan flora has a poorly known but diverse array of symbiotic relationships between vascular plants and cryptogams such as mycorrhizal fungi (Lamont 1984).

11.23 Plant communities in a regional context

Preliminary quantitative work on selected sites (e.g. Griffin *et al.* 1983; Froend 1987) enables a first approximation at placing Lesueur plant communities in a regional context. However, it is clear from the work of Martinick and Associates (1989d) that a substantial injection of resources is needed in this arena before a reasonable understanding is obtained. For example, on the basis of a rapid reconnaissance of surrounding national parks and subjective assessment of communities Martinick and Associates (1989d) were only able to conclude "Thirty-eight vegetation units have been identified in the Hill River Project area. Only three of these were identified definitely in other reserves". The complexity of plant communities in the northern kwongan clearly requires careful quantitative studies at a fine geographic scale to adequately assess plant community conservation status.

11.24 Effects of vegetation clearing or degradation on community processes and population biology

The reduction in area of communities and populations of flora that would arise should vegetation be cleared within the Lesueur Area would have impacts on community processes and population biology that are largely unknown. Such processes became evident in studies on the relationships between *Banksia tricuspis*, the moth larvae that eat it, and predation by Carnaby's Black Cockatoo, and on the pollination ecology of the Black Kangaroo Paw (Chapter 7). Similarly, the potential disruption of community structure and processes through the introduction of dieback disease is great at Lesueur, but specific details and hazard assessment are poorly documented.

11.25 Revegetation of disturbed sites

The feasibility of revegetating disturbed areas in such species-rich communities and on such complex soils requires extensive research. Many important components of the Lesueur vegetation, such as the sedges and rushes, are notoriously difficult to propagate (Fox *et al.* 1987). Experience elsewhere in the region suggests that successful regeneration of kwongan communities after mining is not achievable by existing techniques (e.g. Griffin and Hopkins 1985b).

11.3 FAUNA

As is the case for flora, there are areas where the knowledge of the fauna needs considerable improvement to enable a reasonable assessment of the impacts of the proposed mine and power station.

11.31 Vertebrates

Faunal studies are few. Had not the Department of Fisheries and Wildlife commissioned the Western Australian Museum to carry out a biological survey of the "Horse Breeding" reserve in 1973-74, there would have been few data available to compare with the recent short-term surveys carried out by consultants to the mining companies. CALM's experience with biological surveys is that vertebrate species records continue to accumulate with effort, and that trapping and recording of vertebrates needs to be carried out in as many seasons as possible. The results of the surveys of the Eastern Goldfields, which were carried out over three different seasons, clearly demonstrate this point (McKenzie 1984).

The disadvantages of short-term surveys can be demonstrated by comparing the consultants' results for mammals, reptiles and frogs at Lesueur in 1988 (Martinick and Associates 1989b) with the Museum survey, which was carried out during late spring 1973 and late autumn 1974 (Chapman *et al.* 1977).

The greatest difference between the results of the Museum's and the consultants' results is in the reptile data (Table 11.1). Even though the Museum did not use the modern technique of pit-fall trapping, they recorded 41 species of reptiles compared to 29 by the consultants (who examined a smaller area and fewer landforms). Two of the additional species collected by the consultants, *viz. Lerista christinae* and *Pletholax gracilis* (also recorded by Foulds and McMillan n.d.) would probably have been captured in pitfall traps.

The amount of vertebrate data for the Lesueur Area is not sufficient to properly describe habitat requirements for most species. Considerably more data on the regional distribution and requirements of vertebrates are needed before the long-term conservation of many species can be assured.

11.32. Invertebrates

The most significant shortcoming in the data on the fauna of the Lesueur Area is the lack of detailed information on invertebrates, except for minor, inadequate data from the western landforms and on aquatic fauna. Data available on some groups of invertebrates suggest that there are likely to be many species of invertebrates restricted to the vicinity of the Lesueur Area, because of the close relationship of some invertebrates with specific species of food plants. Many plants depend on invertebrates, especially insects, for pollination. There are few data available on which

Table 11.1
Comparison of Martinick and Associates 1988 results with W.A. Museum 1973-4 results.

Indigenous Mammals

	WAM	M&A
Tachyglossus aculeatus	-	x
Sminthopsis griseoventer	x	x
Sminthopsis dolichura	-	-
Sminthopsis crassicaudata	x	x
Sminthopsis granulipes	x	-
Tarsipes rostratus	x	x
Macropus irma	x	x
Macropus fuliginosus	x	x
Macropus robustus	-	x
Chalinolobus gouldii	x	-
Chalinolobus morio	x	-
Eptesicus regulus	x	-
Nyctophilus geoffroyi	x	-
Pseudomys albocinereus	x	x
Rattus fuscipes	x	x
Totals 15 species	12	9

Reptiles

	WAM	M&A
Ctenophorus maculatus maculatus	x	-
Pogona minor minor	x	x
Tympanocryptis adelaidensis adelaidensis		xx
Crenadactylus ocellatus ocellatus	x	x
Diplodactylus alboguttatus	x	-
Diplodactylus granariensis granariensis	x	x
Diplodactylus ornatus	x	-
Diplodactylus polyopthalmus	x	x
Diplodactylus spinigerus spinigerus	x	x
Gehyra variegata	x	-
Phyllodactylus marmoratus marmoratus	x	-
Underwoodisaurus millii	x	x
Aclys concinna concinna	x	x
Delma fraseri	x	x
Delma grayii	x	x
Lialis burtonis	x	x
Pletholax gracilis	-	x
Pygopus lepidopodus lepidopodus	x	x
Cryptoblepharus plagiocephalus	x	x
Ctenotus fallens	x	x
Ctenotus impar	x	-
Ctenotus lesueurii	x	x
Ctenotus pantherinus	x	x
Egernia kingii	-	-
Egernia multiscutata bos	x	-
Egernia napoleonis	x	x
Lerista christinae	-	x
Lerista distinguenda	x	x
Lerista elegans	-	-
Lerista planiventralis decora	x	-
Lerista praepedita	x	-
Menetia greyii	x	x
Morethia lineoocellata	x	x
Morethia obscura	x	x
Omolepida branchialis	x	-
Tiliqua occipitalis	x	-
Tiliqua rugosa rugosa	x	x
Varanus gouldii	-	x
Varanus tristis tristis	x	x
Morelia stimsoni stimsoni	x	-
Demansia psammophis reticulata	x	-
Notechis curtus	x	x
Pseudonaja nuchalis	x	-
Pseudechis australis	-	-
Rhinoplocephalus gouldii	x	x
Vermicella littoralis	x	-
Vermicella bimaculatus	x	-
Ramphotyphlops australis	x	x
Totals 48 species	42	29

Amphibians

	WAM	M&A
Litoria moorei	x	-
Myobatrachus gouldii	-	x
Ranidella pseudinsignifera	x	x
Heleioporus albopunctatus	x	x
Heleioporus eyrei	x	x
Heleioporus psammiphilus	-	x
Limnodynastes dorsalis	x	x
Neobatrachus pelobatoides	x	x
Pseudophryne guentheri	x	x
Totals 9 species	7	8

pollinators are important for the rare and geographically restricted plants, or what the pollinators require from the environment for their survival.

The lack of data on the terrestrial invertebrate fauna should be remedied by conducting a baseline survey and detailed studies of selected groups where endemism and close association with particular plant species is likely, e.g. the jewel beetles.

The information on aquatic invertebrates should be upgraded by conducting detailed surveys throughout the wet season, and conducting comparative surveys throughout the district.

11.4 OTHER MATTERS

Landscape information lacks a detailed regional basis. The brief study reported here is apparently the first to be conducted in the northern kwongan. Recreational information is also not based on detailed questionnaires or other comprehensive studies.

Knowledge about the regional occurrence and effects of dieback diseases caused by *Phytophthora* species is also inadequate. No systematic surveys of the Lesueur Area and environs have been carried out. CALM's work in the northern kwongan, which commenced only in 1987, has been confined to checking areas where local staff have noticed disease-like symptoms. Of fundamental importance is a better understanding of the ecology of *Phytophthora* spp. in the Lesueur Area and in the northern kwongan generally. Studies on host susceptibility, hazard mapping, rate of spread in differing communities and soils, and control of outbreaks of the disease are needed urgently.

Because of lack of information we have not considered in this report:

1. Possible effects of any development on groundwater levels and quality. Decreases in groundwater levels could seriously affect the survival of the native vegetation and associated terrestrial fauna, particularly under drought conditions (cf Hnatiuk and Hopkins 1981b). Any increase in groundwater levels could kill some vegetation types directly and would increase the chances of survival of *Phytophthora* spp., if introduced.
2. Possible effects of any development on the freshwater springs of the area. These are critical to the survival of the population of Carnaby's Black Cockatoo, and presumably to some species of aquatic invertebrates. The role of Carnaby's Black Cockatoo in the regeneration of *Banksia tricuspis* has been discussed earlier (Chapter 7). The springs in the Salt Lake Complex are extremely important to many birds that utilise the salt lakes as a summer refuge, providing the necessary fresh drinking water.

Because of the lack of data on many aspects of the Lesueur Area, it is instructive to compare the current state of knowledge at Lesueur with the information available at the time that an assessment of proposed coal mining was made in 1972 at what is now the Fitzgerald River National Park. This issue was one of the land-use controversies that led to the creation of the EPA, and was one of the first issues it looked into. When the EPA recommended against mining in Fitzgerald River about 700 species of vascular plants were known to occur there, of which 63 were considered locally endemic. Today, after much more intensive research, 1748 species of vascular plants have been recorded, of which 75 are locally endemic and 14 have been listed as Declared Rare Flora under the Wildlife Conservation Act (Chapman and Newbey 1987).

In 1972 no species of endangered fauna was known to occur in the Fitzgerald River National Park. Now, 10 declared rare species are known to occur there, including three critically endangered rare animals, i.e. Dibbler *Parantechinus apicalis*, Heath Rat *Pseudomys shortridgei* (which, in 1972, was thought to be extinct in W.A.) and the western subspecies of the Ground Parrot, *Pezoporus wallicus flaviventris* (Chapman and Newbey 1987).

Chapter 12

SIGNIFICANCE OF THE LESUEUR AREA

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Abstract

The Lesueur Area is an area of world, national, State and regional nature conservation significance. It has all the characteristics of an important conservation reserve and is the most important nature conservation area in the northern kwongan. Its major characteristics are uniqueness of many geological, landform, and biological attributes, biodiversity, representativeness for the more common components of the northern kwongan flora and fauna, very high nature conservation values and scenic grandeur. Its size is not large for an important conservation reserve and, desirably, it should be larger. There are currently seven national parks and Class A nature reserves in the northern kwongan, totalling only 107 460 ha. The Lesueur Area includes a wider range of ecosystems than any other existing or proposed conservation reserve in the northern kwongan. Reservation of the area as a conservation reserve should have the highest priority.

12.1 INTRODUCTION

The Lesueur Area is an area of world, national, State and regional nature conservation significance.

It has all the characteristics of an important conservation reserve and is the most important nature conservation area in the northern kwongan (Irwin Botanical District), which lies near the west coast between Shark Bay and Moore River.

The major characteristics of Lesueur are:

1. **Uniqueness.** Covers the most species-rich area of the northern kwongan, and includes an exceptionally high number of locally endemic species of plants (Figure 5.3), as well as vegetation associations that do not occur elsewhere. Includes comparatively high numbers of relict species and species at the limit of their geographic range, both plants and animals. Includes the most rugged terrain, which is of high scenic appeal, in the northern kwongan. Includes unique area of complex-faulted Triassic and Jurassic sedimentary rocks and associated soils. Includes northern tip of Bassendean Sands.

2. **Biodiversity.** Very rich in species of vascular plants and vertebrate animals (especially birds and reptiles). Indications that it is very rich in species of invertebrate animals. A special attribute of Lesueur is the very high turnover in plant species across the landscape, even within the same soil types.

3. **Representativeness.** Includes nine landforms, each with different floras and faunas, representative of much of the northern kwongan.

4. **Very high nature conservation values.** As well as attributes mentioned under the above headings, includes vegetation associations and species (including endangered species) not protected by other existing or proposed reserves. Includes the upper portions of catchments of four drainage systems. Only one known current infection with *Phytophthora* spp., and that is some distance from the area of highest nature conservation values.

5. **Scenic grandeur.** Includes arguably the most rugged scenery and spectacular viewsheds between Perth and Kalbarri. Includes rich kwongan vegetation with colourful wildflower displays for most of the year, especially in the spring.

6. **Size.** At 27 500 ha, the Lesueur Area is not large for an important conservation reserve; desirably it should be larger. If a conservation reserve for the Lesueur Area was to be designed without any consideration for existing land tenure, it would include most of the area between Nambung National Park, Badgingarra National Park, Alexander Morrison National Park and South Eneabba Nature Reserve. However, much of this area is now freehold and cleared for farming. This does not mean that the Lesueur Area is not extremely valuable; it reinforces the need to retain as much as possible of this larger area in nature conservation reserves.

Table 12.1

Physiographic regions (after Playford et al. 1976) and vegetation systems (after Beard 1976, 1979) of existing and proposed national parks and nature reserves (2 000 ha) in the northern kwongan between Moore River and Dongara.

Name	Area (ha)	Physiographic Region(s)	Vegetation System(s)
A. Existing national parks and Class A nature reserves			
Nambung NP	17 490	Coastal Belt, Bassendean	Guilderton Bassendean
Drovers Cave NP	2 680	Coastal Belt	Jurien
Badgingarra NP	13 120	Arrowsmith	Lesueur
Alexander Morrison NP	8 510	Arrowsmith, Dandaragan	Tathra, Lesueur, Marchagee
Tathra NP	2 930	Dandaragan	Tathra
Watheroo NP	44 510	Dandaragan, Yarra Yarra	Marchagee, Warroo
Pinjarrega NR	18 220	Yarra Yarra	Marchagee
TOTAL	107 460		
B. Existing Class C nature reserves			
Wanagarren NR	11 070	Coastal Belt	Guilderton
Nilgen NR	5 510	Coastal Belt	Guilderton, Jurien
Namming NR	5 430	Bassendean	Bassendean
Mt Adams Rd NR	6 610	Coastal Belt	Illyarrie, Eridoon
"Beekeepers Rd" NR	2 685	Eneabba Plain	Eridoon
South Eneabba NR	5 980	Arrowsmith, Eneabba Plain	Tathra, Eridoon
Watto NR	2 890	Dandaragan	Tathra
Boothendarra NR	2 075	Dandaragan	Lesueur
Capamaura NR	3 590	Yarra Yarra	Marchagee
TOTAL	45 840		
C. Existing "other"# conservation reserves.			
Lake Logue R	4 840	Coastal Belt, Eneabba Plain	Illyarrie, Eridoon
Beekeepers R	65 000*	Coastal Belt	Cliff Head, Illyarrie
Sthn Beekeepers R	10 850	Coastal Belt	Guilderton, Jurien
TOTAL	80 690		
D. Proposed national parks and nature reserves.			
Lesueur NP (P)	27 500	Coastal Belt, Bassendean, Arrowsmith	Guilderton, Illyarrie, Cliff Head, Jurien, Bassendean, Gairdner, Lesueur
Mt Adams NR (P)	13 250	Arrowsmith	Tathra
Arrowsmith NR (P)	10 000	Eneabba Plain	Eridoon
Coomallo NP (P)	10 500	Arrowsmith	Lesueur
Badgingarra NP	2 660	Arrowsmith	Lesueur
TOTAL	63 910		

Reserves that include the purpose "conservation of flora and/or fauna", but which are not vested
* Estimated area after Lesueur National Park is created.
NP - national park, NR - nature reserve, R - reserve
(P) - proposed reserve, not proclaimed

There is a narrow corridor between Lesueur and the 2 680 ha Drovers Cave National Park and it adjoins the coastal Beekeepers Reserve (65 000 ha, not all contiguous); however, neither of these possess any upland areas.

12.2 WORLD CONTEXT

The World Conservation Strategy (WCS) (IUCN 1980) is based on three objectives:

1. To maintain essential ecological processes and life-support systems.
2. To preserve genetic diversity.
3. To ensure the sustainable utilization of species and ecosystems.

In this context Lesueur is of international importance with respect to the second objective, and contributes to the other two.

There are few other places in the world where such a rich assemblage of plants and animals exists and such a high concentration of local endemic plants has been documented. Obviously, nowhere else in the world provides an opportunity to conserve local endemics such as *Banksia tricuspis* and other species listed in Table 5.6. Moreover, Lesueur contains the majority of known populations of many other geographically restricted species (Appendix 2). It also contains an unusually high number of plant and animal populations at the limits of their known ranges.

12.3 NATIONAL CONTEXT

The National Conservation Strategy for Australia (NCSA) (Anon. 1984) endorsed the WCS and added a further objective:

- To maintain and enhance environmental qualities.

Lesueur meets this objective.

As pointed out above, Lesueur is of national importance because of its numerous conservation reserve attributes.

12.4 STATE CONTEXT

The State Conservation Strategy for Western Australia (SCSWACC 1987) further develops the WCS and NSCA and lists Key Strategies for Western Australia. The Strategy states "The major goals and priority actions listed in the NCSA (paras 25-35) have direct relevance to Western Australia. Hence they should be applied positively and energetically in this State." Additional aspects considered of particular importance to Western Australia are set out below.

These include, under the major heading "managing for sustainable yield while protecting life support systems" two points of relevance to this report:

- Prevent further decline in species and genetic diversity in Western Australia.

- Adequately protect and manage representative areas.

Clearly, declaration of the Lesueur Area as a conservation reserve and prevention of degradation of its values are essential to meet the above.

In comparison with other parts of the State, the Lesueur Area is rich in plant, mammal, bird and reptile species (Table 12.2). Many species are confined to the Lesueur Area or to Lesueur and nearby areas and can only be conserved in their natural ecosystems in Lesueur (e.g. Table 5.6). Many other Lesueur species require reserves at various parts of their geographic ranges in order to conserve all their genetic variability.

The vast majority of Western Australian plant and animal species can not survive on farmed land. Intensive horticulture and husbandry are required to maintain the genetic diversity of species outside natural ecosystems and it is economically unviable to carry out such procedures in such a species-rich area as Lesueur. Even within natural ecosystems, management is often required to maintain genetic diversity or prevent extinction of certain species.

By far the most important and economically cost-effective strategy used in Australia (and most of the world) to preserve genetic diversity is to reserve areas of land and water as national parks or other conservation reserves. Such reserves are not created only to preserve the unusual or unique (although this may be a contributing reason for their creation), but to prevent the decline of the common and representative species of a region.

The Lesueur Area lies at the centre of one of three nodes of extraordinary species richness and endemism in the south-west of the State. The other two nodes are the Stirling Range National Park and the Fitzgerald River National Park, both of which are infected with *P. cinnamomi* as well as several other *Phytophthora* species.

While major parts of the Stirling Range are beyond recovery the Fitzgerald River National Park, which contains only a few widely scattered infections, can be protected from further spread of the disease. The recently released dieback management plan for the park recommends the closure of several catchments to all entry other than on foot (Moore *et al.* 1989).

Table 12.2

Comparison of number of species recorded in Lesueur and other conservation areas.

Reserve Name	Area (ha)	Vascular Plants	Mammals (ex bats)	Birds	Reptiles
Lesueur NP (P)	27 500	821	11	124	47
Kalbarri NP	186 100	-	-	174-	50
East Yuna NR	1 720	-	5	59	34
Toolonga NR (P)	235 500	-	5	61	31
Wandana NR	26 000	-	5	68	41
South Eneabba NR	5 980	429+	-	-	-
Sthn Beekeepers R	10 850	-	4	56	11
Karroun Hill NR	309 700	-	6	64	24
North Karlgarin NR	5 190	-	9	67	22
Durokoppin NR	1 030	-	6	61	26
Tutanning NR	2 130	663	9	-	33
Dryandra Forest	5 000*	-	13	100	-
Dragon Rocks NR	32 100	-	12	59	19
Stirling Range NP	115 700	1 201	-	-	-
Lake Magenta NR	94 170	-	5	98	31
Fitzgerald R NP	242 800	1 748	22	184	41

- comprehensive surveys not carried out or data not available

+ number of species within study area of about 2 000 ha, not all within reserve

* approximate area of bushland in main block

NP = national park, NR = nature reserve, R = other reserve

(P) = proposed reserve

Quarantine is an extremely effective preventative measure for this disease. It also allows time for the development of techniques to eradicate spot infections when they first appear.

The uplands in the Lesueur Area appear to be free of the disease, and will remain that way if properly protected. A dieback management plan for CALM's Moora District has been prepared and will provide regional support for a specific protection plan for the proposed park.

12.5 REGIONAL CONTEXT

The northern kwongan region has some existing and proposed national parks and nature reserves. Those between Moore River and Irwin River are listed in Table 12.1, which also shows the physiographic regions of Playford *et al.* (1976) and vegetation systems of Beard (1976, 1979) that they include (see Figure 1.1 for location of reserves and Figure 3.2 for physiographic regions).

The total area of the seven existing national parks and the single Class A nature reserve is 107 460 ha; the area of the nine Class C nature reserves is 45 180 ha; the area of the three other reserves with conservation in their purpose is 80 960 ha and the area of the four proposed reserves is 60 750 ha. For comparison, the area of Fitzgerald River National Park is about 243 000 ha. Only the first category, national parks and Class A nature reserves, has the highest level of protection from disturbance, since, under current Government Policy, only this category of reserves cannot be mined except with Parliamentary approval. This policy will have a legislative basis if currently proposed amendments to the Mining Act are passed.

Table 12.1 shows that, even at the gross level of physiographic regions and vegetation systems, the Lesueur Area includes a wider range of ecosystems than any other existing or proposed reserve in the northern kwongan. However, as described in this report (Chapter 4), it is clear that considerable complexity exists within vegetation systems, and that plant species composition changes rapidly within a system, and even within one soil type. Therefore, the fact that one system occurs in more than one conservation area does not mean that the two areas protect the same species or associations. When considering physiographic regions, it is clear that Playford *et al.*'s (1976) Arrowsmith Region is a combination of geological and landscape types, with the Gairdner Range being particularly different from the remainder.

Because of the complexity of species distribution and association in the northern kwongan it is clear that many nature conservation reserves well-dispersed across the region are needed to approach adequate conservation by reservation. Burgman (1988) has shown that, for the Roe Botanical District of the southern kwongan, reserves need to be placed closer than 15 km apart to adequately conserve the variation in the flora. The northern kwongan figure is likely to be even smaller (Griffin *et al.* 1983).

The Lesueur, Arrowsmith and Coomallo areas were all recommended for reservation by the EPA following the CTRC reports. All have been endorsed by State Cabinet, but have not been declared, mainly because of mining concerns. The other proposed reserve, Mt Adams (Griffin *et al.* 1982), is also in abeyance, again because of mineral resource concerns. Furthermore, one of the existing reserves, South Eneabba Nature Reserve, is being mined for mineral sands, and another, Lake Logue Reserve, is likely to be mined in future.

Chapter 13

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Chapter 15

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Chapter 15

APPENDICES

15.1 APPENDIX 1

List of the flora of the Lesueur Area.

15.2 APPENDIX 2

Distributional information, reserve status and conservation coding for regional endemics and Declared Rare Flora of the northern kwongan between the Moore and Irwin Rivers.

15.3 APPENDIX 3

Mount Lesueur - Jurien Jewel - A.J.M. Hopkins and S.D. Hopper

See *Landscope* Vol. 4 No. 4 Winter Edition 1989 pp 28-33

15.1 APPENDIX 1

List of the vascular flora of the Lesueur Area.

Column A: Plant family code as given in Green (1985).

Column B: Conservation coding, (1 to 5) CALM's reserve list priorities as outlined in text, (6) Declared Rare Flora.

Column C: Geographic limits of taxa for which the Lesueur Area represents, (1) the northern limit of their geographic range; (2) the northern limit and disjunct populations; (3) the southern limit of their geographic ranges.

Column D: Taxa which are regarded with confidence as being new and as yet undescribed.

Taxa: Taxon name and authority, introduced species indicated by (*).

A	B	C	D	TAXA
163	.	.	.	*Acacia alata* R.Br. var. *alata*
163	.	.	.	*Acacia auronitens* Lindley
163	.	.	.	*Acacia blakelyi* Maiden
163	.	.	.	*Acacia dilatata* Benth.
163	.	1	.	*Acacia drummondii* Lindley
163	.	.	.	*Acacia epacantha* (Maslin)Maslin
163	.	.	.	*Acacia ericifolia* Benth.
163	6	.	.	*Acacia forrestiana* E.Pritzel
163	.	.	.	*Acacia idiomorpha* Cunn. ex Benth.
163	.	.	.	*Acacia incrassata* Hook.
163	.	.	.	*Acacia lasiocarpa* Benth. var. *lasiocarpa*
163	.	.	.	*Acacia latipes* Benth.
163	.	1	.	*Acacia moirii* E.Pritzel ssp. *recurvistipula* Maslin
163	.	.	.	*Acacia multispicata* Benth.
163	2	.	1	*Acacia* aff. *myrtifolia* Benth. (R.J. Cranfield 33)
163	.	2	.	*Acacia obovata* Benth.
163	2	.	.	*Acacia plicata* Maslin
163	.	.	.	*Acacia pulchella* R.Br. var. *glaberrima* Meissner
163	.	.	.	*Acacia pulchella* R.Br. var. *pulchella*
163	.	.	.	*Acacia quadrisulcata* F.Muell.
163	2	.	.	*Acacia retrorsa* Meissner
163	.	.	.	*Acacia rostellifera* Benth.
163	.	.	.	*Acacia saligna* (Labill.)H.L.Wendl.
163	.	.	.	*Acacia sessilis* Benth.
163	.	.	.	*Acacia signata* F.Muell.
163	.	.	.	*Acacia spathulifolia* Maslin
163	.	.	.	*Acacia sphacelata* Benth.
163	.	1	.	*Acacia squamata* Lindley
163	.	.	.	*Acacia stenoptera* Benth.
163	.	2	.	*Acacia teretifolia* Benth.
163	.	.	.	*Acacia truncata* (Burm.f.)Hort.ex.Hoffsgg.
163	3	1	.	*Acacia volubilis* F.Muell.
163	.	.	.	*Acacia xanthina* Benth.

cont'd ...

A	B	C	D	TAXA
54C	.	.	.	*Acanthocarpus canaliculatus* George
54C	.	.	.	*Acanthocarpus preissii* Lehm.
18	.	.	.	*Actinostrobus acuminatus* Parl.
18	.	1	.	*Actinostrobus pyramidalis* Miq.
281	.	.	.	*Actinotus leucocephalus* Benth.
90	.	.	.	*Adenanthos cygnorum* Diels
31	.	.	.	**Aira cupaniana* Guss.
39	.	.	.	*Alexgeorgea nitens* (Nees)L.Johnson & B.Briggs
39	.	.	.	*Alexgeorgea subterranea* Carlq.
70	.	.	.	*Allocasuarina campestris* (Diels)L.Johnson
70	3	.	.	*Allocasuarina grevilleoides* (Diels)L.Johnson
70	.	.	.	*Allocasuarina humilis* (Otto & Dietr.)L.Johnson
70	.	.	.	*Allocasuarina microstachya* (Miq.)L.Johnson
70	.	.	.	*Allocasuarina ramosissima* (C.Gardner)L.Johnson
70	.	.	.	*Allocasuarina thuyoides* (Miq.)L.Johnson
221	.	.	.	*Alyogyne hakeifolia* (Giord.)Alef.
221	.	.	.	*Alyogyne huegelii* (Endl.)Fryx. var. *wrayae* A.S.Mitchell
31	.	.	.	*Amphipogon debilis* R.Br.
31	.	.	.	*Amphipogon turbinatus* R.Br.
97	.	.	.	*Amyema miquelii* (Lehm.ex Miq.)Tieghem
293	.	.	.	**Anagallis arvensis* L. var. *caerulea* Gouan
39	.	1	.	*Anarthria gracilis* R.Br.
288	.	.	.	*Andersonia heterophylla* Sonder
288	.	.	.	*Andersonia lehmanniana* Sonder
288	1	.	.	*Andersonia longifolia* (Benth.) L.Watson
55	.	.	.	*Anigozanthos humilis* Lindley ssp. *humilis*
55	.	.	.	*Anigozanthos manglesii* D.Don ssp. *quadrans* Hopper
55	.	.	.	*Anigozanthos pulcherrimus* Hook.
315	.	.	.	*Anthocercis littorea* Labill.
155	.	.	.	*Aphanopetalum clematideum* (J.Drumm.& Harvey)Domin
40	.	.	.	*Aphelia brizula* F.Muell.
40	.	.	.	*Aphelia cyperoides* R.Br.
345	.	.	.	**Arctotheca calendula* (L.)Levyns
54F	.	1	.	*Arnocrinum preissii* Lehm.ex Endl.
345	.	.	.	*Asteridea pulverulenta* Lindley
175	6	.	.	*Asterolasia drummondii* Paul G.Wilson
288	.	2	.	*Astroloma ciliatum* (Lindley)Druce
288	.	.	.	*Astroloma glaucescens* Sonder
288	3	.	.	*Astroloma microdonta* F.Muell. ex Benth.
288	.	.	.	*Astroloma pallidum* R.Br.
288	2	.	1	*Astroloma* aff. *pallidum* R. Br. (E.A.Griffin 1022)
288	.	.	.	*Astroloma serratifolium* (DC.)Druce var. *horridulum* (Pritzel)Druce
288	2	.	.	*Astroloma* aff. *serratifolium* (DC.) Druce (N.G. Marchants s.n.)
288	.	.	.	*Astroloma stomarrhena* Sonder
288	.	.	.	*Astroloma xerophyllum* (DC.)Sonder
273	.	.	.	*Baeckea camphorosmae* Endl.
273	.	.	.	*Baeckea crispiflora* F.Muell.
273	.	.	.	*Baeckea grandiflora* Benth.
90	.	.	.	*Banksia attenuata* R.Br.
90	.	.	.	*Banksia candolleana* Meissner
90	.	.	.	*Banksia chamaephyton* George
90	.	.	.	*Banksia elegans* Meissner
90	.	1	.	*Banksia grandis* Willd.

cont'd ...

A	B	C	D	TAXA
90	.	.	.	*Banksia grossa* George
90	.	1	.	*Banksia ilicifolia* R.Br.
90	.	.	.	*Banksia leptophylla* George
90	.	1	.	*Banksia littoralis* R.Br.
90	.	.	.	*Banksia menziesii* R.Br.
90	.	.	.	*Banksia micrantha* George
90	.	.	.	*Banksia prionotes* Lindley
90	6	.	.	*Banksia tricuspis* Meissner
32	.	.	.	*Baumea juncea* (R.Br.)Palla
32	.	1	.	*Baumea preissii* Nees
273	3	.	.	*Beaufortia bicolor* Strid
273	.	.	1	*Beaufortia* aff. *bracteosa* Diels (E.A.Griffin 1176)
273	.	.	.	*Beaufortia elegans* Schauer
316	.	.	.	**Bellardia trixago* (L.)All.
185	.	.	.	*Beyeria similis* (Muell.arg.)Benth.
152	.	.	.	*Billardiera bicolor* (Putterl.)E.M.Bennett
152	.	2	.	*Billardiera coeruleo-punctata* (Klotzsch)E.M.Bennett
55	.	.	.	*Blancoa canescens* Lindley
175	.	.	.	*Boronia coerulescens* F.Muell.
175	.	2	.	*Boronia crassifolia* Bartling
175	.	.	.	*Boronia cymosa* Endl.
175	.	.	.	*Boronia ramosa* (Lindley)Benth. ssp. *anaethifolia* (Bartling)Paul G.Wilson
175	.	.	.	*Boronia scabra* Lindley
54F	.	.	.	*Borya sphaerocephala* R.Br.
165	.	.	.	*Bossiaea eriocarpa* Benth.
165	.	2	.	*Bossiaea peduncularis* Turcz.
31	.	.	.	**Briza maxima* L.
31	.	.	.	**Briza minor* L.
54J	.	1	.	*Burchardia bairdiae* Keighery
54J	.	.	.	*Burchardia umbellata* R.Br.
165	.	.	.	*Burtonia conferta* DC.
54F	.	.	.	*Caesia micrantha* Lindley
66	.	.	.	*Caladenia bicalliata* Rogers
66	.	.	.	*Caladenia crebra* George
66	.	.	1	*Caladenia deformis* (R.Br.)
66	.	.	.	*Caladenia denticulata* Lindley ssp. *denticulata*
66	.	.	.	*Caladenia discoidea* Lindley
66	.	.	.	*Caladenia flava* R.Br. ssp. *flava*
66	.	.	1	*Caladenia gemmata* (Lindley)
66	.	1	.	*Caladenia hirta* Lindley ssp. *hirta*
66	.	.	.	*Caladenia latifolia* R.Br.
66	.	.	.	*Caladenia longicauda* Lindley ssp. *calcigena* Hopper ined.
66	.	.	.	*Caladenia longicauda* Lindley ssp. *elassa* Hopper ined.
66	.	.	.	*Caladenia longicauda* x aff. *huegelii*
66	.	1	.	*Caladenia marginata* Lindley
66	.	.	.	*Caladenia reptans* Lindley
66	.	.	1	*Caladenia* sp. (A.P. Brown 198 & S. van Leeuwen)
66	.	1	1	*Caladenia* sp. (S. van Leeuwen 99)
66	.	.	1	*Caladenia* sp. (A.P. Brown 197 & S. van Leeuwen)
111	.	.	.	*Calandrinia calyptrata* J.D.Hook.
54C	.	.	.	*Calectasia cyanea* R.Br.
273	.	3	.	*Calothamnus blepharospermus* F.Muell.

cont'd ...

A	B	C	D	TAXA
273	.	.	.	*Calothamnus hirsutus* T.J.Hawkeswood
273	.	.	.	*Calothamnus quadrifidus* R.Br.
273	.	.	.	*Calothamnus sanguineus* Labill.
273	.	.	.	*Calothamnus torulosus* Schauer
345	.	.	.	*Calotis erinacea* Steetz
273	.	.	.	*Calythropsis* sp. indet. (E.A.Griffin 2224)
273	.	.	.	*Calytrix* aff. *tenuifolia* (Meissner)Benth (E.A.Griffin s.n.)
273	.	.	.	*Calytrix aurea* Lindley
273	.	.	.	*Calytrix flavescens* Cunn.
273	.	.	.	*Calytrix fraseri* Cunn.
273	.	.	.	*Calytrix leschenaultii* (Schauer)Benth.
273	.	.	.	*Calytrix oldfieldii* Benth.
273	.	.	.	*Calytrix sapphirina* Lindley
131	.	.	.	*Cassytha flava* Nees
131	.	.	.	*Cassytha glabella* R.Br.
131	.	.	.	*Cassytha pomiformis* Nees
131	.	.	.	*Cassytha racemosa* Nees
70	.	.	.	*Casuarina obesa* Miq.
32	.	.	.	*Caustis dioica* R.Br.
32	.	.	1	*Caustis* sp. (A.S.George 9318)
345	.	.	.	**Centaurea melitensis* L.
303	.	.	.	**Centaurium erythraea* Rafn.
40	.	.	.	*Centrolepis aristata* (R.Br.)Roemer & Schultes
40	.	.	.	*Centrolepis drummondiana* (Nees)Walp.
40	.	.	.	*Centrolepis inconspicua* W.Fitzg.
54F	.	.	.	*Chamaescilla corymbosa* (R.Br.)F.Muell.ex Benth.
273	.	.	.	*Chamelaucium uncinatum* Schauer
7	.	.	.	*Cheilanthes austrotenuifolia* H.Quirk & T.C.Chambers
165	.	2	.	*Chorizema ilicifolium* Labill.
345	.	.	.	*Chrysocoryne pusilla* (Benth.)Endl.
119	.	.	.	*Clematis pubescens* Huegel ex Endl.
183	3	.	.	*Comesperma acerosum* Steetz
183	.	.	.	*Comesperma calymega* Labill.
183	.	1	.	*Comesperma ciliatum* Steetz
183	.	.	.	*Comesperma drummondii* Steetz
183	.	.	.	*Comesperma scoparium* Steetz
223	.	.	.	*Commersonia pulchella* Turcz.
90	.	.	.	*Conospermum crassinervium* Meissner
90	.	.	.	*Conospermum glumaceum* Lindley
90	.	.	.	*Conospermum nervosum* Meissner
90	.	.	.	*Conospermum stoechadis* Endl.
90	.	.	1	*Conospermum* aff. *triplinervium* R.Br. (E.A.Griffin 5262)
288	.	.	.	*Conostephium pendulum* Benth.
288	.	.	.	*Conostephium preissii* Sonder
55	.	.	.	*Conostylis aculeata* R.Br. ssp. *breviflora* Hopper
55	.	.	.	*Conostylis androstemma* F.Muell.
55	.	.	.	*Conostylis angustifolia* Hopper
55	.	.	.	*Conostylis aurea* Lindley
55	.	.	.	*Conostylis candicans* Endl. ssp. *candicans*
55	.	.	.	*Conostylis canteriata* Hopper
55	.	.	.	*Conostylis crassinerva* J.W.Green ssp. *absens* Hopper
55	.	.	.	*Conostylis crassinerva* J.W.Green ssp. *crassinerva*
55	.	.	.	*Conostylis latens* Hopper

cont'd ...

A	B	C	D	TAXA
55	.	.	.	*Conostylis neocymosa* Hopper
55	.	.	.	*Conostylis teretifolia* J.W.Green ssp. *teretifolia*
55	.	.	.	*Conostylis teretiuscula* F.Muell.
273	.	.	.	*Conothamnus trinervis* Lindley
54F	.	.	.	*Corynotheca micrantha* (Lindley)J.F.Macbr.
345	.	.	.	*Cotula coronopifolia* L.
345	.	.	.	*Craspedia glauca* (Labill.)Spreng.
149	.	.	.	*Crassula colorata* (Nees)Ostenf.
149	.	.	.	*Crassula pedunculacris* (Smith)Meigen
215	.	.	.	*Cryptandra arbutiflora* Fenzl
215	.	.	.	*Cryptandra glabriflora* Benth.
215	.	.	.	*Cryptandra humilis* (Benth.)F.Muell.
215	.	.	.	*Cryptandra leucophracta* Schldl.
215	.	.	.	*Cryptandra pungens* Steudel
307A	.	.	.	*Cuscuta australis* R.Br.
32	.	.	.	*Cyathochaeta avenacea* Benth.
66	.	.	.	*Cyrtostylis huegelii* Endl.
341	.	.	.	*Dampiera alata* Lindley
341	.	.	.	*Dampiera carinata* Benth.
341	.	.	.	*Dampiera cuneata* R.Br.
341	.	.	.	*Dampiera lavandulacea* Lindley
341	.	.	.	*Dampiera lindleyi* Vreise
341	.	.	.	*Dampiera oligophylla* Benth. var. *juncea* (Benth.) Rajput & Carolin
341	.	.	.	*Dampiera spicigera* Benth.
341	.	.	.	*Dampiera teres* Lindley
31	.	.	.	*Danthonia caespitosa* Gaudich.
273	1	.	.	*Darwinia helichrysoides* (Meissner)Benth.
273	1	.	.	*Darwinia helichrysoides* x *neildiana*
273	1	.	.	*Darwinia helichrysoides* x *sanguinea*
273	.	.	.	*Darwinia neildiana* F.Muell.
273	1	.	.	*Darwinia neildiana* x *sanguinea*
273	.	.	.	*Darwinia pauciflora* Benth.
273	5	.	.	*Darwinia sanguinea* (Meissner)Benth.
273	.	.	.	*Darwinia speciosa* (Meissner)Benth.
54C	.	1	.	*Dasypogon obliquifolius* Lehm.ex Nees
281	.	.	.	*Daucus glochidiatus* (Labill.)Fischer *et al.*
165	.	.	.	*Daviesia benthamii* Meissner
165	.	.	.	*Daviesia daphnoides* Meissner
165	.	.	.	*Daviesia decurrens* Meissner
165	.	.	.	*Daviesia divaricata* Benth.
165	3	.	.	*Daviesia epiphyllum* Meissner
165	.	.	.	*Daviesia incrassata* Smith
165	.	1	.	*Daviesia longifolia* Benth.
165	.	.	.	*Daviesia nudiflora* Meissner
165	.	.	.	*Daviesia pedunculata* Benth.
165	.	.	.	*Daviesia preissii* Meissner
165	.	.	.	*Daviesia quadrilatera* Benth.
165	2	.	1	*Daviesia* aff *striata* (M.D.Crisp 6213)
165	.	.	.	*Daviesia triflora* M.D.Crisp
165	1	.	1	*Daviesia* sp. (M.D.Crisp 5429)
54E	.	.	.	*Dianella revoluta* R.Br.
31	.	.	.	*Dichelachne crinata* (L.f.)J.D.Hook.
54F	.	.	.	*Dichopogon capillipes* (Endl.)Brittan

cont'd ...

A	B	C	D	TAXA
54F	.	.	.	*Dichopogon preissii* (Endl.)Brittan
54F	.	.	.	*Dichopogon* sp. (E.A.Griffin s.n.)
59	.	.	.	*Dioscorea hastifolia* Endl.
175	.	.	.	*Diplolaena angustifolia* Hook.
175	3	.	.	*Diplolaena ferruginea* Paul G.Wilson
175	.	.	.	*Diplolaena microcephala* Bartling var. *microcephala*
207	.	.	.	*Diplopeltis huegelii* Endl.
345	.	.	.	**Dittrichia graveolens* (L.)Greuter
66	.	.	.	*Diuris laxiflora* Lindley
66	.	.	.	*Diuris longifolia* R.Br.
66	.	.	.	*Diuris setacea* R.Br.
207	.	.	.	*Dodonaea ericoides* Miq.
143	.	.	.	*Drosera barbigera* Planchon
143	.	.	.	*Drosera erythrorrhiza* Lindley
143	.	.	.	*Drosera gigantea* Lindley
143	.	.	.	*Drosera glanduligera* Lehm.
143	.	.	.	*Drosera heterophylla* Lindley
143	.	.	.	*Drosera leucoblasta* Benth.
143	.	.	.	*Drosera macrantha* Endl.
143	.	.	.	*Drosera menziesii* R.Br. ssp. *menziesii*
143	.	.	.	*Drosera menziesii* R.Br. ssp. *thysanosepala* (Diels)N.Marchant
143	.	2	.	*Drosera microphylla* Endl.
143	.	.	.	*Drosera pallida* Lindley
143	.	.	.	*Drosera stolonifera* Endl. ssp. *humilis* (Planch.)N.Marchant
90	.	.	.	*Dryandra armata* R.Br.
90	.	.	.	*Dryandra bipinnatifida* R.Br.
90	.	.	.	*Dryandra carlinoides* Meissner
90	.	.	1	*Dryandra* aff. *falcata* R.Br. (E.A.Griffin 3489)
90	.	.	.	*Dryandra fraseri* R.Br.
90	.	.	.	*Dryandra nana* Meissner
90	.	.	.	*Dryandra nivea* (Labill.)R.Br.
90	.	.	1	*Dryandra* aff. *patens* Benth. (E.A.Griffin 1507)
90	.	.	.	*Dryandra sclerophylla* Meissner
90	.	.	.	*Dryandra sessilis* (Knight)Domin
90	.	.	.	*Dryandra shuttleworthiana* Meissner
90	3	.	.	*Dryandra tortifolia* Kipp.ex Meissner
90	.	.	.	*Dryandra tridentata* Meissner
39	.	.	.	*Ecdeiocolea monostachya* F.Muell.
31	.	.	.	**Ehrharta longiflora* Smith
32	.	.	.	*Eleocharis acuta* R.Br.
66	.	.	.	*Elythranthera brunonis* (Endl.)George
66	.	.	.	*Elythranthera emarginata* (Lindley)George
137B	.	.	.	*Emblingia calceoliflora* F.Muell.
105	.	.	.	*Enchylaena tomentosa* R.Br.
273	.	.	.	*Eremaea acutifolia* F.Muell.
273	.	.	.	*Eremaea beaufortioides* Benth.
273	.	1	1	*Eremaea* aff. *brevifolia* (Benth.) Domin (D.Coates M1 175.5)
273	.	.	1	*Eremaea* aff. *brevifolia* (Benth.) Domin (D.Coates 818 E4/2)
273	.	.	1	*Eremaea pauciflora* (Endl.)Druce ssp. (D.Coates E8)
273	.	.	.	*Eremaea violacea* F.Muell.
66	.	.	.	*Eriochilus dilatatus* Lindley ssp. *dilatatus*
66	.	.	.	*Eriochilus scaber* Lindley
175	.	.	.	*Eriostemon pinoides* Paul G.Wilson

cont'd ...

A	B	C	D	TAXA
175	.	.	.	*Eriostemon spicatus* A.Rich.
167	.	.	.	**Erodium aureum* Carolin
281	.	.	.	*Eryngium rostratum* Cav.
273	.	.	.	*Eucalyptus accedens* W.Fitzg.
273	.	1	.	*Eucalyptus calophylla* Lindley
273	.	.	.	*Eucalyptus* aff. *decipiens* Endl. (E.A.Griffin s.n.)
273	.	.	.	*Eucalyptus drummondii* Benth.
273	.	3	.	*Eucalyptus erythrocorys* F.Muell.
273	.	2	.	*Eucalyptus exilis* Brooker
273	.	.	.	*Eucalyptus pluricaulis* Brooker & Hopper ined.
273	.	.	.	*Eucalyptus gittinsii* Brooker & Blaxell
273	1	.	1	*Eucalyptus* aff. *haematoxylon* Maiden (E.A.Griffin 2481)
273	6	.	.	*Eucalyptus lateritica* Brooker & Hopper
273	.	2	.	*Eucalyptus marginata* Donn ex Smith
273	.	3	.	*Eucalyptus obtusifolia* DC.
273	.	.	.	*Eucalyptus rudis* Endl.
273	6	.	.	*Eucalyptus suberea* Brooker & Hopper
273	.	.	.	*Eucalyptus todtiana* F.Muell.
273	.	.	1	*Eucalyptus wandoo* Blakely ssp. (M.I.H. Brooker 9885 & C. Souness)
273	.	.	.	*Eucalyptus* sp. (C.A. Gardner 9088)
92	.	.	.	*Exocarpos sparteus* R.Br.
32	.	.	.	*Gahnia* sp. indet. (E.A.Griffin s.n.)
331	.	.	.	**Galium murale* (L.)All.
165	.	.	.	*Gastrolobium bidens* Meissner
165	.	.	.	*Gastrolobium callistachys* Meissner
165	.	2	.	*Gastrolobium ilicifolium* Meissner
165	.	.	.	*Gastrolobium oxylobioides* Benth.
165	.	.	.	*Gastrolobium pauciflorum* C.Gardner
165	.	2	.	*Gastrolobium plicatum* Turcz.
165	.	.	.	*Gastrolobium spinosum* Benth.
276	.	.	.	*Glischrocaryon aureum* (Lindley)Orch.
345	.	.	.	*Gnaphalium sphaericum* Willd.
165	.	.	.	*Gompholobium aristatum* Benth.
165	.	.	.	*Gompholobium knightianum* Lindley
165	.	.	.	*Gompholobium marginatum* R.Br.
165	1	.	1	*Gompholobium* aff. *polymorphum* R.Br.(E.A.Griffin 2306)
165	.	.	.	*Gompholobium preissii* Meissner
165	.	.	.	*Gompholobium tomentosum* Labill.
276	.	.	.	*Gonocarpus nodulosus* Nees
276	.	.	.	*Gonocarpus pithyoides* Nees
341	.	.	.	*Goodenia caerulea* R.Br.
341	.	2	.	*Goodenia fasciculata* Benth.
341	.	.	.	*Goodenia filiformis* R.Br. var. *filiformis*
341	.	.	.	*Goodenia filiformis* R.Br. var. *minutiflora* F.Muell.
341	.	.	.	*Goodenia hassallii* F.Muell.
341	1	.	.	*Goodenia xanthotricha* Vriese
90	.	.	.	*Grevillea acerosa* F.Muell.
90	2	.	.	*Grevillea acrobotrya* Meissner ssp. *uniforma* McGillvray
90	.	.	.	*Grevillea argyrophylla* Meissner
90	.	.	.	*Grevillea eriostachya* Lindley
90	.	.	.	*Grevillea integrifolia* (Endl.)Meissner ssp.
90	5	.	.	*Grevillea olivacea* George
90	.	.	.	*Grevillea pilulifera* (Lindley)Druce

cont'd ...

A	B	C	D	TAXA
90	.	.	.	*Grevillea pinifolia* Meissner
90	.	.	.	*Grevillea rudis* Meissner
9	.	.	.	*Grevillea synapheae* R.Br.
90	1	.	.	*Grevillea thelemanniana* Huegel ex Endl. ssp. *delta* McGillvray
90	.	.	.	*Grevillea thelemanniana* Huegel ex Endl. ssp. *thelemanniana*
223	2	.	1	*Guichenotia* sp. (E.A. Griffin 858)
223	.	.	.	*Guichenotia sarotes* Benth.
108	.	.	.	*Gyrostemon ramulosus* Desf.
55	.	1	.	*Haemodorum laxum* R.Br.
55	.	.	.	*Haemodorum loratum* T.D.Macfarlane
55	.	1	.	*Haemodorum paniculatum* Lindley
55	.	.	.	*Haemodorum simplex* Lindley
55	.	.	.	*Haemodorum simulans* F.Muell.
55	.	.	.	*Haemodorum spicatum* R.Br.
55	.	.	.	*Haemodorum venosum* T.D.Macfarlane
90	.	.	.	*Hakea auriculata* Meissner var. *auriculata*
90	1	.	.	*Hakea auriculata* Meissner var. *spathulata* Benth.
90	.	.	.	*Hakea conchifolia* Hook.
90	.	.	.	*Hakea corymbosa* R.Br.
90	.	.	.	*Hakea costata* Meissner
90	.	1	.	*Hakea erinacea* Meissner var. *erinacea*
90	1	.	.	*Hakea erinacea* Meissner var. *longiflora* Benth.
90	.	.	.	*Hakea flabellifolia* Meissner
90	.	.	.	*Hakea gilbertii* Kipp.ex Meissner
90	.	.	.	*Hakea incrassata* R.Br.
90	.	.	.	*Hakea lissocarp*ha R.Br.
90	.	2	.	*Hakea marginata* R.Br.
90	6	.	.	*Hakea megalosperma* Meissner
90	5	.	.	*Hakea neurophylla* Meissner
90	.	.	.	*Hakea obliqua* R.Br.
90	.	.	.	*Hakea prostrata* R.Br.
90	.	.	.	*Hakea ruscifolia* Labill.
90	.	.	.	*Hakea stenocarpa* R.Br.
90	.	.	.	*Hakea trifurcata* (Smith)R.Br.
90	.	1	.	*Hakea undulata* R.Br.
90	.	1	.	*Hakea varia* R.Br.
165	.	.	.	*Hardenbergia comptoniana* (Andrews)Benth.
345	.	.	.	*Helichrysum apiculatum* (Labill.)D.Don
345	.	.	.	*Helichrysum bracteatum* (Vent.)Andrews
345	.	.	.	*Helichrysum macranthum* Benth.
345	.	.	.	*Helipterum corymbosum* (A.Gray)Benth.
345	.	.	.	*Helipterum cotula* (Benth.)DC.
345	.	.	.	*Helipterum gracile* (A.Gray)Benth.
345	.	.	.	*Helipterum manglesii* (Lindley)F.Muell.ex Benth.
345	.	2	.	*Helipterum oppositifolium* S.Moore
313	.	.	.	*Hemiandra linearis* Benth.
313	.	.	.	*Hemiandra pungens* R.Br.
313	2	.	.	*Hemiandra rubriflora* O.Sarg.
313	.	1	.	*Hemigenia barbata* Bartling
313	1	.	.	*Hemigenia curvifolia* F.Muell.
313	2	3	.	*Hemigenia diplanthera* F.Muell.
313	.	3	.	*Hemigenia saligna* Diels
54F	2	.	.	*Hensmania stoniella* Keighery

cont'd ...

A	B	C	D	TAXA
226	.	.	.	*Hibbertia acerosa* (R.Br.ex DC.)Benth.
226	.	.	.	*Hibbertia aurea* Steudel
226	.	.	.	*Hibbertia crassifolia* (Turcz.)Benth.
226	.	.	.	*Hibbertia desmophylla* (Benth.)F.Muell.
226	.	.	.	*Hibbertia huegelii* (Endl.)F.Muell.
226	.	.	.	*Hibbertia hypericoides* (DC.)Benth.
226	.	.	.	*Hibbertia* aff. *hypericoides*(DC.)Benth. (E.A.Griffin 2227)
226	.	2	.	*Hibbertia montana* Steudel
226	.	.	.	*Hibbertia* aff. *montana* Stuedel (E.A.Griffin 1831)
226	.	.	.	*Hibbertia racemosa* (Endl.)Gilg
226	.	.	.	*Hibbertia rupicola* (S.Moore)C.Gardner
226	.	.	.	*Hibbertia spicata* F.Muell.
226	.	.	.	*Hibbertia subvaginata* (Steudel)F.Muell.
226	.	.	.	*Hibbertia* sp. (E.A.Griffin 2253)
226	.	.	.	*Hibbertia* sp. (E.A.Griffin 2480)
281	.	.	.	*Homalosciadium homalocarpum* (F.Muell.)H.Eichler
165	.	.	.	*Hovea pungens* Benth.
165	.	.	.	*Hovea stricta* Meissner
165	.	.	.	*Hovea trisperma* Benth.
243	.	.	.	*Hybanthus calycinus* (DC.ex Ging.)F.Muell.
243	.	.	.	*Hybanthus* aff. *floribundus* (Lindley)F.Muell. (E.A. Griffin s.n.)
281	.	.	.	*Hydrocotyle diantha* DC.
281	.	.	.	*Hydrocotyle* sp. (E.A.Griffin s.n.)
273	1	.	1	*Hypocalymma* aff. *ericifolium* Benth. (E.A.Griffin 1972)
273	.	.	.	*Hypocalymma angustifolium* Endl.
273	.	.	.	*Hypocalymma xanthopetalum* F.Muell.
273	2	.	1	*Hypocalymma xanthopetalum* F.Muell. var. (C.Gardner 9096)
345	.	.	.	**Hypochoeris glabra* L.
56A	.	.	.	*Hypoxis occidentalis* Benth. var. *occidentalis*
32	.	.	.	*Isolepis marginata* (Thunb.)A.Dietr.
32	.	.	.	*Isolepis nodosa* (Rottb.)R.Br.
90	3	.	.	*Isopogon adenanthoides* Meissner
90	.	2	.	*Isopogon asper* R.Br.
90	.	.	.	*Isopogon divergens* R.Br.
90	.	2	.	*Isopogon drummondii* Benth.
90	.	2	.	*Isopogon dubius* (R.Br.)Druce
90	.	.	.	*Isopogon linearis* Meissner
90	.	2	.	*Isopogon sphaerocephalus* Lindley
90	.	.	.	*Isopogon teretifolius* R.Br.
90	3	.	.	*Isopogon tridens* F. Muell.
340	.	.	.	*Isotoma hypocrateriformis* (R.Br.)Druce
165	.	.	.	*Isotropis cuneifolia* (Smith)Benth. ex B.D.Jackson
165	.	.	.	*Jacksonia angulata* Benth.
165	.	.	.	*Jacksonia capitata* Benth.
165	.	.	.	*Jacksonia floribunda* Endl.
165	.	.	.	*Jacksonia furcellata* (Bonpl.)DC.
165	.	.	.	*Jacksonia lehmannii* Meissner
165	.	.	.	*Jacksonia restioides* Meissner
165	.	.	.	*Jacksonia spinosa* (Labill.)R.Br.
165	.	.	.	*Jacksonia sternbergiana* Huegel
165	.	.	.	*Jacksonia ulicina* Meissner
54F	.	.	.	*Johnsonia pubescens* Lindley
52	.	.	.	*Juncus* sp. indet. (E.A.Griffin s.n.)

cont'd ...

A	B	C	D	TAXA
165	.	.	.	*Kennedia prostrata* R.Br.
54C	.	.	.	*Kingia australis* R.Br.
164	.	.	.	*Labichea cassioides* Gaudich.
164	.	.	.	*Labichea punctata* Benth.
345	.	.	.	*Lagenifera huegelii* Benth.
31	.	.	.	**Lagurus ovatus* L.
90	.	.	.	*Lambertia multiflora* Lindley
223	.	.	.	*Lasiopetalum drummondii* Benth.
223	.	2	.	*Lasiopetalum floribundum* Benth.
223	3	.	.	*Lasiopetalum lineare* S.Paust
221	.	.	.	*Lawrencia glomerata* Hook.
221	.	.	.	*Lawrencia squamata* Nees ex Miq.
54F	.	.	.	*Laxmannia omnifertilis* Keighery
54F	.	.	.	*Laxmannia sessiliflora* Decne. ssp. *drummondii* Keighery
54F	.	.	.	*Laxmannia squarrosa* Lindley
341	.	.	.	*Lechenaultia biloba* Lindley
341	.	.	.	*Lechenaultia floribunda* Benth.
341	.	.	.	*Lechenaultia hirsuta* F.Muell.
341	.	.	.	*Lechenaultia linarioides* DC.
341	.	.	.	*Lechenaultia stenosepala* E.Pritzel
39	.	.	.	*Lepidobolus chaetocephalus* F.Muell.
39	.	.	.	*Lepidobolus preissianus* Nees
39	3	.	1	*Lepidobolus* sp. (E.A. Griffin 2093)
39	.	.	.	*Lepidibolus* sp. (E.A.Griffin s.n.)
32	.	.	.	*Lepidosperma angustatum* R.Br.
32	.	.	.	*Lepidosperma carphoides* F.Muell.ex Benth.
32	.	.	.	*Lepidosperma resinosum* (Nees)Benth.
32	.	.	.	*Lepidosperma tenue* Benth.
32	.	.	.	*Lepidosperma tuberculatum* Nees
32	.	2	.	*Lepidosperma viscidum* R.Br.
66	.	.	.	*Leporella fimbriata* (Lindley)George
39	.	.	.	*Leptocarpus aristatus* R.Br.
66	.	.	.	*Leptoceras menziesii* (R.Br.)Lindley
92	.	.	.	*Leptomeria empetriformis* Miq.
273	.	.	.	*Leptospermum oligandrum* Turcz.
273	.	.	.	*Leptospermum spinescens* Endl.
39	.	.	.	*Lepyrodia macra* Nees
39	.	.	.	*Lepyrodia* sp. indet. (E.A.Griffin 2535)
288	.	1	.	*Leucopogon australis* R.Br.
288	.	.	.	*Leucopogon conostephioides* DC.
288	.	.	.	*Leucopogon gracillimus* DC.
288	.	.	.	*Leucopogon* aff. *planifolius* Sonder (E.A.Griffin 2512)
288	1	.	.	*Leucopogon plumuliflorus* F.Muell.
288	.	.	.	*Leucopogon propinquus* R.Br.
288	2	.	1	*Leucopogon* aff. *rubicundus* F.Muell. ex Benth. (E.A.Griffin 2206)
288	.	.	.	*Leucopogon striatus* R.Br.
288	.	.	1	*Leucopogon* sp. (E.A.Griffin 1031)
288	.	.	.	*Leucopogon* sp. (E.A.Griffin 2153)
288	2	.	1	*Leucopogon* sp. (E.A.Griffin 2641)
343	.	.	.	*Levenhookia dubia* Sonder
343	.	.	.	*Levenhookia octomaculata* R.Erickson & J.H.Willis
343	.	.	.	*Levenhookia pusilla* R.Br.
340	.	.	.	*Lobelia heterophylla* Labill.

cont'd ...

A	B	C	D	TAXA
340	.	.	.	*Lobelia winfridae* Diels
302	.	.	.	*Logania campanulata* R.Br.
302	.	.	.	*Logania spermacocea* F.Muell.
302	.	1	.	*Logania vaginalis* (Labill.)F.Muell.
54C	.	1	.	*Lomandra brittanii* T.S.Choo
54C	.	.	.	*Lomandra caespitosa* (Benth.)Ewart
54C	.	.	.	*Lomandra hastilis* (R.Br.)Ewart
54C	.	.	.	*Lomandra micrantha* (Endl.)Ewart
54C	.	.	.	*Lomandra preissii* (Endl.)Ewart
54C	.	.	.	*Lomandra sericea* (Endl.)Ewart
54C	.	1	.	*Lomandra suaveolens* (Endl.)Ewart
54C	.	.	.	*Lomandra* sp. (E.A.Griffin s.n.)
39	.	.	1	*Loxocarya* aff. *cinerea* R.Br. (E.A.Griffin 1986)
39	.	.	.	*Loxocarya fasciculata* (R.Br.)Benth.
39	.	.	.	*Loxocarya flexuosa* (R.Br.)Benth.
39	2	.	1	*Loxocarya* sp. (B. Briggs 7481)
39	.	.	.	*Lyginea barbata* R.Br.
66	.	.	.	*Lyperanthus nigricans* R.Br.
288	.	.	.	*Lysinema ciliatum* R.Br.
110A	.	.	.	*Macarthuria australis* Huegel ex Endl.
55	5	.	.	*Macropidia fuliginosa* (Hook.)Druce
16A	.	.	.	*Macrozamia riedlei* (Fisch.ex Gaudich.) C.Gardner
273	.	.	.	*Melaleuca acerosa* Schauer
273	.	.	1	*Melaleuca* aff. *acerosa Schauer* (E.A.Griffin 2436)
273	.	.	.	*Melaleuca bracteosa* Turcz.
273	.	.	.	*Melaleuca cardiophylla* F.Muell.
273	.	.	.	*Melaleuca ciliosa* Turcz.
273	.	.	.	*Melaleuca huegelii* Endl.
273	.	.	.	*Melaleuca lateritia* A.Dietr.
273	.	.	1	*Melaleuca* aff. *megacephala* F.Muell. (E.A.Griffin 2359)
273	.	.	.	*Melaleuca platycalyx* Diels
273	.	.	.	*Melaleuca preissiana* Schauer
273	.	.	.	*Melaleuca radula* Lindley
273	.	.	.	*Melaleuca rhaphiophylla* Schauer
273	.	.	.	*Melaleuca scabra* R.Br.
273	.	.	1	*Melaleuca* aff. *sclerophylla* Diels (E.A.Griffin 1590)
273	.	.	.	*Melaleuca scabra* x aff. *megacephala* (E.A. Griffin s.n.)
273	.	.	.	*Melaleuca seriata* Lindley
273	.	.	.	*Melaleuca trichophylla* Lindley
273	.	.	.	*Melaleuca* aff. *trichophylla* Lindley (E.A.Griffin s.n.)
273	.	.	.	*Melaleuca uncinata* R.Br.
273	.	.	.	*Melaleuca undulata* Benth.
273	.	.	.	*Melaleuca viminea* Lindley
32	.	.	.	*Mesomelaena graciliceps* (C.B.Clarke)K.L.Wilson
32	.	.	.	*Mesomelaena stygia* (R.Br.)Nees
32	.	.	.	*Mesomelaena tetragona* (R.Br.)Benth.
313	.	.	1	*Microcorys* sp. (R.J.Hnatuik 771501)
66	.	1	.	*Microtis alba* R.Br.
66	.	1	1	*Microtis* aff. *alba* R.Br. (E.A.Griffin s.n.)
66	.	.	.	*Microtis unifolia* (G.Forster)H.G.Reichb.
345	.	.	.	*Millotia myosotidifolia* (Benth.)Steetz
345	.	.	.	*Millotia tenuifolia* Cass.
165	.	.	.	*Mirbelia floribunda* Benth.

cont'd ...

A	B	C	D	TAXA
165	.	.	.	*Mirbelia spinosa* Benth.
302	.	.	.	*Mitrasacme paradoxa* R.Br.
185	.	.	.	*Monotaxis grandiflora* Endl.
103	.	.	.	*Muehlenbeckia adpressa* (Labill.)Meissner
326	.	.	.	*Myoporum caprarioides* Benth.
345	.	.	.	*Myriocephalus rhizocephalus* (DC.)Benth.
31	.	.	.	*Neurachne alopecuroides* R.Br.
97	.	.	.	*Nuytsia floribunda* (Labill.)R.Br.ex Fenzl
95	.	.	.	*Olax benthamiana* Miq.
95	1	.	.	*Olax scalariformis* Miq.
345	.	.	.	*Olearia axillaris* (DC.)F.Muell.ex Benth.
345	.	2	.	*Olearia ciliata* (Benth.)F.Muell.ex Benth.
345	.	.	.	*Olearia elaeophila* (D.C.)F.Muell.ex Benth.
345	.	2	.	*Olearia paucidentata* (Steetz)F.Muell.ex Benth.
345	.	.	.	*Olearia rudis* (Benth.)F.Muell.ex Benth.
331	.	.	.	*Opercularia vaginata* Labill.
60	.	.	.	*Orthrosanthus* laxus (Endl.)Benth. var. *laxus*
168	.	.	.	**Oxalis* sp. indet. (E.A.Griffin s.n.)
165	.	.	.	*Oxylobium capitatum* Benth.
165	2	.	.	*Oxylobium reticulatum* Meissner var. *gracile* Benth.
66	.	.	.	*Paracaleana nigrita* (Lindley)Blaxell
316	.	.	.	**Parentucellia latifolia* (L.)Caruel
88	.	.	.	*Parietaria debilis* G.Forster
60	1	.	.	*Patersonia argyrea* D.A.Cooke
60	.	.	.	*Patersonia drummondii* (F.Muell.)Benth.
60	.	.	.	*Patersonia occidentalis* R.Br.
90	.	.	.	*Persoonia acicularis* F.Muell.
90	.	1	.	*Persoonia comata* Meissner
90	1	.	.	*Persoonia rudis* Meissner
90	.	.	.	*Persoonia rufiflora* Meissner
90	.	.	1	*Persoonia* aff. *sulcata* Meissner (E.A.Griffin 795)
90	.	.	.	*Petrophile brevifolia* Lindley
90	2	.	1	*Petrophile* aff. *brevifolia* Lindley (E.A.Griffin 2203)
90	.	.	.	*Petrophile chrysantha* Meissner
90	2	.	1	*Petrophile* aff. *divaricata* R.Br. (E.A.Griffin 2547)
90	.	.	.	*Petrophile ericifolia* R.Br.
90	.	.	.	*Petrophile inconspicua* Meissner
90	.	.	.	*Petrophile linearis* R.Br.
90	.	.	.	*Petrophile macrostachya* R.Br.
90	.	.	.	*Petrophile megalostegia* F.Muell.
90	.	.	.	*Petrophile seminuda* Lindley
90	.	.	.	*Petrophile serruriae* R.Br.
90	.	.	.	*Petrophile shuttleworthiana* Meissner
90	.	.	.	*Petrophile striata* R.Br.
50	.	.	.	*Philydrella pygmaea* (R.Br.)Caruel ssp. *pygmaea*
55	.	1	.	*Phlebocarya ciliata* R.Br.
55	3	.	.	*Phlebocarya filifolia* (F.Muell.)Benth.
55	3	.	.	*Phlebocarya pilosissima* (F.Muell.)Benth ssp. *pilosissima*
55	1	.	.	*Phlebocarya pilosissima* (F.Muell.)Benth.ssp. *teretifolia* T.MacFarlane
185	.	.	.	*Phyllanthus calycinus* Labill.
273	.	.	.	*Pileanthus filifolius* Meissner
263	.	.	.	*Pimelea angustifolia* R.Br.
263	.	.	.	*Pimelea argentea* R.Br.

cont'd ...

A	B	C	D	TAXA
263	.	.	.	*Pimelea floribunda* Meissner
263	.	.	.	*Pimelea imbricata* R.Br. var. *piligera* (Benth.)Diels & E.Pritzel
263	.	.	.	*Pimelea suaveolens* Meissner
263	.	.	.	*Pimelea sulphurea* Meissner
263	.	.	.	*Pimelea sylvestris* R.Br.
345	.	.	.	*Pithocarpa pulchella* Lindley
152	.	.	.	*Pittosporum phylliraeoides* DC.
311A	.	.	.	*Pityrodia bartlingii* (Lehm.)Benth.
311A	.	.	.	*Pityrodia verbascina* (F.Muell.)Benth.
281	.	.	.	*Platysace juncea* (Bunge)Norman
281	.	.	.	*Platysace teres* (Bunge)Norman
281	.	.	.	*Platysace xerophila* (E.Pritzel)L.Johnson
182	.	1	.	*Platytheca galioides* Steetz
31	.	.	.	*Poa drummondiana* Nees
345	.	.	.	*Podolepis gracilis* (Lehm.)R.A.Graham
345	.	.	.	*Podolepis lessonii* (Cass.)Benth.
345	.	.	.	*Podotheca angustifolia* (Labill.)Less.
345	.	.	.	*Podotheca chrysantha* (Steetz)Benth.
345	.	.	.	*Podotheca gnaphalioides* R.A.Graham
323	.	2	.	*Polypompholyx multifida* (R.Br.)F.Muell.
185	.	.	.	*Poranthera microphylla* Brongn.
66	.	.	.	*Prasophyllum cyphochilum* Benth.
66	.	.	.	*Prasophyllum elatum* R.Br.
66	.	.	.	*Prasophyllum fimbria* H.G.Reichb.
66	.	.	.	*Prasophyllum giganteum* Lindley
66	.	.	.	*Prasophyllum macrostachyum* R.Br.
66	.	.	.	*Prasophyllum ringens* (H.G.Reichb.)Bates
66	.	.	.	*Prasophyllum ovale* Lindley var. *triglochin* H.G.Reichb.
66	.	1	.	*Prasophyllum parvifolium* Lindley
66	.	.	.	*Prasophyllum sargentii* (Nicholls)George
66	.	.	.	*Pterostylis dilatata* George
66	.	.	.	*Pterostylis nana* R.Br.
66	.	.	.	*Pterostylis scabra* Lindley var *scabra*
66	.	.	.	*Pterostylis scabra* Lindley var. *robusta* (R.Rogers) George
66	.	.	.	*Pterostylis vittata* Lindley var. *vittata*
106	.	.	.	*Ptilotus esquamatus* (Benth.)F.Muell.
106	.	.	.	*Ptilotus gaudichaudii* (Steudel)J.Black
106	.	.	.	*Ptilotus manglesii* (Lindley)F.Muell.
106	.	.	.	*Ptilotus stirlingii* (Lindley)F.Muell. var. *stirlingii*
165	.	2	.	*Pultenaea ericifolia* Benth.
345	.	.	.	*Quinetia urvillei* Cass.
39	3	.	1	*Restio* aff. *sphacelatus* R.Br. (B. Briggs 6293)
39	1	.	1	*Restio* sp. (Briggs 7473 & Johnson)
39	3	.	1	Restionaceae Genus aff. *Ecdeiocolea* (E.A.Griffin 2157)
185	.	.	.	*Ricinocarpus glaucus* Endl.
60	.	.	.	**Romulea rosea* (L.)Ecklon
223	.	.	.	*Rulingia corylifolia* R.A.Graham
223	.	.	.	*Rulingia* sp. indet. (E.A.Griffin s.n.)
345	.	.	.	*Rutidosis multiflora* (Nees)Robinson
293	.	.	.	*Samolus junceus* R.Br.
293	.	.	.	*Samolus repens* (Forster & G.Forster)Pers.
92	.	.	.	*Santalum spicatum* (R.Br.)A.DC.
341	.	.	.	*Scaevola canescens* Benth.

cont'd ...

A	B	C	D	TAXA
341	.	.	.	*Scaevola crassifolia* Labill.
341	.	.	.	*Scaevola glandulifera* DC.
341	.	.	.	*Scaevola lanceolata* Benth.
341	.	.	.	*Scaevola longifolia* Vreise
341	.	.	.	*Scaevola paludosa* R.Br.
341	.	.	.	*Scaevola phlebopetala* F.Muell.
341	.	.	.	*Scaevola pilosa* Benth.
341	.	.	.	*Scaevola thesioides* Benth.
32	.	.	.	*Schoenoplectus pungens* (M.Vahl)Palla
32	.	.	.	*Schoenus asperocarpus* F.Muell.
32	.	.	.	*Schoenus brevisetis* (R.Br.)Benth.
32	.	.	.	*Schoenus curvifolius* (R.Br.)Benth.
32	.	.	.	*Schoenus globifer* Nees
32	.	.	.	*Schoenus grandiflorus* (Nees)F.Muell.
32	.	.	.	*Schoenus nanus* (Nees)Benth.
32	.	.	.	*Schoenus obtusifolius* (Nees)Boeckler
32	.	.	.	*Schoenus pedicellatus* (R.Br.)Benth.
32	.	.	.	*Schoenus pleiostemoneus* F.Muell.
32	.	.	.	*Schoenus* aff. *pleiostemoneus* F.Muell. (E.A.Griffin s.n.)
32	.	.	.	*Schoenus subflavus* Kuck.
32	.	.	.	*Schoenus unispiculatus* F.Muell.ex Benth.
32	.	.	.	*Schoenus* sp. (E.A.Griffin 2541)
32	.	.	.	*Schoenus* sp. (E.A.Griffin 4236)
273	.	.	.	*Scholtzia capitata* F.Muell.ex Benth.
273	.	.	.	*Scholtzia involucrata* (Endl.)Druce
3	.	.	.	*Selaginella gracillima* (Kunze)Alston
345	.	2	.	*Senecio glomeratus* Desf.ex Poiret
345	.	.	.	*Senecio glossanthus* (Sonder)Belcher
345	.	.	.	*Senecio hispidulus* A.Rich.
345	.	.	.	*Senecio minimus* Poiret
221	.	.	.	*Sida hookeriana* Miq.
113	.	.	.	**Silene gallica* L.
345	.	.	.	*Siloxeros humifusus* Labill.
345	.	.	.	**Sonchus oleraceus* L.
54F	.	.	.	*Sowerbaea laxiflora* Lindley
165	.	.	.	*Sphaerolobium linophyllum* (Huegel)Benth.
165	.	.	.	*Sphaerolobium macranthum* Meissner
215	.	.	.	*Spyridium tridentatum* (Steudel)Benth.
185	.	.	.	*Stachystemon axillaris* George
202	.	.	.	*Stackhousia monogyna* Labill.
31	.	.	.	*Stipa compressa* R.Br.
31	.	.	.	*Stipa elegantissima* Labill.
31	.	1	.	*Stipa flavescens* Labill.
31	.	.	.	*Stipa macalpinei* Reader
31	.	.	.	*Stipa* sp. (E.A.Griffin 4279)
31	.	.	.	*Stipa* sp. (E.A.Griffin s.n.)
90	.	.	.	*Stirlingia latifolia* (R.Br.)Steudel
90	.	.	.	*Stirlingia simplex* Lindley
90	.	.	.	*Strangea cynanchocarpa* (Meissner)F.Muell.
343	.	.	.	*Stylidium adpressum* Benth.
343	2	.	.	*Stylidium aeonioides* Carlq.
343	.	2	.	*Stylidium breviscapum* R.Br.
343	.	.	.	*Stylidium brunonianum* Benth. ssp. *brunonianum*

cont'd ...

A	B	C	D	TAXA
343	.	.	.	*Stylidium calcaratum* R.Br.
343	.	2	.	*Stylidium carnosum* Benth.
343	.	.	.	*Stylidium crossocephalum* F.Muell.
343	.	.	.	*Stylidium dichotomum* DC.
343	.	.	.	*Stylidium diuroides* Lindley
343	.	.	.	*Stylidium elongatum* Benth.
343	.	.	.	*Stylidium inundatum* R.Br.
343	5	.	.	*Stylidium inversiflorum* Carlq.
343	.	.	.	*Stylidium junceum* R.Br.
343	.	.	.	*Stylidium leptocalyx* Sonder
343	.	.	.	*Stylidium leptophyllum* DC.
343	3	.	.	*Stylidium maitlandianum* E.Pritzel
343	.	.	.	*Stylidium piliferum* R.Br.
343	.	.	.	*Stylidium pubigerum* Sonder
343	.	2	.	*Stylidium pycnostachyum* Lindley
343	.	.	.	*Stylidium repens* R.Br.
343	.	.	1	*Stylidium* aff. *repens* R.Br.(A.S.George 2341)
343	.	.	.	*Stylidium schoenoides* DC.
90	.	.	.	*Synaphea petiolaris* R.Br.
90	.	.	.	*Synaphea spinulosa* (Burm.f.)Merr.
165	.	.	.	*Templetonia biloba* (Benth.)Polh.
165	.	.	.	*Templetonia retusa* (Vent.)R.Br.
108	.	.	.	*Tersonia cyathiflora* (Fenzl)George
32	.	.	.	*Tetraria octandra* (Nees)Kuek.
182	.	.	.	*Tetratheca confertifolia* Steetz
182	.	.	.	*Tetratheca paucifolia* J.Thompson
182	1	.	.	*Tetratheca remota* J.Thompson
66	.	.	.	*Thelymitra antennifera* (Lindley)J.D.Hook.
66	.	.	.	*Thelymitra campanulata* Lindley
66	.	1	.	*Thelymitra crinita* Lindley
66	.	.	.	*Thelymitra fuscolutea* R.Br. ssp. *fuscolutea*
66	.	.	.	*Thelymitra nuda* R.Br.
66	.	.	.	*Thelymitra pauciflora* R.Br.
66	6	.	.	*Thelymitra stellata* Lindley
66	5	.	.	*Thelymitra variegata* (Lindley)F.Muell. var.*apiculata* George
66	.	.	.	*Thelymitra variegata* (Lindley)F.Muell. var. *variegata*
66	.	.	.	*Thelymitra villosa* Lindley
223	.	.	.	*Thomasia foliosa* Gay
223	.	.	.	*Thomasia grandiflora* Lindley
223	.	1	.	*Thomasia pauciflora* Lindley
273	.	.	.	*Thryptomene baeckeacea* F.Muell.
54F	1	2	.	*Thysanotus anceps* Lindley
54F	.	1	.	*Thysanotus arbuscula* Baker
54F	.	.	.	*Thysanotus arenarius* Brittan
54F	.	.	.	*Thysanotus asper* Lindley
54F	.	.	.	*Thysanotus dichotomus* (Labill.)R.Br.
54F	.	1	.	*Thysanotus glaucus* Endl.
54F	.	.	.	*Thysanotus manglesianus* Kunth
54F	.	.	.	*Thysanotus patersonii* R.Br.
54F	.	.	.	*Thysanotus sparteus* R.Br.
54F	2	.	1	*Thysanotus* aff. *sparteus* R.Br. (E.A. Griffin 2511)
54F	.	.	.	*Thysanotus thyrsoideus* Baker
54F	.	.	.	*Thysanotus triandrus* (Labill.)R.Br.

cont'd ...

A	B	C	D	TAXA
54F	2	.	.	*Thysanotus vernalis* Brittan
281	.	.	.	*Trachymene coerulea* R.A.Graham
281	.	.	.	*Trachymene cyanopetala* (F.Muell.)Benth.
281	.	.	.	*Trachymene pilosa* Smith
55	.	.	.	*Tribonanthes australis* Endl.
345	.	2	.	*Trichocline spathulata* (Cunn.ex DC.)J.H.Willis
54F	.	.	.	*Tricoryne elatior* R.Br.
54F	2	.	1	*Tricoryne* aff. *humilis* Endl. (E.A.Griffin 1451)
165	.	.	.	**Trifolium campestre* Schreber
26	.	.	.	*Triglochin centrocarpa* Hook.
26	.	.	.	*Triglochin mucro nata* R.Br.
202	.	.	.	*Tripterococcus brunonis* Endl.
31	.	.	.	**Trisetaria cristata* (L.)Kerguelen
215	.	1	.	*Trymalium floribundum* Steudel
215	.	.	.	*Trymalium ledifolium* Fenzl
215	.	.	.	*Trymalium wichurae* Nees ex Reissek
215	.	.	1	*Trymalium* aff. *wichurae* Nees ex Reisse (E.A.Griffin 2234)
345	.	.	.	**Ursinia anthemoides* (L.)Poiret
323	.	2	.	*Utricularia menziesii* R.Br.
341	.	.	.	*Velleia trinervis* Labill.
341	.	.	.	*Verreauxia reinwardtii* (Vreise)Benth.
273	.	.	.	*Verticordia chrysantha* Endl.
273	.	.	1	*Verticordia* aff. *brownii* (Desf.) DC. (A.S. George 16562 & E.A. George).
273	.	.	.	*Verticordia densiflora* Lindley
273	.	.	.	*Verticordia grandis* J.Drumm.ex Meissner
273	.	.	.	*Verticordia huegelii* Endl.
273	.	.	.	*Verticordia insignis* Endl. ssp. (A..S. George 16871 & E.A. George)
273	.	.	.	*Verticordia nobilis* Meissner
273	.	.	.	*Verticordia ovalifolia* Meissner
273	.	.	.	*Verticordia pennigera* Endl.
273	.	.	.	*Verticordia picta* Endl.
273	.	.	.	*Verticordia* sp. indet.(E.A.Griffin s.n.)
165	.	.	.	*Viminaria juncea* (Schrader & Wendl.)Hoffsgg.
31	.	.	.	**Vulpia myuros* (L.) C.Gmelin var. *hirsuta* Hack.
339	.	.	.	**Wahlenbergia capensis* (L.)A.DC.
339	.	.	.	*Wahlenbergia preissii* Vreise
345	.	.	.	*Waitzia aurea* (Benth.)Steetz
345	.	.	.	*Waitzia paniculata* (Steetz)F.Muell.ex Benth.
345	.	.	.	*Waitzia suaveolens* (Benth.)Druce
108	3	.	.	*Walteranthus erectus* Keighery
313	.	.	.	*Westringia dampieri* R.Br.
54J	.	.	.	*Wurmbea dioica* (R.Br.)F.Muell. ssp. *alba* T.Macfarlane
54D	.	.	.	*Xanthorrhoea drummondii* Harvey
281	.	.	.	*Xanthosia fruticulosa* Benth.
281	.	.	.	*Xanthosia huegelii* (Benth.)Steudel
281	1	.	.	*Xanthosia tomentosa* George
90	.	.	.	*Xylomelum angustifolium* Kipp. & Meissner

15.2 APPENDIX 2

Distributional, information, reserve status and conservation coding for regional endemics and Declared Rare Flora of the Northern Sandplain between the Moore and Irwin Rivers.

Column A: Geographic range of the taxa, (1) less than 50 km, (2) 50 to 160 km, (3) greater than 160 km.

Column B: Location within Lesueur Area, (0) not present, (1) coastal, (2) western uplands, (3) eastern uplands.

Column C: Conservation coding, (1 to 5) CALM's reserve list priorities as outlined in text, (6) Declared Rare Flora, (7) other taxa (unallocated and non-priority species).

Column D: Undescribed taxa (1).

Column E: Geomorphology on which the taxa have been recorded, (1) Arrowsmith, (2) Bassendean Dunes, (3) Coastal Belt, (4) Dandaragan Plateau, (5) Eneabba Plain, (6) Yandanooka Uplands, (7) Yarra Yarra Region.

Herbarium Location Data

Column F: Number of records.

Column G: Per centage in conservation reserve.

Column H: Per centage in Lesueur Area.

Column I: Per centage in eastern uplands of Lesueur Area.

TAXA	A	B	C	D	E	F	G	H	I
Acacia aff. *bidentata* (B.R. Maslin 6122)	1	0	2	1	7	4	25	0	0
Acacia cliftoniana ssp. *cliftoniana*	1	0	1	0	17	5	0	0	0
Acacia epacantha	2	23	7	0	14	12	0	33	8
Acacia fagonioides	2	0	7	0	1357	14	0	0	0
Acacia flabellifolia	2	0	1	0	7	6	0	0	0
Acacia forrestiana	2	23	6	0	14	5	0	80	40
Acacia aff. *microbotrya* (S. van Leeuwen 269)	1	0	6	1	1	1	0	0	0
Acacia aff. *myrtifolia* (R.J. Cranfield 33)	2	23	2	1	14	6	0	50	17
Acacia nodiflora	1	0	1	0	7	3	0	0	0
Acacia plicata	2	23	2	0	1	7	0	43	29
Acacia retrorsa	1	23	2	0	18	12	6	3	13
Acacia volubilis	2	23	3	0	147	11	0	36	9
Acacia aff. *xanthina* (A.R. Chapman 564)	2	0	2	1	135	6	0	0	0
Adenanthos stictus	2	0	3	0	7	11	18	0	0
Alexgeorgea subterranea	3	2	7	0	1237	15	13	13	0
Allocasuarina grevilleoides	2	23	3	0	14	13	15	15	7
Allocasuarina ramosissima	2	23	7	0	14	17	0	12	6
Andersonia longifolia	1	2	1	0	1	2	0	100	0
Anigozanthos humilis ssp. *chrysanthus*	1	0	6	0	4	2	0	0	0
Anigozanthos humilis ssp. (S.D. Hopper 6730)	2	0	1	1	12	3	0	0	0
Anigozanthos viridis ssp. terraspectans	1	0	6	0	2	3	0	0	0
Arnocrinum drummondii	3	0	2	0	7	2	0	0	0
Arnocrinum gracillimum	1	0	1	0	1	1	0	0	0
Asterolasia drummondii	2	23	6	0	1	11	0	82	36
Astroloma microdonta	3	2	3	0	145	20	20	20	0

cont'd ...

TAXA	A	B	C	D	E	F	G	H	I
Astroloma aff. pallidum (E.A. Griffin 1022)	2	23	2	1	145	7	14	28	14
Astroloma aff. *serratifolium* (N. Marchant s.n.)	2	2	2	1	15	6	0	17	0
Banksia burdettii	3	0	7	0	147	60	17	0	0
Banksia chamaephyton	2	3	7	0	147	31	19	6	6
Banksia elegans	2	1	7	0	35	10	10	10	0
Banksia grossa	2	23	7	0	147	57	11	11	5
Banksia hookeriana	2	0	7	0	135	30	10	0	0
Banksia lanata	2	0	7	0	145	23	17	0	0
Banksia micrantha	2	23	7	0	15	33	18	33	6
Banksia tricuspis	1	23	6	0	1	72	0	90	64
Beaufortia bicolor	2	3	3	0	1	14	28	7	7
Beaufortia aff. *bracteosa* (E.A. Griffin 1176)	2	23	7	1	1457	27	29	7	3
Beaufortia eriocephala	2	0	1	0	4	5	0	0	0
Beyeria cygnorum	3	0	3	0	0	3	0	0	0
Caladenia crebra	2	1	7	0	3	16	56	6	0
Caladenia denticulata ssp. (S.D. Hopper 6589)	1	0	1	1	5	1	0	0	0
Calothamnus longissimus	3	0	7	0	145	20	5	0	0
Calothamnus pachystachyus	2	0	2	0	47	5	0	0	0
Calytrix chrysantha	1	0	2	0	15	4	50	0	0
Calytrix drummondii	2	0	2	0	4	3	66	0	0
Calytrix eneabbensis	1	0	2	0	15	8	40	0	0
Calytrix platycheiridia	1	0	2	0	4	1	0	0	0
Calytrix superba	1	0	2	0	15	12	50	0	0
Caustis sp. (A.S. George 9318)	1	0	2	1	14	2	100	0	0
Chamelaucium sp. (G.J. Keighery 11009)	1	0	6	1	1	1	0	0	0
Comesperma acerosum	2	23	3	0	15	8	12	38	13
Comesperma rhadinocarpum	3	0	1	0	12	3	0	0	0
Conospermum crassinervium	2	2	7	0	15	19	16	32	0
Conospermum nervosum	2	23	7	0	1345	32	22	16	3
Conostylis aculeata ssp. *breviflora*	2	23	7	0	123457	33	15	12	3
Conostylis aculeata ssp. *spinuligera*	2	0	2	0	2	5	0	0	0
Conostylis angustifolia	2	2	7	0	124	20	0	10	0
Conostylis canteriata	2	2	7	0	134567	42	5	5	0
Conostylis crassinerva ssp. *absens*	3	23	7	0	125	48	18	8	2
Conostylis crassinerva	2	2	7	0	145	22	23	5	0
Conostylis dielsii ssp. *dielsii*	2	0	7	0	16	13	0	0	0
Conostylis festucacea ssp. *filifolia*	1	0	7	0	47	6	17	0	0
Conostylis hiemalis	3	0	7	0	13457	39	13	0	0
Conostylis neocymosa	2	2	7	0	1357	20	5	5	0
Conostylis seminuda	1	0	3	0	14	13	38	0	0
Conostylis tomentosa	1	0	7	0	15	10	10	0	0
Corynanthera flava	2	0	7	0	147	18	27	0	0
Cryptandra humilis	2	2	7	0	147	13	38	8	0
Dampiera tephrea	1	0	1	0	3	1	0	0	0
Darwinia acerosa	1	0	6	0	4	7	0	0	0
Darwinia helichrysoides	1	23	1	0	13	9	0	78	11
Darwinia neildiana	3	23	7	0	1245	39	15	21	3
Darwinia pinifolia	1	0	3	0	124	7	14	0	0
Darwinia sanguinea	2	23	5	0	1235	22	18	36	5
Darwinia speciosa	2	2	7	0	145	30	23	3	0
Dasypogon obliquifolius	2	23	7	0	15	8	25	25	12
Daviesia epiphylla	1	23	3	0	1	4	0	50	25
Daviesia aff. striata (M.D. Crisp 6213)	1	23	2	1	15	5	20	40	20

cont'd ...

TAXA	A	B	C	D	E	F	G	H	I
Daviesia sp. (M.D. Crisp 6480)	1	0	6	1	7	5	0	0	0
Daviesia sp. (M.D. Crisp 5429)	1	2	1	1	1	8	0	50	0
Daviesia sp. (S.D. Hopper 4829)	1	0	6	1	4	2	100	0	0
Diplolaena ferruginea	3	23	3	0	15	16	6	31	6
Dryandra aff. *armata* (A.S. George 16787)	1	0	1	1	7	2	0	0	0
Dryandra carlinoides	3	3	7	0	1245	89	10	1	1
Dryandra aff. *conferta* (E.A. Griffin s.n.)	2	0	7	0	14	30	20	0	0
Dryandra aff. *falcata* (E.A. Griffin 3489)	2	3	7	1	14	50	20	2	2
Dryandra aff. *frazeri* (J.S. Beard 7275)	2	0	1	1	17	8	0	0	0
Dryandra aff. *hewardiana* (A.S. George 16789)	1	0	1	1	7	11	0	0	0
Dryandra kippistiana	3	0	7	0	1457	51	18	0	0
Dryandra nana	2	2	7	0	1	28	7	4	0
Dryandra aff. *patens* (E.A. Griffin 1507)	2	3	7	1	1457	22	18	9	9
Dryandra aff. *polycephala* (E.A. Griffin 4945)	2	0	1	0	47	16	6	0	0
Dryandra aff. *pteridifolia* (E.A. Griffin 3475)	2	0	7	0	14	5	40	0	0
Dryandra sclerophylla	1	23	7	0	14	35	22	14	3
Dryandra aff. *sclerophylla* (A.S. George 16866)	1	0	1	1	4	1	0	0	0
Dryandra serratuloides	2	0	6	0	17	6	0	0	0
Dryandra shuttleworthiana	3	23	7	0	1245	18	8	2	1
Dryandra subulata	2	0	3	0	14	13	30	0	0
Dryandra tortifolia	2	3	3	0	15	7	14	14	14
Dryandra tridentata	2	2	7	0	12345	13	15	15	0
Dryandra sp. (E.A. Griffin 3453)	1	0	1	1	14	2	0	0	0
Dryandra sp. (R.D. Royce 9625)	1	0	1	1	14	2	100	0	0
Eremaea beaufortioides	2	0	1	0	15	5	0	0	0
Eremaea aff. *brevifolia* (D. Coates 818 E4/2)	1	0	2	1	145	5	40	0	0
Eremaea aff. *brevifolia* (D. Coates MI 175.5)	2	0	2	1	15	4	25	0	0
Eremaea aff. *paucifolia* (D. Coates 687)	1	0	1	1	7	1	0	0	0
Eremaea aff. *paucifolia* (D. Coates WAT2)	1	0	2	1	7	1	100	0	0
Eremaea aff. *violacea* (D. Coates WI 3/4/88)	1	0	1	1	47	2	0	0	0
Eremaea aff. violacea (E.A. Griffin 1557)	2	0	3	1	14	8	25	0	0
Eremophila microtheca ssp. (S.D. Hopper 2478)	1	0	6	1	3	1	100	0	0
Eriostemon pinoides	2	2	7	0	145	13	15	8	0
Eucalyptus aff. *accedens* (M.I.H. Brooker 8823)	1	0	6	1	1	1	0	0	0
Eucalyptus carnabyi	2	0	5	0	14	4	0	0	0
Eucalyptus foecunda ssp. (M.I.H. Brooker 9556)	1	0	2	1	3	2	100	0	0
Eucalyptus aff. *haematoxylon* (E.A. Griffin 2481)	1	23	1	1	1	7	0	100	43
Eucalyptus johnsoniana	1	0	6	0	15	12	58	0	0
Eucalyptus lateritica	1	23	6	0	1	13	0	62	23
Eucalyptus macrocarpa ssp. (S.D. Hopper 3121)	2	0	5	1	1245	37	3	0	0
Eucalyptus pendens	2	0	5	0	1	22	13	0	0
Eucalyptus suberea	1	23	6	0	1	11	0	73	27
Eucalyptus sp. (M.I.H. Brooker 9740)	2	0	2	1	147	2	0	0	0
Eucalyptus sp. (M.I.H. Brooker 9026)	1	0	6	1	1	2	0	0	0
Eucalyptus sp. (M.I.H. Brooker s.n.)	1	0	1	1	4	1	0	0	0
Eucalyptus sp. (M.I.H. Brooker 9025)	1	0	6	1	1	1	100	0	0
Eucalyptus sp. (S.D. Hopper 2764)	3	0	1	1	1	4	0	0	0
Eucalyptus sp. (M.I.H. Brooker 9744)	1	0	6	1	1	1	0	0	0
Eucalyptus sp. (M.I.H. Brooker 9736)	1	0	6	1	1	2	0	0	0
Eucalyptus sp. (M.I.H. Brooker 8734)	2	0	6	1	7	2	50	0	0
Eucalyptus sp. (M.I.H. Brooker 8634)	1	0	3	1	3	8	63	0	0
Eucalyptus wandoo ssp. (M.I.H., Brooker 9885 and C. Souness)	2	23	7	1	1247	11	0	27	9

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TAXA	A	B	C	D	E	F	G	H	I
Eucalyptus aff. *wandoo* (M.I.H. Brooker 9205)	2	0	6	1	1	3	30	0	0
Gastrolobium appressum	1	0	6	0	7	11	0	0	0
Gastrolobium bidens	2	23	7	0	124	30	0	27	7
Gompholobium aff. *aristatum* (B.R. Maslin 1427)	1	0	1	1	7	3	0	0	0
Gompholobium eatoniae	1	0	2	0	47	3	33	0	0
Gompholobium aff. *polymorphum* (E.A. Griffin 2306)	1	23	1	1	1	3	0	100	33
Goodenia xanthotricha	1	2	1	0	13	2	0	50	0
Grevillea acrobotrya ssp. *uniforma*	1	23	2	0	1	6	0	50	17
Grevillea aff. *bipinnatifida* (S.D. Hopper 6333)	1	0	2	1	1	1	0	0	0
Grevillea aff. *hookeriana* (S.D. Hopper 6350)	1	0	6	1	1	3	0	0	0
Grevillea leptopoda	1	0	1	0	7	1	0	0	0
Grevillea makinsonii	1	0	1	0	1	2	0	0	0
Grevillea murex	1	0	1	0	7	1	0	0	0
Grevillea olivacea	1	1	5	0	35	9	44	44	0
Grevillea rudis	2	2	7	0	145	19	26	5	0
Grevillea saccata	2	0	6	0	14	13	0	0	0
Grevillea thelemanniana ssp. *delta*	1	23	1	0	1	2	0	100	0
Grevillea thrysoides	2	0	1	0	1247	6	0	0	0
Guichenotia sp. (E.A. Griffin 858)	2	2	2	1	1235	6	16	33	0
Haemodorum loratum	2	23	7	0	15	5	0	40	20
Haemodorum venosum	2	2	7	0	145	13	8	8	0
Hakea auriculata var. *spathulata*	2	23	1	0	14	3	0	66	33
Hakea conchifolia	2	23	7	0	14	5	20	40	20
Hakea erinacea var. *longiflora*	1	23	1	0	1	8	12	63	13
Hakea flabellifolia	2	23	7	0	14	11	27	27	9
Hakea megalosperma	2	23	6	0	14	11	10	54	36
Hakea neurophylla	1	23	5	0	1	10	0	80	20
Haloragis foliosa	1	0	1	0	7	3	66	0	0
Hemiandra gardneri	1	0	6	0	7	6	0	0	0
Hemiandra rutilans	2	0	6	0	147	11	27	0	0
Hemigenia curvifolia	2	23	1	0	147	8	0	38	13
Hensmania stoniella	2	2	2	0	1257	6	0	17	0
Hybanthus aff. *floribundus* (E.A. Griffin s.n.)	2	2	7	1	1357	12	10	8	0
Hypocalymma aff. *angustifolium* (G.J. Keighery 4595)	1	0	2	1	1	1	100	0	0
Hypocalymma aff. *ericifolium* (E.A. Griffin 1972)	1	23	1	1	1	2	0	100	50
Hypocalymma tetrapterum	2	0	2	0	124	5	0	0	0
Hypocalymma aff. tetrapterum (G.J. Keighery 5151)	1	0	2	1	12	2	0	0	0
Hypocalymma aff. tetrapterum (C.A. Gardner 9014)	1	0	2	0	14	2	0	0	0
Hypocalymma xanthopetalum ssp.(C.A. Gardner 9096)	1	2	2	1	13	3	0	67	0
Hypocalymma aff. *xanthopetalum* (E.A. Griffin 1524)	1	0	2	1	14	5	20	0	0
Isopogon adenanthoides	3	23	3	0	125	26	0	15	4
Isopogon tridens	2	2	3	0	145	12	33	8	0
Jacksonia carduacea	2	0	3	0	147	7	42	0	0
Jacksonia eremodendron	2	0	2	0	7	8	0	0	0
Kunzea sp. (D.J.E. Whibley 4887)	1	0	1	0	7	2	0	0	0
Lasiopetalum drummondii	2	2	7	0	1357	21	38	14	0
Lasiopetalum lineare	2	2	3	0	1245	7	42	14	0
Lasiopetalum aff. *membranaceum* (Stoate s.n.)	1	0	1	1	1	2	0	0	0
Lasiopetalum aff. *oldfieldii* (Reid 101)	1	0	1	1	7	1	0	0	0
Lechenaultia juncea	2	0	1	0	7	3	0	0	0
Lepidobolus sp. (B. Briggs 7770)	1	0	1	1	7	2	0	0	0
Lepidobolus (sp. E.A. Griffin 2093)	2	23	3	1	145	11	0	27	9
Leucopogon obtectus	1	0	6	0	5	11	27	0	0

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TAXA	A	B	C	D	E	F	G	H	I
Leucopogon oliganthus	2	0	3	0	124	4	50	0	0
Leucopogon phyllostachys	2	0	3	0	147	6	83	0	0
Leucopogon plumuliflorus	1	23	1	0	1	6	0	100	16
Loxocarya sp. (B. Briggs 7498 & L. Johnson)	2	0	1	1	15	4	0	0	0
Loxocarya aff. *jasiculata* (B. Briggs 6319)	3	0	1	1	1	2	50	0	0
Loxocarya ssp. (B. Briggs 7481)	2	2	2	1	15	4	0	25	0
Macarthuria aff. *georgeana* (B. J. Banyard 517)	1	0	1	1	1	2	0	0	0
Macropidia fuliginosa	3	23	5	0	14	16	6	31	6
Menkea draboides	3	0	1	0	1	1	100	0	0
Mesomelaena stygia ssp. *deflexa*	2	0	1	0	15	2	50	0	0
Myriocephalus suffruticosus	1	0	1	0	14	2	0	0	0
Olax scalariformis	3	2	1	0	125	6	17	17	0
Oxylobium reticulatum var. *gracile*	2	23	2	0	1	6	16	32	16
Paracaleana sp. (E.A. Griffin 2625)	1	0	2	1	15	2	50	0	0
Patersonia argyrea	1	23	1	0	1	3	0	66	33
Patersonia spiralifolia	1	0	2	0	1	3	33	0	0
Persoonia rudis	1	23	1	0	1	3	0	100	33
Petrophile biternata	2	0	2	0	1	3	0	0	0
Petrophile chrysantha	2	23	7	0	1457	24	17	21	4
Petrophile inconspicua	2	23	7	0	145	23	17	30	4
Petrophile sp. (E.A. Griffin 5464)	1	0	2	1	4	1	100	0	0
Phlebocarya filifolia	2	23	3	0	13	13	23	23	8
Phlebocarya pilosissima ssp. *pilosissima*	2	3	3	0	1	13	15	8	0
Phlebocarya pilosissima ssp. *teretifolia*	1	2	1	0	13	5	0	100	100
Physopsis spicata	2	0	2	0	14	13	8	0	0
Pityrodia viscida	1	0	1	0	167	3	0	0	0
Platysace dissecta	3	0	4	0	0	0	0	0	0
Regelia megacephala	1	0	1	0	7	5	0	0	0
Restio sp. (B. Briggs 7738)	1	0	2	1	14	5	20	0	0
Restio sp. (B. Briggs 850)	2	0	3	1	14	1	0	0	0
Restio sp. (B. Briggs 6308)	3	23	3	1	123	5	20	40	20
Restio sp. (B. Briggs 7473 & L. Johnson)	1	2	1	1	1	1	0	100	0
Restionaceae Genus aff. *Ecdeiocolea* (E.A. Griffin 2157)	1	23	3	1	1	7	28	43	14
Scaevola sp. (H. Demarz 985)	1	0	1	1	5	1	0	0	0
Schoenus aff. *indutus* (E.A. Griffin 3842)	1	0	2	1	15	4	25	0	0
Schoenus aff. *obtusifolius* (E.A. Griffin 3841)	3	0	2	1	5	2	50	0	0
Scholtzia teretifolia	2	0	3	0	14	8	37	0	0
Sphaerolobium macranthum var. *pulchellum*	2	0	3	0	145	11	18	0	0
Spirogardnera rubescens	2	0	6	0	1	4	25	0	0
Stawellia dimorphantha	1	0	6	0	5	2	0	0	0
Strangea cynanchocarpa	2	23	7	0	15	23	9	39	13
Stylidium aeonioides	1	23	2	0	1	6	16	83	17
Stylidium aff. *bulbiferum* (A.H. Burbidge 2100)	2	0	3	1	14	9	0	0	0
Stylidium inversiflorum	1	2	5	0	12	10	20	20	0
Stylidium maitlandianum	2	3	3	0	1245	15	20	7	7
Stylidium nonscandens	1	0	2	0	14	5	40	0	0
Stylidium pseudocaespitosum	1	0	1	0	3	1	0	0	0
Stylidium aff. *repens* (A.S. George 2341)	3	2	7	1	125	30	9	7	0
Tetratheca remota	1	23	1	0	1	2	0	50	0

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TAXA	A	B	C	D	E	F	G	H	I
Thelymitra stellata	3	23	6	0	1	11	0	36	36
Thelymitra variegata var. *apiculata*	2	23	5	0	1	8	0	38	25
Thomasia formosa	1	0	1	0	7	2	0	0	0
Thysanotus aff. *sparteus* (E.A. Griffin 2511)	1	23	2	1	1	3	0	66	33
Thysanotus anceps	3	2	1	0	1	3	0	67	0
Thelymitra variegata var. *apiculata*	2	23	5	0	1	8	0	38	25
Thomasia formosa	1	0	1	0	7	2	0	0	0
Thysanotus spinigera	2	0	2	0	145	10	30	0	0
Thysanotus vernalis	1	23	2	0	12	4	0	75	25
Tricoryne aff. *humilis* (E.A. Griffin 1451)	2	2	2	1	123	3	0	33	0
Trymalium aff. *wichurae* (E.A. Griffin 2234)	1	23	7	1	12	4	0	50	25
Verticordia aff. *acerosa* (A.S. George 16351 & E.A. Berndt)	2	0	7	1	0	0	0	0	0
Verticordia aff. *chrysostachys* (F. Lullfitz 1934)	1	0	7	1	0	0	0	0	0
Verticordia aff. *chrysantha* (A.S. George 16318 & E.A. Berndt)	1	0	7	1	0	0	0	0	0
Verticordia aff. *chrysantha* (A.S. George 7856)	3	0	7	1	0	0	0	0	0
Verticordia aff. *grandiflora* (A.S. George 16315 & E.A. Berndt)	2	0	7	1	0	0	0	0	0
Verticordia grandis	3	23	7	0	14567	0	0	0	0
Verticordia insignus ssp.(A.S. George 16871 & E.A. George)	2	0	7	0	0	0	0	0	0
Verticordia aff. *muelleriana* (B. Barnsley 892)	1	0	7	1	0	0	0	0	0
Verticordia muelleriana ssp. *muelleriana*	2	0	7	0	0	0	0	0	0
Verticordia aff. *nitens* (A.S. George 12932)	1	0	7	1	0	0	0	0	0
Verticordia patens	2	0	7	0	147	0	0	0	0
Verticordia aff. *pennigera* (M. Morgan 15A)	2	0	7	1	0	0	0	0	0
Verticordia aff. *pennicillaris* (C. Chapman 52C)	1	0	7	1	0	0	0	0	0
Verticordia spicata ssp. (C. Chapman 42)	1	0	7	1	0	0	0	0	0
Verticordia sp. (A.S. George 16361 & E.A. Berndt)	1	0	7	1	0	0	0	0	0
Verticordia sp. (A.S. George 3219)	1	0	7	1	0	0	0	0	0
Walteranthus erectus	1	1	3	0	3	5	40	20	0
Xanthosia tomentosa	1	23	1	0	12	15	0	67	13