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VEGETATION SURVEY OF THE PROPOSED ALUMINIUM SMELTER SITE AND SURROUNDS - KEMERTON

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SUMMARY

The vegetation of the proposed Kemerton aluminium smelter site near Australind has been described and a vegetation list compiled. Fifteen vegetation associations have been defined and mapped.
The area is diverse in landform and soil type and this is reflected in the size and diversity of the species list. 306 plant species have been identified including 15 tree species. The area includes Jarrah - Banksia woodland species, wetland species and a number of elements from both coastal and scarp vegetation associations.

The study site includes two upland ridges (dunes), one supporting *Eucalyptus gomphocephala* (Tuart) - *Agonis flexuosa* (Peppermint) forest and the other *Eucalyptus decipiens* (Redheart) - *Agonis flexuosa* (Peppermint) low forest. The interdune lows have three chains of swamplands of varying vegetation types which include dense fringing bands of trees and dense heathlands. The remaining sandy slopes consist of *Eucalyptus marginata* (Jarrah) - *Banksia* woodlands and areas of partially (parkland-) cleared to totally cleared pasture.

Although much of the site has been disturbed, areas of well preserved natural vegetation remain and degradation by disease, weed infestation and introduced animals is minimal. The site includes significant populations of the gazetted rare plant *Pultenaea skinneri* as well as populations of other rare or geographically restricted species.

A feature of many sites is the large size of individuals of the remaining tree species. Some very large specimens of *Eucalyptus marginata* (Jarrah), *Agonis flexuosa* (Peppermint) and *Melaleuca preissiana* (a paperbark) occur and these provide visual appeal as well as being relatively uncommon, particularly in the case of Jarrah.

INTRODUCTION

The following has been taken from the consultancy Offer and Acceptance letter and gives an idea of the reasons for and requirements of the study.

PROJECT DESCRIPTION AND REQUIREMENTS

1. Project Description - The project is designed to provide baseline information on the Kemerton region in terms of its current flora. The region is of considerable importance because of the variety of vegetation types contained within the area (several wetlands and the woodlands of the Bassendean geomorphological unit). These areas are poorly reserved and little is known about the flora or fauna of this region. To plan future management strategies, this information is urgently required.

2. Project Requirements - The vegetation survey should treat the area to:

i) Produce a vegetation map for the region at the formation level with each formation to be further sub-divided into associations described by dominant species in the highest strata.

ii) Provide a series of association descriptions based on the classification system devised by B. Muir (1977), which describe the range of associations found in the region. The site of each description should be in a replicated 50 or 100 m^2 quadrats recorded on the appropriate vegetation map.

iii) Collect and identify a representative sample of the flora within the region (and especially provide an exhaustive list of the plant species within each quadrat). Specimens should be lodged in the W.A. Herbarium.

iv) Identify vegetation associations and habitat types which, as a matter of priority, should remain undisturbed. Particular attention should be given to identifying those areas where passive recreation can be undertaken, and where fire should be excluded.

v) Record the identity, location and estimated population size of any gazetted rare plants which may occur within the region.

vi) Assess the importance, for conservation purposes, of the vegetation types recorded on the site in a regional context (southern Swan Coastal Plain, this aspect of particular importance).

HISTORY OF LAND USE

The Kemerton site lies between the old coast road leading to Australind and Bunbury and the dairying and cattle producing townships of Benger and Brunswick Junction (Figure 1). An early attempt at settlement was made at Australind in the 1840's but was abandoned by 1857 (James , 1979). Development of land at and around Kemerton was carried out from the early part of this century and included the clearing of the lower drainage lands and parts of the limestone ridges and slopes. The area has been used extensively for the grazing of cattle, sheep and goats and the introduction of many pasture plant species has occurred. Timber cutting has also been carried out in many areas with many of the large jarrah trees being removed.

The area currently includes an abattoir, piggery and gun club and also incorporates the natural gas pipeline and easement extension from Wagerup to Bunbury on its eastern edge. Three minor roads traverse the area, two of which are unsealed. Additionally a drainage channel has been constructed through the eastern wetland chain feeding water to a shallow, open lake at the south eastern edge of the survey site. A small area of rural housing blocks is situated near the Perth-Bunbury road and two farms with houses and accompanying buildings remain.

GEOLOGY AND SOIL TYPES

The survey site covers three landform/soil formations as defined by Churchward and MacArthur (1980). These are made up of Quarternary geological formations and serve to divide the study area from north to south.

The western most soil and landform type is the Yoongarillup which consists of ridges and swales of shallow yellow and brown sands over marine deposits of limestone. The neighbouring Karakatta complex is an undulating landscape of stabilized dunes with deep yellow sand over limestone. The easternmost region of Bassendean sand includes grey/white sand plains with low dunes and occasional swamps with iron or humus podzols. Swamps and wetlands were also seen to be encompassed in the Yoongarillup and Karakatta complexes as mapped by Churchward and MacArthur (Figure 2).
No limestone outcropping was observed but an area of the central ridge has been used as a limestone quarry and very shallow sands occur along most of this upland.

The western ridge reaches a height of 30-35 metres while the eastern ridge peaks at 54 metres above sea level. The lowest point in the study is at approximately 5 metres above sea level (Figure 2).

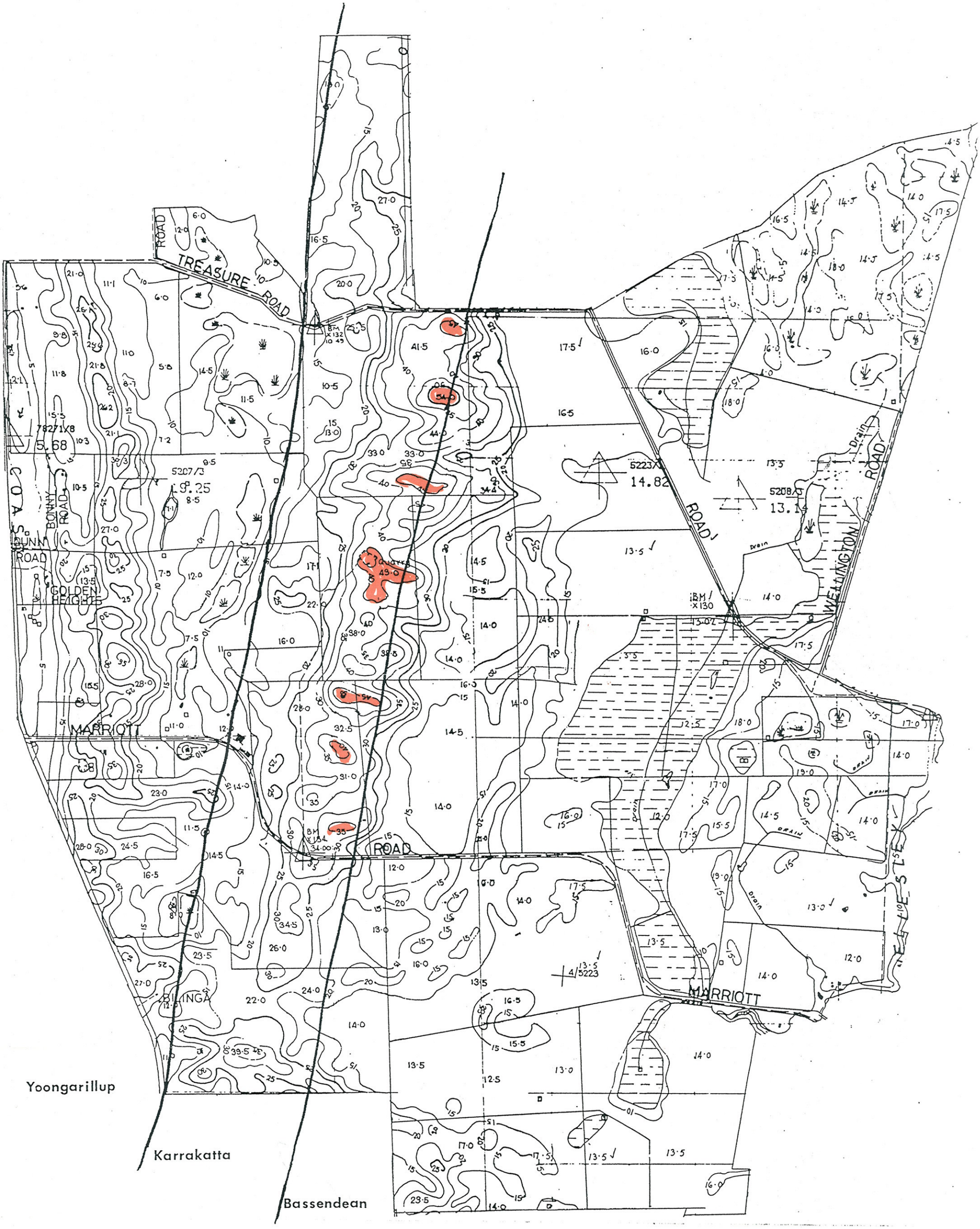

FIGURE 2. TOPOGRAPHY AND VEGETATION/SOIL COMPLEXES

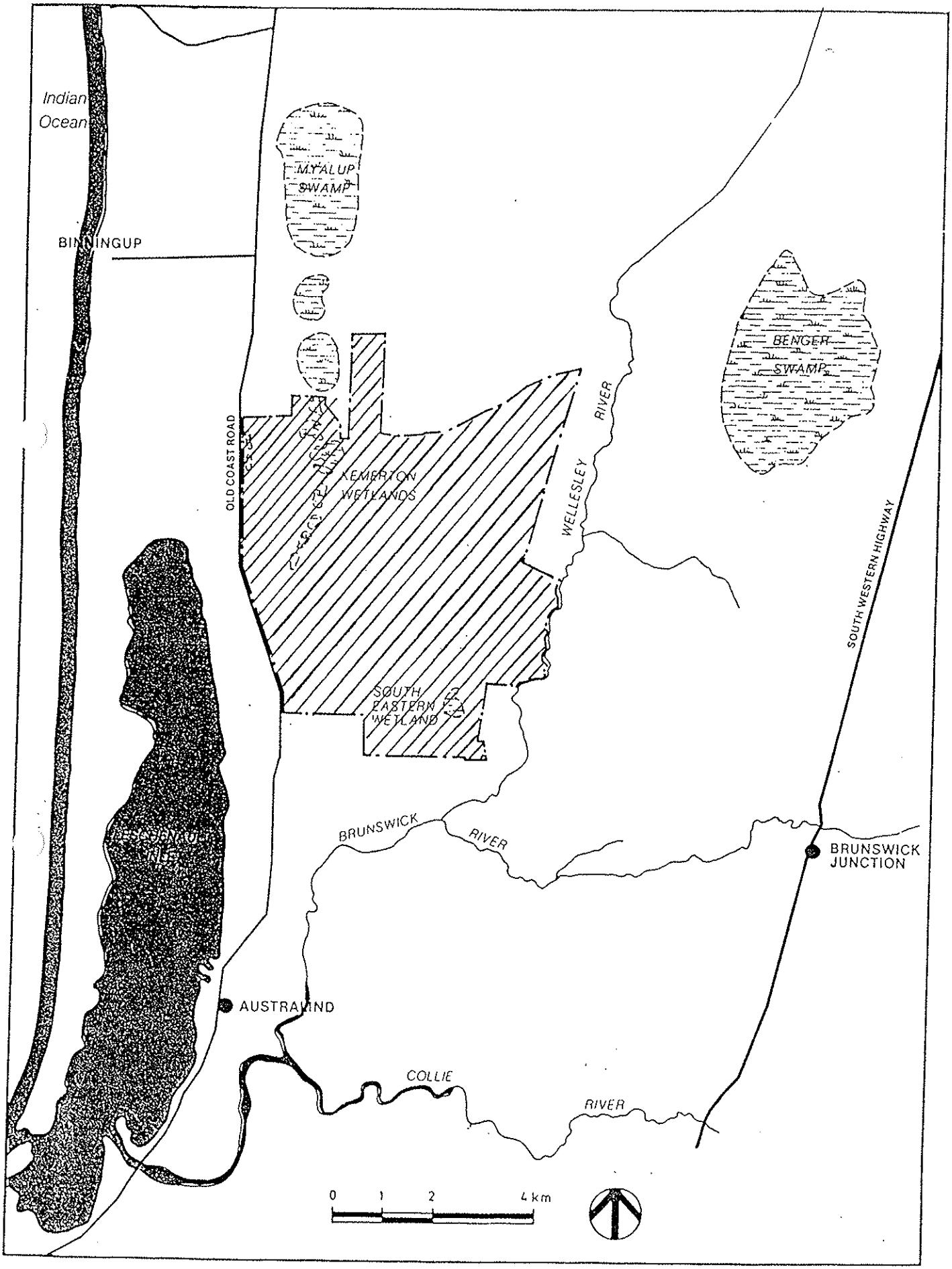

FIGURE 1. LOCATION OF SURVEY SITE

CLIMATE

The climate of the study area is typically Mediterranean with hot, dry summers and mild, wet winters. The average annual precipitation at the nearby Lechenault Peninsula is 881 mm (Semeniuk and Meagher, 1981), falling mainly in April to November and at Wokalup, inland and slightly north of the site the annual average is 996 mm. It is likely that the annual rainfall of the Kemerton site lies somewhere between these figures. Temperatures reach a mean maximum of approximately 29.5^{o}C in January and 16.8^{o}C in August. The mean minimum temperature for winter is approximately 8.0^{o}C.

The latitude of the survey site and its position between the ocean and the Darling Scarp ensure a reasonable rainfall and although the sand dunes are well drained some of the wetlands incorporated into the area retain open water all year and are surrounded by areas of damper, humus-rich soil.

VEGETATION AND FLORA

As with soil types the Kemerton study area can be divided into three vegetation complexes which represent changes in those soil types.

The area lies in the Drummond sub-district of the Darling District as defined by Beard (1980). Erikson *et al.* (1977) noted that the flora of this sub-district had relatively few tree species but a very rich understorey and this is borne out by the species lists for many quadrats in the area.

Heddle et al. (1980) produced broadscale boundaries for vegetation complexes in this region (Figure 1b). The western Yoongarillup complex consists of woodland to tall woodland of *Eucalyptus gomphocephala* with *Agonis flexuosa* in the second storey. Less consistently an open forest of *E. gomphocephala - E. marginata - E. calophylla* is found. The Karrakatta complex is predominantly open forest of *E. gomphocephala - E. marginata - E. calophylla* and woodland of *E. marginata - Banksia*. Finally, the extensive Bassendean complex ranges from woodland of *E. marginata - Allocasuarina fraseriana - Banksia* spp. to low woodland of *Melaleuca* spp. and sedgelands on the moister sites. The actual occurrence of the *Eucalyptus gomphocephala* vegetation units is considerably less than indicated by the map produced by Heddle *et al.* but the three major complexes are represented in the study area.

A brief vegetation survey of part of the Kemerton site was carried out by Glossop (1980) and incuded a species list and notes on rare and geographically restricted plants for the area. Work on the wetland chains by Bamford and Watkins (1983) also made note of vegetation types in these areas and included maps of major species occurring around the swamps.

FIRE HISTORY

No evidence of large fires having occurred in the study area for some years was seen. A small area south of Marriott Road was burnt in autumn 1984 and the area around some of the swamps appears to have been cleared and burnt within the last five years. It is possible that a wildfire destroyed the vegetation around one large swamp 10 to 15 years ago as this area is densely covered with even-aged marri and jarrah saplings and includes large fallen logs and dense stands of bracken. The limestone ridges appear to have been unburnt for a considerable time.

METHODS

The definition and mapping of the vegetation units and collection of specimens was carried out in early to mid October and included extensive field traverses by foot and vehicle. The mapping of the vegetation units was based on the interpretation of recent (January 1984) coloured aerial photographs at a scale of 1: 25,000 and checked by field observations as completely as time permitted.

Vegetation divisions were based on the use of floristic and landscape observations and indicator species. Site descriptions follow Muir's classification system (Muir 1977). Exhaustive species listings were made at 31 sites consisting of a 10 x 10 m quadrat. (See Fig. 3 for quadrat locations.) Detailed descriptions of vegetation changes on traverses along with opportunistic plant collections made up the remainder of the data. Mapping was done directly onto colour photocopies of the aerial photographs to ensure high accuracy in mapping.

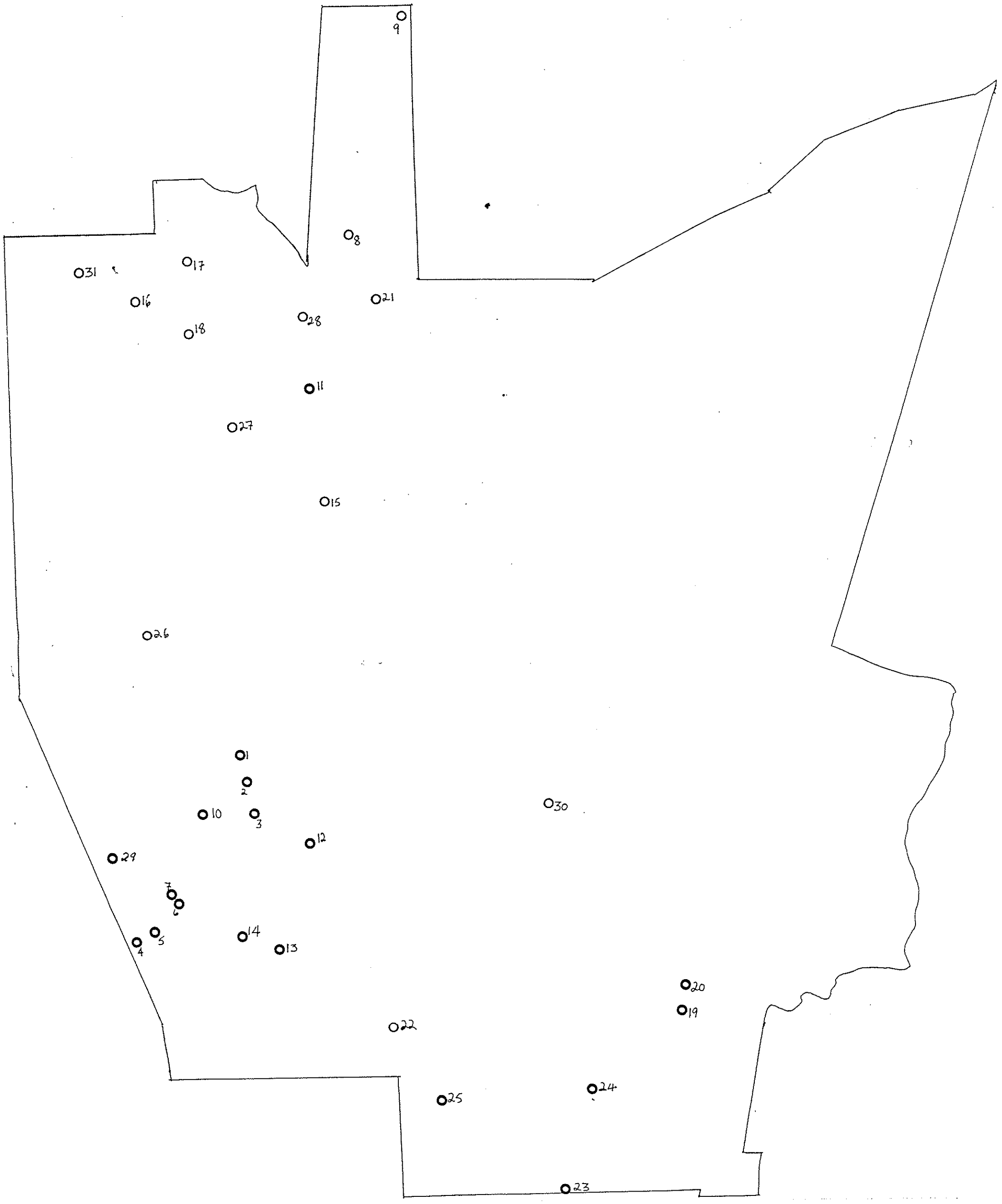

FIGURE 3. VEGETATION MAPPING SITE LOCALITIES

RESULTS AND DISCUSSION

The vegetation of the Kemerton survey area is largely determined by the changing topography, soil and landform complexes in an east-west direction. The major complex of Jarrah-*Banksia* woodland to the east of the coastal Tuart belt is dissected by two wetland chains and a limestone ridge, all of which have differing vegetation units and which are joined by intermediates of the Jarrah-*Banksia* woodland.

Fifteen vegetation units were mapped (Figure 4). Descriptions of these are found in Appendix 1. Some, such as the *Eucalyptus decipiens* - *Hakea prostrata* Forest are particularly distinct and dependant upon limited the occurrence of topographic and geological factors. Other units do not follow such a mappable pattern and contain mosaics of types and intermediates between them.

Two major upland units were delineated, four on dune slopes and raised swales and nine in low lying areas and drainage lines (Table 1). Swamps and their fringing vegetations have not always been mapped as separate units because of their small size and are included in a general discussion of wetlands. Units are numbered from uplands down to swamps and low numbers do not necessarily represent more common vegetation types.

Because of the extensive clearing in the central and north-eastern sector of the study area, extrapolation of unit boundaries was difficult. Remnant bush areas in paddocks and on road verges gave some indication of pre-existing natural vegetation. Mapping is also based heavily on topography and the position of drainage lines on aerial photographs.

GENERAL VEGETATION DESCRIPTION

As stated previously the study area is divided by distinct topographic features which are aligned in a north-south direction. The following description treats the vegetation generally from west to east.

The westernmost part of the study area is largely open parkland cleared and consists of a chain of swamps and depressions with or without fringing vegetation. Understorey shrubs are generally non-existent but the tree species of *Eucalyptus gomphocephala* and *Agonis flexuosa* in the drier areas combine to form Open

Tall Woodland - Open Woodland over pasture. Remnant understorey vegetation on road verges includes *Hibbertia cuneiformis, Acacia saligna, Pteridium aquilinum* and patches of the introduced Arum lily. *Melaleuca preissiana, M. rhaphiophylla, Eucalyptus rudis* and *Banksia littoralis* are found fringing the sometimes permanent water-holes and occur as Low Forest A to Open Low Woodland A.

The land then rises moderately quickly to a dune of up to 35 m in height. The top of this dune delimits the upland vegetation of *Eucalyptus gomphocephala - Agonis flexuosa* Woodland (Unit 1) which again has had much of the original understurey removed. *Banksia attenuata, B. grandis* and *E. marginata* are also found in this unit in varying percentages and some areas of the ridge could be considered more as intermediates between Unit 1 and the neighbouring Jarrah - Banksia woodland areas. Understorey species in Unit 1 include *Hibbertia hypericoides, Xanthorrhoea gracilis, Phyllanthus calycinus* and *Synaphaea polymorpha.*

The eastern face of the first dune ridge consists largely of an intermediate vegetation type containing elements of ridge flora (notably *Agonis flexuosa)* and of the extensive and variable Jarrah-Banksia slopes. This latter complex has been divided into three units (Units 4, 5 and 6) which are based on their understorey components. The three units are often found in a mosaic and mixtures are common. The *Banksia* species in these areas are *B. attenuata, B. grandis* with occasional pockets of *B. ilicifolia* in damper, lower-lying areas. Understorey species common to the types include *Phlebocarya ciliatum, Melaleuca thymoides, Hibbertia hypericoides, H. racemosa* and *Bossiaea eriocarpa* (Plates 1 and 2).

Variable bands of vegetation surround the central swamp chain which occurs at the lowest point between the two dune ridges. Again much of the vegetation has been destroyed in some areas but there is sufficient remaining to show type distinctions. The wetland chain can be roughly divided into northern and southern regions, each with a different major vegetation association. The southern section features an association of *Eucalyptus rudis, Banksia littoralis, Melaleuca preissiana* and thickets of *Acacia saligna* and *A. extensa* (Unit 12, Plates 3 and 4) and as such has similarities with the western wetland chain. The northern section also comprises *E. rudis, Banksia littoralis* and *Melaleuca preissiana* but does not have *Acacia spp.* thickets and has the addition of *Banksia ilicifolia, Pericalymma ellipticum, Burtonia scabra* and *Platytheca galeoides* (Unit 11 and Plate 5).

The seasonally inundated and permanently wet areas of this chain however, have a similar vegetation throughout. Permanently wet areas are often choked with dense swards of *Lepidosperma* or *Baumea spp.* (Plate 6) with the addition of the introduced sedge *Typha orientalis* in some cases. Drier swamplands are commonly populated with a stand of *Melaleuca teretifolia* (Unit 13, Plate 7) with the addition of *Cassytha spp.*, *Stylidium junceum* and *Comesperma virgatum*. (Bamford and Watkins (1983) map major vegetation belts around swamps in more detail than has been possible here but with the exclusion of non- dominant species.)

The west-facing slopes of the eastern dune are again populated with associations of Jarrah- Banksia Woodland (Units 4, 5 and 6) with Unit 6 often occurring in shallow swales. Unit 3, which occurs on and around the dune ridge is possibly an intermediate of the slope and upland vegetations but appears to be found within a distinct topographical limit. This Low Forest association includes *Agonis flexuosa*, *Eucalyptus marginata* and *Banksia attenuata* with occasional clumps or old trees of *E. calophylla*. Significant understorey species are *Thomasia foliosa and Hakea prostrata* with small amounts of *Xanthorrhoea ?gracilis* and *Melaleuca thymoides*.

The eastern dune ridge supports a distinct association with the main indicator species being *Eucalyptus decipiens*. This species is found in a tall mallee form and is associated with *Agonis flexuosa, Hakea prostrata, Thomasia foliosa, Ptilotus ?spathulata* and *Acacia cochlearis* (Plate 8). It appears to have a definite distribution as a result of height above sea level and only grows on points over 30 m high within the study area.

Lower slopes on the eastern face of the *Eucalyptus decipiens* ridge again comprise of a mosaic or intermediates of Units 4, 5 and 6. These associations grade into one of the two major vegetation types in the eastern low-lying, drainage line sector. Because of the extensive clearing which has been carried out in the eastern part of the study area the boundaries of associations are difficult to ascertain in some cases. However, the two major types (Units 7 and 14) are delineated fairly clearly by topographic factors. Unit 7 occurs on the light grey sand flats and low rises and is a variable type with the dominant species being *Banksia ilicifolia* in the drier parts and *Kunzea vestita* in damper areas. A mosaic of these occurs with the remnant patches of *K. vestita* in cleared areas perhaps indicating proximity to previous drainage lines. *Agonis flexuosa* was observed in one quadrat representing the Unit but this is not thought to be a general indicator species for it.

TABLE 1. VEGETATION UNITS

Uplands

1. *Eucalyptus gomphocephala - Agonis flexuosa* Woodland.
2. *Eucalyptus decipiens - Hakea prostrata* Low Forest.

Slopes

3. *Eucalyptus marginata - Agonis flexuosa* Low Forest.
4. *Eucalyptus marginata* Woodland.
5. *Eucalyptus marginata - Xanthorrhoea gracilis* Woodland.
6. *Banksia attenuata - Stirlingia latifolia* Open Low Woodland.

Drainage lines and flats

7. *Banksia ilicifolia* Low Woodland.
8. *Banksia ilicifolia - Allocasuarina fraseriana* Low Woodland.
9. *Eucalyptus calophylla - Agonis flexuosa* Forest.
10. *Eucalyptus calophylla - E. marginata* Dense Low Forest.
11. *Banksia ilicifolia - Eucalyptus calophylla* Low Forest.
12. *Eucalyptus rudis - Acacia saligna* Open Woodland.
13. *Melaleuca teretifolia* Dense Heath.
14. *Pericalymma ellipticum* Dense Heath.
15. *Melaleuca rhaphiophylla - M. incana* Thicket.

Understorey species include *Jacksonia furcellata, Acacia semitrullata, Boronia dichotoma* and *Hibbertia vaginata* with very variable percentages of *Pericalymma ellipticum*.

Unit 8 may be described as a variant of Unit 7 in that it is a basically similar vegetation association with the addition of *Allocasuarina fraseriana*. Only one area of this type was observed and much of it had been cleared, leaving remnant trees of *A. fraseriana* in paddocks and on the road verge.

Drainage lines and swampy areas without open water in the eastern sector support a species-rich vegetation type (Unit 14) which remains constant throughout. Where patches have been cleared the dominance of species has sometimes changed but indications of the original vegetation type are still available. Unit 14 generally occurs as a dense heath of *Pericalymma ellipticum, Melaleuca incana, M. teretifolia, Astartea fascicularis, Hibbertia stellaris ,Eutaxia virgata* and others (Plate 9). Emergents of *Melaleuca preissiana* and *Xanthorrhoea preissii* are indicators of the type and can be dominant in areas which have been cleared and are regenerating. A partially cleared patch which appears to represent this type was found to the west of the main south-eastern swamp. The area contains very attractive mature and spreading individuals of *Xanthorrhoea preissii, M. preissiana, Banksia littoralis* and *Eucalyptus rudis* with a mainly pasture understorey (Plate 10).

Finally, the immediate surrounds of the major eastern swamp (the only one in the eastern chain with permanent water) have been classified as *Melaleuca rhaphiophylla - M. incana* thicket (Unit 15). Dense stands of these *Melaleuca spp.* (plus *M. teretifolia)* occur in or near shallow water at the swamp edge (Plates 11 and 12) and give way to colourfully flowering thickets of *Astartea fascicularis, Eutaxia virgata, Aotus gracillima, and Oxylobium linearifolium* as a second, narrow band around the eastern and southern swamp boundaries.

FLORA

Because of the variety of habitats available within the study area there is considerable diversity in the flora. 306 plant species were identified (Appendix 2) and these were mostly representative of Jarrah-Banksia woodland flora and sandplain wetlands. However, elements of the flora from near-coastal dunes and the Darling Scarp were also found.

Leguminoseae was the family with the largest number of species (37) followed by Liliaceae (28), Myrtaceae (28), Asteraceae (25), Orchidaceae (19) and Proteaceae (15). Few genera were particularly well represented but Melaleuca (10), Acacia (9), Stylidium (10) and Lomandra (8) had the most species. 16 species were found to be introduced but no account was taken of pasture plants and thistles which were found abundantly in cleared and semi-cleared areas. It is possible that more members of the Orchidaceae family may be represented in the study area. The time available did not allow orchid leaves to be collected and possibly identified and the coastal sandplains of the south-west are known to particularly rich in orchid species.

A number of species were observed commonly over the Kemerton site and were not restricted to particular vegetation associations. Annotations next to names in Appendix 2 give some indication of the numbers of a species seen. The most common tree species were *Banksia attenuata, Eucalyptus marginata and B. ilicifolia. Banksia attenuata* was found in all areas except low-lying wetlands and was generally associated with *Eucalyptus marginata*. Very common shrub and herb species included *Melaleuca thymoides, Jacksonia furcellata, Bossiaea eriocarpa, Eriostemon spicata, Xanthorrhoea ?gracilis, Hibbertia hypericoides, H. racemosa , Petrophile linearis, Dampiera linearis, Dasypogon bromeliifolius* and *Phlebocarya ciliatum*. Common sedges were *Lyginia barbata* and *Hypolaena exsulca*.

Of particular interest was a perennial species of *Stylidium* which is undescribed (Alan Burbidge, Pers. comm) and which was found at Site 9 in typical Jarrah-Banksia woodland

A sma ll number of species were found to be an unusual occurrence in the area and some were considerably outside their recorded range. One plant of *Verticordia nitens* was found in the far north of the survey site and although it was also listed by Trudgen and Tingay (1984) on the Wagerup to Bunbury natural gas pipeline route, its main distribution is north of Perth. *Verticordia ?hughanii* was seen in large numbers in a low lying flat in an area of Unit 14. This plant is very poorly collected and has only been found previously at Cranbrook and Meckering. *Ptilotus ?spathulata, Oxylobium lanceolatum* and *Siloxerus pygmaeus* were also found a considerable distance from their recorded distribution area.

Unit 10 contained five species which were only found in that limited area. *Phebalium anceps, Oxylobium lanceolatum, Thomasia pauciflora, Agonis linearifolium* and *Dampiera sp.* were only observed at Site 28.

Rare and Restricted Species

One plant which is Gazetted Rare (Patrick and Hopper, 1982) was found in the Kemerton study site. *Pultenaea skinneri* is known to occur at Collie, Boyanup and Bunbury in restricted areas. Large numbers of this plant were observed in the eastern wetland area (generally Unit 7) in patches around the major open swamp near Marriott Road and in low lying areas through to Wellesley Road (Figure 5). Its population size was estimated at over 1000, with one large and quite dense group occurring immediately north of the swamp. The preferred habitat of the species appeared to be damp grey sand with moderate humus and it was associated with Marri-Jarrah-Peppermint-*Banksia ilicifolia* Forest (a variant of Unit 7) with a sometimes dense understorey of bracken. Other common plants in the area were *Hibbertia hypericoides, H. vaginata* and *Scaevola pilosa*. Plants were up to 1.3 m in height and many young plants were observed.

Six species were regarded as being of restricted distribution (Marchant and Keighery (1979), Barrett (1981)), two to within a range of 100km and two within 160km.

Acacia semitrullata was found in a number of damper sites but was very scattered so population estimates were not made. *Acacia flagelliformis* was less common but was also observed at more than one site. *Cartonema phylidroides* and *Boronia dichotoma* were restricted to damp sites, the former being found as an opportunistic herb in cleared sands around some swamps. *Conostylis juncea* and *Lomandra hermaphropdita* were both found throughout the study area in good numbers. *Villarsia lasiosperma*, which occurred mainly in Unit 14 was regarded as being in need of assessment and monitoring (Marchant and Keighery, 1979).

CONCLUSIONS AND RECOMMENDATIONS

The Kemerton area encompasses three vegetation complexes as described by Heddle *et al.* (1980) and in doing so includes a number of physical habitats ranging from coastal limestone dune ridges to ephemeral and permanent wetlands and sand flats. Because of this habitat range a large number of species occurs in a relatively small area.

The study area has a number of unusual features and is impressive for its conservation value as a result of these features. Discussion on elements of the vegetation follows.

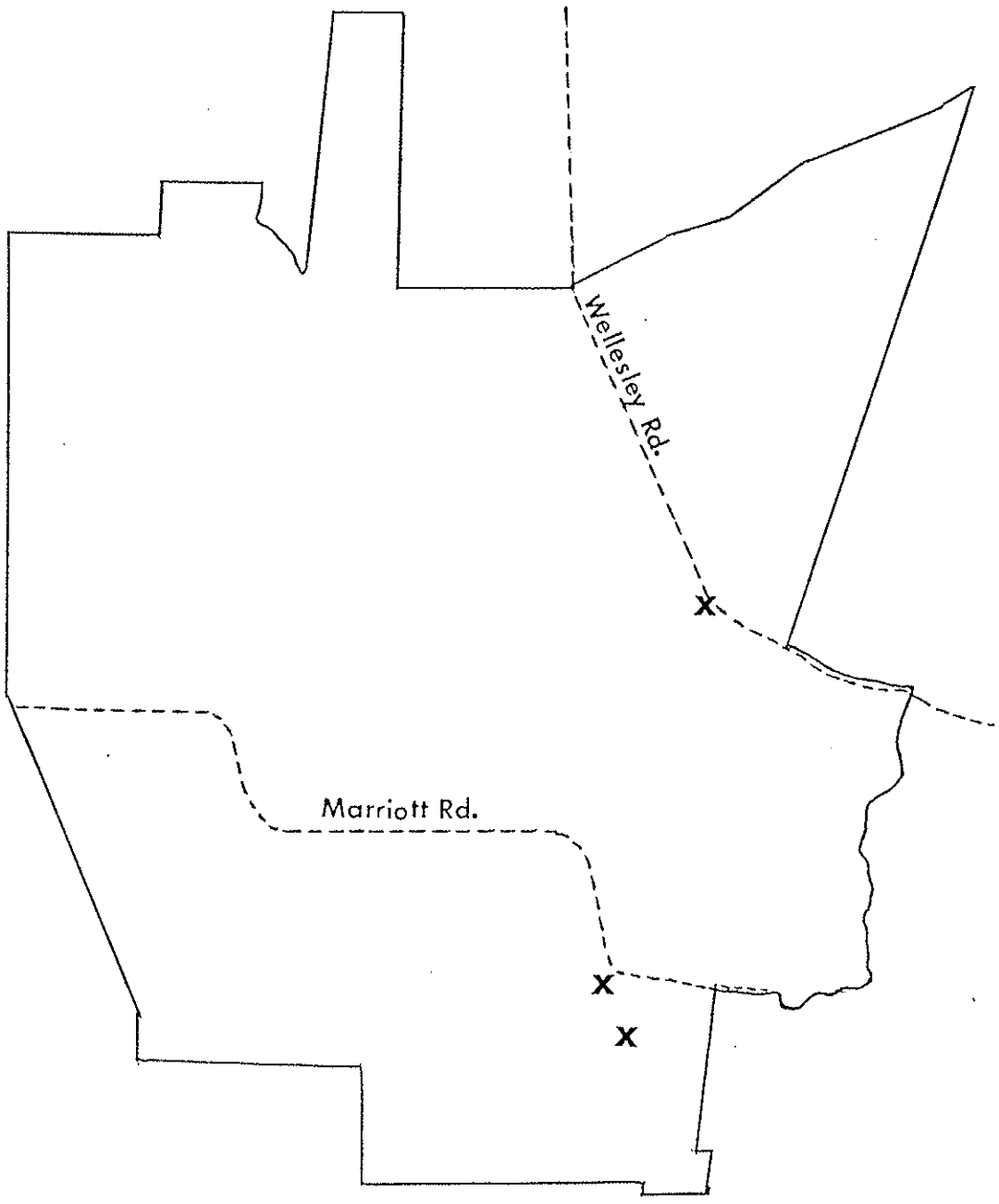

FIGURE 5. LOCATION OF POPULATIONS OF *PULTENAEA SKINNERI*

1. *Eucalyptus decipiens - Hakea prostrata* Low Forest.

This vegetation association has not been commonly encountered on the coastal plain south of Rockingham. *E. decipiens* has a discontinuous range, occurring in scattered locations on the Swan coastal plain (from Moore R. to Rockingham), near Mandurah, at Canal Rocks and south of Katanning towards the Stirling Ranges and south coast (Blackall and Grieve (1980), M. Trudgen and C. Keating (pers. comm.)). Localized occurrences of this species were also reported by Blackwell *et al.* (1983) on low undulating land on the Wagerup to Bunbury natural gas pipeline extension route. The main dune ridge running parallel to the coast through the study area supports largely undisturbed patches of Low Forest containing *E. decipiens* in a mallee form and with a distinct suite of associated species. It is suggested that such an area is uncommon and should be preserved if possible. As the association lies in a transitional zone between the Bassendean and Karrakatta vegetation complexes which are both very poorly represented in reserves it is unlikely that an example of the type has been protected elsewhere. It is also recommended that fire be excluded from the dune ridge areas. Due to the exposed nature of such sites a fire could cause irrepairable damage by promoting wind erosion and weed invasion.

2. Bassendean Complex - Central and South.

Over 50% of the Kemerton study area falls into the Bassendean vegetation complex range. This complex includes Jarrah-Banksia woodlands and *Melaleuca* wetlands and is found in a broken band from Gnangara (just north of Perth) to just south of Bunbury. Despite the distance covered by the type there is a severe lack of conserved areas. Most of the Bassendean Complex has been claimed for agricultural or urban purposes and only very small areas are securely retained for conservation purposes. Some wetlands are protected as Nature Reserves but very little of the Jarrah-Banksia woodland remains undisturbed. The area of land to the east of the *Eucalyptus decipiens* ridge is included in the Bassendean complex and almost undisturbed bush areas remain in the southern and northern parts of the study site. These have a high conservation value.

3. Eastern wetland chain and *Pultenaea skinneri*.

The south-eastern swamplands, particularly, contain a diverse and attractive range of flowering plants and trees. A number of species (particularly in the Papilionaceae family) were only found in that area and a large number of orchids were also recorded. The Dense Heath communities stand out for their species

richness and for the occurrence of very large and attractive individuals of *Melaleuca preissiana* and *Xanthorrhoea preissii* scattered throughout.

The Gazetted Rare species, *Pultenaea skinneri* , found at Kemerton grows around the main swamp as does *Boronia dichotoma* and *Acacia flagelliformis* (both geographically restricteed).

4. Condition of vegetation.

Although a high percentage (possibly around 65%) of land at Kemerton has been disturbed either by clearing or as a result of grazing, the remaining natural vegetation is remarkably intact. Weed invasion and damage or evidence of introduced animals is minimal in the forest and woodland areas although some wetland areas have suffered from introduced plants such as *Typha orientalis*. Any burning of remaining natural bush or partially cleared areas is certain to aid in the introduction of exotic grasses and herbs from adjacent pasturelands.

5. Size of tree species.

One noticeable feature in a number of vegetation types in the study area is the large size of some individuals of tree species. Of particular interest was the size of a number of trees of *Eucalyptus marginata* (Jarrah). As this species does not often attain a mature size due to logging or dieback disease the occurrence of large trees deserves comment. One individual near the central dune ridge was estimated to be over 30m high and was measured at breast height to 5.6 m in circumference (diameter of approximately 1.78 m) (Plate 13). This compares with trees referred to as "King Jarrah" south of Bunbury. Other trees of similar dimensions were observed.

There were also a number of areas supporting very large and attractive trees of *Melaleuca preissiana* in low lying areas. There trees are thought to be representative of very old climax wetlands and as such, as well as for their great visual appeal should be retained. Such trees are often associated with low and relatively sparse understorey (some which have been grazed) and provide excellent sites for passive recreation such as walking and picnicking (Plates 14 and 15).

LAND USEAGE AND CONSERVATION VALUES

Proposed establishment of softwood plantataions over much of the Kemerton area (Anon, 1985) disregards the high conservation value of many of the present ecosystems. As stated previously, the protection of areas of Bassendean Complex vegetation is minimal and urban and 'hobby-farm' development will further erode natural bush areas of this type. The condition of the vegetation in these units at Kemerton is good and although logging of *Eucalyptus marginata* has occurred in many areas the remaining woodland is worthy of preservation.

Areas of the Yoongarillup Complex are conserved in the Yalgorup National Park and McLarty and Clifton Forest Management Priority Areas but there is a recognised need to further protect the diminishing 'Tuart belt' resource (Trudgen, 1985). Little of the understorey of the areas in the Yoongarillup Complex (Unit 1) remains but the open forest provides pleasant passive recreational amenity.

A number of other sites in the study area are of interest for walk trails and scientific study and these include wetland and drainage lines and the western and central ridges from which very attractive vistas of the nearby Scarp can be had (Plate 16). The provision of barbeque facilities in the central ridge, however, is not recommended due to the sometimes dense unergrowth and inherent fire risk.

The marginally economic production of pinewood on poor quality soils as an alternative to conservation of an attractive recreational and education resource is not seen as appropriate, except in areas which have been totally cleared or badly degraded.

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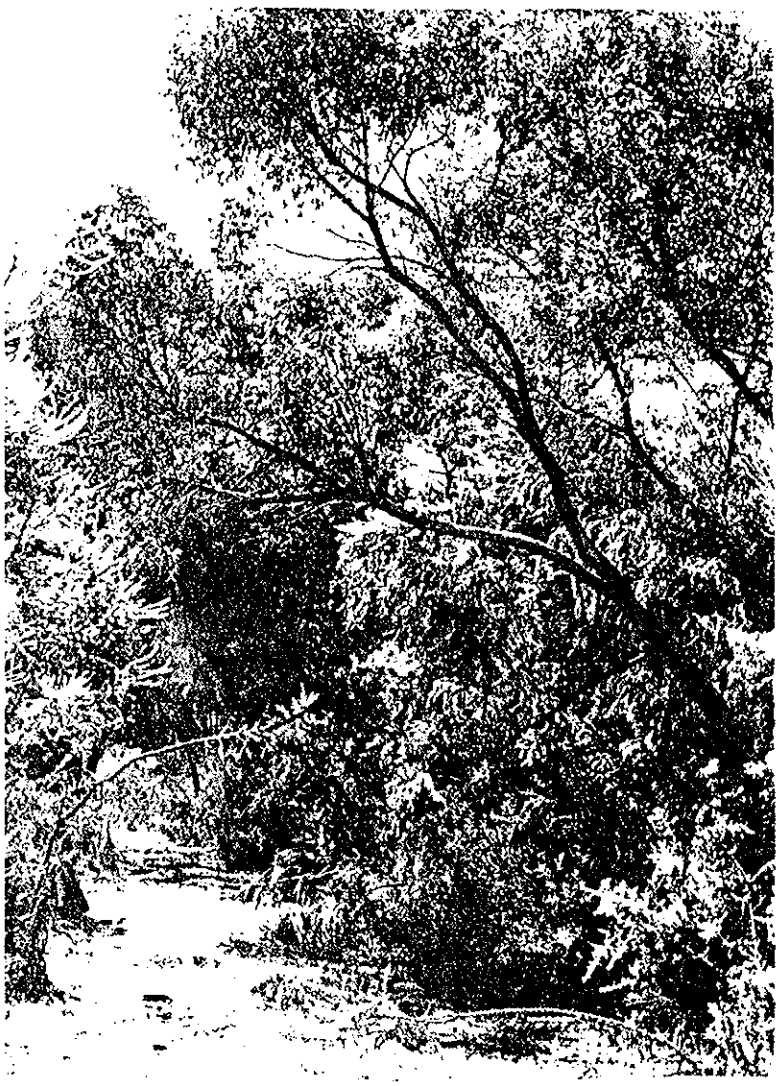


Plate 15 A very old and attractive specimen of *Melaleuca preissiana* near Site 22 in vegetation type [illegible].

Plate [illegible] View of the [illegible] from a partially cleared portion of the [illegible]

VEGETATION UNIT DESCRIPTIONS

1. *Eucalyptus gomphocephala - Agonis flexuosa* Woodland.

Woodland over Low Forest A over Dwarf Scrub C.
SITE NOS. 31, 26

Although *Eucalyptus gomphocephala* is only found as up to 10% cover in this unit it is the main indicator species. The occurrence of *Agonis flexuosa* on the dune ridge is also the basis for the association. *Banksia grandis, B. attenuata* and *Eucalyptus marginata* are also found in this type. Although most of this area has been parkland cleared and grazed some understorey species remain in some areas. Common species include *Hibbertia hypericoides, Conostylis aculeata, Xanthorrhoea ? gracilis, Phyllanthus calycinus,* and *Synaphaea polymorpha. Hibbertia cuneiformis* was seen in the damper parts.

This vegetation type does not extend onto the eastern face of the western ridge on the study site but occiasional trees of both Tuart and more commonly *Agonis* can be seen.

Soil Type - Variable grey to brown/yellow deep sands were observed.

2. *Eucalyptus decipiens - Hakea prostrata* Low Forest.

Low Forest A over Low Scrub A over Low Scrub B over Low Heath C.
SITE NOS. 12, 13.

This vegetation association has *Eucalyptus decipiens* as its major delineator tree species. Trees are in a semi-mallee form to 11 m and between 10-30% cover. Agonis *flexuosa* is included with admixtures of *Banksia attenuata, B. grandis* and *Acacia cochlearis* thickets in some areas. Understorey species include *Hakea prostrata, Jacksonia furcellata, Thomasia foliosa and Phyllanthus calycinus* and *Melaleuca scabra.*

An unusual occurrence of *Ptilotus ?spathulata* (well out of its range) was found on

considerably. Occasional clumps of *E. calophylla* are seen in this type but no obvious pattern of occurrence emerged.

Soil Type - Deep grey/white sand on stabilized dune slopes.

5. *Eucalyptus marginata - Xanthorrhoea gracilis* Woodland.

Woodland - Low Woodland A over Open Low Woodland B over Low Heath D.
SITE NOS. 1, 2, 5, 8.

This unit comprises of a variable Woodland to Low Woodland A of *Eucalyptus marginata* with common to occasional *E. calophylla* (usually in very scattered clumps if common), with a second layer of *Banksia attenuata, E. grandis* and occasional *Xylomelum occidentale*. The latter three species vary considerably in height and can be included in Low Woodland A or B. The Low Heath D stratum has varying percentages (20-60%) of *Xanthorrhoea gracilis* with consequently varying percentages of *Melaleuca thymoides, Hibbertia racemosa, H. hypericoides, Conostylis spp.* and *Phlebocarya ciliata*.

This vegetation unit usually occurs on lower slopes than Type 4 and is often found mixed with Types 4 or 6. The percentage of *Xanthorrhoea gracilis* varies considerably due to fire history (fire encourages dominance, at least temporarily), overstorey and possibly moisture availability.

This unit appears to occur mainly on the lower slopes of low stabilized dunes in the Karrakatta Complex and the western edge of the Bassendean Complex.

Soil Type - Grey - grey/white sand.

6. *Banksia attenuata - Stirlingia* Open Low Woodland.

Open Low Woodland A over Heath B - Low Heath C over Dwarf Scrub D.
SITE NOS. 3, 14.

A generally sparse over storey of *Banksia attenuata* with occasional trees of *Eucalyptus marginata* and *Nuytsia floribunda* separates this vegetation type. The main indicator species is *Stirlingia latifolia* which occurs as up to 40% of the understorey cover and is accompanied by *Calytrix flavescens, Helipterum cotula, Anigosanthos manglesii, Calectasia cyanea* and particularly

Allocasuarina humilis. The latter species does not always occur in this type but is always an indicator of the type.

Species which require well drained soils appear to be included in this vegetation association which is often found near the bottom of gentle dune slopes and which is sometimes found mixed with Type 5.

Soil Type - Grey/white sand.

7. *Banksia ilicifolia* Low Woodland.

Low Woodland A over Dwarf Scrub C over Dwarf Scrub D.
SITE NOS. 19, 22, 24.

This is a very variable type which changes as a consequence of the availability of moisture. Drier sites include *Eucalyptus marginata* as a first stratum with *Banksia ilicifolia* and *B. attenuata* below. Damper sites include pockets of dense *Kunsea vestita* and occasional *Melaleuca preissiana* with an understorey of *Xanthorrhoea preissii*. One site representing the type includes *Agonis flexuosa* but this is seen to fade out as the unit becomes further from the swampy areas.
Understorey species include *Jacksonia furcellata*, *Hibbertia vaginata*, *Boronia dichotoma*, *Acacia semitrullata* and very variable percentages of *Pericalymma ellipticum*.

Soil Type - Deep grey sand.

8. *Banksia ilicifolia - Allocasuarina fraseriana* Low Woodland.

Woodland over Low Woodland A over Dwarf Scrub D.
SITE 30

This vegetation unit was seen as two remnants within cleared paddocks and on a road verge area. It is the only unit containing *Allocasuarina fraseriana* but has a close affinity with Type 7. There is a first stratum of *Eucalyptus marginata* over Low Woodland A of *Banksia ilicifolia*, *Allocasuarina fraseriana* and *Banksia attenuata*. As with Type 7, low lying areas within the type contain *Kunsea vestita* thickets.
Soil Type - Deep grey sand.

9. *Eucalyptus calophylla - Agonis* Forest

Woodland over Low Forest A over Dwarf Scrub C over Dwarf Scrub D.
SITE NO. 6

A single area of this unit occurs as a band in damper soil around the southernmost swamp in the central wetland chain. This type has affinities with Site 27 but does not contain *Banksia ilicifolia*. *Eucalyptus calophylla* occurs in the first stratum and is found over Low Forest of *Agonis flexuosa*. *Banksia attenuata* and occasional *E. grandis*
Understorey species include *Pelargonium capitatum* and *P. littorale*. *Hibbertia hypericoides*. *Acacia pulchella* and *Logania serpyllifolia*.

Soil Type - Damp grey sand.

10. *Eucalyptus calophylla - E. marginata* Dense Low Forest.

Dense Low Forest A over Low Scrub A over Open Dwarf Scrub D.
SITE NO. 28
This unusual association (for the Kemerton area) appears to have occurred as a result of a hot wildfire some 10 - 15 years ago. An even- aged dense stand of Jarrah and Marri over bracken *(Pteridium aquilinum)* or over a distinct set of understorey species has grown at the boundary of a swampy area. Understorey species were principally *Phebalium anceps*. *Oxylobium lanceolatum*. *Sphaerolobium vimineum*. *Thomasia pauciflora* and *Agonis linearifolium*. none of which were seen at any other site in the study area.
The area covered by this type was not well established due to lack of time and the density of the vegetation.

Soil type - Light to dark grey, damp sand.

11. *Banksia ilicifolia - Eucalyptus calophylla* Low Forest.

Low Forest A over Dense Heath B - Low Scrub B over Dwarf Scrub C.
SITE NOS. 17, 18, ?27

Overstorey species in this association vary in proportion but usually include *Banksia ilicifolia*. *Eucalyptus calophylla*. *E. rudis* and *Melaleuca preissiana*. A variable density of understorey from Dense Heath B to Low Scrub B

occurs and features *Astartea fascicularis*, *Jacksonia furcellata*, *Burtonia scabra* and *Hypocalymma angustifolium*. Dwarf Scrub species are *Platytheca galioides*, *Acacia semitrullata* and *Baumea juncea*.

Areas which have been previously semi-cleared or which are adjacent to more open patches such as firebreaks contain a higher percentage of shrub species. Dense scrub of *Astartea fascicularis*, *Pericalymma ellipticum* and *Burtonia scabra* was observed in one such area which was also associated with a drop in height from the surrounding vegetation.

Soil Type - Grey to dark grey peaty sand. The amount of humus in the soil varies with its proximity to swamps.

12. *Eucalyptus rudis - Acacia saligna* Open Woodland/Thicket.

Open Low Woodland A over Thicket.
SITE NO. 7, 10, ?27.

This is a very variable unit due to the part-clearing which has occurred in the central wetland chain. Bands of vegetation surrounding the often deepened swamps in the southern areas of the central and western wetland chains include *Eucalyptus rudis* and *Melaleuca preissiana* as the dominant tree species with occasional *Banksia littoralis*, *Eucalyptus calophylla* and *Melaleuca rhaphiophylla*.

A second stratum of a dense stand of *Acacia saligna* and/or *Acacia extensa* can occur and this only allows a herbfield of *Villarsia spp.* to survive as understorey. Where *A. saligna* does not occur understorey species include *Hovea pungens*, *Acacia pulchella*, *Adenanthos meisneri*, *Melaleuca teretifolia* and *Aotus gracillima*.

Soil Type - Grey peaty sand.

13. *Melaleuca teretifolia* Dense Heath.

Heath B over Open Herbs.

This association occurs in seasonally inundated swamp flats in the central wetland chain. The dominant *Melaleuca teretifolia* is often covered with *Cassytha racemosa*. Occasional emergents of *Melaleuca preissiana*, *M. rhaphiophylla*

and *Banksia littoralis* occur. Other species include *Stylidium junceum*, *Lepidosperma angustatum* and *Comesperma virgatum*.

This association has similarities to Type 14 but is much less diverse and probably wetter in winter.

Soil Type - Dark grey sandy peat. When dry this soil can be easily broken up but it forms a moderate to heavy mud when wet.

14. *Pericalymma ellipticum* Dense Heath.

Open Low Woodland A over Dense Heath B over Open Herbs.
SITE NOS. 20, 23.

Emergents of *Xanthorrhoea preissii* and *Melaleuca preissiana* occur in this vegetation type which is dominated by *Pericalymma ellipticum*. The association is species rich and includes *Melaleuca incana*, *Astartea fascicularis*, *Melaleuca teretifolia*, *Calothamnus lateralis*, *Euchilopsis linearis*, *Hibbertia stellaris* and *Lepidosperma angustatum*. Herbaceous species include *Dampiera linearis*, *Pentaschistis airoides*, *Villarsia lasiosperma* and *Sileroxus pygmaeus*.

These areas may be seasonally inundated but support a dense and varied vegetation. Many areas of this type within the study area have been cleared and dominant species have regenerated in paddocks and along roadverges. The eastern wetland unit differs from that of the central swamp chain in that it includes *Pericalymma ellipticum* and *Melaleuca incana*.
Soil Type - Light to dark grey peaty sand. The colour and humus content of the soils of the unit vary with the amount of water trapped in the area. Wetter areas are darker and richer than those which have been drained or cleared.

15. *Melaleuca rhaphiophylla - M. incana* Thicket.

This is a swamp fringing vegetation type which occurs in the eastern wetland chain. A dense band of *Melaleuca spp.* occurs at the waters edge. Open mud flats between clumps of *Melaleuca* support *Juncus bufonius*, *Cotula coronopifolia* and *Villarsia spp.*

APPENDIX 2 - KEMERTON VEGETATION LIST

KEY

* indicates an introduced species
\+ indicates a species collected by Glossop (1980) but not in the present survey
R indicates rarely seen
O indicates occasional
LC indicates locally common
C indicates common
VC indicates very common

PTERIDOPHYTA (ferns)

Dennstaediaceae

Pteridium aquilinium	C

ANGIOSPERMAE

Zamiaceae

Macrozamia reidlei	C

Podocarpaceae

Podocarpus drouyniana	LC

Typhaceae

*Typha orientalis	LC

Juncaginaceae

Triglochin calcitrapa	R

Poaceae

Amphipogon amphipogonoides	R
*Briza maxima	VC
*B. minor	VC
*Pentaschistis airoides	C
Poa dummondii	R
Stipa mollis	O
+Tetrarrhena laevis	
Vulpia sp.	O

Cyperaceae

Baumea articulata	LC
B. juncea	C
Lepidosperma angustatum	C
L. gladiatum	LC
L. longitudinale	O
L. sp.	O
Schoenus nanus	R
S. rodwayanus	LC
Schoenus sp.	
Tetraria octandra	R

Restionaceae

Hypolaena exsulca	C
Leptocarpus raycei	
L. scariosus	O
Loxocarya aspera	O
+L. cinerea	
L. fasciculatus	O
L. flexuosa	O
Lyginia barbata	VC

Juncaceae

Juncus articulatus	R
*J. bufonius	LC
J. ? holoschoenus	R
J. pallidus	VC
J. polyanthemus	C

Commelinaceae

Cartonema phylidroides	O

Liliaceae

Agrostocrinium scabrum	C
Arthropodium capillipes	O
Burchardia umbellata	VC
Caesia parviflora	R
Calectasia cyanea	O
Chamaescilla corymbosa	O

Dasypogon bromeliifolius	VC
Dianella revoluta	R
+Johnsonia acaulis	
Laxmannia squarrosa	R
Lomandra hermaphradita	C
L. integra	O
L. micrantha	C
L. nigricans	C
L. odora	C
L. sericea	O
L. sonderi	
L. suaveloens	O
Sowerbaea laxiflora	C
Thysanotus anceps	O
T. arenaria	O
T. dichotomous	O
T. multiflorus	O
T. patersonii	O
T. tenellus	O
Trichoryne elatior	C
Xanthorrhoea gracilis	VC
X. preissii	LC

Haemodoraceae

Anigozanthos manglesii	O
Conostylis aculeata	VC
C. juncea	VC
+C. setigera	
Haemodorum laxum	O
Phlebocarya ciliata	VC

Iridaceae

Patersonia occidentalis	C

Orchidaceae

Caladenia flava	C
C. latifolia	R
C. aff. longicauda	O
C. marginata	R
C. pectinata	O
+Diuris longifolia	
Drakea elastica	

+Elythranthera brunonis	
E. emarginata	R
Eriochilus dilatatus	R
Lyperanthus nigricans	R
L. serratus	R
Microtis unifolia	C
*Monadenia bracteata	O
Pterostylis recurva	R
Thelymitra crinita	O
T. fuscolutea var. fuscolutea	R
T. nuda	C

Casuarinaceae

Allocasuarina humilis	O
A. fraseriana	O

Proteaceae

Adenanthos obovatus	O
A. meisneri	C
Banksia attenuata	VC
B. grandis	C
B. ilicifolia	LC
B. littoralis	LC
Conospermum capitatum	O
Hakea prostrata	LC
H. varia	R
Persoonia longifolia	O
P. saccata	O
Petrophile linearis	VC
Stirlingia latifolia	LC
Synaphaea	O
Xylomelum occidentale	C

Santalaceae

Choretrum glomeratum	R
Leptomeria cunninghamii	R

Loranthaceae

Nuytsia floribunda	O

Amaranthaceae

Ptilotus ?spathulata	R

Portulacaceae

Calandrinia calyptrata	R

Caryophyllaceae

Silene gallica	O

Ranunculaceae

Clematis pubescens	O

Lauraceae

Cassytha racemosa	
Cassytha sp.	C

Brassicaceae

*Heliophila pusilla	
Stenopetalum robustum	R

Droseraceae

Drosera glanduligera	O
+v. macrantha	
+v. menziesii	
D. neesii ssp. neesii	R
D. pallida	O
D. stolonifera	C

Crassulaceae

Crassula colorata	O

Pittosporaceae

Billardiera variflia	R

Mimosaceae

Acacia cochlearis	LC
A. extensa	VC
A. flagelliformis	O
A. huegelii	O
A. pulchella	VC
A. saligna	LC
A. semitrullata	LC
A. stenoptera	O
A. wildenowiana	O

Papilionaceae

Aotus gracillima	LC
A. procumbens	O
Bossiaea eriocarpa	VC
Burtonia conferta	O
B. scabra	O
+Chorizema diversifolium	
Daviesia divaricata`	C
D. incrassata	C
Dillwynia dillwynioides	O
Eutaxia virgata	LC
Euchilopsis linearis	O
Gomphlobium polymorpha	O
G. tomentosum	VC
Hardenbergia comptoniana	O
+Hovea chorizemifolia	
H. pungens	LC
H. trisperma	O
Isotropis cuneifolia	C
Jacksonia furcellata	VC
J. sternbergiana	C
Kennedia coccinea	O
K. prostrata	C
O. capitatum	R
O. lanceolatum	LC
O. linearifolium	LC
O. reticulatum	R
Pultenaea skinneri	LC
Sphaerolobium vimineum	O

Geraniaceae

Erodium spp.	C
*Geranium molle	O
*Pelargonium capitatum	C
Pelargonium littorale	O

Rutaceae

Boronia dichotoma	O
Eriostemon spicata	VC
Phebalium anceps	LC

Tremandraceae

Platytheca galioides	C
Tetratheca aff. hirsuta	LC

Polygalaceae

Comesperma calymega	R
C. virgatum	C

Euphorbiaceae

Monotaxis occidentale	O
Phyllanthus calycinus	VC

Stackhousiaceae

Stackhousia huegelii	R

Sterculiaceae

Thomasia foliosa	O
T. pauciflora	LC

Dilleniaceae

Hibbertia cuneiformis	R
H. hypericoides	VC
H. racemosa	VC
H. stellaris	O
H. subvaginata	O
H. vaginata	LC

Violaceae

Hybanthus calycinus	C

Thymelaceae

Pimelea rosea	R

Myrtaceae

Agonis flexuosa	VC
A. linearifolia	R
Astartea fascicularis	VC
Baeckea camphorosmae	R
Calothamnus lateralis	O
Calytrix flavescens	C
Eucalyptus calophylla	C
E. decipiens	O
E. gomphocephala	O
E. marginata	VC
E. rudis	O
Hypocalymma angustifolia	C
+H. robustum	
Kunzea vestita	VC
Melaleuca acerosa	R
M. incana	LC
M. laterita	O
M. pauciflora	O
M. preissiana	VC
M. rhaphiophylla	LC
M. scabra	R
M. teretifolia	LC
M. thymoides	VC
M. viminea	O
Pericalymma ellipticum	LC
Verticordia ?hughani	LC
V. nitens	R

Haloragaceae

Glischrocaryon aureum	R
Gonocarpus cardiger	R

Apiaceae

Platysace compressa	C
Trachymene pilosa	VC
Xanthosia pusilla	C
X. huegelii	O

Epacridaceae

Astroloma ciliatum	O
A. ?drummondii	O
A. pallidum	C
Conostephium pendulum	C
C. preissii	O
Leucopogon australis	R
+L. ?carinatus	
L. conostephoides	R
L. polymorpha	O
L. propinquus	C
Lysinema ciliatum	O

Loganiaceae

Logania serpyllifolia	O

Manyanthaceae

Villarsia albiflora	C
V. lasiosperma	LC
V. violifolia	C

Lamiaceae

Hemiandra pungens	C

Scrophulariaceae

*Parentucellia latifolia	LC
*P. viscosa	LC

Orobanchaceae

Orobanche australiana	O

Rubiaceae

+Opercularia ?apiciflora
+O. hispidula

Campanulaceae

Wahlenbergia gracilenta	R

Lobeliaceae

Isotoma hypocrateriformis	O
Lobelia tenuior	O

Goodeniaceae

Dampiera linearis	VC
Dampiera aff. linearis	R
D. trigona	R
Lechenaultia biloba	R
Scaevola holosericea	R
S. pilosa	O

Stylidiaceae

Levenhookia stipitata	LC
Stylidium brunonianum	VC
S. calcaratum	R
+S. carnosum	
S. divaricatum	O
S. diversifolium	C
S. junceum	O
S. piliferum	VC
S. repens	R
S. schoenoides	C
S. sp. (undescribed)	R

Asteraceae

Asteridea pulverulenta	C
+Brachycome bellidioides	
B. iberidifolia	O
B. pusilla	LC
Cotula coronopifolia	LC
Craspedia uniflora	R

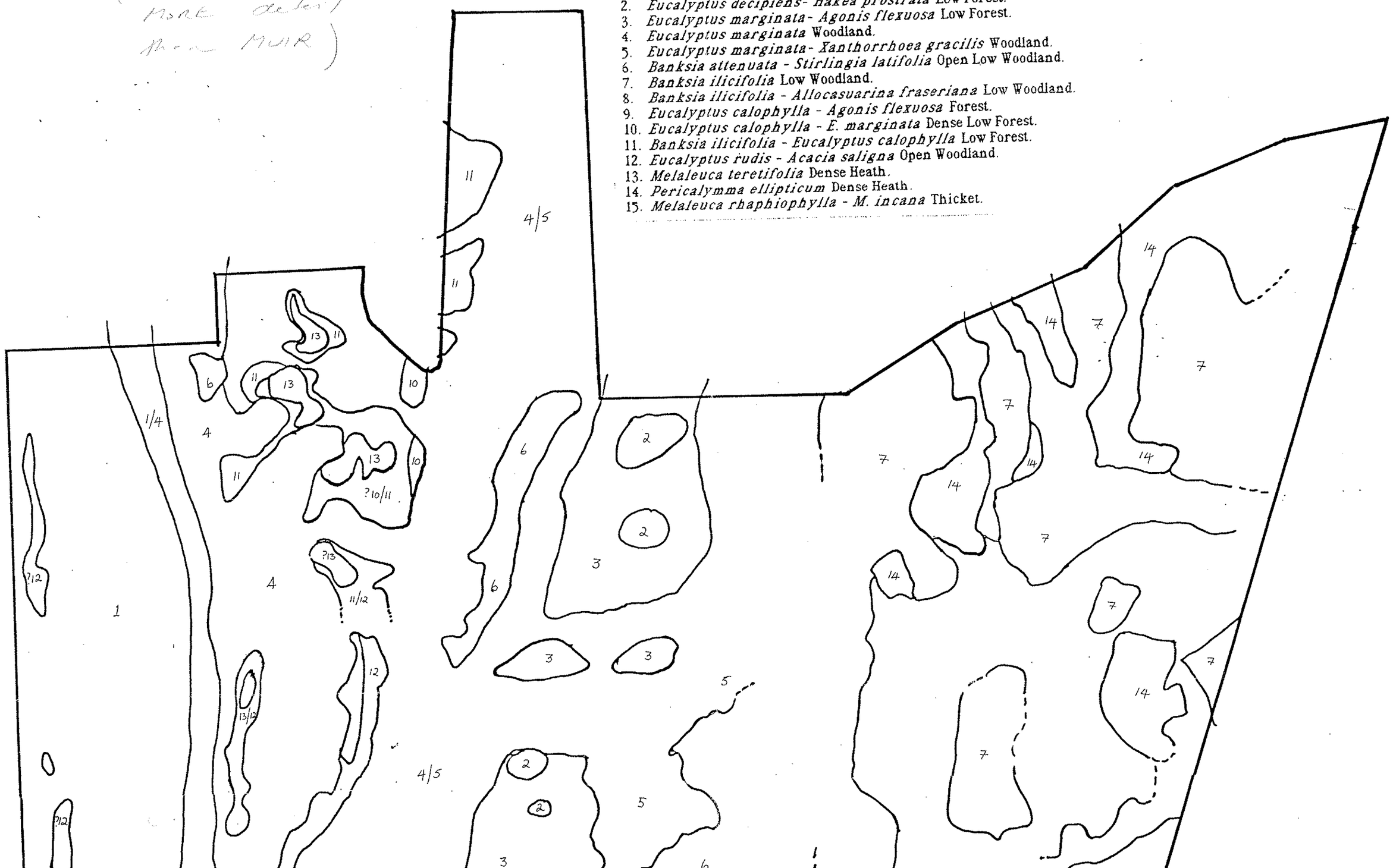
Gnaphalium sphaericum	R
Helichrysum cordatum	O
Helipterum cotula	VC
+H. floribundum	
Lagenifera huegelii	O
Millotia tenuifolia	R
Olearia axillaris	C
Podplepis gracilis	O
Podotheca angustifolia	R
P. chrysantha	R
P. gnaphaloides	R
*Pseudognaphalium luteo-album	O
Quinettia villii	R
Senecio hispidula	O
S. lautus	R
Siloxerus pygmaeus	R
Trichocline spathulata	R
*Ursinia anthemoides	VC
*Vellereophyton dealbata	R

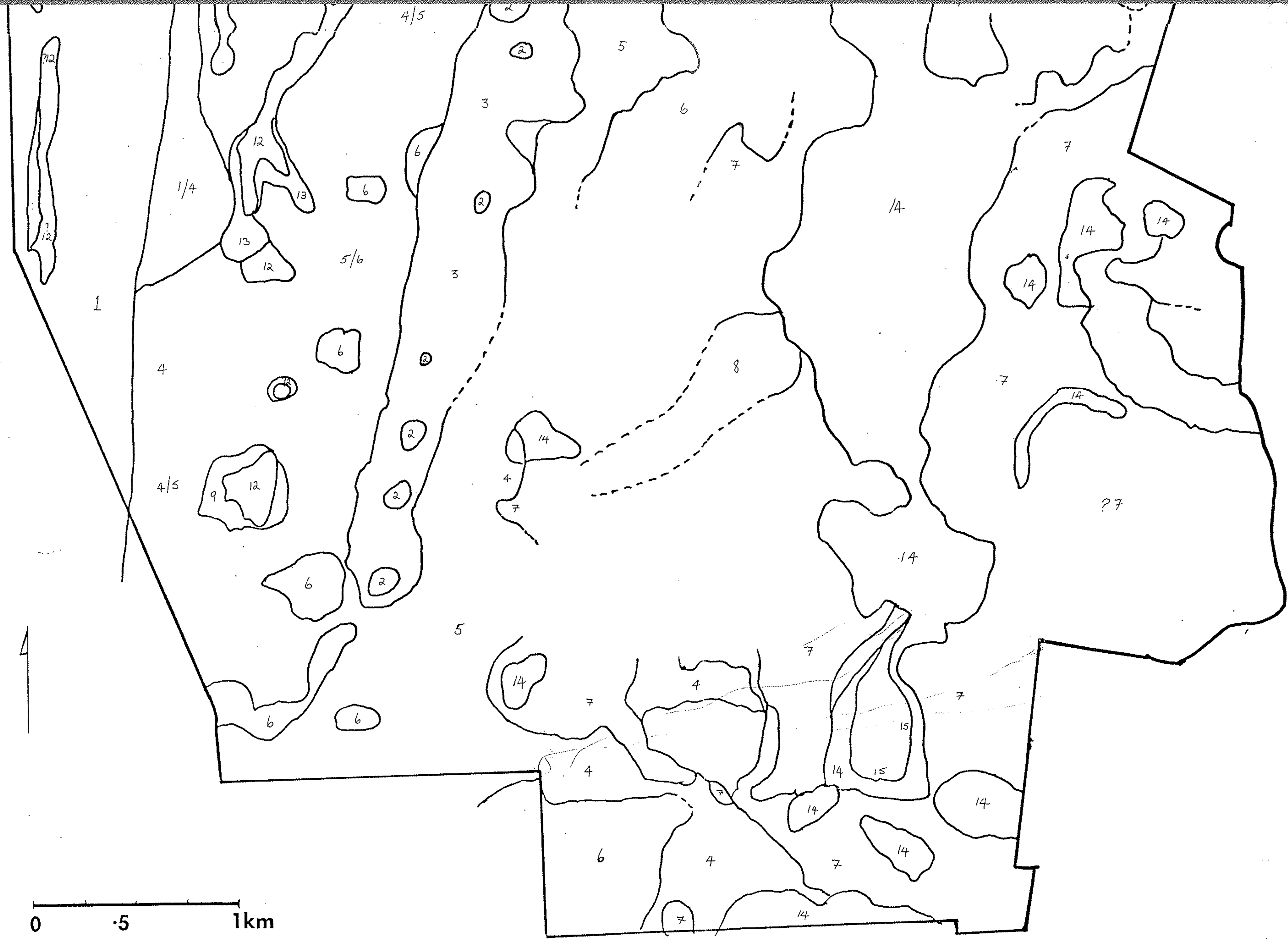
REMERTON VEGETATION MAP

Napier 1985
(This shows more detail than MUIR)

FIGURE 4. VEGETATION UNITS

1. *Eucalyptus gomphocephala - Agonis flexuosa* Woodland.
2. *Eucalyptus decipiens- Hakea prostrata* Low Forest.
3. *Eucalyptus marginata- Agonis flexuosa* Low Forest.
4. *Eucalyptus marginata* Woodland.
5. *Eucalyptus marginata- Xanthorrhoea gracilis* Woodland.
6. *Banksia attenuata - Stirlingia latifolia* Open Low Woodland.
7. *Banksia ilicifolia* Low Woodland.
8. *Banksia ilicifolia - Allocasuarina fraseriana* Low Woodland.
9. *Eucalyptus calophylla - Agonis flexuosa* Forest.
10. *Eucalyptus calophylla - E. marginata* Dense Low Forest.
11. *Banksia ilicifolia - Eucalyptus calophylla* Low Forest.
12. *Eucalyptus rudis - Acacia saligna* Open Woodland.
13. *Melaleuca teretifolia* Dense Heath.
14. *Pericalymma ellipticum* Dense Heath.
15. *Melaleuca rhaphiophylla - M. incana* Thicket.

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