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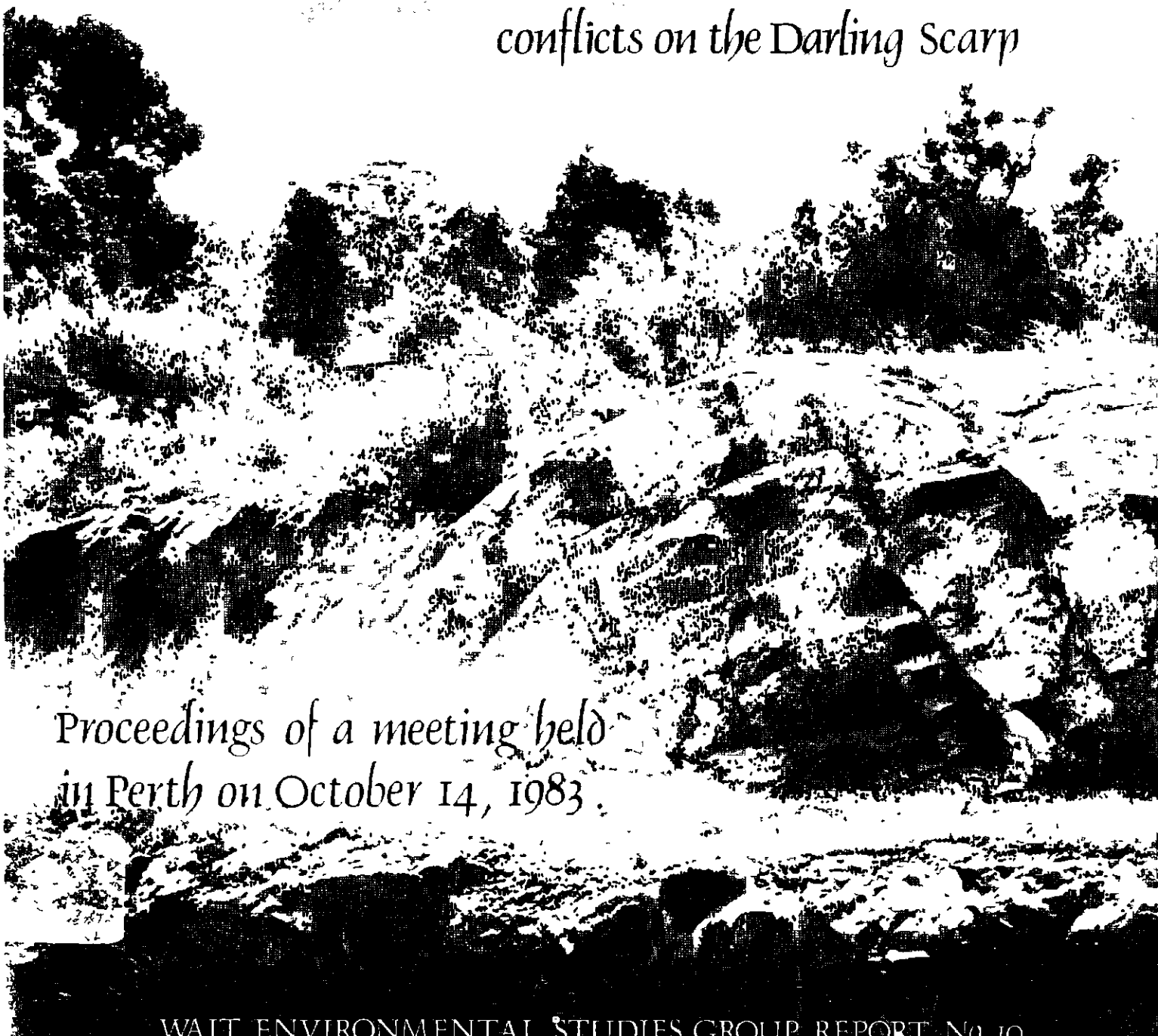
Scarp Symposium

A one day symposium to review land use and conflicts on the Darling Scarp



Proceedings of a meeting held in Perth on October 14, 1983.

WAIT ENVIRONMENTAL STUDIES GROUP REPORT No 10

Scarp Symposium

Proceedings of a meeting held in Perth on

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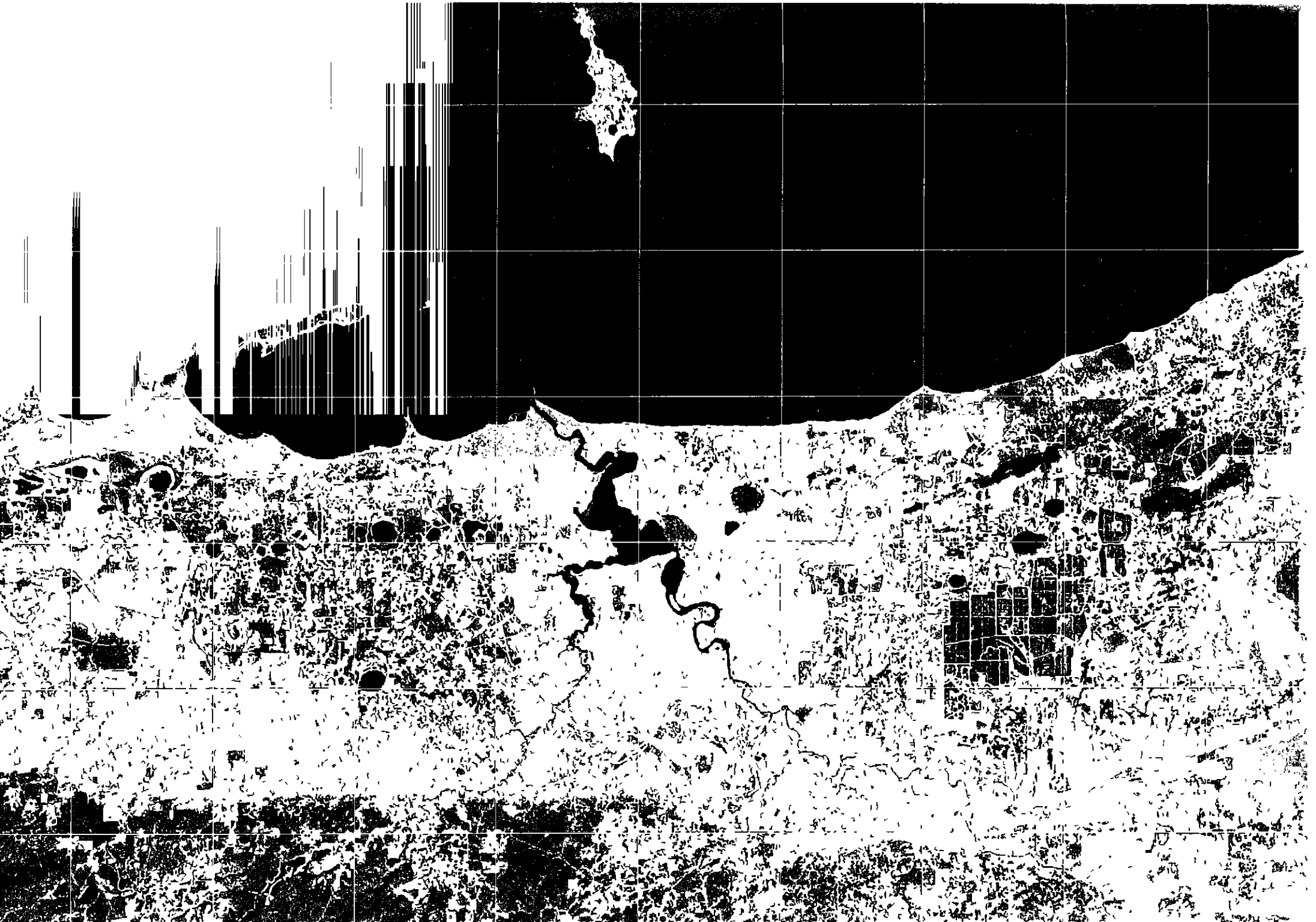

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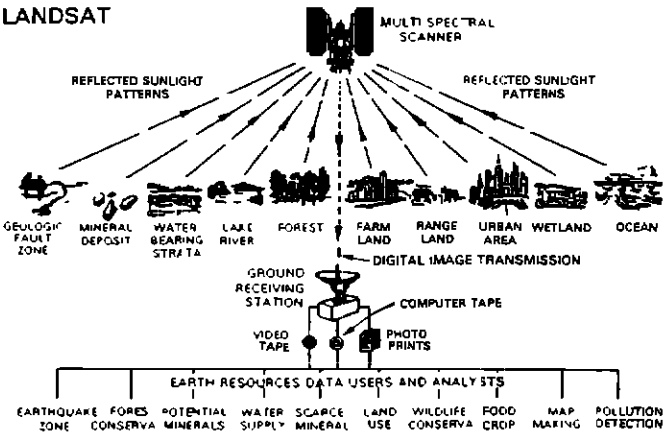

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The Perth scene illustrated was taken in December 1980. A 10 km grid has been superimposed. The light blue tones of the city centre and industrial zones contrast with the pinks and reds of residential areas. These "false" colours highlight the many varied land uses of the Swan River Coastal Plain.

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PREFACE

The WAIT Environmental Studies Group is a loosely affiliated group of WAIT staff from various disciplines who share a common interest in matters of concern to the environment. E.S.G. activities include the teaching of interdisciplinary courses on environmental topics, research and survey work and public information excercises.

Generally speaking, the E.S.G. undertakes a number of projects in any given year. Sometimes, however, the Group concentrates its resources on one particular topic. The recent survey of Woodman Point's ecology and resources by E.S.G. members is an example of one such enterprize. This Symposium on land-use and conflicts on the Darling Scarp is the Group's major initiative for 1983.

A number of Western Australian land-use or conservation-orientated reports have been released in recent years. In the south-west the Darling Range Study Group Report (1982) looked at land-use policy and co-ordination of land-use planning in the Darling Range and the System 6 Report (1981) identified, and made recommendations for, a system of national parks, nature reserves and recreation areas in the Darling System. The latter Report recommended a system of reserves on the Darling Scarp (see Appendix in the Proceedings). However, apart from this recommendation, the Darling Scarp itself has not received a great deal of attention.

The aim of this Symposium was to bring together existing information and new ideas on the geology, biology, tenure and conflicts of the Darling Scarp. There is a feeling amongst the community living near the Scarp that all is not well with this area. Frequent fires, off-road vehicles, subdivision, weed invasion, quarrying and many other factors are all contributing to the down-grading of this important area. It is therefore hoped that this Symposium, and the accompanying proceedings, will act as a catalyst to inspire authorities to take action to ensure that this area is well managed.

The geographical unit under consideration here is the boundary between the Swan Coastal Plain and the Darling Range. Symposium contributors were asked to focus their attention on the region of the Scarp close to Perth, i.e. between Muchea and Serpentine. It has been necessary in some cases to include information from further afield.

The following individuals assisted with the organisation of the Symposium:

John Burling	-	Treasurer
June Dunstan	-	Publicity
Barry Oldfield	-	Media arrangements
Elizabeth Rehfeldt	-	Typing
Rob Rippingale	-	Catering liaison

Jonathan D. Majer
1983 Chairman of E.S.G.

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GEOLOGY OF THE DARLING SCARP

K.K. Sappal

Introduction

To the geologist the Darling Scarp is the eroded western margin of the Darling Plateau. It almost certainly marked the position of the Darling Fault, and it has been eroded to its present location. The fault is one of the major tectonic features of the earth's crust. The Scarp retains a strongly linear form and has a north-south trend roughly parallel to the coast. The steep rocky slopes of the Scarp rise from a series of discontinuous foothills 75m above sea level to the crest of the Darling Plateau at elevation of 270m, and this generally occurs over a horizontal distance of one to two kilometers except where the Scarp is dissected by major streams. The Scarp is a prominent geomorphic feature between Muchea in the north and Serpentine in the south.

Geomorphology

The major geomorphological features of the area are the Darling Plateau in the east and the Swan Coastal Plain and the underlying sediments of the Perth Basin in the west. The Darling Plateau also referred to as the Darling Range exists as a topographic feature mainly due to its ancient igneous and metamorphic rocks in contrast to the much younger surficial and softer sediments of the Swan Coastal Plain to the west. Their common boundary is marked by an abrupt change in elevation of the landscape along the Darling Scarp. The Darling Scarp, the surface expression of the Darling Fault which extends for almost 1000km in length along north-south trend (Figure 1). There has been a considerable amount of movement along the Darling Fault in the geological past, and it is considered that the present Scarp is as much the result of differential erosion as a reflection of the movement, Wilde (1981).

The geomorphic units of the Swan Coastal Plain and the Plateau are shown in Figure 2. A brief description of the units from east to west follows.

Darling Plateau

The Darling Plateau overlies Archaean rocks and has an average elevation of 300m above sea level with isolated peaks such as Mt. William reaching 480m. The plateau forms the western part of a much larger unit described as the Great Western Plateau by Jutson (1950). The Archaean rocks of the Plateau are blanketed by a layer of laterite and associated gravel which tend to mask changes in the bed rock topography. Briefly, laterite is a weathering product of rocks, and forms under warm and moist climatic conditions, usually with strongly defined. alternating periods of drying and wetting of the soil profile. This process concentrates alumina and iron oxide in the near surface horizons, thus giving a peculiar red-brown colour and leading to the development of a hard duricrust or "cap rock" on prolonged dehydration of the soil profile.

Darling Scarp

The Darling Scarp as mentioned in the introduction, represents the Western Edge of the Darling Plateau. The Scarp has a relief of 90m north of Bullsbrook and further south it rises to over 200m above the level of the Swan Coastal Plain. The higher relief in the south is the result of marine erosion in the late Tertiary which appears to have removed an earlier extensive blanket of Cretaceous sediments, similar to those making up the Dandaragan Plateau. The Scarp is usually referred to as the surface expression of the Darling Fault, but it does in fact, lie some 1 to 3 km inland of the actual fault trace based on geophysical evidence. This is because of Scarp retreat due to rapid erosion prior to and during the early Cretaceous, Wilde (1981).

Ridge Hill Shelf (Piedmont Zone)

It is represented by a line of foothills 1 to 3 km wide at the base of the Darling Scarp. The western margin of the shelf approximatedly corresponds to the position of the Darling Fault, and it is also closely parallel to the South Western Highway. It has a maximum elevation of 75m and is dissected by stream action, and exists as a series of lateritized and sandy spurs. Remnants of two emergent strandline deposits, the Ridge Hill Sandstone and Yoganup Formation are present. The self represents a Piedmont Zone consisting of coalescing alluvial fans deposited by streams easing grade at the bottom of the Scarp.

Pinjarra Plain

The Pinjarra Plain consists of low lying alluvial sediments with an elevation range of 12 to 40m above sea level. The overlapping alluvial fans form a complex of sediment and soil type which are fertile. The plain extends westwards up to 8km from the valleys where the major drainages emerge from the Darling Scarp.

Bassendean Dune System

The system consists of sand dunes which occur in a 15km wide zone between the Pinjarra Plain and the Coastal Belt. They consist of leached quartz sands on which humus podzol soils have developed. The dunes have a relief of only 5 to 15m above the plain. Sandy swamps occupy the interdune depressions and the dunes may reflect old Coast lines.

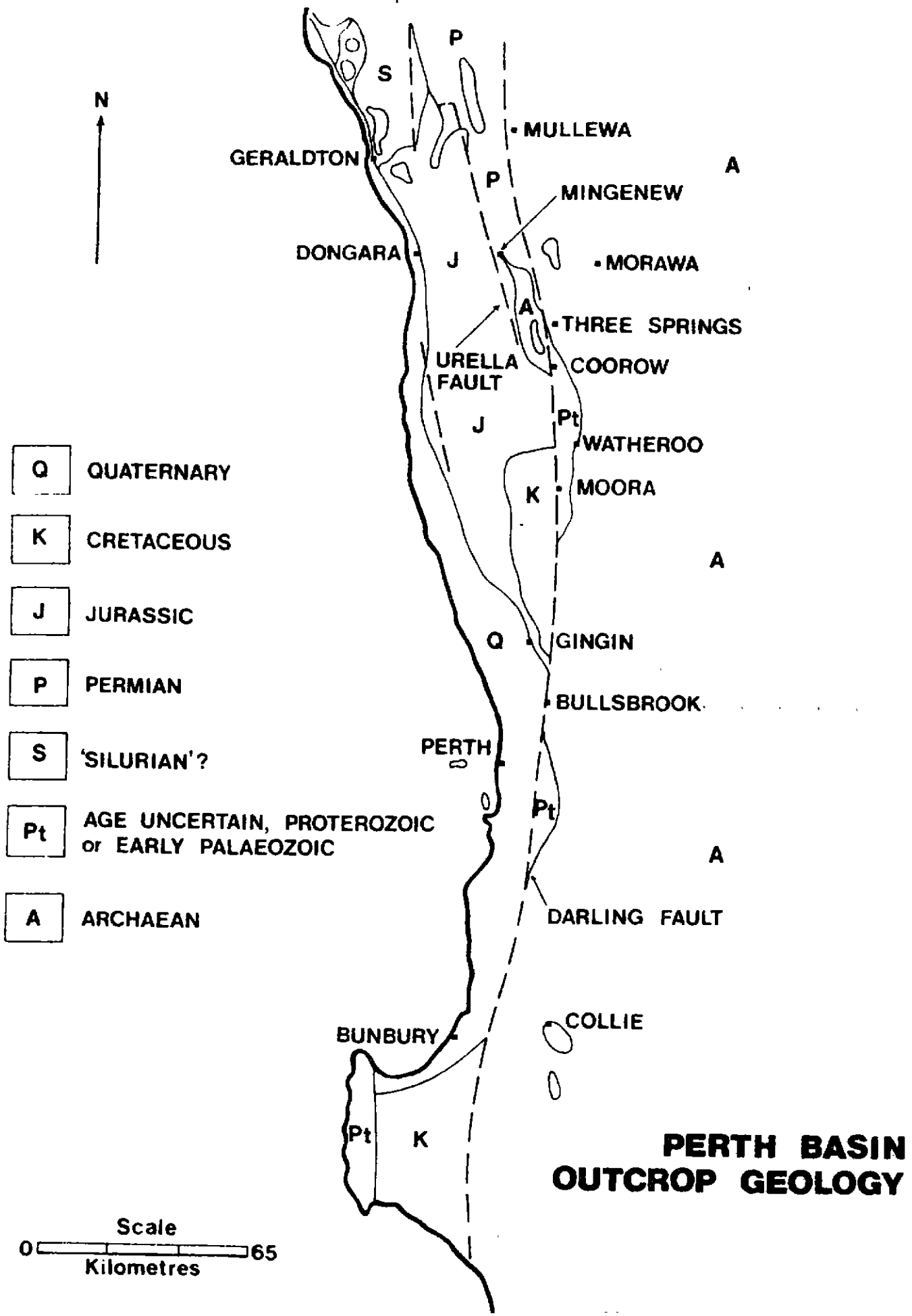

Figure 1. Darling Fault and outcrop geology of the Perth Basin.

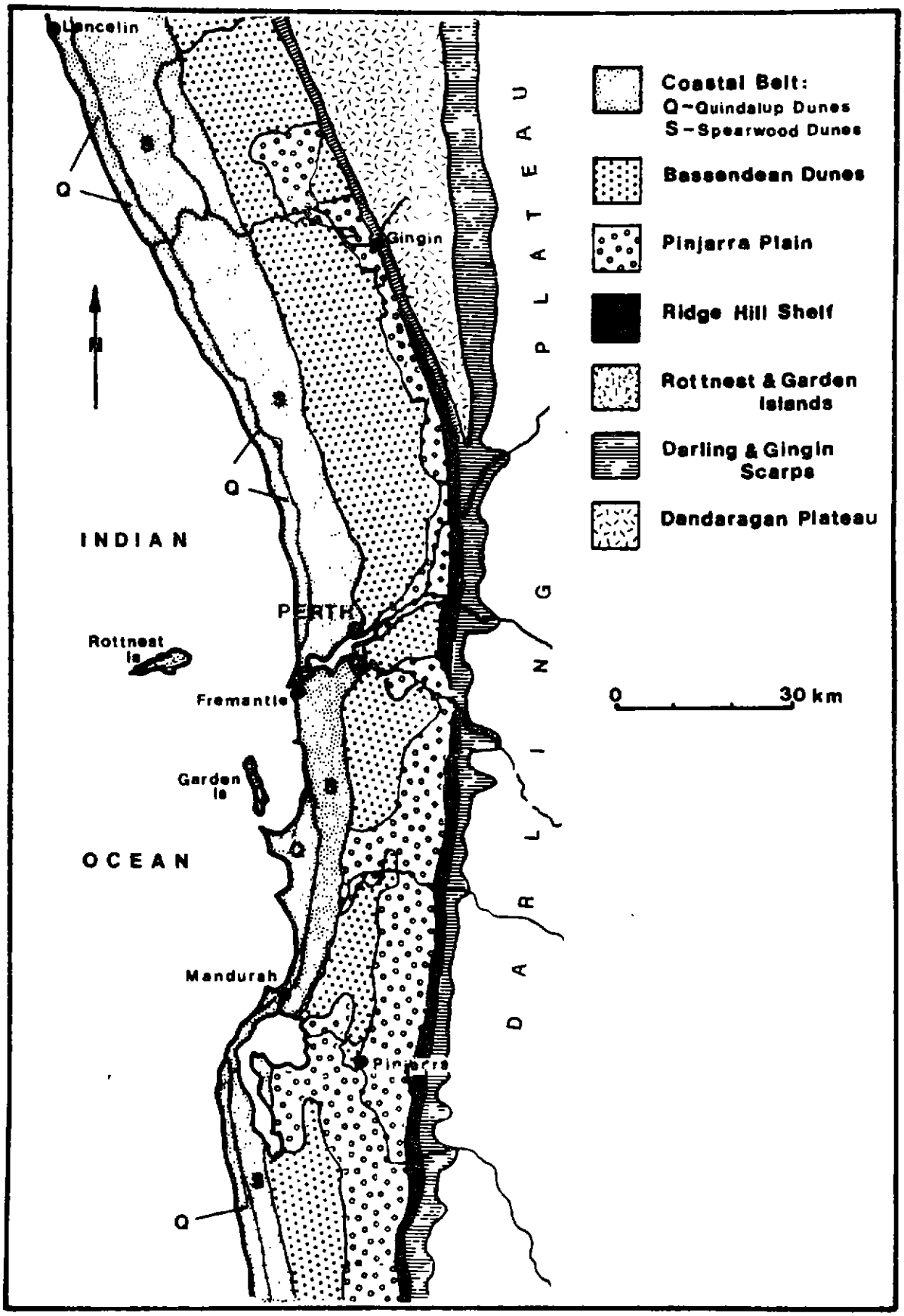

Figure 2. Geomorphic units of the Swan Coastal Plain and the Darling Plateau (after Wilde, 1981).

Spearwood and Quindalup Dune Systems (Coastal Belt)

The Spearwood and Quindalup Dune Systems occupy a 10-15km wide zone between the Bassendean Dunes and the Indian Ocean. The dunes consist of calcarenite, calcrete and leached siliceous sandhills and the carbonate content of the sand decreases from west to east. According to McArthur (1976) these dunes have experienced a complex history of erosion, deposition and soil formation.

Darling Fault

The Darling Fault is a major crustal feature 1000km long, trending north-south, and it marks the western margin of the Yilgarn Block. The Darling Fault is regarded by most geologists as a normal fault with the fault plane dipping to the west, with a maximum west block movement of about 15km. The west block is defined as the Perth Basin (Figure 1) containing 15,000m of sediments of Silurian (?) to Tertiary in age.

It appears that the major active phase of movement on the Darling Fault extended from Middle Triassic to the Cretaceous, from about 200 m.y. to 125 m.y., Seddon (1972), but there is growingevidence that a sub parallel zone of deformation was already in existence during the Archaean. The evidence for an Archaean deformation zone is supported by the occurrence of extensively sheared rocks (mylonites) at various locations along the Darling Scarp, (Blight et al., 1980).

The Phanerozoic history and the movement on the Darling Fault and the subsequent sedimentation in the Perth Basin is summarised below.

(i) Development of a downwarp in the Ordovician/ Silurian, possibly between 500 to 395 m.y. ago, and the commencement of paralic sedimentation in the Perth Basin in the Early Permian (280 m.y. ago).

(ii) Formation of a deep graben in the centre of the downwarp and the maximum movement on the fault between Late Triassic to the Cretaceous (between 200 m.y. to 125 m.y. ago), and the deposition of Mesozoic sediments in the Perth Basin. During the later part of this period (Neocomian) the super continent of Gondwanaland started to break up, and Western Australia began to break apart from Greater India. The actual continental break-up occurred along a major fault near the original western margin of the Perth Basin, and not along the Darling Fault. There is no evidence to suggest that any movement has occurred on the Darling Fault since the Neocomian (125 m.y. ago).

Geology and Stratigraphy

The Darling Scarp is sandwiched between two distinct geological provinces. The eastern province is the Archaean Yilgarn Block, which mainly contains igneous and metamorphic rocks and constitutes the major nucleus of the Australian continent. The western province is the Perth Basin, an elongate sedimentary basin, containing 15,000m of sedimentary rocks of Silurian (?) to Tertiary age. Only a brief introduction to the geology of the two provinces is given in this paper. The interested reader is referred to the numerous publications on the topic, e.g. Compston and Arriens (1968), Gee (1979), Johnstone et al. (1973), Jones and Pearson (1972), Low et al. (1970), McArthur et al. (1959), McWhae et al. (1958), Playford et al. (1975) and Wilde (1980).

Archaean Rocks (>3,000 to 2,600 m.y. old)

The Archaean rocks of the Yilgarn Block consist of granite, gneiss, migmatite and metamorphosed volcanic and sedimentary rocks (green stones), together with some intrusive dolerite dykes. The rocks exposed in the Darling Range near Perth are mainly granites, gneisses, migmatites and dolerites. However, in adjacent areas of the Yilgarn Block (Figure 3), metamorphic rocks are also exposed. These are more than 3,000 m.y. old, and are described under the following:

Chittering Metamorphic Belt
Jimperding Metamorphic Belt
Balingup Metamorphic Belt

There is also a belt of volcanic rocks near Boddington defined as the Saddleback Group. These are about 2,600 m.y. old and are similar to the green stones around Kalgoorlie. Also around 2,600 m.y. ago, there was a large scale granitisation throughout the Yilgarn Block, and this formed migmatites, which are also referred to as mixed rocks consisting of an earlier gneissic portion and a granitic component. There was an emplacement of intrusive granite rocks as large batholiths. The term granite is used in the broad sense to include plutonic rocks with composition variation that of quartz monzonite, granodiorite, adamellite and granite.

Proterozoic Succession (2,600 to 570 m.y. old)

The sedimentary rocks of Middle to late Proterozoic age are exposed just east of the Darling Fault in a narrow belt from Gosnells to Serpentine. These are described as the Cardup Group and consist of conglomerate, sandstone, siltstone and shale, and were laid down as shallow marine sediments on the Continental Shelf. The contact of the Cardup Group with the underlying basement is unconformable, and dips 60° to the west.

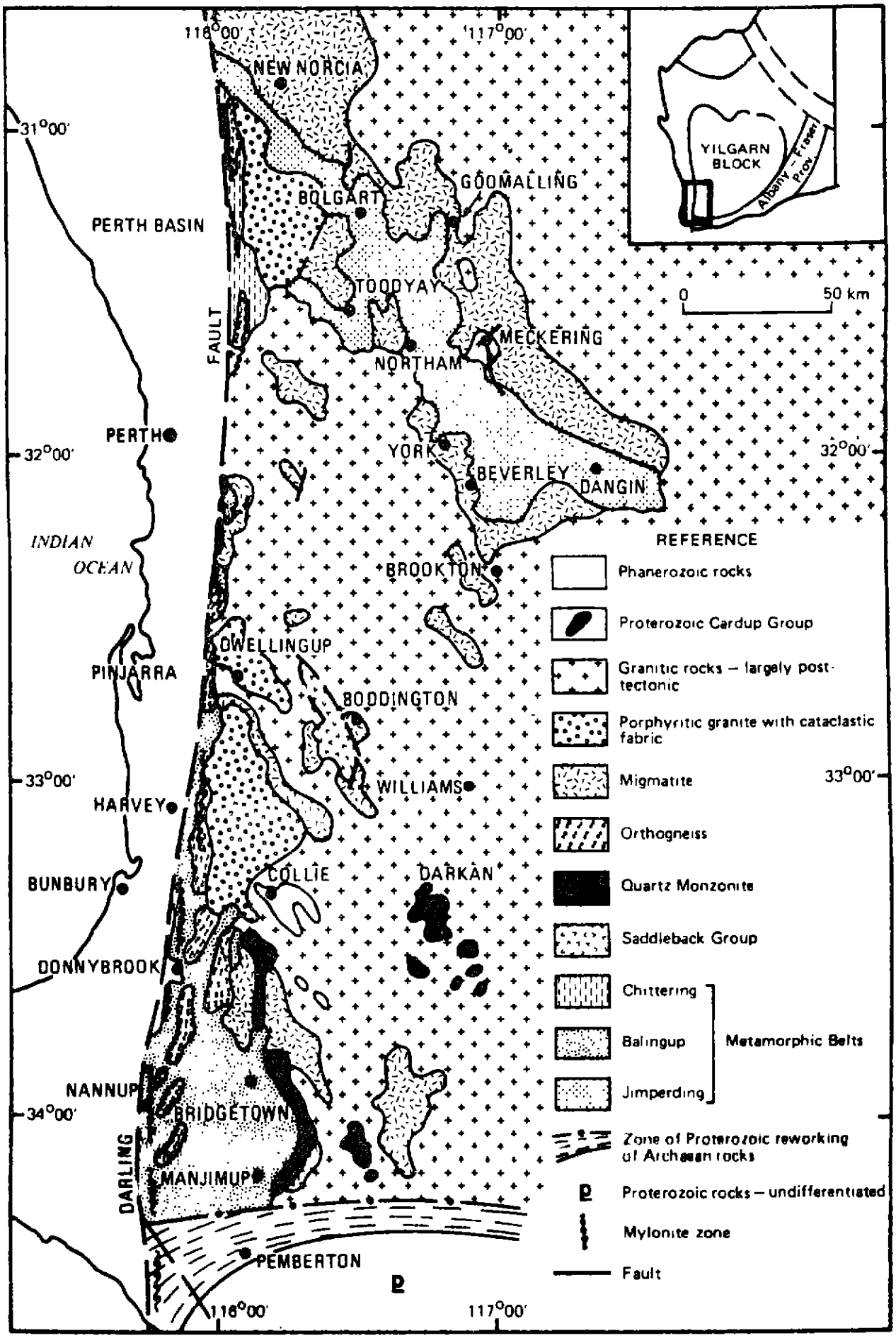

Figure 3. Regional geology of the south western part of the Yilgarn Block. (after Wilde 1980)

The sequence of Proterozoic rocks is intruded by quartz dolerite dykes, with an age of 560-590 m.y. determined by Compston and Arriens (1968). It is possible that some of the dolerite dykes may be older than 590 m.y. (Giddings, 1976). Other rocks of possible Proterozoic age exposed close to the western edge of the Yilgarn Block are described from north of the present area. These have been named (from north to south) as the Billeranga Group and Dudawa Beds, Yandanooka Group and Moora Group.

Palaeozoic Succession (570 to 230 m.y. old)

The thickness of sediments estimated by geophysical techniques in the Perth Basin reaches a maximum of 15,000m (Figure 4) and the bore holes in the basin have not penetrated deeper than 5000m. The lower thickness of 10,000m could be Palaeozoic sediments. These rocks are not exposed between Muchea and Serpentine. The rocks of Silurian age (?) are exposed along the Murchison River, and thse are described as the Tumblagooda Sandstone. The Permian rocks are exposed at the surface in the Irwin Sub-basin (Figure 1) and consist of Nangetty Formation, Holmwood Shale, Fossil Cliff Formation, High Cliff Sandstone, Irwin River Coal Measures, Carynginia Formation and Wagina Sandstone. At Walyunga National Park there are boulder beds in the foothills of Darling Ranges that have been described as of Permian age (?), Seddon (1972). Other Permian rocks occur in the Collie and Wilga Basins. The Collie Basin at present is the only commercial source of coal for Western Australia.

Mesozoic Succession (230 to 65 m.y. old)

Triassic and Jurassic sediments of approximately 5,000m thickness underlie the Swan Coastal Plain, and these have been encountered in a number of boreholes drilled in the Perth Basin. The only Mesozoic rocks exposed at the surface are of Cretaceous age (Figure 1) and these are exposed at Gin Gin (including true chalk). Five km east of Muchea are exposed the Bullsbrook Beds, they consist of conglomerate, sandstone and siltstone with plant fossils of early Cretaceous age. Near Bullsbrook Hotel, the Osborne Formation consisting of grey-green marine sandstone is exposed.

Tertiary Succession (65 to 1.8 m.y. old)

Only two groups of Tertiary rocks are known from the area. One is the King's Park Shale, which is encountered in bore holes near Perth, and consist of marine and estuarine grey calcareous shales and clays of Paleocene to Early Eocene age, based on foraminifera. The other unit is the laterite of the Darling Plateau which consists of aluminous or ferruginous layers generally 2m thick. The laterite is associated with sand which commonly defines ancient river courses on the plateau.

Quaternary Succession (1.8 m.y. to recent)

The Quaternary deposits of Swan Coastal Plain are unconsolidated or partly lithified, and relate to depositional and erosional processes caused by fluctuations in sea level from the foothills of the Darling Range to a shore line west of Rottnest. The Quaternary sediments are classified under the following units in stratigraphic order.

Safety Bay Sand and Wetland Deposits
Tamala Limestone (Coastal limestone and leached Quartz Sand)
Bassendean Sand
Guildford Formation
Yoganup Formation (Ridge Hill Sandstone)

The above geological units do not necessarily correspond to the geomorphic units of the Swan Coastal Plain described earlier in the paper, however, some close correlation is possible in some cases.

Summary

The Darling Scarp is an important geological and geomorphic feature sandwiched between the Swan Coastal Plain and the Darling Range (Darling Plateau). It resulted initially from West-block-down movement along the Darling Fault. However, extensive marine erosion prior to and during the Cretaceous led to Scarp retreat between 1 and 3km. Further marine erosion during the Tertiary removed the Cretaceous sediments between Muchea and Boyanup and this re-emphasized the Scarp in this region.

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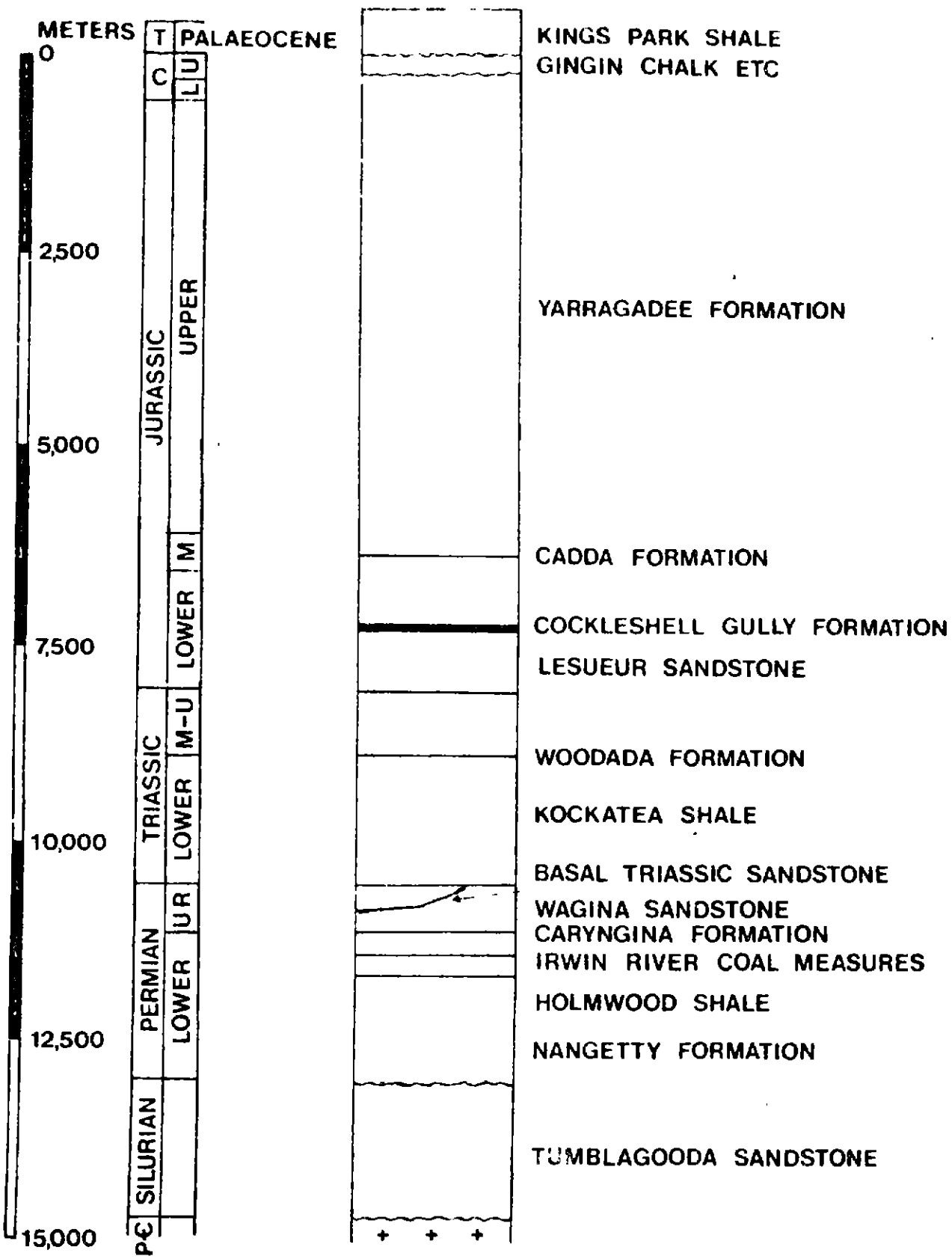

Figure 4. Generalised stratigraphic column
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THE STATUS OF VEGETATION ON THE SCARP

Heddle, E.M. and Marchant, N.G.

Introduction

The Darling Scarp forms a boundary between the Swan Coastal plain to the west and the Darling Plateau to the east. The large variety of landforms and soils supports a specialized and characteristic flora. Although many species occur in adjacent areas, available records show that at least ten plant species are restricted to the Darling Scarp. Many more occur as outliers of populations in other areas.

The range of habitats include large expanses of granitic outcrops and laterite. Soil depth appears to be a critical factor in the occurrence of wetland and forest species. The distinctive changes in landforms, soils and climatic conditions from south to north are reflected in the structural and floristic components of the plant communities.

The close proximity of Perth has led to increasing demands upon the natural resources of the Scarp. The effect of land-use pressures on the current status of the Darling Scarp vegetation is reviewed.

The Environment

Landforms and Soils

The Darling Scarp forms a straight, linear escarpment which reaches elevations greater than 300m (Churchward and McArthur, 1980). This escarpment is dissected by a series of westward flowing streams. The steeper slopes which are characterized by numerous rock outcrops and shallow soils have some affinities with the "Cooke surface" on the Darling Plateau (Havel, 1975b). The soils adjacent to the outcrops form a mosaic of erosion products. In the south, the steeper slopes support a higher proportion of granites, mixed rock granites, migmatites and basic rocks (Seddon, 1972). In the north, the Scarp is generally lower and more undulating with a higher proportion of colluvium and less outcropping.

The rivers and streams lose their moderately steep gradient when they enter the plain and consequently drop their sediments. The latter deposits have been described by Bettenay et al. (1960) as the 'Pinjarra Plain'. In between the watercourses, the deposits form an undulating shelf (Ridge Hill Shelf) at the foot of the escarpment. These alluvial deposits accumulated during the Pleistocene and Recent periods, and are less than 2½ million years old, in dramatic contrast to the granites and metamorphic rocks of the Darling Scarp which are more than 2,000 million years old (Seddon, 1972).

Climate

Climatic conditions on the Darling Scarp are similar to those of Perth, with two main seasons, namely cool, moist winters and hot, dry summers (Gentilli, 1948; Bureau of Meteorology, 1965 and 1966). Winter rains occur when moist westerly winds rise over the coast and Darling Scarp; this leads to an increase in rainfall immediately east of the Scarp. The rainfall then decreases as one travels eastwards. A similar decrease in rainfall occurs along the Scarp, from an annual rainfall in the vicinity of 1200mm near Serpentine to less than 700mm near Muchea.

The elevation of the Darling Plateau also affects the temperature. The maximum temperatures immediately east of the Darling Scarp at Kalamunda are generally lower than at Guildford on the Coastal Plain. (Seddon, 1972). This trend is reversed for the minimum temperatures in the winter months. The Darling Scarp appears to affect the velocity of the local easterly winds due to the influence of gravity, i.e. because of the katabatic effect (Mitchell, 1979). Mitchell presents evidence supporting this effect by ranking wind damage to the local tree species.

There have been investigations on the ancient climates of the region in view of their importance to soil formation and plant distributions. Churchill (1968) postulated that more arid periods occurred between 500 BC and 300 BC and between AD 500 and AD 1500 on the basis of palynological evidence.

Vegetation

Earlier Studies

The first major investigation was by Diels (1906), who attempted to establish relationships between plants and the environmental conditions in which they grew. Jarrah (Eucalyptus marginata) was associated with the gravelly soils on the main plateau. Other observations included the recognition of east-west and north-south trends in the plant communities and the greater degree of endemism in the north, where environmental gradients were steeper.

Gardner (1944) examined broad vegetation categories in relation to environmental conditions. He recognized the broader Jarrah formations and the edaphically controlled formations on the extreme sites, e.g. granitic outcrops.

Williams (1932, 1945) studied the northern Jarrah forest in greater detail at several sites immediately east of the Darling Fault. These sites occur on that portion of the Darling Plateau which has been dissected by the Helena River and its tributaries; they are similar to the Darling Scarp in that outcrops dominate the landscape. Williams related the communites to different underlying rocks and soils. These

relationships included the occurrence of Jarrah on the laterites and Wandoo (Eucalyptus wandoo, formerly E. redunca) on the soils derived from epidiorites.

The next major contribution to the field was by Speck (1952, 1958). He refined the earlier studies of Diels (1906) and described the communities in greater detail. This included the definition of three major formations for the Perth region, namely forest, woodland and scrub, defined by height and density of the dominant stratum. Speck was aware of the continuous variation within the forest. Speck's work has been recognized as providing a broad framework for later community studies in the area. In 1972, Seddon simplified and summarized Speck's studies for the Swan Coastal Plain, including the communities on the alluvial deposits downslope from the Darling Fault.

Further detailed quantitative studies of the relationships of vegetation to the environment were carried out on the northern Darling Plateau by Havel (1975a, 1975b). The vegetation was found to approximate a continuum, with species occurring in different ranges of environmental conditions. Havel identified a series of indicator species in his subdivision of the continuum into 21 site-vegetation types.

All these approaches had common basic objectives, namely to detect patterns in vegetation at different scales and to establish correlations between communities or individual plant species and the underlying environmental conditions. At a larger scale, several authors have mapped the plant communities on the Darling Scarp and the adjacent areas (Beard, 1979a, 1979b; Heddle, 1979; Heddle et al., 1980). Beard mapped the communities on the Darling Scarp as woodland and open woodland of predominantly Marri (Eucalyptus calophylla) and Wandoo. Beard also referred to the vegetation on the granitic outcrops, the Jarrah forest on the screes descending from the laterite plateau, the Marri-Wandoo woodlands on the younger red soils of the Scarp and slopes excavated by the main watercourses and the River gum or Flooded gum (Eucalyptus rudis) and Paperbarks (Melaleuca spp.) along the watercourses. Beard also noted the occassional Butter gum (Eucalyptus laellae) on the granitic outcrops.

Heddle (1979) and Heddle et al. (1980) identified a similar range of plant communities on the Darling Scarp, namely the woodland and open woodland of Wandoo-Marri on the younger red soils, the open forest of Jarrah-Marri on the laterite gravels on the upper slopes of the Darling Scarp, the heaths and herblands on the granitic outcrops and the low open woodland of Rock Sheoak (Allocasuarina huegeliana - formerly Casuarina huegeliana) on the shallow soils associated with the granitic outcrops. These studies enlarged on the site-vegetation type approach of Havel for the northern Jarrah forest. This permitted the definition of a series of vegetation complexes which related to the underlying landform and soil units as defined by Churchward and McArthur (1980).

Vegetation

Open forest of Jarrah - Marri

This forest occurs on the lateritic gravels of the Darling Scarp. The forest varies in composition as a result of the range of soils and climatic conditions. Tree admixtures include Sheoak (Allocasuarina fraseriana) on the sandier soils and Bull Banksia (Banksia grandis) on the gravelly soils. The north-south trend in climatic conditions is reflected in a reduction of the height and foliage cover in the north. Other tree species of interest include the occurrence of Mountain Marri (Eucalyptus haematoxylon) south of Serpentine. This species reaches its maximum development in the Whicher Range to the south. The restricted Eucalyptus lane-poolei extends onto the Scarp from adjacent populations on the Ridge Hill Shelf. This species also occurs to the north near Jurien Bay. Heddle et al. (1980) noted the presence of site-vegetation types R and G as defined by Havel (1975a, 1975b) in the Darling Scarp vegetation complex. Common understory species include Persoonia longifolia, Macrozamia riedlei, Adenanthos barbigerus, Leucopogon capitellatus, L. propinquus, Hakea lissocarpha and Dryandra sessilis.

Woodland and Open Woodland of Wandoo - Marri

This woodland occurs on the younger red soils and the deeper soils of the Darling Scarp. The height and foliage cover varies from south to north. In the north this community dominates the landscape due to the lower proportion of outcrops and higher proportion of clay soils. Wandoo occurs predominantly in the lower rainfall areas to the north and east of the Jarrah forest on the Darling Plateau (Heddle et al., 1980). Its presence on the Scarp in higher rainfall areas appears to reflect the summer arid conditions on the exposed soils. The restricted tree species, Butter gum (Eucalyptus laellae), occurs in pockets within this community near Serpentine. Other outliers of this species include the stands on Mt. Cooke further inland on the Darling Plateau. The distinctive Christmas tree (Nuytsia floribunda) occurs as an admixture with Marri and Wandoo on the Scarp. Understory species include Hakea lissocarpha, Macrozamia riedlei, Blackboys (Xanthorrhoea preissii) and a range of Hibbertia species. The heath elements from nearby shallow soils may also appear in the understory. Species from the heath include Dryandra armata, Hakea trifurcata, H. undulata and Hypocalymma angustifolium.

Low open woodland and Rock Sheoak (Allocasuarina huegeliana)

This woodland occurs on the erosional soils adjacent to or over the granitic outcrops. Rock Sheoak is mainly restricted to the granitic outcrops in the Wheatbelt. This community occurs in close proximity to the heaths and

herblands on the granitic surfaces and consequently similar understory species are recorded. These include Phyllanthus calycinus, mosses (Bryum spp.), lichens (Parmelia spp.), ferns (commonly - Cheilanthes tenuifolia) and a range of sundews (Drosera menziesii, D. erythrorhiza and D. macrantha).

Heath

A range of closed and open heaths occur on the granitic outcrops. These are particularly diverse in species composition. Distinctive species include Cryptandra arbutiflora, Grevillea endlicheriana, G. pilulifera, G. bipinnatifida, Petrophile biloba, Hakea trifurcata, H. incrassata, H. undulata, Allocasuarina humilis, Oxylobium cuneatum, Melaleuca scabra, Hibbertia commutata (previously known as H.montana), Stylidium adnatum and Dryandra armata. The dominance of the respective species varies in different locations. This variation may relate to changes in soil, rock, climatic conditions or fire regimes. Despite its proximity to Perth, detailed studies have been lacking on the Scarp. Possibly this may alter in the near future.

Herblands

The herblands occur on the granitic outcrops, particularly where the soil layer is absent or restricted. Species include the mats of Borya sphaerocephala, the fern (Cheilanthes tenuifolia), the lichens (species of Parmelia and Siphula), the mosses (Bryum billardieri and Campylopus bicolor) and a range of herbaceous species.

Other plant communities include the stands of Banksia littoralis and the paperbark Melaleuca preissiana on moister localities along the Scarp and the woodlands of Marri and Wandoo associated with the alluvial soils formed on the erosional surfaces near the main watercourses. The early settlers recognized the agricultural potential of these communities. Consequently, few understory species remain, exceptions include the Blackboys and several species of Hibbertia. Beard (1979a) reviewed the early settlers accounts of the Upper Swan area. It appears that these woodlands, even in the early days had a largely herbaceous understory. The latter could relate to the burning practices of the aboriginals during hunting.

The main watercourses are fringed by a woodland of Flooded gum (Eucalyptus rudis) and species of Melaleuca (M. rhaphiophylla and M. preissiana). Casuarina obesa may also occur in pockets of brackish swampy areas.

Flora

Southern species on the Darling Scarp

The increased rainfall caused by the orographic effect of the Darling Scarp would be expected to provide suitably moist habitats enabling species to extend their range northwards from wetter parts of the Darling Plateau.

Valleys such as Neerigen Brook which have almost permanent streams support viable, expanding populations of the introduced tree fern Cyathea cooperi. This indicates that certain areas of the Scarp could support northern extensions or outliers of moisture-loving species. This does not appear to be the case.

Only a few records exist of southern species which have range extensions or outliers on the Darling Scarp near Perth, namely:

Adiantum aethiopicum
Aotus cordifolia
Boronia molloyae
Podocarpus drouyniana
Xyris sp.

The reason for the paucity of southern species on the Darling Scarp near Perth may be due to the existence of arid periods in the past geological history. In addition, the early clearing of the moister lower valley slopes along the Scarp may have eliminated many of the populations. This clearing occurred as early as 1840, well before the flora was documented.

Northern Species on the Darling Scarp

The highest parts of the Darling Scarp east of Perth support a number of plant species which have a relatively geographically limited distribution. At least seven species occur near Perth and extend northward to the Moore River - Mogumber area at the northern end of the Darling Fault.

Two of these species are very common, prominent species which form extensive populations on the shallow granitic soils. Grevillea endlicheriana ranges from small populations near Mogumber to near the Serpentine River. Petrophile biloba occurs from the same northern part of the Darling Fault to the Canning River. Other species with similar distribution include:

Conospermum huegelii
Darwinia rhadinophylla
Hakea myrtoides
Hibbertia lasiopus
Microcorys longifolia

Eastern species on the Darling Scarp

At least eight species occur on the Darling Scarp and extend as far as Wooroloo (and in one case York) and from suburban Perth to Dwellingup. These are:

Anthocercis gracilis	Mundaring - Bickley
Conostylis setosa	Bindoon - Dwellingup
Diplolaena andrewsii	Swan View - Wooroloo
Eucalyptus laeliae	Helena Valley-Harvey and inland to Mt. Cooke

Gastrolobium epacridoides	Millendon - Mundaring
Hakea crassinervia	Bickley - York
Hakea cristata	Millendon - Mundaring
Haloragis tenuifolia	Midland - Wooroloo
Lasiopetalum bracteatum	Mundaring-Dwellingup

Darling Scarp endemics

Available records show that at least ten plant species are restricted to the Darling Scarp (i.e. west of Darlington - Kalamunda - Bickley) between the Avon and Serpentine Rivers. These species each occur on particular soil types ranging from valley floors to laterite uplands. They mostly occur as small disjunct populations. In most cases it appears that the present-day disjunctions have been caused by development. Species restricted to the Darling Scarp are:

Acacia anomala	Chittering - Bickley
Acacia horridula	Helena Valley - Serpentine
Astroloma foliosum	Bickley - Gosnells
Boronia tenuis	Helena Valley - Gosnells
Darwinia pimelioides	Millendon - Swan View
Darwinia sp. nov.	Kalamunda
Halgania corymbosa	Millendon - Gosnells
Stylidium rigidifolium	Helena Valley - Bickley
Synaphea acutiloba	Helena Valley - Kenwick
Synaphea pinnata	Millendon - Gosnells

The effects of European settlement on the status of vegetation are presented in tabular form for the reasons of brevity (Table 1).

There has been little attempt to assess the nature and extent of the effects of European settlement on the natural resources of the Darling Scarp. Historically the impact of settlement has been present from the early days of the colony. Sections of the vegetation were cleared before botanists were able to thoroughly collect the flora. This early clearing activity is particularly evident in the Upper Swan valley. The early settlers avoided the less favourable sites for agriculture; namely the rock outcrops, the shallow soils and the steeper slopes. In fact, the very nature of these areas enabled their reservation in recent decades. However, this reservation does not protect the vegetation from other direct or indirect influences. For example, the establishment of a road or power-line through a flora reserve increases the likelihood of the introduction of herbaceous and weed species. At the present time there is insufficient information on the biology of individual plant species for the Darling Scarp to predict the influence of different managment options, e.g. the effect of different intensities and frequencies of fires.

Summary

The status of the native vegetation on the Darling Scarp varies significantly. In many instances only remnants of the plant communities exist today. In view of the increasing pressures being placed on the natural resources of the region, it is essential that the flora and vegetation be investigated at the earliest opportunity. This would enable an improvement in management of the remaining areas of native vegetation.

Changes in the native vegetation is not a new phenomena, however, the rate at which the changes are occurring is dramatic. This trend appears to be Australia wide (Adamson and Fox, 1980). Therefore, every effort should be made in future planning and management schemes to minimize both direct and indirect impacts on this unique and characteristic flora. Only then will it be possible for the local population of Western Australia to proudly use the term - THE WILDFLOWER STATE.

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Table 1. Effects of European settlement on the status of vegetation.

Consequences of European Settlement	Effects and Comments
Displacement of Aborigines	Change in fire regime.
Cultivation and Grazing	Vegetation cleared by ringbarking, felling, bulldozing and burning. Isolated shade trees become senescent. Establishment of crop and pasture species, so replacing native understory. Application of fertilizers, herbicides and insecticides affect the biota. Vegetation on moister and more fertile sites eliminated by agricultural practices. Fire regime of adjacent vegetation altered due to burning-off practices. Altered balance between birds and insects - affect remaining eucalypts (one type of dieback, Old et al., 1981).
Hydrological Changes	Side effects of dams upstream, leading to less seasonal flow. Altered water courses, alteration of water quality - siltation and salinity levels. Clearing upslope from communities - leading to different moisture conditions.
Forestry	Selective logging, elimination of older trees used by animals for breeding sites. Changed fire regimes.
Plant Introductions	An unknown number of plants have been introduced and many species have become naturalized. Overall, 25% of the flora of the Perth region are naturalized aliens (Marchant and Perry, 1981). Introductions include aquatic species, fungal species, garden plants and agricultural species. Management difficulties associated with eradication and control of introduced species.
Animal Introductions	Introduced as draught animals (horse, donkey), for hunting (rabbit, fox), as pets (dogs, cats), accidentally (mouse, rat) or as food (pigs, goats). A large number of these animals have become naturalized. Others include the introduction of bird species (e.g. the Kookaburra) that have displaced the native species. All to varying degrees either directly or indirectly affect the local fauna and flora.
Residential and Industrial	Urban development removes vegetation, seals soil surfaces, alters drainage patterns and interrupts continuity of plant communities. The resulting islands of native vegetation are subject to boundary problems, e.g. fertilizer drift, alteration of fire regimes and introduction of plant species (particulary herbaceous species). Communication needs also interrupt communities, power lines, roads and railways.
Mining	Clearing activities, provision of additional communication needs, disposal of waste material and creation of new landscapes. Post-mining revegetation is now recognized, although it often involves a change in structure and floristics.
Recreational Activities	Direct and indirect effects associated with active and passive recreation. Removes or damages native vegetation, assists in introduction of plants and animals.

THE IMPORTANCE OF THE DARLING SCARP TO FAUNA

J. Dell

Introduction

In the Sir William Macleay Memorial Lecture, Frankel (1970) summed up the need not only for the survival but the continuing evolution of organisms. For conservation of natural communities he concluded that wild species can only be preserved in the context of communities within their natural environments; and in Australia the distribution and abundance of native species are contracting at an increasing rate. He concluded that short-term expediency must be replaced by long-term planning and our sights should be set for centuries rather than decades or generations.

It is timely, therefore, in an assessment of land use and conflict on the Darling Scarp to review our knowledge of fauna of the area and to consider its conservation. The Darling Scarp has not attracted any comprehensive faunal studies despite various perturbations by man's activities and its proximity to the major population centre of Western Australia. This is surprising, considering the great diversity of habitats present in the Scarp and the fact that many of them are not duplicated elsewhere, either on the Coastal Plain to the west or in the Jarrah woodlands further east.

The Perth metropolitan area's requirement for fresh water has resulted in the gradual damming of most rivers and major streams flowing through the Darling Range. Even though this would have resulted in major changes to the aquatic fauna, no limnological survey has been made. This lack of interest prevails despite early zoological interest in freshwater crustaceans in the area by Nicholls (1923) with the description of a new genus, and later comments by Butler (1952) and Glauert (1953) on this same rare isopod.

Many vertebrate species (especially birds and mammals) on the Coastal Plain have declined as natural vegetation was removed for housing development: some have become locally extinct and the future of others seems precarious. Knowledge of the fact that most of these species occur also in the Darling Scarp has hardly been considered in land use planning. There have been marked changes in the distribution and abundance of animals as the more fertile pockets of soil along valley slopes have been cleared for orchards and for pasture for domestic stock, and as urbanization has steadily encroached throughout the area.

In this review, I assess our knowledge of the fauna - both vertebrate and invertebrate - of the Darling Scarp and highlight the need for a coordinated survey before future land use considerations are undertaken.

Invertebrates

Recent studies have been undertaken on the Coastal Plain and in the Jarrah forest on the seasonal activity of invertebrates (Majer and Koch, 1982) and the effect that burning has on terrestrial invertebrates (Koch and Majer,1980). However, none of this work has been carried out in the Darling Scarp. Their data indicated that different sequences of events operated in different localities. As a consequence we cannot make any assumptions about the effects of fire on terrestrial invertebrates in the Darling Scarp.

Nicholls (1923) indicated the presence of a new genus of isopod crustacean at Lesmurdie Falls and later Nicholls (1933) discussed the relation-ships of the Western Australian fauna and considered that the south-west was sufficiently distinctive to be regareded as a separate faunal region from eastern Australia.

Recently, in describing a new species of tiny gastropod from Wungong Brook, Bunn and Stoddart (1983) reviewed the biogeographic affinities of the south-west and concluded that the distinctiveness of the local fauna largely results from isolation from tropical elements, the effect on evolution of the episodic nature of the freshwater, and the absence of some habitat types.

In a report to the Department of Conservation and Environment, Edward and Bunn (1983) reviewed studies being undertaken on invertebrate fauna of streams in the Darling Range. They highlighted the fact that some elements of the fauna were unnamed, some were rare, ancient and relictual and have great biogeographical significance. There was an urgent need for their conservation. Hill et al. (1983), in a recent study of two Bothriembryon species, note that one species is restricted to King's Park and the Darling Scarp and that both species are endangered by the spread of the metropolitan area. Kendrick (pers. comm.) notes that in the Darling Range-Swan Coastal Plain area, the Scarp environment is the major one for land snails. There are five families of land snails in the South West. All, except one, are widely distributed and the Scarp and extensions inland via river valleys are a major centre for them.

Several freshwater studies are currently being undertaken by the University of Western Australia, which include research on specific freshwater groups such as crayfish Cherax, the non-biting midges (chironomids), freshwater isopod and amphipod crusaceans, the stoneflies (Hynes and Bunn, 1983), and the blackfly fauna (stimulids), as well as the general invertebrate freshwater communities. All these studies are revealing unknown species and are highlighting the importance of freshwater environments of the Darling Scarp.

Scarp Symposium (Ed. J.D. Majer). Perth, 14th October, 1983. (W.A.I.T.: Bentley).

Vertebrates

There are few published data on the vertebrate fauna of the Darling Scarp. Some bird information was included by Serventy (1947), and incidental notes appeared in Main (1954) and in short notes by various authors in the Western Australian Naturalist. Serventy (1968) provided a list of birds seen on one day in an area just west of the Scarp. Elsewhere in the Darling Range considerable information has been compiled as part of the environmental assessment of bauxite mining. Most of this data refers to Jarrah forest and woodlands and is not particularly relevant to the Wandoo woodlands of the Scarp itself. Like the birds, there has been no systematic survey of the reptile, mammal or fish fauna of the Scarp.

Reptiles and Frogs

The herpetofauna of the Darling Scarp is inadequately documented. Currently fifty-one species, comprising 10 frogs, 1 tortoise, 7 geckos, 6 legless lizards, 2 dragons, 11 skinks, 3 monitors, 3 blind snakes, 2 pythons and 6 elapid snakes, are known to occur. These are listed in Appendix 1 along with a brief consideration of their status and habitat. This list is compiled from data from specimen registers in the W.A. Museum and from my observations in the area.

Most of the 10 frog species are present primarily in the pools and seasonally moist clay margins of ephemeral and permanent streams. Some require water in winter for breeding, while others such as the tree frogs (Litoria) require water for most of the year. The two burrowing frogs (Heleioporus) have been adversely affected by clearing and drainage of damp low-lying clay areas. Crinia georgiana disperses widely from shallow ephemeral water where it breeds and may frequently be found aestivating far from water.

Reducing the volume and permanency of water by damming the major streams has greatly reduced the population level of the Long-necked Tortoise. This tortoise was once readily seen but is now rarely recorded.

One species of gecko, Gehyra variegata, and the dragon Ctenophorus ornatus, are restricted to surface granites and live under exfoliated slabs. Both these species have declined and some populations have been exterminated on granite outcrops by removal of surface rocks for garden decoration. Five other gecko species live predominantly under rocks and logs and are undergoing a similar, but less marked, decline. The two pythons are now extremely rare in the Darling Scarp and are perhaps locally extinct.

Birds

Alexander (1921), when documenting the birds of the Swan River District, restricted himself to that area west of the Darling Scarp. The paucity of published information on the Darling Scarp was alleviated somewhat by Serventy (1947) who greatly expaned the scope of Alexander's area to include part of the Darling Ranges. However, little specific reference was made of the Scarp itself.

Neighbouring areas have attracted considerable documentation. Sedgwick (1955, 1956) provided an assessment of status and habitat of birds of the Jarrah forest at Wooroloo; Job (1969) outlined the avifauna of Wandoo woodland on the eastern side of the forest block; and Storr et al. (1978) presented much original data and reviewed literature on birds on the northern Swan Coastal Plain.

There are a few brief notes on birds in the Darling Scarp chiefly as incidental notes in the Western Australian Naturalist. the only detailed information are single species studies by Immelmann (1960) on the biology of the Red-eared Firetail in the Wungong gorge and Rowley (1981) on the Splendid Fairy-wren in the Helena Valley-Gooseberry Hill area.

Appendix 2 lists 100 species (51 nonpasserines and 49 passerines) occurring in the Darling Scarp. This list was compiled chiefly from my casual observations in the area as well as taking note of published information. A few other species have been recorded in or close to the area; these are omitted because they are mainly vagrants or occasional sightings (especially of uncommon raptores) which have little relevance to the Darling Scarp.

Current knowledge precludes detailed assessment of status and abundance. Where a species is present throughout the year it is indicated as resident irrespective of whether the same individuals are present all the time. Migratory species, or those that are known to be absent for part of the year, are listed as non-resident. Some species such as the Black-throated Grebe may abandon areas that become seasonally unfavourable but remain in more favourable areas. Individuals of some less common species such as the Little Eagle probably roam widely in the Scarp and adjacent areas.

Appendix 2 indicates the major vegetation types in which a species is likely to be encountered. Being highly mobile, individuals of most species are likely to be recorded occasionally in most vegetation types. Surface water, and its vegetated or unvegetated margins, is the major habitat of 13 species of non-pesserines. The 10 species of hawks and falcons are most likely to be encountered flying over a range of habitats; it is difficult to ascribe any relationships between these species and particular vegetation types.

In general, the passerines are less mobile than non-passerines and are adversely affected by fragmentation of natural vegetation. Of particular importance are habitat requirements of the While-breasted Robin, Yellow Robin, Golden Whistler, Grey Shrike-thrush, Western Thornbill, White-browed Scrub-wren, Splendid and

Red-winged Fairy-wrens, Southern Emu-wren, Rufous Tree-creeper, Tawny-crowned Honeyeater, Little Wattlebird, Red-eared Firetail and Grey Currawong. Most of these species have declined dramatically and some now no longer occur on the Coastal Plain and populations are declining in the Darling Scarp.

The White-breasted Robin previously occupied gullies north to the Helena River but no longer occurs in the northern parts of the Scarp. Although still present in gullies at Armadale and along the Wungong, its continued survival here depends on maintenance of riparian vegetation and associated woodland margins. The Red-winged Fairy-wren is undergoing a similar decline but still occurs in suitable habitat north of Armadale.

Populations of the rare and endangered Red-eared Firetail have declined considerably since the study by Immelmann (1960). Its survival also depends on adequate areas of riparian vegetation and maintenance of the different species of sedge (Lepidosperma) upon which the bird feeds.

European settlement in the Darling Scarp has affected all species of birds. A few such as Richard's Pipit, Magpie-lark, Magpie and Australian Raven have benefited from orchard cultivation, clearing for pasture and additional food associated with parks and domestic gardens. However, the great majority of species have been affected by clearing of riparian vegetation and the too-frequent burning of both creekside thickets and the understorey heath of the Wandoo woodland. Unless adequate areas are retained for conservation, and properly managed to exclude fire from the stream edges, the long-term survival of habitat specific species is doubtful.

A factor often overlooked when considering conservation of birds is the effect of habitat fragmentation. Saunders (1977) disputes the common belief that, provided areas are reserved for nesting sites and there is sufficient food around the breeding area, mobile species like birds will find the food and exploit it efficiently. Discontinuous verges along roads and isolated patches of vegetation are not adequate as sources of food. Birds need to be led from one source of food to another by belts of favourable habitat. They cannot afford to spend time searching through unfavourable habitats.

An aspect of bird movement not generally understood is the effect of large urban areas on seasonal movement and migration especially by small passerines. Much of the population of Grey Fantail, Western Warbler, and Spotted and Striated Pardalotes move northwards in winter from the high rainfall areas of the south-west. We need to determine what happens to many individuals of these species when they reach the Perth metropolitan area, and whether a barrier has been created by the spread of urban areas from the coast to the Scarp edge. We also need to ascertain the importance of the Scarp itself in facilitating movement by these species.

Some species of birds are seasonal in the Darling Scarp. The White-winged Triller is sometimes a common breeding species in the Wandoo woodlands of the Scarp. Honeyeaters are known to undertake seasonal movements searching for areas of suitable flowering plants. The importance of the Scarp in providing food at certain seasons for these species and the importance of the area in facilitating movement in those species which are not found in the Jarrah forest needs to be studied.

Mammals

Twenty-three species of native mammal are known from the Darling Scarp. These are listed in Appendix 3 with a brief synopsis of their status and habitat. This list is compiled chiefly from Kitchener and Vicker (1981), augmented by my observations and a review of the literature.

Several mammal species have declined not only in the Darling Scarp but throughout the south-west. The Western Quoll is now on the list of gazetted rare fauna; the Brush-tailed Phascogale, Numbat, Quenda, Brush-tail possum, Tammar Wallaby and Quokka have all declined over much of their range. The Tammar Wallaby no longer occurs in the Darling Scarp, the Quokka has disappeared from the northern sections (see White, 1952) and the Numbat is close to extinction. The supposed increase in some native mammals in the early 1950's (Serventy, 1954) has not been sustained and was more likely a presumption of greater awareness and better transport of observers.

The Yellow-footed Antechinus, Quenda and Quokka are predominantly inhabitants of dense riparian vegetation. More information is needed on habitat requirements before a fire-management strategy can be devised to favour these species Dell (1971) has drawn attention to the need for litter for nest construction and the effects of fire on the Quenda.

The effect of burning the heath understorey on the two small possums, the Western Pygmy-possum and the Honey Possum needs to be ascertained.

Fish

There have been no surveys of the current status and distribution of freshwater fishes in the streams of the Darling Scarp. Chubb et al. (1979) list only 4 indigenous species in the Swan-Avon system viz. Galaxias occidentalis, Tandanus bostocki, Bostodia porosa and Edella vittata. They list at least six species of introduced fishes in the same river system. Attention is drawn by Chubb et al. (1979) to the effects of damming, the consequent drying-up of long stretches of stream, eutrophication and run-off from agricultural land.

The importance of crustaceans and freshwater insects in the diet of freshwater fishes can be judged from an analysis of diet by Sarti and Allen (1978). Studies need to be undertaken into the ecology of freshwater fishes before management plans can be devised for their conservation. This urgent need mirrors the situation of the freshwater invertebrate fauna.

Consideration should also be given to changes to water quality and of reduced volume of water flowing from the Scarp to the Coastal Plain. These will affect populations of freshwater fish in the Coastal Plain adjacent to the Scarp. Sarti and Allen (1978) have reviewed the freshwater fish fauna of the northern part of the Swan Coastal Plain and highlighted the importance of Ellen Brook and its tributaries. Compared to the Darling Scarp, this stream system has a comparatively rich native fish fauna with seven species.

Conclusions

This review highlights the paucity of information on the fauna of the Darling Scarp and indicates the need for comprehensive biological surveys as a precursor to conservation and management strategies. All groups of fauna warrant study in the Darling Scarp. Fauna associated with freshwater habitats such as the seasonal cascading streams, the deeper pools and ephemeral seepages emanating from granite outcrops need urgent study. Much of his fauna is unknown and many recent studies are discovering undescribed species.

Changes in the fauna of the Darling Scarp as a consequence of activities of man have led to the local extinction of a number of species of mammals and greatly reduced the populations of several birds and reptiles. We must recognize the importance of natural habitat and understand the biology of animals before conservation strategies are decided. An integrated system of conservation areas linked by corridors of appropriate vegetation as recommended by Willis (1974) must be planned if we are to maintain the assemblage of native fauna in the Darling Scarp. We must ensure that fragmentation of the vegetation and isolation of animals in areas too small to avoid natural attrition does not occur as has happened in the wheatbelt (Kitchener et al., 1982) where many conservation areas are too small to support some of the habitat specific fauna.

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Appendix 1. List of amphibians and reptiles occurring in the Darling Scarp. Abundance is shown in ascending order of uncommon (U), moderately common (MC), or common (C). A species occurring on or below the ground is indicated as terrestrial (T) and on trees or elevated rocks as arboreal (A). Presence in the four broad vegetation types is indicated. Some frogs are highly vagile and disperse from breeding areas.

	Status	Woodland	Granites	Heath	Riparian
LEPTODACTYLIDAE					
Crinia georgiana	C,T	Transient Aestivating	Resident	Transient Aestivating	Resident
Geocrinia leai	MC,T				Resident
Heleioporus barycragus	U,T				Resident
H. inornatus	C,T	Transient			Resident
Limnodynastes dorsalis	MC,T	Transient	Transient	Transient	Resident
Pseudophryne guentheri	U,T		Resident		Resident
Ranidella glauerti	C,T				Resident
R. pseudinsignifera	C,T				Resident
HYLIDAE					
Litoria adelaidensis	C,TA	Transient			Resident
L. moorei	MC,T		Transient		Resident
CHELONIDAE					
Chelodina oblonga	UC,T				Resident
GEKKONIDAE					
Crenadactylus ocellatus	UC,T	X	X		
Diplodactylus granariensis	UC,T	X			
D. polyophthalmus	C,T	X	X		
D. pulcher	UC,T	not known			
D. spinigerus	C,A	X		X	
Gehyra variegata	C,T		X		
Phyllodactylus marmoratus	C,A	X			
Phyllurus milii	C,T	X	X	X	
PYGOPODIDAE					
Aprasia pulchella	MC,T		X		
A. repens	MC,T	X	X		
Delma fraseri	U,T	not known			
D. grayii	U,T	not known			
Lialis burtonis	MC,T	X		X	X
Pygopus lepidopodus	U,T				X
AGAMIDAE					
Ctenophorus ornatus	C,T		X		
Pogona minor	C,TA	X	X	X	X
SCINCIDAE					
Cryptoblepharus plagiocephalus	C,A	X	X		
Ctenotus fallens	U,T		X		
C. labillardieri	C,T	X	X	X	X
Egernia napoleonis	C,TA	X	X	X	X
E. kingii	U,T				X
Hemiergis initialis	C,T	X	X	X	X
Leiolopisma trilineatum	MC,T				X
Lerista distinguenda	C,T	X	X	X	X
Menetia greyi	C,T	X	X	X	X
Morethia obscura	C,T	X	X	X	X
Tiliqua rugosa	C,T	X	X	X	X
VARANIDAE					
Varanus gouldii	U,T	X	X	X	
V. rosenbergi	U,T	X	X	X	
V. tristis	U,TA	X	X		
TYPHLOPIDAE					
Ramphotyphlops australis	C,T	X		X	X
R. pinguis	?,T	not known			
R. waitii	?,T	not known			

Appendix 1 cont.

	Status	Woodland	Granites	Heath	Riparian
BOIDAE					
Liasis childreni	U,T		X		
Python spilotus	U,TA				X
ELAPIDAE					
Acanthophis antarcticus	U,T		X		
Notechis scutatus	MC,T				X
Pseudonaja affinis	C,T	X	X	X	X
Rhinoplocephalus gouldii	C,T	X	X	X	X
R. nigriceps	U,T	X	X	X	X
Vermicella semifasciata	U,T		not known		

Appendix 2. List of birds occurring in the Darling Scarp. Status refers to whether the species is present throughout the year (R=resident, N=non-resident); abundance refers to estimated daily counts (1=<5, 2=<20, 3=<50, 4=>50); primary feeding category codes are I=invertebrate feeders, C-carnivore, O=ominivore, G=granivore, N=nectarivore, V=vegetation; breeding indicates the species is known to breed in the area; strata groupings indicate where the species most frequently occurs.

	Status	Abundance	Primary Feeding Category	Breeding	Eucalypt Canopy	Branches Trunks	Understorey	Heath	Riparian	Surface water & margins	Open areas	Aerial	Ground
PODICIPEDIDAE													
Black-throated Grebe	RN	1	X							X			
Hoary-headed Grebe	N	1	I							X			
PHALACROCORACIDAE													
Little Black Cormorant	U	1	C							X			
Little Pied Cormorant	U	1	I							X			
ARDEIDAE													
Pacific Heron	N	1	I/C							X	X		
White-faced Heron	N	1	I/C							X	X		
ANATIDAE													
Black Duck	U	2	V	X						X			
Grey Teal	N	1	V							X			
Wood Duck	N	2	V	X						X	X		X
Musk Duck	U	1	I							X			
ACCIPITRIDAE													
Black-shouldered Kite	N	1	C					X			X	X	
Square-tailed Kite	N	1	C		X							X	
Brown Goshawk	U	1	C	X	X	X						X	
Collared Sparrowhawk	U	1	C	X	X	X						X	
Little Eagle	R	1	C	X								X	
Wedge-tailed Eagle	U	1	C									X	
FALCONIDAE													
Peregrine Falcon	N	1	C									X	
Australian Hobby	N	1	C									X	
Brown Falcon	U	1	C/I					X			X	X	
Australian Kestrel	U	1	C/I					X			X	X	
TURNICIDAE													
Painted Button-quail	R	1	O	X									X
RALLIDAE													
Banded Land Rail	U	1	I						X				
Spotless Crake	R	1	I	X					X				
Dusky Moorhen	U	1	V							X			
Coot	U	1	V							X			
CHARADRIIDAE													
Banded Plover	U	1	I								X		
Black-fronted Plover	U	1	I							X			
COLUMBIDAE													
Spotted Dove	R	2	G	X							X		
Laughing Dove	R	2	G	X							X		
Common Bronzewing	R	2	G	X			X	X	X		X		X
PSITTACIDAE													
Purple-crowned Lorikeet	N	2	N		X								
Ring-necked Parrot	R	3	G	X	X	X	X	X	X		X		X
Red-capped Parrot	R	3	G	X	X	X	X	X	X				
Western Rosella	R	3	G	X	X	X	X	X	X				
Elegant Parrot	N	2	G	X		X		X			X		
Baudin's Cockatoo	N	1	G		X			X					
Carnaby'Cockatoo	N	1	G		X								
Red-tailed Black Cockatoo	U	1	G		X								
Galah	U	1	G			X		X			X		
CUCULIDAE													
Pallid Cuckoo	N	1	I			X	X	X			X		
Fan-tailed Cuckoo	N	2	I	X		X	X	X	X				
Horsfield's Bronze Cuckoo	N	1	I					X					
Shining Bronze Cuckoo	N	2	I	X		X	X	X	X				

	Status	Abundance	Primary Feeding Category	Breeding	Eucalypt Canopy	Branches Trunks	Understorey	Heath	Riparian	Surface water & margins	Open areas	Aerial	Ground
STRIGIDAE													
Barn Owl	U	1	C			X					X		
Boobook Owl	U	1	I/C		X	X	X						
PODARGIDAE													
Tawny Frogmouth	R	1	I			X	X						
AEGOTHELIDAE													
Australian Owlet-nightjar	R	1	I			X							
ALCEDINIDAE													
Laughing Kookaburra	R	2	I/C	X		X	X		X		X		
Red-backed Kingfisher	N	1	I								X		
Sacred Kingfisher	N	1	I	X		X					X	X	
MEROPIDAE													
Rainbow Bee-eater	N	2	I	X		X		X				X	X
HIRUNDINIDAE													
Welcome Swallow	U	3	I			X		X		X	X	X	
Tree Martin	N	4	I	X		X		X		X	X	X	
MOTACILLIDAE													
Richard's Pipit	U	2	I					X			X		
CAMPEPHAGIDAE													
Black-faced Cuckoo-shrike	N	2	I	X	X	X	X						
White-winged Triller	N	2	I	X		X		X					
PACHYCEPHALIDAE													
Jacky Winter	U	1	I			X	X						
Scarlet Robin	R	2	I	X	X	X	X	X	X				
White-breasted Robin	R	1	I	X			X		X				
Yellow Robin	R	1	I	X		X	X						
Golden Whistler	R	2	I	X	X	X	X		X				
Rufous Whistler	U	2	I	X	X	X							
Grey Shrike-thrush	R	2	I	X	X	X	X		X				
MONARCHIDAE													
Grey Fantail	RN	3	I	X	X	X	X	X	X			X	
Willie Wagtail	U	2	I	X			X	X	X		X	X	
Restless Flycatcher	N	1	I			X						X	
ACANTHIZIDAE													
Western Flyeater	U	3	I	X	X	X	X		X				
Weebill	R	4	I	X	X		X						
Broad-tailed Thornbill	R	3	I	X	X	X	X	X	X				
Western Thornbill	R	4	I	X		X	X	X	X				
Yellow-rumped Thornbill	R	3	I	X			X	X			X		
White-browed Scrub-wren	R	3	I	X			X	X	X				
MALURIDAE													
Splendid Fairy-wren	R	3	I	X			X	X	X				
Red-winged Fairy-wren	R	1	I	X			x		X				
Southern Emu-wren	R	1	I					X					
SYLVIIDAE													
Clamorous Reed Warbler	U	1	I							X			
DAPHOENOSITTIDAE													
Australian Sittella	R	1	I			X							
CLIMACTERIDAE													
Rufous Tree-creeper	R	1	I	X		X							
DICAEIDAE													
Mistletoebird	N	1	I		X								
PARDALOTIDAE													
Spotted Pardalote	N	2	I	X	X	X	X		X				
Striated Pardalote	N	3	I	X	X	X							
ZOSTEROPIDAE													
Grey-breasted White-eye	RN	4	I	X	X	X	X	X	X				
MELIPHAGIDAE													
Brown Honeyeater	N	4	N/I	X	X	X	X	X	X				
Singing Honeyeater	R	2	N/I	X				X					

	Status	Abundance	Primary Feeding Category	Breeding	Eucalypt Canopy	Branches Trunks	Understorey	Heath	Riparian	Surface water & margins	Open areas	Aerial	Ground
White-naped Honeyeater	R	2	I/N	X	X	X	X		X				
New Holland Honeyeater	R	4	N/I	X	X	X	X	X	X				
White-cheeked Honeyeater	N	1	N/I				X	X					
Tawny-crowned Honeyeater	R	4	N	X				X					
Western Spinebill	R	4	N	X	X	X	X	X	X				
Little Wattlebird	R	2	I/N	X	X	X	X		X				
Red Wattlebird	N	2	I/N		X	X	X						
White-fronted Chat	N	2	I	X				X					
PLOCEIDAE													
Red-eared Firetail	R	1	G	X					X				
GRALLINIDAE													
Magpie-lark	U	1	I	X		X				X	X		X
ARTAMIDAE													
Black-faced Woodswallow	U	2	I					X			X	X	
Dusky Woodswallow	N	2	I		X	X						X	
CRACTICIDAE													
Grey Butcherbird	R	1	C	X		X	X						
Australian Magpie	R	3	O	X		X		X			X		X
Grey Currawong	R	1	O			X	X						
CORVIDAE													
Australian Raven	R	3	O	X		X		X			X		X

Appendix 3. List of mammals in Darling Scarp.

TACHYGLOSSIDAE

Tachyglossus aculeatus (Echidna). Uncommon. Wandoo and Jarrah woodland; terrestrial; insectivorous on termites.

DASYURIDAE

Antechinus flavipes (Yellow-footed Antechinus). Uncommon. Riparian thickets; terrestrial, Carnivorous on invertebrates.

Dasyurus geoffroii (Western Quoll). Previously common, now uncommon (on gazetted rare fauna list). Wandoo and Jarrah woodland; terrestrial and arboreal. Carnivorous on vertebrates and invertebrates.

Phascogale tapoatafa (Brush-tailed Phascogale). Previously common, now uncommon. Wandoos and Jarrah woodlands; arboreal, Carnivorous on vertebrates and invertebrates.

Sminthopsis sp. (Dunnart). Uncommon. The *murina* species complex is currently being revised. Possibly two species occur in the Darling Scarp. Terrestrial. Carnivorous on invertebrates.

MYRMECOBIIDAE

Myrmecobius fasciatus (Numbat). Rare or locally extinct. Wandoo woodland. Chiefly terrestrial. Carnivorous on termites.

PERAMELIDAE

Isoodon obesulus (Quenda). Moderately common. Riparian thickets and adjacent parts of Wandoo and Jarrah woodlands; terrestrial. Carnivorous on invertebrates.

PHALANGERIDAE

Trichosurus vulpecula (Brushtail Possum). Uncommon, previously common. Wandoo woodland; arboreal and terrestrial. Omnivorous, chiefly vegetable material.

BURRAMYIDAE

Cercartetus concinnus (Western Pygmy-possum). Moderately common. Wandoo and Jarrah woodlands, mainly in understorey heath; arboreal and terrestrial. Carnivorous on invertebrates, nectarivorous on nectar and pollen.

MACROPODIDAE

Macropus fuliginosus (Western Grey Kangaroo). Moderately common. All types of vegetation; terrestrial. Vegetarian.

M. irma (Western Brush Wallaby). Moderately common. Wandoo and Jarrah woodland; terrestrial. Vegetarian.

M. eugenii (Tammar Wallaby). Previously common, locally extinct since about 1940. Terrestrial. Vegetarian.

Setonix brachyurus (Quokka). Previously common, locally extinct over most of the area except Byford southwards. Riparian thickets, terrestrial. Vegetarian.

TARSIPEDIDAE

Tarsipes rostratus (Honey Possum). Probably moderately common. Heath and understorey of Wandoo woodlands; arboreal on shrub strata. Nectarivorous on nectar and pollen.

MOLOSSIDAE

Tadarida australis (White-striped Mastiff-bat). Moderately common. Wandoo and Jarrah woodland; arboreal and aerial. Carnivorous on flying insects.

Tadarida planiceps (Little Mastiff-bat). Status not known. Recorded in areas marginal to the Darling Scarp.

VESPERTILIONIDAE

Chalinolobus gouldii (Gould's Wattled Bat)
C. morio (Chocolate Wattled Bat)
Eptesicus regulus (King River Eptesicus)
Nyctophilus geoffroyi (Lesser Long-eared Bat)
N. major (Greater Long-eared Bat)
Pipistrellus tasmaniensis (Great Pipistrelle)

} Status of small bats is not known. Most occur in woodland throughout the area.

MURIDAE

Hydromys chrysogaster (Water-rat). Uncommon. Riparian thickets and pools of larger streams; terrestrial and aquatic. Carnivorous on crustaceans, molluscs and insects.

Mus musculus (House Mouse). Common. All habitats; terrestrial. Vegetarian on seeds and plant material.

Rattus rattus (Black Rat). Common. Riparian thickets and adjacent parts of Wandoo and Jarrah woodland; terrestrial and arboreal. Omnivorous.

CHANGES TO THE SCARP LANDSCAPE: IMPLICATIONS FOR MANAGEMENT

W.G. Schmidt

Introduction

Lanscape can be thought of as the visual expression or appearance of an area's physiographic and environmental characteristics. All landscapes vary according to these characteristics which, in turn, are a reflection of dynamic geologic and climatic processes (Laurie, 1975). Many landscapes also reflect varying degrees of human involvement, where man has intervened to shape the land according to his needs.

Every landscape thus possesses a unique combination of natural features which often have been subject to human modification. Such is the case with the Darling Scarp, which marks the western margin of Western Australia's Darling Plateau.

The Scarp landscape is an important geologic feature as it is the surface expression of the Darling Fault, on of the major tectonic features of the earth's crust (Biggs and Wilde, 1980). This fault, which extends some hundreds of kilometres in a north-south direction, separates the sedimentary trough known as the Perth Basin from the igneous and metamorphic shield which forms the Plateau.

As a landscape unit, the 200-300 metre high slopes which characterise the Scarp can hardly be described as spectacular. It is a subdued and ancient landform, having been subjected to millions of years of weathering by rain and wind. While some early explorer's accounts referred to the Darling Scarp and Ranges as 'mountains', they have perhaps more accurately been described as "nothing more than a 1,000 foot step-up to the flat plateau" (Seddon, 1972).

This is not to suggest, however, that the Darling Scarp has little importance or significance as a major landscape feature. To the contrary, the Scarp serves as an attractive bakcdrop to the Perth region and is a visible link with the forested ranges which lie to the east.

For hills residents, the Scarp offers distant views of the cityscape and Indian Ocean beyond. It is, therefore, an important landscape resource, both in the sense of serving as a 'viewing platform' as well as providing a scenic attraction in its own right.

The Darling Scarp is also important visually in that it is the meeting place of the Coastal Plain and Plateau. Thus, it is an edge or transition zone between two very distinctive landforms. Edges such as this are noted for their high biological diversity and generally possess considerable visual variety. The Scarp, with its varied soils, steep slopes, rock outcrops, water features and distinctive flora, is no exception.

The remainder of this paper briefly describes the changes which have and are occurring to this landscape resource and suggest several means by which such changes can be regulated without destroying the scenic appeal of the Scarp.

Changes to the Scarp Landscape

The Scarp landscape has undergone considerable change since the advent of European settlement a little more than 1½ centuries ago. Much of this change has been of a gradual nature until recently and therefore may not be readily apparent to the casual observer. It has only been in the last several decades, with the continued expansion of the Perth Metropolitan Region, that the face of the Scarp has begun to alter appreciably.

Such growth has understandably led to increasing land use activity and pressures along much of the Scarp, particularly the areas within and immediately adjoining the Perth region. These land use pressures and the changes they have brought to the landscape can be briefly summarised as follows:

Agriculture

Initial pressures on the Scarp largely ocurred as the result of small-scale agricultural development. Early settlers were quick to discover the more fertile pockets of alluvial soils near the base of the Scarp where numerous streams dissect the Ranges. Such areas were taken up for farming and partially cleared. In more recent times, small holdings situated in the dissected portions of the landscape near the western edge of the Plateau have been developed. Here the landscape has taken on a more cultured, manicured appearance, with the establishment of various orchard crops.

The agricultureal value of much of the Scarp is severely limited due to the steep topography and shallow soils. Nevertheless, many of the lower and middle slopes along the Scarp to the north and south of Perth have been progressively cleared for pasture development. The advent of aerial applications of fertiliser no doubt hastened this development.

Thus, the major visual impact of farming along the Scarp has been to create a pastoral landscape which is quite attractive. In some instances, rectilinear paddocks have been hacked out of the slopes, but for the most part clearing has been of a parkland type.

Of greater concern are the visual impacts resulting from recent hobby farm development. Increasing numbers of farming properties along the base of the Scarp are being carved up into small farmlets generally of 5-10 hectares in size. The Ridge Hill Shelf between Byford and Pinjarra in particular has come under pressure for this type of development.

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Hence, extensive tracts of what was and in many instances, still is attractive pastoral landscape are undergoing a form of 'rural urbanisation'. Unfortunatley, many of these developments display a disregard or lack of understanding of basic site planning and design principles. The siting of residences and outbuildings, choice of architectural styles and building materials, the consturction of roads, layout of paddocks and the clearing and replanting of trees is seldom done with any noticable sensitivity for the surrounding landscape.

The main impact of such development is a loss of scenic quality, both for the public at large as well as the residents of these developments. Ironically, it is the very people who are attracted by and end up buying into such 'pristine' rural landscapes who are unwittingly contributing to their degradation as a visual resource.

Residential Development

While the Scarp provides a natural boundary to the expansion of the Metropolitan Region, it has nonetheless come under increased pressure for residential development. New suburbs along the southeast corridor are slowly creeping up the face of the Scarp at centres such as Kelmscott and Armadale. There is also a continual infill of housing along established roads on the Scarp while still other developments are beginning to spill over the edge.

The availability of city and ocean views is no doubt one of the major attractions of Scarp real estate. There also appears to be a psychological attraction to living in the'hills'.

The very act of ascending from the coastal plain contributes to a sense of leaving the city behind, an aspect which has been successfully exploited by property developers and real estate agents.

Portions of the Scarp within the Metropolitan Region are therefore taking on an urbanised appearance. It is difficult to generalise about the positive and negative visual impacts of such enroachment. There are some examples of sensitive site planning and architectural design where a conscious attempt has been made to fit in with the Scarp landscape. However, there are many other instances where property developers and home owners have ignored the character of the landscape in which they have built. The end result is a man dominated landscape which is losing much of its inherent scenic appeal.

Development of Roads and Utilities

The growth and survival of the Metropolitan Region is very much dependent on the water and energy (coal) resources of the Darling Range. As the city has expanded, there has been a need to establish a greater number of links between the coastal plain and its 'life support systems' in the Ranges.

These links include major power transmission corridors, water pipelines and a number of regional and local roads, which cross the face of the Scarp at various locations.

The visual impacts of these corridors are variable, depending on the scale and location of associated clearing and the design of structures such as power pylons. For ease of construction, many corridors have been located in major valleys dissecting the Scarp. These areas are, unfortunately, often of the highest scenic and recreational value.

In recent times, greater emphasis has been placed on the aesthetic aspects of developing utility corridors. The State Energy Commission, for example, has engaged consultants to advise on corridor selection and design for the development of additional transmission lines from Muja to Perth (Seddon and Polakowski, 1977). However, increased consideration needs to be given to this aspect of landscape management along the Scarp.

Extractive Industries

The Scarp environment provides a valuable and readily accessibly source of raw materials for construction and road building. A number of quarries, the most noticeably being the Readymix site at Gosnells, are presently being worked.

The visual impacts of such operations are largely localised. The main exception is the Gosnells quarry, a dominant and spreading scar on the landscape which is visible from much of the metropolitan area.

Attempts have and are being made to minimise the visual impact of quarry operations both through on-site planting and the use of land exchanges (that is, the relocation of operations into less visible areas). Other techniques such as the use of spray painting to help camouflage raw rock faces have been employed in similar sites elsewhere (e.g. Adelaide). However, it is not known whether such alternatives are being considered locally.

Industrial Development

The bulk of industrial development in the southwest has, for reasons of access, been located adjacent to the coast. The advent of bauxite mining on the Darling Plateau has, however, led to the construction of 2 large alumina refineries at the base of the Scarp near Pinjarra and at Wagerup.

Both refineries and their ancillary developments are visible from various vantage points near or atop the Scarp. However, they are much less evident from the coastal plain due to the careful selection of sites and an extensive tree planting programme which helps screen the installations from view of the Southwest Highway.

One notable blight on the landscape is the conveyor line servicing the Pinjarra refinery. This has created a linear scar down the face of the Scarp that is visible from as far afield as Mandurah and Peel Inlet some 20 kilometres distant. The siting of the conveyor at Wagerup has, in contrast, been handled much more sensitively.

Recreation

The uplifted Scarp landform, with its series of incised valleys, diverse flora and rock outcrops, is an important scenic and hence recreational resource. Part of its value for recreation lies in the role it plays as a supportive landscape, that is, as an amenity resource to be viewed from adjoining land units.

The most popular recreation attractions occur where the Scarp has been dissected by the major rivers such as the Avon, Serpentine and Murray. Here the combination of views and water provide a picturesque environment.

The obvious scenic value of such areas has been recognised and a series of small 'vest pocket' national parks and recreation reserves have been created. In the main, these reserves contain low key developments to cater for sightseers, picnickers, bush walkers and other day users. Other forms of recreation are restricted due to the steep slopes and shallow, erodable soils. There is evidence of damage from trail and/or trial bikes in some areas, but apart from such localised distrubances, the recreational use and development of the Scarp has resulted in only minor changes to the landscape.

Other, often more subtle changes to the landscape have also occurred along the length of the Scarp. These include the decline and loss of native vegetation due to the effects of dieback and frequent wild fires. Many so-called 'natural areas' have also been invaded by weeds, which have been able to successfully compete with and in some instances, displace native shrub and groundcover species.

With the exception of fire, most of these changes have been gradual and tend to go unnoticed. Nevertheless, they are occurring and have increasingly contributed to the evolution of the Scarp environment from a natural to a man-modified landscape.

It can be concluded then that while the Darling Scarp landscape may appear on superficial inspection to be largely intact, it has under gone considerable changes. It is very much a landscape in transition, one which has and will continue to service a wide range of human activity.

If one accepts the premise that the Scarp is a working landscape which will continue to change over time, the question remains as to how this change can be accommodated without destroying the scenic appeal of the Scarp in the process.

Management of the Scarp as a Visual Resource

The suggestion that a public resource such as the Darling Scarp should be managed for its scenic value presupposes that there is at least some concern and community support for such management. Previous environmental studies and reports (Darling Range Study Group, 1982; Department of Conservation and Environment, 1981; Metropolitan Region Planning Authority, 1977) suggest that such concern does in fact exist. For example, it has been recommended as part of the System 6 Inquiry (Department of Conservation and Environment, 1981) that investigations should be undertaken to identify areas suitable for landscape conservation. Similarly, other recommendations have been put forth calling for tighter planning procedures for activities such as quarrying.

Given that the community would support increased efforts at actively managing the Scarp landscape, there are a number of options available for minimising negative visual changes.

The assessment, identification and reservation of areas of outstanding or high landscape quality, as indicated, represents one such option. But the conservation of landscape values through land reservation is only part of the answer. It is not always possible nor necessarily desirable to lock up large areas of landscape and exclude all use. Rather, an active 'hands on' approach to management is sometimes required, particularly where the forces for change are intense as is the case with much of the Scarp. Among the mechanisms for regulating visual impacts are those which have a legal basis. These include zoning and the establishment of scenic easements.

Zoning

Zoning is a widely employed control whereby the use and development of land is subject to regulation, usually according to some predetermined plan. Such regulations are commonly used to control the type of land use, the density of population and the size and height of structures. Zoning has also been increasingly used to preserve historical areas, protect structures of architectural merit and restrict development on environmentally sensitive areas (Hagman, 1971; Strong, 1983).

The use of zoning ordinances to protect against the degradation of the landscape is not without its problems, however. One of the major shortcomings is that zoning controls often place an inequitable financial burden on those members of the community whose land is subject to restrictions. For example, those owners of farming properties along the base of the Scarp whose land values have escalated due to mounting development pressures may be encouraged to subdivide their land. Obviously any zoning ordinance which would prevent such owners from realising a captial gain from the subdivision and sale of their property would be unpopular.

For this very reason, zoning is continually subject to change. Often local government authorities are placed under considerable pressure by commercial interests to alter zoning schemes so as to permit more intensive development and use of an area. Such alterations, depending on their location and extent, may ultimately contribute to a marked decline in landscape quality as perceived by both adjoining property owners and the public.(1)

Scenic Easements

The use of scenic easements provides an alternative mechanism for the protection of landscape values. The term easement refers to an interest in land less than full ownership. In the case of a scenic easement, such interests may be acquired for the purpose of maintaining the character of a particular landscape by restricting certain land use activities such as the clearing of vegetation.

Because an easement permanently restricts the landowner from developing a property in the way they may wish, it obviously reduces the utility or value of that property. Thus, the cost of an easement is the difference between the value of the land before any restrictions were placed on it and its value for uses allowed under the easement.

Easements are being increasingly used in countries such as the United States to acquire a public interest in and protect regional landscapes. Their use has been further enhanced by federal taxation laws which under specified conditions permit landowners to deduct from their income the value of easements established over their properties (Strong, 1983). Thus the main advantage of easements over zoning is that they provide fair compensation to the property owners whose activities have been restricted. Easements have also proven to be a significantly cheaper means of protecting landscape values than is the case when land is subject to resumption or purchase on the open market.

Planning and Design

Another means of minimising visual impacts and protecting scenic values is through the application of sound planning and design principles. The whole essence of landscape planning and design is to accommodate land use activities in a manner which caters for both functional and aesthetic concerns.

Much can be done through sensitive design to accommodate land use pressures along the Scarp. It is imperative, however, that such design and planning input occurs prior to development rather than as a cosmetic afterthought. Only in this way will we be able to cater for increasing use of the Scarp without unduly compromising the landscape in the process.

(1) The recent controversy over the future development of the Majestic Hotel site in Applecross is a case in point.

Conclusions

Human intervention has, in the short span of 1½ centuries, played an important part in transforming the landscape character of much of the southwest of Western Australia. The Darling Range, as a major scenic resource of this region, has not escaped such change.

There is considerable scope for applying various landscape planning and design controls along the Scarp to protect and, in some instances, restore landscape values. The creation of additional reserves or landscape protection zones, while an important step, is not the total answer.

It must be recognised that the Scarp landscape will be subjected to further changes largely brought about by increased unbanisation. Such changes need not be detrimental for, as George Seddon (1972) has pointed out..."The concrete mixer and the bulldozer can make landscapes as well as mar them, and the emphasis in conservation, especially in urban areas, should be on intelligent land use and on environmental design as well as on preservation, although there is also much that should be preserved. The first step in design is recognition, the ability to see what there is. Only then can we ask whether a given structure is appropriate to its setting, or whether a proposed land use is appropriate in a given environment."

This ability to see what is there and to recognise what is appropriate will not occur overnight. Such insights will only be gained through a concerted educational programme directed towards making the community at large more aware of our landscapes and the need to conserve and manage them widely. Each of us has a role to play in this programme.

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WHAT RESIDENTS APPRECIATE ABOUT THE SCARP

Alan Lonsdale

Introduction

In one sense this paper sits somewhat uncomfortably within the overall series. It is preceded and followed by papers dealing with scientific, planning and management questions which are based on systematic inquiry and research. In contrast, this paper is totally unscientific, and is personal, subjective, impressionistic and value laden.

But this is what I was asked to do. I was told that there was no expectation that the paper would, for example, report on the results of systematic surveys of residents, but that it should be based on my own observations, experiences and feelings. Later, however, I will comment on the value of a more systematic approach to finding answers to the question: "What do residents appreciate about the Scarp?".

Accordingly, the paper is mainly concerned not with what residents in general appreciate about the Scarp, but with what an individual resident appreciates. Such an approach may not be without merit however. Social scientists are increasingly recognising the importance of a qualitative rather than a quantitative approach to inquiry which seeks to understand how individuals think and act and which, while it may not lead to generalizations, can sometimes enable more perceptive insights. In this case it may assist in illuminating some of the issues relating to land use conflicts and management on the Scarp.

Not many residents actually live on the Scarp, if the Scarp is defined as the leading edge of the Darling Range - the boundary between the coastal plain and the range. In the localities of Lesmurdie, Kalamunda and Gooseberry Hill a limited number of people live on the upper sections of the Scarp, with the main body of population in those localities being concentrated in the region approximately three kms wide immediately to the East of the Scarp. The Scarp itself is more densely settled in the Greenmount area and in limited regions in the proximity of Armadale and Kelmscott. The emphasis in this paper is on those localities immediately adjacent to the Scarp. The localities of Lesmurdie, Kalamunda and Gooseberry Hill have developed because of the existence of the Scarp, and there is a close relationship between the origins and characteristics of those localities and the Scarp. I have chosen therefore, to broaden the discussion slightly so as to include the residential areas not only on the Scarp but immediately to the East of it.

Living on the Scarp

One approach to discussing what residents appreciate about the Scarp is to compare living on the Scarp with living elsewhere, and to infer from this what is appreciated. A second is to consider how the Scarp influences one's daily living; this is the approach I will take and, at least in part, it will also answer the comparative question. But first, let me indicate why I became a resident in the first place, before I really knew whether I would appreciate the Scarp.

My family has lived about 2 kms east of the Scarp for 12 years. Why did we deliberately settle in Lesmurdie? We had previously developed a set of family interests which placed a high value on interaction with the environment. Put simply, we enjoy the bush. We also enjoy the water. So there was a choice - should we settle on the Scarp of whould we seek to live closer to the ocean or the river? We sought a sense of space, a bushland environment in which to live and the opportunity to lead a lifestyle which enable us to interact with that environment. In addition, we had, and still have, a particular fondness for Western Australian wild flowers. We wished to have a genuine bush garden in, so far as possible, its original unspoilt state. These were the factors which drew us to living on the Scarp. Since then, we have come to appreciate many other aspects of living there.

Take a typical working day. One wakes in the morning to quietness, punctuated by the calls of many species of birds. The view from the bedroom window is of bushland and wild flowers. The air is crisp and clear. I can see no houses, no people, no streets and no cars - a consequence of being able to site a residential building on a fifth hectare block so as to maximize the advantages of the environment.

The walk up the drive to collect the newspaper extends the experience. On can absorb the pleasurable aspects of a bushland setting and briefly examine the wild flowers which are just starting to bloom. The street is quiet and tree lined. Adjoining houses nestle in their own bushland settings. In winter, the tall trees and the street may be shrouded in dense cloud which, while posing a problem when one is driving, deepens the sense of privacy and seclusion, and lends an atmosphere of mystery.

As I drive to work, the view of Perth from the crest of the Scarp is always enjoyable, not only because of its inherent value, but because it represents a separation between the residential area of the Scarp and the city. I see moss covered rocky outcrops dripping with moisture in winter, an ever changing array of wild flowers on the granite areas through winter and spring, and, as I reach to foot of the hill, am able to enjoy the semi-rural vistas on either side of the road.

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The evening drive from work is tinged with expectation - the expectation of again "escaping" from the city and relaxing in a more peaceful setting. The panorama changes as the sun sinks over Rottnest Island. On Friday one's thoughts turn to those activities in which the family will engage during the weekend, which frequently will bring them into more direct interaction with the bushland environment - walking the dog, strolling or barbequeing in the bush, gardening or simply enjoying living in a pleasant environment.

Those who live directly on the Scarp enjoy additional bonuses - the view, the wildflowers and trees, the landforms, the tumbling streams (although on some still mornings in summer and spring the view may be somewhat obscured by the polluted atmosphere above Perth).

Of course, not all of this applies to all residents. Most do not live on the Scarp. Some live on busy roads, some live on small blocks, some are not surrounded by bushland and many work in the area in which they live.

The foregoing represents largely a personal view, and reflects my own values, attitudes and interests. In preparing this paper I did talk informally with a number of people who live on, or close to the Scarp, to check the extent to which the reasons I considered important are shared more generally. (In no way could this be considered to be a systematic, representative survey). One conclusion emerging from these discussions is that it is difficult to generalize. Residents give a wide variety of reasons for living on or near the Scarp. Any particular individual or family group will identify with a particular subset of these, which may be quite different from those of importance to another individual or group. There are, however, some common threads. Fairly predictably, the main reason given is the environment - the sense of space, quietness, the bushland setting, wild flowers, the rocky outcrops, the landscape forms, the misty mornings and the climate (contrary to conventional wisdom the climate on and adjacent to the Scarp is milder than that in Perth). Many also appreciate the rural or semi-rural atmosphere. They feel that through living on the Scarp they can be part of Perth but separate from it. Access to the city for work, education or recreation is readily available; at the same time, there is a sense of being distant from a major metropolis.

These various factors combine together to enable a quality of living which is not reflected in any one factor, nor any direct summation of them - it is indeed true that, in a manner which is difficult to describe, the whole - living on the Scarp - is greater than the sum of the parts. And it is something which is experienced with all of the senses. From the residents' perspective, the Scarp is more than a geographical or geological feature. It comprises a complex environmental system in dynamic interaction with a social system - with a community.

One consequence is that the Scarp not only influences individuals and groups through its immediate and obvious environmental impacts, but that it also, at least in part, influences the type of community to be found there. To many people these community and social dimensions are also important. People may come to the Scarp largely for environmental reasons. In turn the aggregation of people with particular values and interests appears to result in a community with a difference. Many residents have indicated that there exists a village atmosphere and a sense of community which may not be available in the continuous and extended suburbs of the greater metropolitan area. There is a sense of living in a community which is somewhat isolated from the major concentrations of metropolitan population - from the urban sprawl. Residents appreciate this small sense of being separate - of being part of what is (and what was in previous times much more so) truly a rural community. Much of the atmosphere of the original rural community still persists. Even within the main centres of population along the Scarp, remnants of earlier days when fruit growing, market gardening and other agricultural pursuits were extensive are still evident. On the outskirts of the Scarp population centres, orchards are still very much an important agricultural activity. The area of greenbelt at the foot of the Scarp, whilst not continuous, creates a partial sense of isolation or separateness from Perth and helps to reinforce the feeling of a rural community.

One of the consequences of this partial geographical isolation is that the community on the Scarp tends to exist as an entity in its own right, with more clearly defined boundaries. This may result, for example, in what is perhaps a higher rate of participation than is usual in community affairs, local government and in education. In Lesmurdie, we saw a graphic example of this two years ago when the local community banded together in the interests of the establishment of a joint community-school library at Lesmurdie High School. These examples illustrate the dynamic interaction between the environmental system and the social system on the Scarp. In fact, it is probably more accurate to say that the whole - the physical environment and the community living within it - constitutes a total system. The Scarp influences people and the way in which they live; at the same time, people affect the Scarp.

Dilemas and Conflicts

But there are dilemmas and conflicts and, of course, it is dangerous to generalize. Many of these reasons for appreciating the Scarp derive from personal and social values which are not necessarily shared by all who live in the region. One can readily point to those who settle in the area, presumably because of the quality of the environment, but whose first step is to completely clear the building site of all native vegetation, including perhaps 20 metre jarrah or marri.

The provision of services, particularly roads and footpaths, is frequently in conflict with the environment and often with the preferences of residents. Safety needs and increasing traffic densities dictate that roads must be straight, resulting in the loss of important natural areas. Road construction techniques often result in the clearing of most of the vegetation for the full width of the road verge, resulting in quite barren roadsides. Verges are frequently cleared and then gravelled, resulting in severe run-off problems during heavy rain. Retention of more of the original vegetation would not only assist in retaining the original character of the region, but would also reduce run-off and erosion.

The very qualities which residents appreciate are the qualities they themselves are progressively disturbing and, in some cases, destroying. Welshpool Road, a major road servicing the Scarp area, illustrates this point. Until fairly recently this was, for most of its length, a two lane road, sufficient to handle the traffic density at the time and affording a pleasant drive to or from the hills. The inevitable build up of population has placed substantial pressures on this main artery, resulting in the necessity to up-grade the road progressively to a four lane highway. This in turn may add to the attraction of the area for others, thereby perpetuating the cycle.

Land use conflicts are also demonstrated through the proposals to construct a scenic drive along the Scarp in the Lesmurdie/Kalamunda region. For many years, long range planning for the metropolitan area has included the notional provision of a scenic drive along the Scarp immediately below the residential areas. A major justification given for such a road is the tourist value and the opportunity it would afford to others, as well as residents, to also enjoy the vistas, land forms and wild flowers. Construction of such a road would almost certainly destroy a major geographic feature, throwing into focus conflict between environmental values, the needs and values of residents and those of non-residents - visitors, tourists and town-planners. There is no easy resolution of such conflicts. That which has been adopted by the Shire of Kalamunda is, at least so far as residents are concerned, most desirable. For the time being it appears that the scenic drive will not be constructed and that environmental values will be protected. It is significant that values associated with alternative forms of land use assumed prominence in this debate - rather than building a scenic drive, more passive forms of recreation are being facilitated and encouraged through the establishment of walking trails on part of the Scarp and in related areas. This development was influenced by the example set by the City of Boulder in Colorado, USA, which nestles at the foot of the Rocky Mountains and in which, over the years, the foothills environment immediately adjacent to the city has been progressively protected in its natural state, but managed in a way which enables large numbers of residents to enjoy the environment on their doorstep.

The dilemmas for planners and decision makers are formidable. Perhaps the most significant of these is growth, for it is through population growth and its concomitants that many of the conflicts arise. Perhaps unfortunately, the Australian community places a high value on growth, which is often seen as being desirable in its own right, regardless of the costs and disadvantages. Biggest is frequently equated with best. Size and growth are used as indicators of performance by a wide range of organisations and institutions - schools and colleges, shires and cities, businesses and industries, and shopping centres. Shire councils are heard to proudly announce their population growth over the past three years. Increasingly they experience economic pressures to expand their income from rates through growth in the number of rateable properties, a trend which is encouraged by pressures from landowners and developers to extend residential areas. And, of course, if being a resident of the Scarp is as attractive as I have suggested, it is inevitable that more people will wish to live there.

It is not unusual to hear existing residents advocating a freeze on further development and growth. In essence they are saying: "Now that I am here and able to enjoy the environment, others should be excluded, as they will reduce the quality of that environment". And so they will. Similarly, as increasing numbers of visitors from Perth and elsewhere crowd into Lesmurdie Falls and other recreational areas, growing management problems can be expected. (Park rangers are already kept busy on Sundays in Spring controlling parking, unwanted dogs, litter and people). Local residents express concerns over the danger of fire escaping from barbeques, litter (not only household refuse, but unwanted kittens, car bodies and sump oil are left behind), vandalism, off-road vehicles and erosion. Again, their values - and the reasons they appreciate the Scarp - are in conflict with those of others.

The social and community components of the system, as well as the environmental components, are also affected by growth. To what size can a community grow while still retaining a village atmosphere? A number of residents have indicated that over the past ten years this point has already been passed and that, at least in this respect, living on or near the Scarp is no different from living elsewhere in Perth.

Conclusion

I don't pretend to know the answers to these conflicts and dilemmas, but they certainly exist and it is not difficult to predict that they will become more acute over the years to come. It is also clear that their resolution may need to involve not only environmental, urban and regional planning, but also perceptive and sensitive social planning. A team effort will be essential.

Finally, as I thought about the question of what residents appreciate about the Scarp, I realised that we probably know very little about the answer to the question. I have tried to indicate that there is a wide variety of reasons, and that these reasons lead to important conflicts in terms of land use and other aspects of the environmental-social system which pose dilemmas for planners and decision makers.

Various procedures are available which may be used to assist our understanding and resolution of such matters. One of these - social judgement analysis - is specifically designed to make explicit the values underlying preferences and policies, and could be of particular value.

Could I suggest that it may be of considerable value to engage in a more systematic survey to ascertain what residents appreciate about living on the Scarp, to obtain information which would undoubtedly be helpful for land management, urban and regional planning and local government policy making.

MINERAL AND RAW MATERIAL RESOURCES OF THE DARLING SCARP

Malcolm Carson

Introduction

The Darling Scarp offers a wide range of aesthetic features and natural resources. Recognition of the aesthetic value of natural bushland is not a new concept to Western Australia. For example, early pioneers set aside the Kings Park area when there was abundant natural bushland surrounding the growing community. This area was, and still is, potentially one of the most attractive residential sites in the Perth area. Even today, reserving potentially attractive residential areas would be difficult to achieve. Kings Park demonstrates the awareness of our early pioneers. Today an inherently aware community must rationalise potential land and natural resource uses in natural bushland areas. It is therefore necessary to define and order land and recource use priorities so as to develop long lasting land use plans which will enable future generations to enjoy community standards that exist today. Inclusive of this standard is not only recognition of perceived aesthetic values but also cultural norms which have and are being satisfied by the existence of valuable, relatively cheap raw material resources. Unfortunately, quarrying severely impacts the environment. Therefore, there is a need for rational planning including the identification of current and future resource requirements both in aestheitc and cultural terms.

The Scarp offers aesthetic values, a vast backdoor recreation potential and vital raw material resources required for the construction, to an expected standard, of houses, offices, factories, roads, hospitals, schools ect. West Australians consider that double brick houses are the norm. This standard has only developed because of readily available brick making clays in close proximity to residential developments. The clays are now in short supply and substitute materials from the Scarp area have been introduced to the brick making process. In the not too distant future, housing costs will escalate in order to preserve the building standard or, alternatively, substitute products will be introduced.

In order to rationalise the multiple values and land uses on the Scarp area, there is a need to identify the natural resources, including raw material resources, to determine how these resources will be used and to what extent they will contribute to the standard of living in future generations. There is clearly a need for the members of the community, quarry operators and planners, to recognise and appreciate the concerns and requirements of others (including future generations) in order to develop balanced land use plans which will minimise the impact on the Scarp's natural resources and associated society values and needs. In order to avoid adverse impacts arising from quarrying operations, appropriate liaison is required during the preparation, operation and post operation of any activity so as to ensure that the disturbed areas are suitably sited and rehabilitated.

Although the Scarp contains abundant raw material deposits, many of these will never become extractable resources because of economic, commercial and societal constraints. Provided that these constraints have been determined through objective and quantifiable criteria then the decision to exploit or not to exploit will be rational and future generations are more likely to uphold the approach.

This paper is not one to discuss philosophical issues but one that is prepared to illustrate and draw attention to the existence of mineral and raw material resources within the Scarp area and to the significance of these resources in relation to current living standards which, it is assumed, would at least be suitable for future generations.

Raw Material Resources

There are four major raw material deposits which can occur in the immediate Scarp area. These deposits are illustrated on Figure 1. and consist of the following:

1. Aggregate;
2. Brick, tile and pipe making material -
   a) Red Clay - Cardup shale and slate
      - Cretaceous silt stones and mud stones
      - Archaean schist
   b) White Clay - Kaolin;
3. Gravels -
   a) Bauxite
   b) Road Gravels;
4. Sand -
   a) Colluvium - can contain sand, gravel and clay.
   b) Yogonup sands.

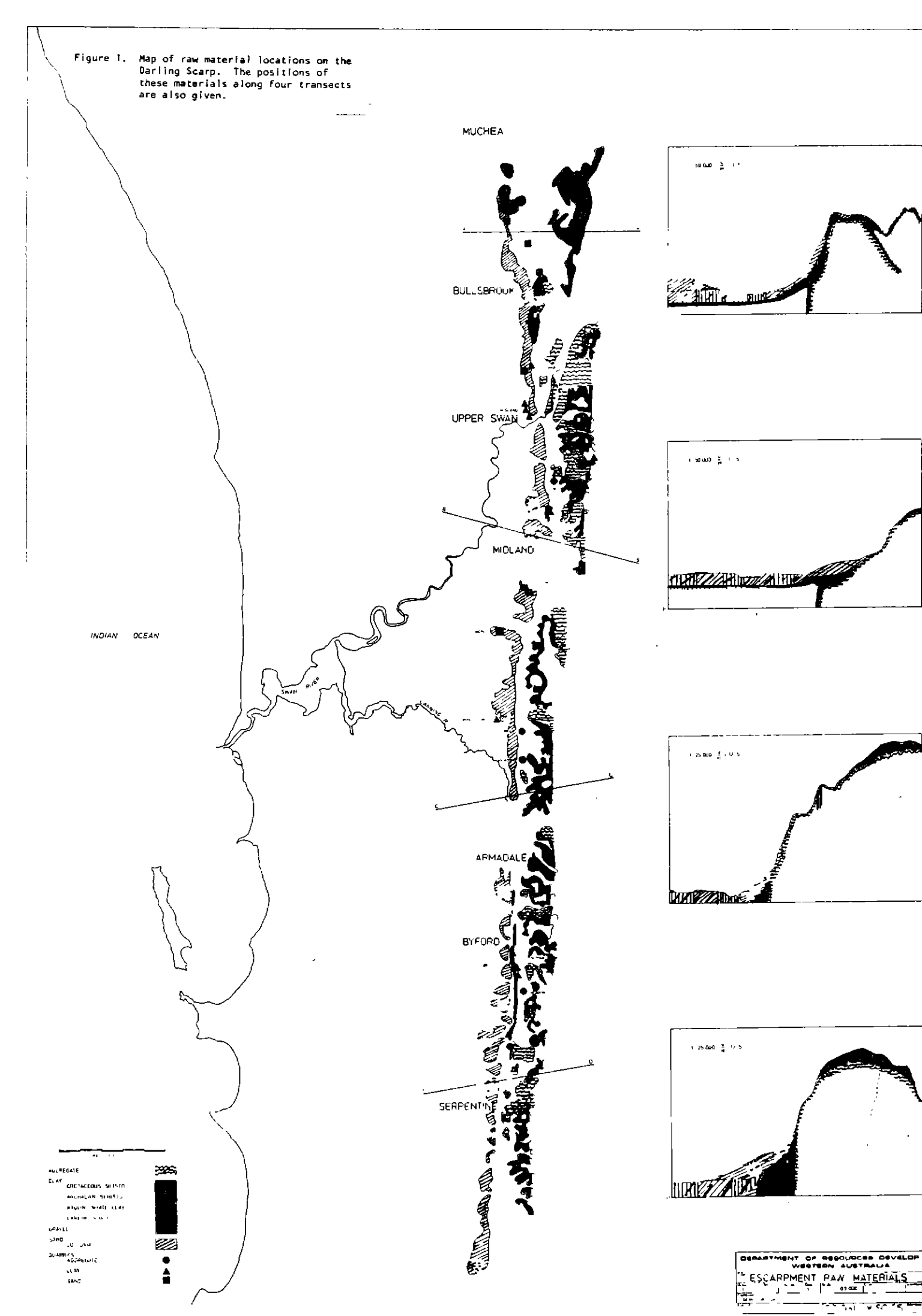
Aggregate

(i) General Description

Aggregate (or blue metal) is quarried at a number of locations along the Darling Scarp (see Figure 1.) Western Australians are well aquainted with these operations particularly the Readymix site in Gosnells. Aggregate is chosen from crystalline rocks, Archaean in age and usually of acidic/intermediate in mineralogy: Market factors and the specifications set by end users determine the appropriate mineralogic and physical characteristics of the stone and ultimately the product.

Scarp Symposium (Ed. J.D. Majer). Perth, 14th October, 1983. (W.A.I.T.: Bentley).

Figure 1. Map of raw material locations on the Darling Scarp. The positions of these materials along four transects are also given.



DEPARTMENT OF RESOURCES DEVELOPMENT
WESTERN AUSTRALIA
ESCARPMENT RAW MATERIALS

The Scarp contains enormous resources of hard rock. Although this resource is restricted by existing constraints both in terms of extraction economics and in terms of regional planning, it will be able (in the worst case situation) to supply the maximum development scenario (housing for approximately 3 million people) with only about 5 percent of the potential resource being consumed (approximately 140 million tonnes).

A committee was established in the late 1970's to investigate the aggregate resources of the Darling Scarp. A number of potential sites were identified (from aerial photographs) in a strip 10 km wide from Bullsbrook to Serpentine. These deposits contain aggregate resources of substantial tonnages and it was estimated that there are sufficient resources within economic, technical and environmental constraints to satisfy the requirements of Perth for many hundreds of years.

For example, the four operating quarries estimated their reserves at approximately 1,500 million tonnes or about 600 years supply at current extraction rates.

(ii) Exploitation Factors

a) Supply

Given the geology of the Darling Scarp, the potential supply of this resource is largely unlimited. However, the sources of supply are restricted by the physical characteristics of the rock including surface weathering, economic constraints, commercial specifications, environmental factors, urban development, distance to market and general planning constraints arising from multiple land uses and alternative priorities.

However, it is recognised that the current operators, Readymix, Bells and Pioneer, should be able to supply the requirements of Perth for at least 30 years from the existing sites.

b) Demand

The primary use for hard rock aggregate is concrete (1.75MTPA) with a less extensive use in wearing surfaces and road base (0.26MTPA) and as a railway line ballast (0.02MTPA). Special projects may use large quantities of stone in a short period. For example, the Armour stone on the north and south moles in Fremantle was extracted from quarries in the Darling Ranges and railed to the site.

It is estimated that by the year 2,000 (at an assumed annual growth rate of 3% per annum) hard rock production in the city of Perth could well be in the order of 4.5MTPA with the total cumulative consumption being in the order of 70 million tonnes. Total consumption to achieve the maximum growth scenario (3 million people) will be approximately 135 million tonnes.

It is predicted that the main future growth will occur towards the extremities of the MRPA corridor plan areas. There will also be a substantial market in the central Perth area arising from the construction of commercial buildings.

c) General Considerations

With growth towards the extremities of the corridors it means that the existing operators may well find the transport task a greater burden and an increasing proportion of the delivered rock cost. As the demand for aggregate increases it is likely that the central quarry operations could have difficulty in supplying the outer areas of Perth. Therefore, it is conceivable that additional quarries may well be required to supply the areas of residential development with a product that can be supplied at reasonable cost well before the existing quarries are exhausted. The timing of such developments will be entirely dependent on demand growth in both absolute and geographical terms.

Transport costs for aggregate (and most other raw material resources) is singularly the most important economic factor in determining the strategic location of a quarry and the competitiveness of its product. In an overal sense, however, it would require quite a substantial increase in transport distances to cause a large ongoing cost to the community. (For example, 1978-79 the aggregate cost was only 0.5% of the total construction cost and approximately 7% of the cost of concrete).

Further to the recognised significance of the strategic location of quarries, additional planning considerations are required in order to minimise the potential impact of major quarries established on the Scarp area. Quarrying does effect small areas and significantly changes the land form, removes the existing vegetation and alters the drainage pattern. If the quarrying operations are clearly visable from the coastal plain or inland looking back towards the City, there is a major impact on scenic appeal. This impact can be minimised by careful planning and progressive rehabilitation, but it may well remain. On the other hand, the old unrehabilitated and disused quarries can be used for specific recreation purposes relieving some pressure on remaining undistrubed areas.

Although aggregate is in abundant supply in the Darling Ranges and is well placed from a strategic point of view on the Scarp face, environmental constraints and community pressures in relation to the unsightly impact of quarrying in such an exposed area can effectively sterilise a large proportion of this resource. It is essential, therefore, that recognition be given to the contribution of aggregate (and other raw material resources described below) in relation to the needs which are to be satisfied during the expansion of the Perth metropolitan area.

As there are abundant supplies of the aggregate raw material resource there is a wide selection of possible sites which could contain quarries with a long life expectancy. Careful consideration should be given to selecting sites in multiple land use plans so as to enable the exploitation of the resource and to minimise the impact on other important land uses.

Brick Tile and Pipe Making Products

(i) General Description

a) Alluvial Plastic Clays - Swan Valley Type

Plastic clay is an essential component for the manufacture of bricks (greater than 10%), tiles (greater than 40%) and pipes (greater than 40%). The major deposits of plastic clay are located in the Swan Valley. The existence of these deposits in close proximity to urban and suburban development has enabled people of Perth to build double brick, tiled roofed houses and to view such construction as the norm. In fact, it is stated that the tonnage of bricks used per capita in Perth is the highest in the world.

Such a unique situation has only been retained through the introduction of new technology for the brick making process and due to the close proximity of the appropriate raw material deposits. New technologies include tunnel kilns, automatic extrusion processes, hollow bricks and clay substitutes.

The plastic clay substitutes are the raw materials to be addressed in this paper. These materials exist in the Scarp area. The material must have characteristics which do not adversely effect the shape or strength of the brick during extrusion and firing or the specifications of the end product.

Red plastic clay remains essential to brick, tile and pipe manufacture in that it imparts the appropriate strength to the green product and responds in an appropriate manner during firing. The importance of the clay component in the manufacture of these products must be borne in mind when considering the substitute products; particularly as there is a shortage of suitable clays in the Swan Valley which could well limit the exploitation of substitutes.

The substitute raw material resources are as follows:

1. Proterozoic slates and shales from Byford, Cardup and Gosnells.
2. Kaolinised Archaean Granites, Gniesses from Toodyay and Chittering.
3. Cretaceous silt-stones and mud-stones from Muchea.

It is considered that there is sufficient supplies of these raw materials to satisfy demand for the next 50 years, however, as stated above, their exploitation will remain dependant (at least with present technology) on the presence or absence of plastic clays.

b) Proterozoic slates and shales

The location of slates in the Armadale area has encouraged the brick making manufacturers to establish factories at Byford and Cardup. The industry in this area is based on the slates of the middle Proterozoic Cardup series. This is thought to be a series of shallow water shelf sediments composed largely of quartzitic sandstones and slates intruded by dolerites and quartz veins. The series crops out as a narrow steeply dipping band at the foot of the Darling Scarp between Mudljong and Kelmscott with a further outcrop at Gosnells.

Slate is currently being extracted from four quarries, three in the Cardup area and one at Gosnells. Other quarries have been developed at Kelmscott and Armadale but these are now disused.

The major horizon being worked has a maximum width of outcrop of approximately 100m with the eastern edge being normally marked by quartzite or dolerite. On the western side the slate outcrop disappears beneath an increasing thickness of chocolate or redish-brown loamy soil and alluvium although in some situations the western boundary may be defined by dolerite dyke.

In general, the slate appears to be dark-grey at the base through a succession of pale-greenish-grey to purple. In some cases there are no clear colour successions.

The slate is invariably silty or finely sandy with a considerable variation in cleavage ranging from a very well cleaved fissile slate to a poorly cleaved sandstone. From the point of view of quarry design the slate generally dips 70° to the West although on occassion it can be near vertical or high angled to the East. As a consequence the pits tend to be very narrow, steeply sided and limited in depth.

c) Kaolinised Granites

Often bricks, pipes and tiles require the use of white clay for colour control and aslo to shorten highly plastic clay. The material is generally derived from pockets of kaolinised Archaean granites and associated rocks in the Darling Ranges. The fact that kaolinisation is in small pockets or thin sheets within or close to drainage channels implies that the material has been formed by weathering rather than by hydrothermal activity.

A wide range of feldspar bearing Archaean rocks have been kaolinised and all these deposits are being worked for use in brick, pipe and tile production with apparently equal success. As a result of the complexity of the original rocks there are a wide variety of kaolinised products. The material is normally pale grey to white, composed of quartz, kaolinised feldspar and occasionally muscovite in varying quantities. Multi-coloured iron oxide staining is often present but generally near the surface. The clay often contains small stringers or veinlets of milky quartz sometimes reaching thicknesses of up to 2m.

d) Schists and Gneisses of the Toodyay and Chittering Areas.

Weathered and/or kaolinised archaean schists and gneisses in the Toodyay and Chittering areas are worked for sources of white clay for use in brick pipe, and tile production. Several pits have recently been opened up in a complex assemblage of kaolinised feldsphathic gneisses and schists to the south of lower Chittering. The material worked is a quartz-kaolin-muscovite rock of variable hardness. It is generally white but is invariably stained with red, brown or purple, although the staining intensity varies. In Chittering the material tends to be used exclusively in brick production.

e) Cretaceous Siltstones and Mudstones of the Muchea Area.

Silstones of the lower Cretaceous Bullsbrook formation are worked extensively 5 km east of Muchea. The siltsones are used in brick production. They are generally pale grey to white and contain both muscovite and kaolinite. Staining from iron-oxide is usually present and is most intense beneath the thin laterite cover. The grain size varies considerably from almost quartz free mudstone varieties ot fine sandstones.

(ii) Exploitation Factors

a) General considerations

Plastic clays in the Swan Valley are of limited supply largely due to exploitation, environmental constraints and sterilization from alternative land uses. It has been necessary, therefore, to introduce substitutes into the brick making process which will not adversely affect the end product. The raw material resources which have been used to substitute clay have been described above. There are abundant reserves of these materials for the producing companies for at least the next 50 years and there should be no difficulty associated with supplying these substitute products in the immediate future.

Clay and associated raw material resources in the Perth region are used almost entirely for the manufacture of bricks, vitrified clay pipes and roofing tiles. Small quantitites of clays are used in ceramics but in general because of the end use, longer transport distance for specialist materials can be justified. On the other hand, the producers of bricks, pipes and tiles, need their clay supplies close to their production plant and market so as to reduce transport costs and maintain a competitive selling price for their product. As a consequence, they are forced to use locally derived clays and to adjust production techniques so as to utilize the available materials. Many materials that are used today some years ago would have been considered entirely unsuitable. In fact, no single clay deposit in the Perth region contains materials entirely suitable for the manufacture of bricks, pipes or tiles, so it is necessary to blend and mix clays from several sources in order to make the appropriate mixture. Another problem occurs because the deposits are not necessarily homogeneous and, therefore, the blend needs to be constantly monitored and adjusted to maintain a consistent product. As a consequence it is not possible to give a specification for the brick clay or pipe clay, but it is possible to define the properties important to the final blend.

b) Clay and Brick Production

In 1978/79 2,470,000 tonnes of clay was extracted and 380 m bricks were produced.

Although there has been a considerable fluctuation due to economic and other factors, there has been a marked increase in clay and brick production since 1967. This has been largely due to increased population, increased demand for private dwellings, installation of tunnel kilns, the use of brick cladding and the increase -ed use of clay tiles. It is considered that there will be a continual increase in demand for bricks and continued pressure on the use of the dwindling clay resources.

Ultimately, it will be the availability and cost of plastic clay which will decide whether bricks remain competitive in a Western Australian market place and this in turn will impact raw material resources currently mined from the Scarp area such as schist, siltstones, slate and shale. This fundamental relationship must be borne in mind when considering the quarrying operations for these raw material resources on the Scarp and adjacent area.

Sands

(i) General Description

There are a large number of sand units which supply sand to the Perth metropolitan area for building purposes, construction materials and fill. There is a general misconception that sand is in unlimited supplies. However, societal constraints, quality constraints, transport distances and the substantial sterilization due to housing construction has limited the availability of all sand products. In general, along the Scarp, the most important deposits of sand exist in the colluvium. The colluvium consists of a material which is draped

over the face or deposited at the base of the Scarp. Within the colluvium deposits of clay and gravel can also occur and these have been exploited in the Bullsbrook area, in conjunction with the sand.

One of the most important sands is the Yogonup Sand which exists at various localities along the base of the Scarp. In some cases it is difficult to separate purely colluvial sands from sand of Yogonup origin. the Yogonup formation has been described as a shoreline deposit which consists of a basal beach conglomerate with the latter being composed of moderately well sorted medium to coarse rounded quartz grains.

(ii) Exploitation Factors

The physical characteristics of sand are generally more important than their chemical properties with the exception being in the case of blast sand which has strict chemical limits in addition to physical requirements. Generally, sharp or angular sands are suitable for concrete manufacture whereas soft or rounded sand grains are preferable for mortar and a finer sand is required for plastering. Perth sands used for plaster and cement manufacture do not fit the ideal specifications for these products. The Yogonup sands are described as "fatty" sands and these are widely used for land fill.

(iii) Supply and Demand

In 1977/78 the consumption of sand was about five million cubic metres or approximately 6½ to 7½ million tonnes. The amount of fill sand is not well known. It is considered, however, that the annual consumption of sand is about 1½ to 1.6 million cubic metres or 2½ million tonnes. The majority of sands is extracted from the coastal plain. However, there are sand deposits on the Scarp in the Yogonup formation and in the colluvium. Undoubtedly these deposits will continue to be exploited if they lie within economical tansport distances.
Within the colluvium, however, there are deposits in lenses of gravel and clay in conjunction with the sand and as a consequence multiple extraction operations have been and may be continued to be established in order to exploit all three resources. The scale of operations on the base of the Scarp may tend to be fairly small with the major large volume operations taking place on the coastal plain.

Gravels

(i) General Description

There are numerous small gravel pits scattered along the top of the Scarp and well into the ranges. The gravel is generally in the form of pisolitic laterite formed from the lateritization of ancient chrystalline or sedimentary rocks. Gravel pits have been developed on the face of the Scarp and also at the base of the Scarp within the colluvium or within reworked laterite (lateritite) deposits. Many of these pits have not been mapped becuse of their small size and because they have been developed for specific use by local land owners or shires, particularly for road construction and maintenance.

(ii) Exploitation Factors

Many of the pits are still active and may lay idle for some years with just small amount being extracted as required. Gravel fits into a similar category as aggregate in that there are abundant supplies and as a result there should not be any difficulty with locating appropriate sites and establishing operating guidelines which satisfy planning requirements and societal parameters.
The gravel can also be bauxitic and as a consequence contain high concentrations of alumina. The aluminium companies have mineral leases which cover the Scarp area. However, exploitation of bauxite in exposed steep sloped areas is unlikely to occur. The companies have, in any case, responded to the sensitive nature of the Darling Ranges environment and have developed comprehensive rehabilitation techniques and environmental safeguards. The steepness of the exposed Scarp would undoubedly impact the cost effectiveness of operations and render any bauxitic deposits uneconomic.

Conclusion

There are vital raw material resources available on the Scarp area. These resources will be required for any future development of the region. Fortunately, the resource which is consumed in the largest quantities exists in enormous tonnages. Consequently, it is possible to design and plan in such a way as to minimise the impact of the extraction of this resource on other natural resources and land uses in the area.

Other natural resources such as shale, slate, schist and siltstone are very dependent on the existence of dwindling supplies of plastic clays. Unless new supplies of plastic clays or substitutes can be introduced the remaining deposits will be exhausted.

Raw material resources such as gravel, sand, white clay cand aggregate are in abundant supply. Sand is also readily available on the coastal plain in large deposits within topographically desirable areas. This may well limit the exploitation of similar deposits adjacent to the Scarp.

Gravel on the other hand, will continue to be exploited in small privately owned pits and some planning considerations would undoubtedly be desirable. Aggregate exists in enormous quantities but it is usually located in the most sensitive and exposed area of the Scarp. Aggregate is essential as a product required to satisfy the needs of an expanding metropolitan area. The very availability of this resource should enable its its exploitation whilst at the

same time ensuring the environmental impact is minimised. It is unlikely that bauxite mining will ever develop on the Scarp face itself.

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CONSERVATION RESERVES OF THE DARLING SCARP

B.G. Muir

Introduction

For the purpose of this paper the Darling Scarp is considered to be that area of land within 10-15 km east and west of a line formed by the visible landscape feature popularly known as "the edge of the Darling Range." Also for present purposes the strip of land is considered to begin in the north in the vicinity of Gingin and run southwards to the vicinity of Dardanup, east of Bunbury.

This 20-30 km wide belt of land, with the Scarp running down its centre, contains portion of the Pinjarra Plain geomorphological element on its western side as well as most of the Ridge Hill Shelf and small areas of Bassendean Dunes (Seddon, 1972). The part east of the Scarp line lies on the dissected edge of the Darling Plateau. Consequently, four major geomorphic elements are represented within this zone and can be expected to be quite diverse despite the limited area under consideration. This relatively diverse nature within a small area sets the scene for the needs of conservation, and indirectly the aspects which make such conservation difficult.

Within each geomorphic unit are numerous vegetation types and associated habitat types of which it is desirable to preserve representative samples. This desirability is not only for altruistic, aesthetic or recreational purposes, as important as these may be in the vicinity of a State capital city, but for their value for research, education and tourism is enormous.

This same proximity to Perth prevents preservation of large areas for conservation, firstly because historically much of the land has already been cleared for housing or agriculture and pressure for alienation of bushland for various purposes can be expected to continue. Consequently, existing reserves for conservation are mostly small, and future encroachment could easily bring about further reductions in areas unless the land is carefully protected. An outstanding example of these events is Kings Park, which being on the edge of the City, has come close to alienation for housing on numerous occasions, but has survived, and its present day value for recreation and aesthetics is inestimable.

Land for Conservation of Flora and Fauna

Land with high conservation value for flora and fauna is usually relatively undisturbed and thus indirectly preserves representative samples of geology, soils and landscape (whereas the converse may not be true). Such land may have historically been recognised as having conservation value and been reserved for protection. Alternatively, land may be held in free-hold or set aside in reserves for other purposes, e.g. timber or townsites, but not used and now retains valuable representative bushland.

More recently, a comprehensive review of land with conservation value on the Swan Coastal Plain and adjacent land to the east (Department of Conservation and Environment, 1981) has been undertaken, and many endorsements and changes to enhance conservation values suggested. This report is at the moment the definitive statement on land for conservation along the Darling Scarp and the reader is referred to it for details of many of the areas discussed.

About 36 portions of land are recognised which retain high conservation value; some as reserves, others freehold, or mixtures of reserve and free-hold.

Thirty-one reserves of various types exist, of which six are specifically set aside for the protection of flora and fauna and vested in the Western Australian Wildlife Authority (W.A.W.A.); seven as National Parks vested in the National Parks Authority (N.P.A.); eight are set aside for recreation with various vestings or no vesting, and the remainder are reserves for gravel, timber, townsites, water supply or some other purpose not directly related to conservation.

The flora and fauna reserves vested in the W.A.W.A., and the National Parks are listed briefly in Table 1.

From Table 1 it is seen that only 2 reserves have areas over 1,000 ha, and six of the remainder are less than 100 ha in size; considerably smaller than is considered suitable for long term viability (Slatyer, 1975).

Additionally, although the vegetation and habitats of the upper Scarp are relatively well represented in all seven National Parks, four of the six nature reserves vested in the W.A.W.A. are specifically to protect wetlands of the coastal plain and only one preserves a reasonable sample (Reserve A3345, 259 ha) of the coastal plain vegetation in the immediate vicinity of the foot of the Scarp.

Land with High Conservation Value and Under Control of Authorities other than W.A.W.A. or N.P.A.

There are six areas of land adjacent to the Scarp which enjoy high levels of protection from disturbance; five are Management Priority Areas (MPA's) under control of the Conservator of Forests; the last is Pearce Aerodrome under Commonwealth of Australia control. Details of the MPA's are set out in Table 2.

The Forest Department MPA's are used for recreation and are managed for this purpose and for conservation by that Department. Pearce Aerodrome is of about 650 ha of which about 40% is cleared or partly cleared, the remainder being relatively undisturbed. It

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Table 1. Department of Conservation and Environment (1981) report numbers and reserve numbers of the flora and fauna reserves vested in the W.A.W.A. and the National Parks vested in the N.P.A. which occur in the vicinity of the Darling Scarp between Gingin and Dardanup. The area of each reserve, its major habitat type and controlling Local Authority are also given.

Dept. Conservation (1981) number	Reserve Number	Reserve Name	Area (ha)	Major Habitat Type	Local** Authority
C5	A3345	Moore River	259	Banksia woodland	VP
C19	C29538	Chittering	231	Wetland on plains	Chit.
M17	A27621	Twin Swamps	155	Wetland on plains	Swan
C10	A9838	Wannamal Lake	81	Wetland on plains	Gin.
M17	A27620	Ellen Brook	67	Wetland on plains	Swan
C26	C4070	Bullsbrook North	17	Eucalypt woodland	Chit.
M18	C2065	Walyunga N.P.*	1790	" " (hills)	Swan
M21	A7537	John Forrest N.P.	1578	" " "	Mun.
M85	A28862	Serpentine N.P.	635	" " "	Serp.
M34	A21314	Kalamunda N.P.	375	" " "	Kal.
M29	A25313	Greenmount N.P.	56	" " "	Mun.
M80	A22515 A26247	Lesmurdie N.P.	56	" " "	Kal.
M34	A30200	Gooseberry Hill N.P.	33	" " "	Kal.

* N.P. = National Park

** Abbreviated Local Authority Names as follows:

VP = Victoria Plains, Chit. = Chittering, Gin. = Gingin, Mun. = Mundaring, Serp = Serpentine-Jarrahdale, Kal. = Kalamunda.

Table 2. Management Priority Areas under control of the Conservator of Forests, their Department of Conservation and Environment (1981) report numbers, areas, brief description and the Local Authority in which they occur.

Dept. Conservation (1981) number	MPA name	Area (ha)	Description	Local** Authority
M84	Gooralong	705	Vigin Jarrah*	Serp.
C87	Serpentine	7562	Yarri*-granite	Serp.
C72	Teesdale	1728	Jarrah	Dwel.
C73	Murray Valley	11159	Mixed forest	Dwel.
C75	Samson	1035	Bullich*	War.

* Jarrah = Eucalyptus marginata, Yarri = E. patens, Bullich = E. megacarpa.

** Abbreviated Local Authority names as follows:

Serp. = Serpentine-Jarrahdale, Dwel. = Dwellingup, War. = Waroona.

contains eucalypt forest, Sheoak (Allocasuarina fraseriana) woodland, Banksia woodland, paperbark (Melaleuca spp.) woodland and areas of quite diverse heath.

Proposed Future Reserves of High Conservation Value

Other than enhancement of existing reserved land, as set out in Department of Conservation and Environment (1981), two proposals of major impact have been described in that report.

These are to provide four special linear reserves to protect waterways, and a reserve specifically located and managed to preserve a representative sample of the Darling Scarp.

The linear riverine parks or reserves are designed to provide buffer zones between the rivers and adjacent land use, to act as pathways for migratory and nomadic fauna and to provide visual buffers and recreation facilities. Such reserves are proposed for the Swan River between Guildford and Walyunga National Park; for Jane Brook; for Helena River between Guildford and Darlington; and along the Upper Canning and Southern Rivers.

The reserve to provide representation of the Darling Scarp has been proposed as a Regional Park in the report (op. cit.) and is described as follows:

M80 Darling Scarp. "The area extends from Kalamunda Road in the north almost to Wungong Brook in the south. It includes the Scarp face itself, portion of the Darling Range immediately east of the Scarp, and portions of the upper slopes and ridges above the south of the Canning River..."

"The area runs north-south for a distance of about 24 km. It comprises numerous Land Act Reserves and freehold land, owned privately and by the Metropolitan Regional Planning Authority Most of it is 'reserved' for Parks and Recreation under the Metropolitan Region Scheme. Additional land has been proposed for 'reservation' in the Stage A South-East Corridor Report"..."The Scarp is the most prominant landform.....rising to a maximum height of 300 m. It consists of granite outcrops, ridges, valleys supporting winter-flowing creeks, several 'hanging' swamps, dolerite dykes, laterite screes and the laterite capping of the western edge of the Darling Range."

"Most of the Scarp flora is represented in the areas described above.....(including) a stand of the very rare Salmon White Gum (Eucalyptus lanepoolei)..... a rare species of Dryandra (Dryandra praemorsa)..... and an unnamed species of buttercup (Hibertia sp.) which is restricted to the top of the Scarp east of Perth."

"Scenically, these portions of the Scarp contrast with other areas which have been partly cleared, developed for residential use, or which are dissected by east-west or north-south roads. The Scarp forms a natural skyline behind much of the city, and provides panoramic views over the city and Coastal Plain and even as far as Garden Island."

Such a description presents a picture of a pleasing area of high conservation value and its declaration will be a major step towards preservation of the character of the Scarp.

Management of Conservation Reserves

Existing reserves and those proposed for the future are of little long-term value if not appropriately managed. Large wilderness areas may require little direct management but small reserves with nearby agricultural or residential activities require active environmental and public control.

Numerous influences such as fire (Good, 1981), windblown fertilizers (Muir, 1979a), accidental or deliberate clearing or grazing (Muir, 1979b), rubbish dumping, weed invasion (Australian Institute of Agricultural Science, 1976) and several other factors ultimately bring about changes in the natural vegetation and fauna. Even the small size of the reserve can itself cause reduction in species numbers over the long-term, as described by Diamond (1975), Slatyer (1975) and others.

Superimposed on these influences is the increasing and legitimate pressure for public recreation areas. Long established and well known reserves such as John Forrest National Park (declared 1901 and the oldest national park in Western Australia) experience up to half a million visitors per year. The effects of trampling and overuse steadily become apparent despite several full-time management staff to control and direct activities.

Accompanying direct visitor pressure is demand for horse trails, canoeing facilities, orienteering paths, nature walks and other developments which inevitably take their toll on the bushland. Some activities such as horseriding have serious and widespread detrimental effects including dieback spread, introduction of weeds and increased erosion.

Although outdoors activities of this type are legitimate recreational pursuits, it is inevitable that conservation values must eventually decline and recreational values increase despite the most careful management. To further enhance this dilemma recent research by S. Hopper (pers. comm.) has shown that numerous Gazetted Rare plant species occur only in metropolitan National Parks and should be protected for future study. Such protection becomes increasingly difficult under the conditions described above.

Conclusion

To summarise the above comments, it is fair to say that the majority of National Parks and all the Management Priority Areas represent quite well the forest vegetation of the top of the Scarp in its southern portion. Conspicuously absent are large reserves protecting the more open woodlands and other vegetation types of the northern part of the upper slopes of the Scarp between Bullsbrook and Gingin.

Similarly, while existing Nature Reserves are fairly well scattered along the Scarp foot, all are small and most protect predominantly wetlands, often for specific purposes, e.g. Short-necked Tortoise sanctuaries. There are no large reserves of woodland or other associations on the Scarp foot, and little potential exists for their creation because of clearing.

It is my opinion that a programme to encourage freehold land owners to place protective caveats on their uncleared land or to give large portions of uncleared land on their properties to conservation management agencies as reserves, perhaps under joint agency/landholder management, may be the only effective manner of increasing the Scarp foot conservation value. Provision of linear riverine reserves and the sprecifically proposed Scarp Reserve will be major improvements to the conservation reserve system when they come to fruition.

With regard to management, it would seem that only two options exist if the value of existing (and future) conservation reserves on the Scarp adjacent to Perth are to be retained. Either continual slow degradation, despite active management, must be tolerated or some reserves with special values must be closed to public access and managed carefully for conservation and research. The remaining reserves should then be developed as foci for recreation both to compensate for loss of the conservation areas and to provide much needed outdoor recreation facilities for a steadily increasing population.

I personally feel the latter approach the best alternative as it presents a wider range of future options; action should be immediate to minimize further damage to the reserves chosen for closure.

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FIRE ON THE SCARP

J. Robley

Introduction

The Darling Scarp is a significant geographic feature in the most heavily populated part of Western Australia.

Steep slopes and river valleys with scrub and forest fuels combine to provide a significant fire protection problem. The area forms a scenic back drop to Perth and its environs are highly prized by those who wish to live in a bushland setting.

The climate associated with this area provides for a 6 month long "fire season" i.e., the period when serious fires may occur is generally from November to April each year although seasons may vary up to a month either way.

Typical of this season are hot days with low to moderate relative humidities, strong overnight and early morning easterly winds with afternoon sea breezes from the west to south west. The most serious fire weather conditions occur with the easterly movement of low pressure systems and troughs following periods of rising temperature.

In these circumstances, winds back from the north east to the north west and strengthen and there is associated atmospheric instability giving rise to local thunderstorms and lightning.

The area experiences approximately 110 days of high fire danger, 26 days of very high fire danger and 3 to 5 days of extreme fire danger each year (McArthur grassland fire danger rating).

Occasional "blow up" days occur the most recent being during Cyclone "Alby" in April 1978 when fire danger conditions exceeded the scale of 1-100 on the McArthur Grassland Fire Danger Meter Scale.

Annual drought factor conditions reach an upper level of 1700 in most years (Mount Soil Dryness Index) and a maximum on the index of 2000 was recorded in 1983.

Taking into account the terrain, weather and fuel types, the Bush Fires Board assessment of the Scarp area is one of very high fire potential.

Fire History

Recorded history of all fires on the Darling Escarpment between Gingin and Serpentine is sketchy. The statutory source of information is reports provided by volunteer fire control and brigade officers to local authorities who are required to make annual returns to the Board.

Prior to 1976 when the Board made a determined effort to upgrade reporting, this source of information was unreliable. However, major fires were reported with a high degree of accuracy and particularly by the Forests Department in areas where their forces were involved.

Major fires i.e., those requiring several brigades to extinguish them and posing severe threats to life and property, have occured at regular intervals since the first recorded in 1914. History records major fires in the hills as follows:
1914, 1922, 1923, 1928, 1930, 1931, 1933, 1935, 1936, 1938, 1945, 1951, 1955, 1960, 1961, 1966, 1971, 1972, 1973, 1974, 1978, 1983.

The numbers and severity of these fires however, has decreased enormously due in part to improved access for fire control, a much more sophisticated and efficient bush fire brigade system and fuel reduction and strategic fire-break construction.

The maps at Figure 1, demonstrate the diminishing severity of bush fires on a susceptible portion of the scarp over the last 10 years. However, between 1976 and 1982, there was almost a 400% increase in "all" fires attended by brigades in the Swan Region as a whole. See Table 1.

Table 1. Number of fires attended by brigades in Swan Region per year.

Year	1976	1978	1980	1982	1983
No. of fires reported	192	255	624	977	1000

This spectacular increase may be partly due to a rapid spread of suburbia into the area controlled by busy fire brigades particularly in the northern suburbs.

It is significant that following the introduction of fuel reduction and strategic firebreak schemes, the average size of fires attended by bush fire brigades has fallen from 17.5ha (1976) to 6.6ha (1983).

Responsibility for Fire Protection

The Scarp face falls within the area protected by volunteer bush fire brigades of the Shires of Chittering, Swan, Mundaring, Kalamunda, City of Gosnells, Town of Armadale and the Shire of Serpentine/Jarrahdale.

These brigades are registered and administered by the local authorities concerned and equipped by those authorities or from their

Figure 1. Areas of major fire occurrence (dark shading) on the Darling Scarp from Gidgegannup to Maddington. Map scale is 1:100,000 and source is G. Van Didden (1983).

own resources by public donations. They are the most highly organised and motivated bush fire brigades in the State. A mutual aid fire suppression arrangement exists between these brigades and the Forests Department, the Western Australian Fire Brigades Board, the National Parks Authority and the Department of Fisheries and Wildlife.

Fire suppression and fire management activities are co-ordinated through a voluntary body, the Swan Region Fire Protection Committee, acting in an advisory capacity to all member authorities and the Bush Fires Board. A second Committee co-ordinates fire protection of the Avon Valley area.

These co-ordination schemes cover the whole of the 10 local authorities surrounding the Perth Metropolitan Fire District and the Shires of Chittering, Toodyay, Swan and Mundaring respectively.

Basic responsibility for fire management lies with individual land holders who have an obligation to comply with the minimum fuel reduction and firebreak construction requirements issued by local authorities. Government Departments and authorities, while not bound by these requirements are instructed by Government to co-operate.

The Bush Fires Board designs and implements integrated hazard reduction, firebreak construction schemes and mutual aid fire control schemes covering assessed high fire risk areas and co-ordinates all fire management works in these areas.

In addition, the Board seeks to maintain high standards of fire prevention throughout the area by liaison with all the various bodies concerned.

Fire Prtoection Strategy

1. Areas of high fire potential are identified taking into account the factors of:

   Topography
   Fuel type
   Access
   Fire history
   Brigade capability
   Values at risk

2. The aim is to maintain available fuel loadings in bush areas at a level not exceeding 6 to 8 tonnes per hectare with not more than 20% of areas carrying the maximum fuel loading.

   The figure of 6 to 8 tonnes is regarded as the maximum loading which can be suppressed by well equipped and trained fire crews on a normal summer day.

3. As far as possible, the aims and objectives of land management authorities are accommodated within the fire management strategies.

4. Fuel reduction is carried out on a mosaic pattern to avoid fuel build up to a maximum loading over a significant single area.

5. Firebreaks are located to form strategic systems designed to provide access to known high fire risk areas, to provide lines from which fires may be fought to the best advantage and to break up areas of bush-land so that prescribed burning operations are limited to pre-determined areas.

   Firebreaks on small residential blocks, compliment this system.

6. The Bush Fires Board makes fire safety recommendations to Councils and the Town Planning Board on all zoning and sub-divisional proposals. These include firebreak requirements, provisions of access and water supplies.

7. Priority is afforded to fuel reduction activities on the northern side of residential development as this is the direction from which the most devastating fires can be expected.

8. All fire protection works are designed in such a way as to take account of environmental and aesthetic considerations.

   Prime areas of concern lie in the risks of soil erosion, the spread of plant diseases such as Phytophthora cinnamomi and the invasion of exotic weeds and grasses which can exagerate the fire problem by creating an annual hazard. Specifically, the Scarp requires special consideration in view of steep slopes, the visual impact of fire protection works and the need to exclude the invasion of exotic weeds and grasses.

Fire Protection Objectives

Due to steep slopes on the Scarp face and river valleys, fire behaviour in the area differs from more gently undulating terrain. Fire spread doubles per 10° of slope and is four times greater on 20° slopes. Fire prevention measures must take this phenomenon into account. Similarly, if fire protection measures are to be accepted by the public, they must be as unobtrusive as possible as the Scarp is a significant landmark.

The main objectives are to separate residential land from undeveloped or agricultural land both at the top and bottom of the Scarp face, to protect the Scarp itself from fires arising outside the area and to provide access for fire fighting appliances to contain fires within as small an area as possible.

To achieve these objectives systems of strategic firebreaks have been used, located as far as possible on "dead ground" to reduce the visual impact and linking existing roads and tracks.

Additional firebreaks have been constructed on the slopes where existing roads are too few to enable fires to be contained within a reasonable area. These strategic breaks are re-inforced by low fuel buffers burnt on a regular cycle of 5 to 6 years. Care is taken with this burning to avoid further introduction of exotic weeds and grasses.

Planned strategic firebreaks backed by regular rotational burning have less environmental impact than the "let it burn" policies of the late 1960's when many grass invaded areas were burnt annually.

Housing development, particularly that which occurred more than 10 years ago favoured road systems at the rear of development, thus placing homes in direct juxtaposition with bush fuels with no access for fire fighters to position themselves between the homes and fires. In these circumstances, firebreaks and burnt buffers are essential.

Ideally, residential development should be as indicated at Figure 2, where adequate access is provided for fire prone areas.

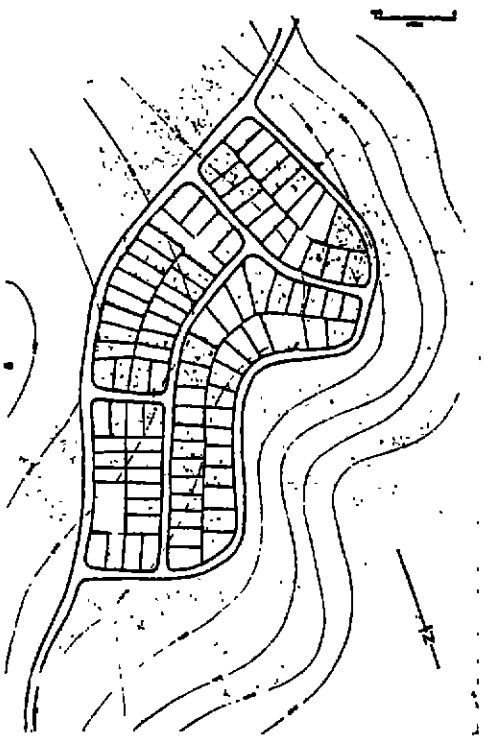

Figure 2. Hypothetical residential development designed to allow adequate access to fire areas.

In the construction of firebreaks proper engineering standards are recommended by the Board to avoid soil erosion and the machinery used is cleaned and checked in accordance with the Western Australian Forests Departments guidlines on prevention of the spread of Jarrah Dieback disease.

Fire Causes and Public Education

The majority of fires in the Swan Region and the Scarp Area can be attributed to human agency.

The greatest single cause remains escapes from burning off or destruction of rubbish which accounts for 30% of reported causes and an increasingly significant proportion (up to 20%) being attributed to deliberate lighting (arson). This is a normal pattern Australia wide. Other causes relate to escapes from picnic and barbecue sites, motor vehicles and the operation of internal combustion engines, S.E.C. lines and children playing with matches. On "blow up" days, lightning and fire associated with power lines assume greater significance. Few fires actually start on the Scarp face itself, most start outside and spread into the area.

Public education through publicity campaigns using the electronic media and local press appear to have little impact on the number of fires which start.. The most effective public education system appears to be through personal contact (a door knock) in limited areas but this is so demanding on manpower that it cannot be widely or frequently used.

Subdivisional Planning and Zoning

Up to 1976, there was no input to the planning process by fire authorities. The organisation was reactive only to development wich took place.

With public demands for a more rural lifestyle and the creation of Special Rural Zones and Hobby Farms, fire management problems for bush fire brigades increased considerably. Currently, the Bush Fires Board is called to advise on fire safety considerations which can be applied to this type of development at the subdivisional and zoning stages, thus avoiding many of the more fundamental fire protection problems which can arise. Advice given by the Board is included in the conditions imposed by the Town Planning Department.

These problems relate to homes in a bushland setting with poor access for fire control, mediocre water supplies and all to frequently, brigade structure, disposition and equipment must be appraised and re-deployed. Manpower problems arise as the majority of residents commute to work in the city each day. The latter problem has been largely overcome by an increasing number of ladies joining brigades and taking an active part in fire control activities.

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REGIONAL OPEN SPACE ON THE SCARP

M.D. Poole

Introduction

The term "Regional Open Space" infers, probably correctly, a system of open space designed to serve the population of an urban region. However, prior to relating to the Darling Scarp, the term is of sufficient interest to warrant some minor investigation into its background in relation to Perth.

In March 1831 William IV directed the Governor of the Colony of Western Australia, among other things,

"to require and authorise the said Surveyor General further to report to you what particular lands it may be prepared to reserve in each County, Hundred and Parish so to be surveyed by him as aforesaid for public roads .... or as places to be set apart for recreation and amusement of the inhabitants of any town or village or for promoting the health of the inhabitants...."

However, it was not until 1872 that it was found necessary to set aside reserves of land for what we would today call "National Parks and Nature Reserves". This was done under the Land Regulations for the Colony of Western Australia. The Parks and Reserves Act of 1895 went one step more and empowered the Governor to appoint Boards to control and manage parks and reserves which could be created under regulations prepared in 1887, this going further towards the situation we have today.

The Land Act of 1898, and the Permanent Reserves Act of 1899, consolidated previous land regulations and specifically provided for the setting aside of lands as reserves for the protection of indigenous flora and fauna. The Permanent Reserves Act 1899 created the three classes of reserves; Class A, B and C.

Introduction of Town Planning as a Discipline

Town Planning, as a separate discipline was gradually introduced into the State in the early part of this century, commencing with the initiative of City of Perth's Town Clerk Bold, who attended a world health conference in Britain where the Garden City Movement was the main theme of discussion. Possibly based on the facts contained within the detailed report Bold put to the Council on his return, by 1915/16 a group of prominent citizens had formed an association with the objective of having enacted in W.A. Town Planning legislation. Bold led this group, which included people such as Harold Boas, Vic Steffeno and George Temple-Poole.

It took this group until 1928 to accomplish their objective with the gazettal of the Town Planning and Development Act.

The Metropolitan Town Planning Commission

In 1930 a Royal Commission chaired by Harold Boas, presented the first comprehensive statement on Regional Planning in Western Australia. On the matter of regional open space (as distinct from playgrounds and recreation areas), the Metropolitan Town Planning Commission had this to say:

"Whilst the Commission has in view the practical needs of the community for the present and the immediate future, within its capacity to afford these needs, yet wisdom dictates that a vision of the future also implies some practical steps towards the ultimate needs of the existing community. The Commission visualises within 50 years a large thickly populated area within the metropolitan area, comprising within the 137 square miles, 1,000,000 people, and for the purpose of meeting the needs of that time, a system of parkway and belts and reserves should be devised so that provision can be made gradually for the system as development occurs."

In referring to the location of these parkway belts, the report of the Commission stated:

"This belt would run ..... and thence across to the upper reaches of the Swan and the tributaries leading therefrom. One of these tributaries, Jane Brook, would lead direct to National Park. From there the parkway system would have to follow south across the hills country until it reached the tributaries of the Canning River and its tributaries...." (Boas, 1931)

Had this report resulted in a Statutory Planning Scheme, it is almost certain that the Darling Scarp would have been reserved for Open Space.

Plan for the Metropolitan Region

The State Government commissioned Town Planning Consultant Professor Gordon Stephenson early in the 1950's to prepare a regional plan for the Cities of Perth and Fremantle in conjunction with the Town Planning Commissioner Alistair Hepburn.

Their report of 1955, titled the "Plan for the Metropolitan Region Perth and Fremantle" was the basis for the 1963 Metropolitan Region Scheme.

Stephenson and Hepburn in their report, distinguished regional open space from local and district open space. They described regional open space as "including the major recreational centres used by and forming focal points for, the region as a whole."

That report further defined Regional Open Space by giving examples of the concept:

" a) ocean beaches,
b) rivers and river foreshores,
c) areas of landscape value,
d) picnic areas, camping grounds, tourist cabin areas etc.,
e) nature reservations,
f) central parks,
g) zoological gardens,
h) regional sports centre and stadium,
I) motor parkway, and
J) open country "

(Stephenson-Hepburn, 1955)

The Stephenson and Hepburn Plan recommended the reservation of land for "Public Open Space" and showed such a reservation extending along the Darling Scarp from Toodyay Road in the North to Armadale in the South. (See Figure 1. Plan for the Metropolitan Region). The Metropolitan Region Scheme Report which was published in 1962, stated that Regional Open Space "represents a collection of areas of many types, some reserved because of their natural flora and fauna, others for their scenic attraction, others because of their potential for development into areas for recreation and the enjoyment of leisure."

The Metropolitan Region Scheme, gazetted in 1963, reserved a total of 26700ha of land for "Regional Open Space" (in statutory terms this reserve is called "Parks and Recreation"). It should be emphasized that the Metropolitan Region Scheme is not a Static Plan, but is continually being reviewed and amended. Consequently it is of interest to note that in 1981 the total area reserved for Parks and Recreation had increased by 5265ha to 31965ha, of this total, the MRPA owned 11475ha, 16303ha was in Crown ownership, and 4187ha was still privately owned.

In 1973 the Corridor Plan was adopted as the strategy for the future growth of the Perth Metropolitan Region. (See Figure 2. Corridor Plan). The Report on the Corridor Plan stated "It will be the aim of the Metropolitan Region Planning Authority to continue acquisition, as fast as possible, of the parks and recreation reserves designated in the Metropolitan Region Scheme" (MRPA, 1970).

The structure of the Corridor Plan is influenced as much by the Darling Scarp, as it is by the line of swamp land and lakes running parallel to the foreshore along the coastal plain. Although the urban zone of the eastern corridor protrudes through the scarp, the bulk of the future population of the region will be located in the South East North West and South West Corridors.

That the Darling Scarp is significant in regional terms as a Regional Reserve is evident from the fact that of the almost 32000ha of land reserved for Parks and Recreation in the Metropolitan Region Scheme, 12600ha relates to reservations along the Scarp. (almost 40%) (The Stephenson-Hepburn Plan suggested the reservation of 11259ha between Toodyay Road and Serpentine Falls).

The Region Scheme in Relation to Regional Open Space

The above comments have outlined the background from a planning point of view to the concept of setting aside large parcels of land for the purpose of regional use. Obviously the planning reasons coincide with some objectives under which other bodies, such as the National Parks Authority operate (See Muir, this proceedings).

Unlike smaller recreational reserves for local and district purposes, where it is possible to establish a relationship between the population and the area or number of reserves required, regional parks relate more to the following points:

(a) The preservation of areas of land for the enjoyment, in one way or another of present and future populations. Thus areas of natural beauty become as significant as areas preserved for the protection of specific flora or fauna.

(b) The protection of areas from unnecessary or unsightly development for the purpose of ensuring the optimum landscape value for present and future populations.

(c) The setting aside of areas of open space for active use by present and future populations. Increased leisure time and increasing mobility results in greater access to outdoor areas by the general public. A large percentage of the public are interested in leisure based activities such as picnics, barbecues, bushwalking, trail bike use, camping etc.

The metropolitan Region Scheme gives the Metropolitan Region Planning Authority total development control over all reserved land in the Region, including that which is privately owned. Thus, although an application to commence development on land reserved for parks and recreation on the Scarp may be approved, this would only occur after thorough investigation. Normally, such an application on privately owned land will result in the Authority commencing negotiations for the purchase of that land.

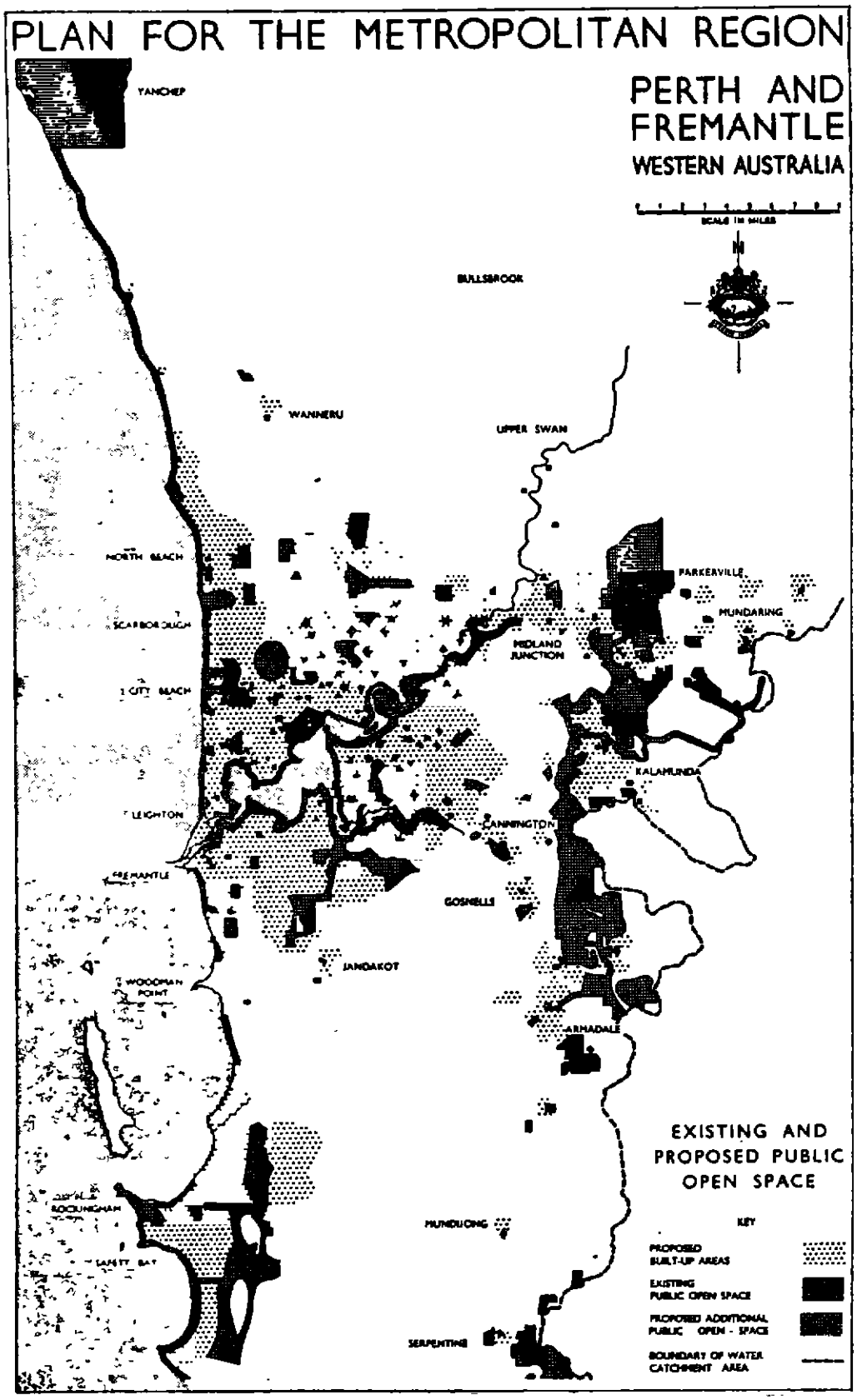
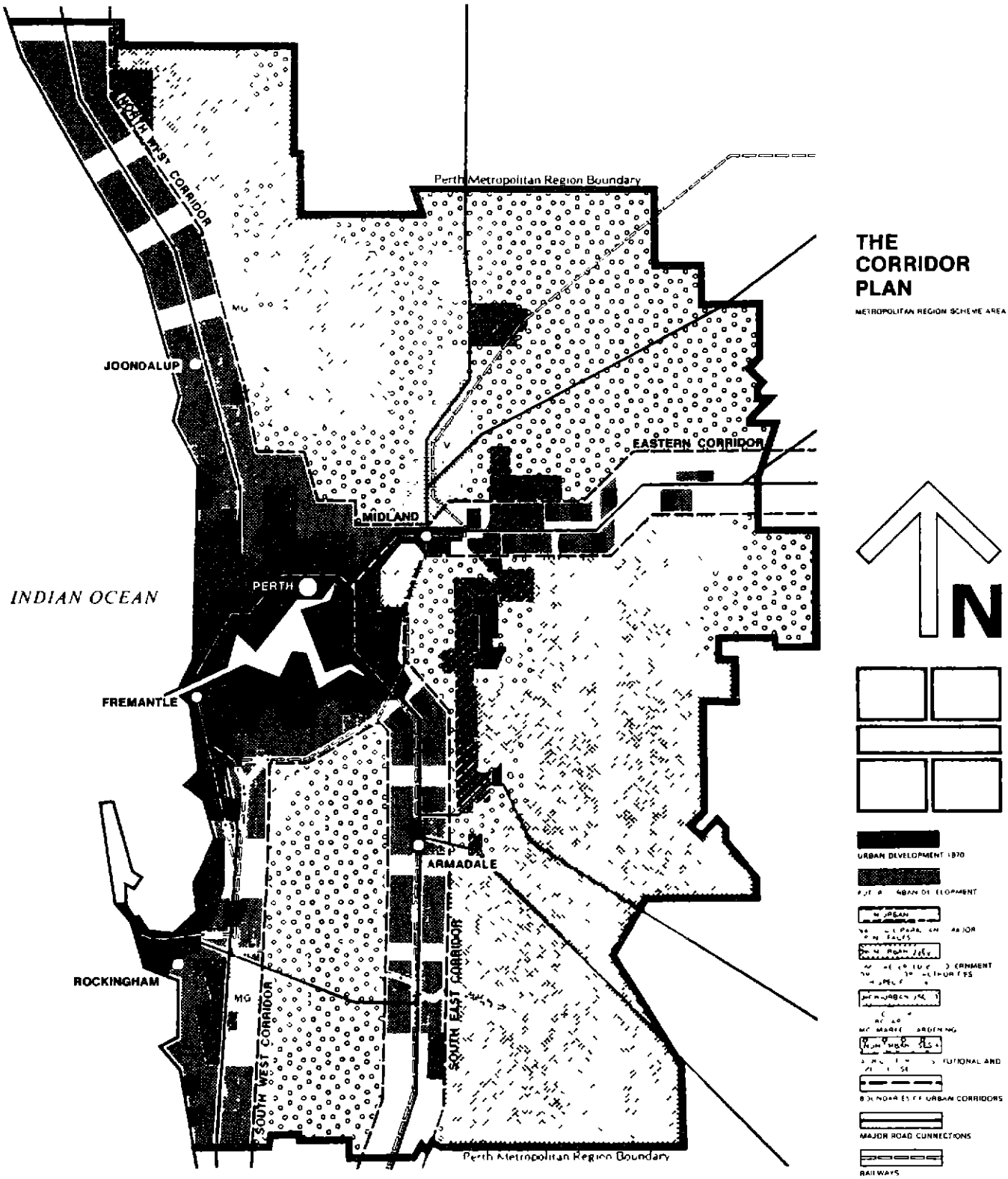


Figure 1. Plan for the Metropolitan Region.



Reproduced from. THE CORRIDOR PLAN FOR PERTH, The Metropolitan Region Planning Authority, Perth, 1970.

Figure 2 Corridor Plan

Darling Scarp Scenic Drive

For some time there has been expressed, particularly by the local authorities of Mundaring and Kalamunda, concern about the proposed Scenic Drive which forms part of the Metropolitan Region Scheme, and runs North South along the Scarp from Toodyaya Road to Albany Highway just south of Armadale. This scenic drive was inititated by the Stephenson-Hepburn Plan. The report for that plan, in emphasising the need to reserve land along the scarp face stated:

"It is strongly recommended that the escarpment edge should be held for the public. In a metropolis spread generally on flat coastal plain, it is of great importance to preserve a number of vantage points where good views can be obtained. This is a guiding rule in relation to the Swan River. The same principle should apply in certain parts of the Hills. At Kalamunda, the escarpment edge and an area on the hill top should be acquired and held for public recreation. The reserves of public open space created should be traversed by a scenic drive."

(Stephenson-Hepburn, 1955)

The concept of a continuous Scenic Drive was thus seen as an integral part of the open space system of the Scarp, providing access to the extensive parks and recreation reserves as well as linking points of scenic interest.

The Scenic Drive route - shown in principle in the 1955 plan - was subsequently incorporated in the Metropolitan Region Scheme in 1963, designated as an Important Regional Road.

The route is about 72 kilometres in length, running along the western face of the Darling Scarp between Albany Highway in the south and Toodyay Road in the north.

The sections of the Scenic Drive that have been constructed to date, amounting to some 38 kilometres, generally follow declared local road reserves serving existing urban and rural development, with a 9 kilometre section existing within John Forrest National Park.

The remaining sections of the gazetted route lie largely within or adjacent to land reserved for parks and recreation. For the most part, this land is in either MRPA or Crown ownership.

In recent years, the retention of the Scenic Drive as an Important Regional Road in the Metropolitan Region Scheme has become a somewhat controversial local issue - a factor which may be largely attributed to the increased residential development along the scarp and in nearby areas. Opposition to the current proposal has come from several quarters:

(a) Individual land owners whose properties abutt the road reserve.

(b) Community groups and local press, concerned that the Scenic Drive as gazetted would become a major traffic generator, thus spoiling the views and generally disturbing the 'peaceful' environs of the scarp.

(c) The Local Authorities through which the gazetted route passes - principally the Shires of Kalamunda and Mundaring, requesting the deletion of the Scenic Drive from the Metropolitan Region Scheme due to the likely costs of construction and in support of the opposition expressed by local residents.

(d) The Group "D" District Planning Committee, of the MRPA supporting the proposal of the Local Authorities to delete the road from the Scheme.

(e) Conservationists fearing the destruction of the natural landscape of the scarp. The Environmental Protection Authority's System 6 study although making no specific recommendation regarding the Darling Scarp Scenic Drive, drew attention to submissions received opposing the proposal due to the likely damaging affect of earthworks on valuable areas of Scarp bushland. As such the Study did not support the concept of a Scenic Drive along the face of the Scarp.

Further to this predominantly local opposition, the construction of the Scenic Drive as currently gazetted (i.e. as a continuous route along the escarpment) was not supported in either the Eastern or South-East Corridor Studies:

(a) Recommendation 59 of the Eastern Corridor Study (Taylor and Burrell, 1978, p. 257) suggested that:

"The Scenic Drive concept along the length of the Scarp be not pursued and instead access be provided by non through-traffic routes from a system of roads further east or west of the sensitive Scarp edges."

(b) The South-East Corridor Study Stage A Report (M.R.P.A., 1978, p. 111) re-iterated this view, recommending a planning concept for the hills area which included:

"..a Scenic Drive system to amend and augment the present scenic drive in the Metropolitan Region Scheme."

The proposed system was to be formed by a series of loops using existing roads and tracks where possible.

Therefore, while both these studies recommended that the concept of a continuous Scenic Drive be abandoned, they clearly acknowledged the need for some form of scenic drive/access system as part of the open space structure of the Darling Scarp.

This factor along with the increasing local interest in the matter, led to the MRPA accepting the need to evaluate the Scenic Drive route - as safeguarded in the Metropolitan Region Scheme and the revised route suggestion - as part of an overall study of the escarpment reserves. This study has not yet commenced, but its details and objectives have been set.

Management of Parks and Recreational Reserves

The Metropolitan Region Planning Authority was not established as a "Construction Authority", and until an amendment to the Act in 1982, the only avenue open to the Authority for development of open space was by way of an Improvement Plan. (e.g. Whiteman Park - Improvement Plan No. 8).

Similarly, until this amendment it was also doubtful if the Authority had the power to lease land it owned to bodies, such as Local Authorities. The new Clause, 27A, states:

"27A. The Authority may, with the approval of the Minister, carry out on land held by it that is reserved in the Scheme for the purposes of parks and recreation such works as may be incidental to the maintenance and management of the land or by conducive to the use of the land for such purposes and may, in order to facilitate the maintenance and management of such land, enter into an agreement with any person under which that person may acquire a lease of, a licence in respect of, or any other estate or interest in, any such land."
(Metropolitan Region Town Planning Scheme Act 1959 - 1982)

Although the Authority now has the Statutory Power to develop its land for the purpose for which it was reserved in the Scheme, this is basically subsidiary to its main objective of Regional Planning.

Consequently, management, and to a certain extent development of much of the Regional Open Space is still subject to discussion. At present the situation is handled by local authorities, and in the case of specific reserves, by the appropriate government agencies (Forests Department, Fisheries and Wildlife, National Parks Authority).

In the future however, as local authorities become aware of the expertise and cost involved in managing regional reserves, and as new outer reserves are selected to cater for an expanding urban area, further decisions on its management question will need to be resolved.

The Future

As stated earlier, the Metropolitan Region Scheme is a statutory document capable of being continually amended and reviewed to cater for an increasing and changing population. Regional Planning involves allowances for the future to a greater degree than the detailed planning undertaken by the local authorities.

The Metropolitan Region Planning Authority uses the resources of the Town Planning Department for investigation and research, and the predictions of other agencies where warranted.

In this regard the Environmental Protection Authority recommendations in System 6 Study Report are perhaps relevant. (See Figure 3, System 6 Proposals for the Darling Scarp and Avon Valley).

"(i) Selected portions of the Darling Scarp area should be classed as regional parks and planning developed according to that Concept.

(ii) The Environmental Protection Authority should endorse the Metropolitan Region Planning Authority's recommendation to 'reserve' portions of the Darling Scarp for Parks and Recreation under the Metropolitan Region Scheme.

(iii) The operators of existing and new quarries on the Darling Scarp should be required to present quarrying proposals, including an outline of options for the final use of the quarries when extraction is complete, to the responsible authorities.

(iv) Further subdivision of land on the Darling Scarp should be restricted.

(v) Detailed land use planning should be carried out for the portion of the Darling Scarp indicated. This should aim at minimising the visual and other impacts of quarrying and other land uses on conservation, recreation and scenic values, and on each other. It is recognised that such planning is proceeding with respect to aggregate resources" (Environmental Protection Authority, 1981).

There is no doubt that these points will influence the decisionson Regional Planning along the Scarp.

Finally, major changes along the Scarp in the future will also be in response to urban and regional growth. All forms of development, from quarrying to subdivision, require approval by various instrumentalities in accordance with MRPA Policy. Consequently when the "Brigadoon Country Estate" subdivision proposal was put to the Town Planning Board recently, the Authority was asked to comment. And, the preliminary

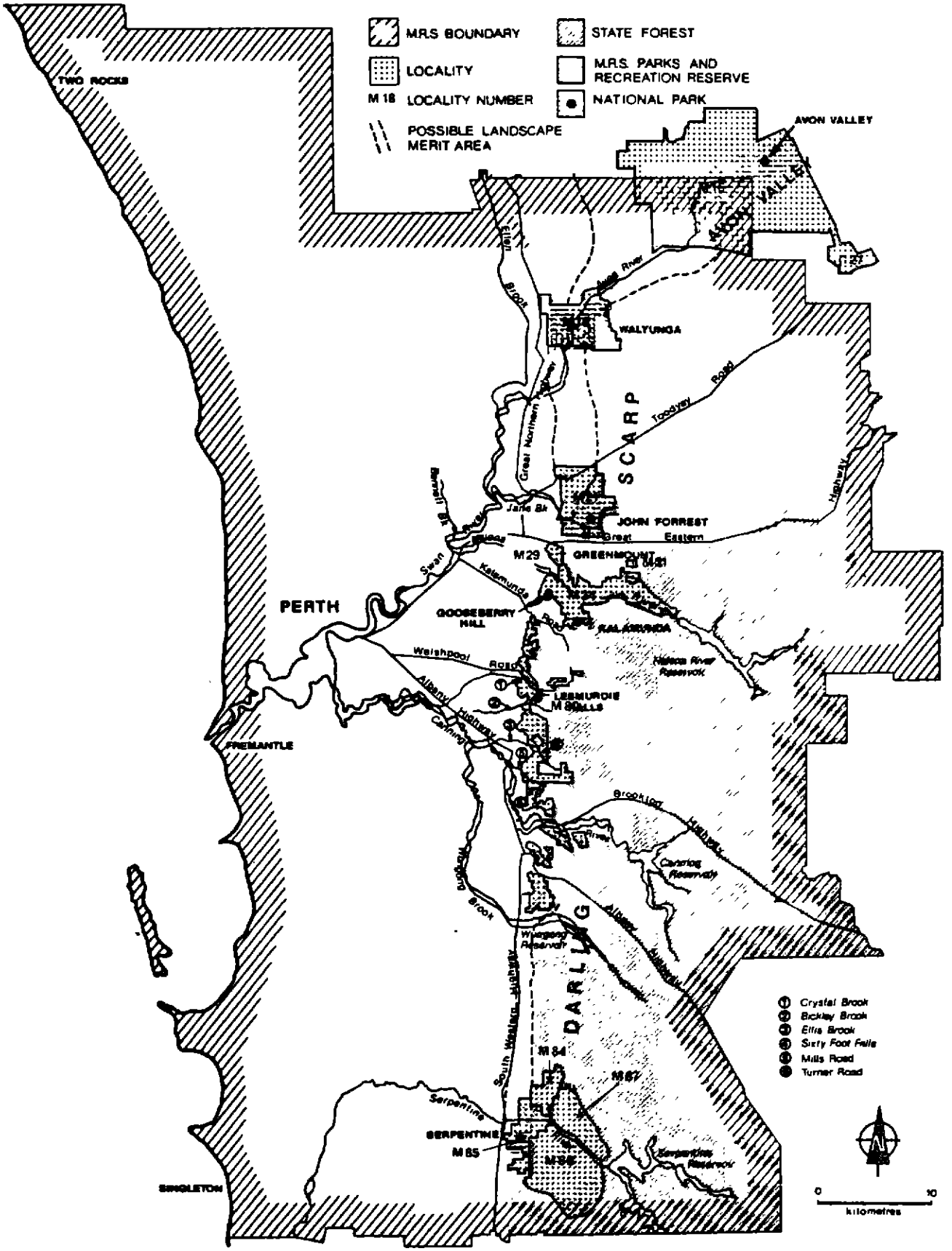


Figure 3. System 6 Proposal for the Darling Scarp and Avon Valley.

approval for the rezoning from rural to special rural in the Shire of Swan Town Planning Scheme, of this estate resulted in the Authority making a formal submission opposing the development. Not withstanding this, should that subdivision receive final approval, 590ha of land would become available for a Parks and Recreation reserve in the Region Scheme.

Development such as this estate is an indicator of the changing patterns and the expansion of the Perth Region. The Authority with its planning powers, has the ability to plan ahead in policy form, such as the Eastern Corridor Study, and thus ensure that future populations are as well served as present populations with regional reserves for Parks and Recreation. (See Figure 4, Regional Open Space Resource Concept).

Conclusion

The above comments give an outline of the postion of Regional Planning in Relation to open space along the Darling Scarp. The Metropolitan Region Planning Authority, while carrying out its primary function responds to the general requirements of a growing population, whilst recognising the value of the natural environment.

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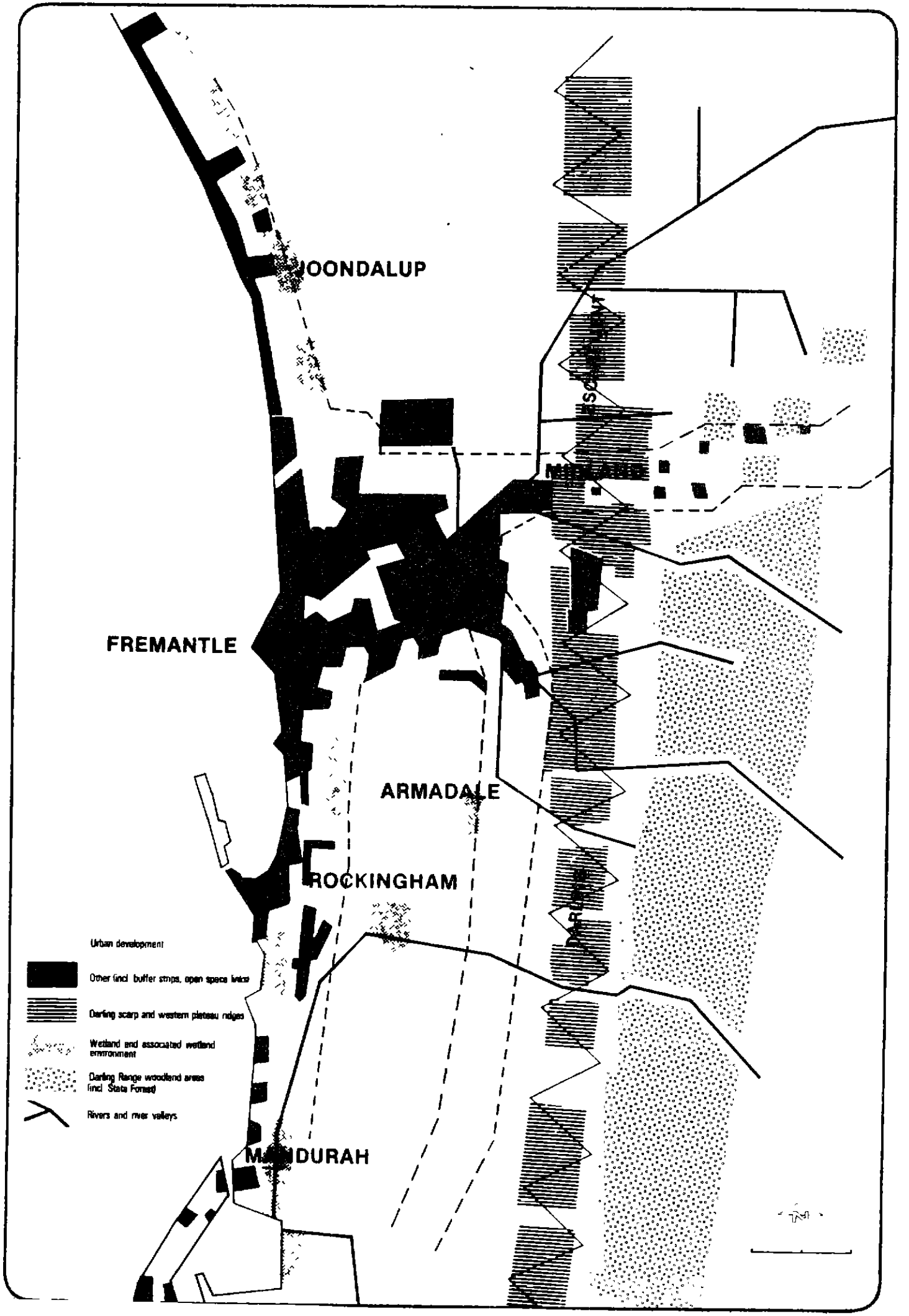
JOONDALUP
FREMANTLE
ARMADALE
ROCKINGHAM
MANDURAH
Urban development
Other (incl. buffer strips, open space lakes)
Darling scarp and western plateau ridges
Wetland and associated wetland environment
Darling Range woodland areas (incl. State Forest)
Rivers and river valleys

LOCAL GOVERNMENT PLANNING ON THE SCARP

D. Gray

Let me start off by defining what I mean by the Scarp. It seems to me that the area that should be of greatest concern is the face of the Scarp rising from the coastal plain and the immediately adjoining hinterland.

The Scarp so defined stretches well north and south of the boundaries of the Shire of Kalamunda and, of course, the Metropolitan region. However, I must limit my comments with the qualification of greater experience with the area in the Shire of Kalamunda; some knowledge of the areas to the north; but unfortunately less knowledge of the southern parts of the Scarp in the Metropolitan region.

The Metropolitan Region Scheme shows the broad proposals for land use along the Scarp and there is an obvious mixture with part Rural, part Regional Reserve for Parks and Recreation including some National Parks, and part Urban. This pattern of proposed land use is reflected in the various District Planning Shemes, and each of the Municipalities with part of the Scarp do, of course, have such a District Scheme.

Further eastwards the mixture of land use is further complicated with State Forest Reserves, and Water Catchment Reserves overlay other classifications. That is, Rural zoned land or Reserves for State Forest may have an overlaying reserve for Water Catchment.

Water Catchment areas and associated controls are important in local land use planning and the Lower Helena Water Catchment area is most significant for the Shires of Mundaring and Kalamunda. The Lower Helena Pipehead Dam is a major source of water which is pumped back up into the Mundaring Weir catchment for supply to country areas.

Interestingly, The Lower Helena Water Catchment area is not protected by a Reserve in the Metropolitan Region Scheme.

There are other water catchment areas for Metropolitan supply, some of these are currently used and some are planned for future development. Generally, these Metropolitan catchment areas are reserved in the Metropolitan Region Scheme.

The significance of the Metropolitan Region Scheme Reserves whether for Parks and Recreation, State Forest, or Water Catchment is that development applications for land in the Reserves or land abutting the Reserves, must be referred to the Metropolitan Region Planning Authority for determination.

With six Municipalities encompassing the area of the Scarp, and the potential for different planning philosophies and objectives, it is obvious that there is not a common approach to local land use planning issues.

But it must be acknowledged that where Reserves do exist in the Metropolitan Region Scheme there is the opportunity for consistency even if that doesn't come from the separate Local Authorities.

Without trying to delve too deeply into the process of administration of the Metropolitan Region Scheme, it should be recognised that the six Municipalities along the Scarp are members of Group District Planning Committees with the northern three in the Eastern Group and the southern three in the South Eastern Group. This membership of a Planning Committee which is meant to discuss regional planning issues as well as planning issues of common interest, does provide the base for consideration of issues affecting the Scarp.

Unfortunately, the District Planning Committees have not worked as successfully as some would like, and there has not been a great deal of discussion on planning issues affecting the Scarp.

The boundary between the two Group District Planning Committees is the boundary between the Shire of Kalamunda and the City of Gosnells and the existence of these Committees has resulted in a degree of introverted discussion with, for instance, the Shire of Kalamunda relating very much more closely with the Shires of Swan and Mundaring than its southern neighbour, the City of Gosnells.

So at a local planning level, what is the situation particularly in the Shire of Kalamunda?

Council has been able to adopt a report dealing with planning policies for the Foothills areas, but so far has been unsuccessful with a Hills Orchard Study covering the non urban parts of the District.

One of Council's prime concerns in initiating the Hills Orchard Study was to provide the means for encouragement for orchardists to continue with horticultural use of their land.

A draft Hills Orchard Study report was prepared several years ago and distributed to affected Public Authorities for comment prior to further discussion by Council. The reason for lack of further progress with the Study is that there are unresolved problems with the Public Works Department relating to land affected by the Lower Helena Water Catchment area.

The attitude of the Public Works Department, I believe, can be summarized as opposing anything which may result in any additional housing, whether that involves the further release of Crown Land or subdivision or re-zonings.

Scarp Symposium (Ed. J.D. Majer). Perth, 14th October, 1983. (W.A.I.T.: Bentley).

Council's objectives include tree preservation, land use control and statutory control of further subdivision. But recognise that in this process, there may be a trade-off which results in some subdivision.

So at the present time there is some disagreement between the Public Works Department and Council with respect to the Hills Orchard Study and, I must be pessimistic about the possibility of an early resolution to that conflict of interest.

So Council's decisions in the non urban eastern parts of the District are predicated on a study report which remains a draft report and has no formal acceptance. Decisions and recommendations made in accordance with the terms of that report would, therefore, be more vulnerable in an appeal situation than if the report was adopted and published as a Policy Statement. I suspect that there are similar situations existing with other municipalities along the edge of the Scarp where affected by Water Catchment controls.

As you would know, the Authority for determining subdivision applications is the Town Planning Board of Western Australia. Council is consulted on subdivision applications within the area of the Municipality as it is an affected Public Authority. The areas that are of greatest interest for subdivision are the eastern non urban parts, where in recent years Council has seen the incursion of the hobby farmer or person who simply wants to live on a larger lot in a rural environment. Often the satisfaction of these lifestyle ambitions has been at the expense of a productive orchard, and therein lies the concern of the Council in its preparation of the Hills Orchard Study.

The Town Planning Board, in adopting the Rural Smallholdings Policy Study Report adopted a minimum lot size of 12 ha for the Hills Orchard areas. Council has in the past had some disagreement with this minimum lot size on the grounds that it referred to a commercial orcharding business employing labour and not a commercial orcharding family operation.

However, that is only part of the question, the other part being the need to provide for the rural residential demand whilst recognising the viable orcharding properties.

To that end, it has been proposed that the viable orcharding properties which exhibit the characteristics of suitable soil types and water supply be classified for intensive horticultural purposes in the District Planning Scheme with land use and subdivision controls.

The remaining land could be recognised as suitable for rural residential purposes, but with the need for development controls and tree preservation. A different lot size could apply in those areas. The different lot sizes could be say 12 ha in the intensive horticultural areas, and perhaps 4 ha for the rural residential use. Statistical analysis of existing lot sizes would indicate that these minimums would deny subdivision potential to almost all properties in the eastern non urban parts of the District.

Residents of the Shire of Kalamunda often refer to the "rural character" of the area as one of the paramount reasons for them deciding to live in the District. Interestingly enough, this comment comes from people throughout the District, from people living on 700 square metre lots, one hectare Special Rural lots, to the large rural properties.

This attitude is reflected by Council in several Policy Statements and is a consideration in assessment of development applications.

This consideration of preservation of the environment and care for the amenity of an area can lead to positions of conflict with Public Authorities, and even with the Metropolitan Region Planning Authority.

An example of the latter is the Scenic Drive proposal which is shown in the Metropolitan Region Scheme as a blue road - an important Regional Road - along the face of the Scarp.

There have been a number of questions raised with the Authority about the validity of the Scenic Drive concept and Council has taken the position of requesting the Authority to review the need for retention of the reservation in the Region Scheme.

At one time a consultant's brief was prepared by the Authority for assessment of the road concept, but funding was not available and the review did not proceed.

The Council, in company with other affected Local Authorities, is concerned about the impact of the Scenic Drive on the Scarp, particularly those parts of the road where no road reservation or carriageway now exists. Even where there is a road reserve or a carriageway now, a Scenic Drive would have a significant impact through upgrading.

These concerns relate principally to the local impact of such a road with, as a lesser priority, concern about the visual impact from some distance, for this road would require substantial earthworks to be completed.

Related to construction of this road is also the concern that it would serve as a local collector as it would be the most westerly north-south link between Welshpool and Kalamunda Roads.

Another section of the Scenic Drive could provide a more direct link between Toodyay Road and the Great Eastern Highway, although this would depend on alignment through the John Forrest National Park.

The problem of the Scenic Drive remains unresolved and I believe that it is one of the major decisions that will have to be taken by the Authority affecting the environment of the Scarp.

There has been some tourist intrusion into the Parks and Recreation Reserve along the face of the Scarp, with a notable area being Lesmurdie Falls. You will no doubt also be aware of the current publicity for walk trails, many of which include parts of the face of the Scarp. Obviously, public usage is currently being encouraged, albeit still at a limited scale.

Public usage and appreciation of the reserve along the face of the Scarp could be improved with a major attraction such as the often mentioned international restaurant on a prominent location on the Scarp with panoramic outlook over the coastal plain and through to Rottnest. When I say that this is an often mentioned proposition the references have been whispers and I am not aware of any serious proposition being put the the M.R.P.A. Such a development would, no doubt, create problems but these should be capable of resolution.

There are problems with management of the Parks and Recreation Reserve along the Scarp and I believe that some selective and licensed private occupation would allow for better management without obvious denial of the original principles of the Scarp being reserved as a regional asset.

There is some concern with reservation without implementation of management, and it is considered insufficient to deal with fire breaks on an annual basis and give little attention to the day to day problems of the reserve, such as littering, trail bike riders, and horse riders. These problems are not solved by proliferation of regulatory signs.

There is a recognisable dichotomy in encouraging public usage such as with the walk trail programmes against the issues of environmental protection. Perhaps they lead back to the management question of allowing some occupation on a licensed basis with caretaking responsibilities.

The title of this paper originally encouraged me to believe that it would be relatively simple to prepare. However, I very quickly became conscious of the multiplicity of problems and the possibility to devote all of may time to one selective part of local land use planning concern. In deciding not to concentrate in that way, but to try and give some degree of overview, I may have appeared to gloss over an issue which you consider to be of great relevance. If that is the case, perhaps you would direct your questions and further enquiries to those issues.

CO-ORDINATION OF LAND USE AND MANAGEMENT OF THE DARLING SCARP

F.E. Batini

Introduction

In this paper I propose to describe key issues which affect land use planning and management; to discuss action which has been taken to address these issues; and to propose some desirable features for an appropriate planning mechanism.

Elements of Similarity Between Planning for Land Use in the Scarp, the Coast, Town Planning, the Darling Range and the Karri Forest

* The area can provide various benefits or resources, e.g. minerals, recreation, landscape etc.

* Demand is greater than supply. Some demands are unsatisfied and there is competition for land. Public goods (such as land) are often underpriced.

* Some resources are readily quantifiable in economic terms (e.g. $, jobs), others are not (landscape).

* Benefits to some (economic/recreational) may cause disbenefits to others (views, noise, litter). There is a tension between the present and the future.

* Adequate research data are often unavailable.

* The issues are complex. Several parties with different perceptions are involved in the debate:

Local Government
State Government
Australian Government
Industry
Developers
Residents
Public

* Issues are often politically sensitive (coverage, emotion, pathos, newsworthiness), because public goods are allocated by Governments.

* Often there is no clear jurisdiction (e.g. on Tenure). Acts are overlapping and confused, reflecting the narrow perspectives of Departments. There is no centralised authority except Government (Cabinet). The parts are managed adequately, but the whole may be mismanaged.

* Sometimes there is no provision for appeals. Standing is not recognised by Australian Courts. Courts in the U.S.A. and the N.S.W. Land Environment Court are often used as a model.

* There are many opinions, but few workers generating objective comparisons and evaluating alternatives.

* There is a desire to incorporate the public in the decision process.

Action which has been Taken to Address this Type of Issue in W.A., and in Australia

W.A.

Statutory

Metropolitan Regional Planning Authority(Figure 1)
Town Planning (Figure 1)
Local Authority Planning (Figure 1)
E.P.A.

Reports

Graham (Figure 2)
Gorham (Figure 3)
Stanford (Figure 4)
Darling Range Study Group (Figure 5)
Coastal Management Committee
System 6 Report (Figure 6)

VICTORIA

Land Conservation Council
State Co-ordination Council (Figure 7)

N.S.W.

Planning and Environment Department (Figure 8)
Premier's Department

QUEENSLAND

State Co-ordinator's General Department

Desirable Features of an Appropriate Planning Mechanism

* Adequate analysis, staff and evaluation. Framework not reactive planning.

* To involve appropriate bodies, at the appropriate level.

* Comprehensive, but not buried in red tape, or with undue delays, or unecessary costs.

* Reports to be made public; reports to Premier; reports to examine alternatives, setting out pros and cons.

* Statutory or non-statutory? Either could work.

Scarp Symposium (Ed. J.D. Majer). Perth, 14th October, 1983. (W.A.I.T.: Bentley).

* Independent Advisory Group reporting to Premier. Staff 4 - 10. Advisory Group to interact with three committees representing:

  Government (State) Departments
  Industry
  Public and Local Government

* Goodwill and trust between the participants.

References and Further Reading

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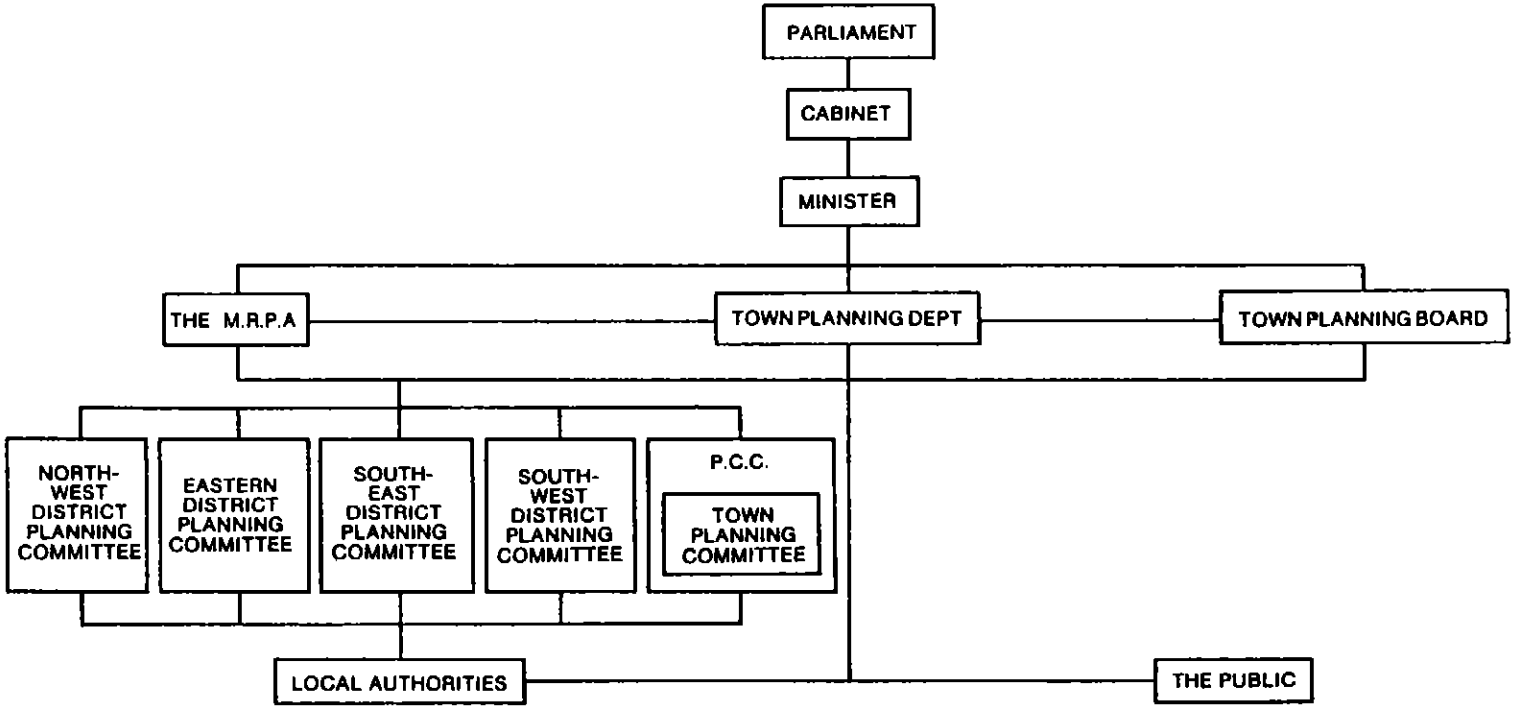


Source: MRPA Annual Report July 1981

Figure 1. A simplified organisational framework of planning authorities in Western Australia.

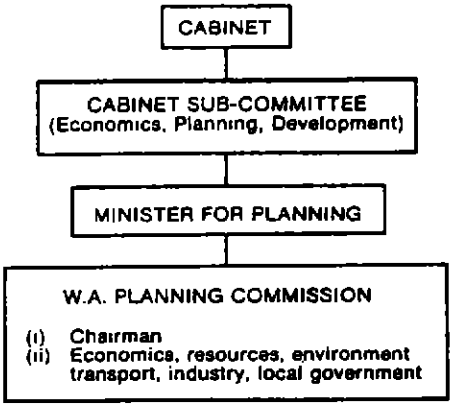


Figure 2. Recommended planning mechanisms: The Graham Report (1977).

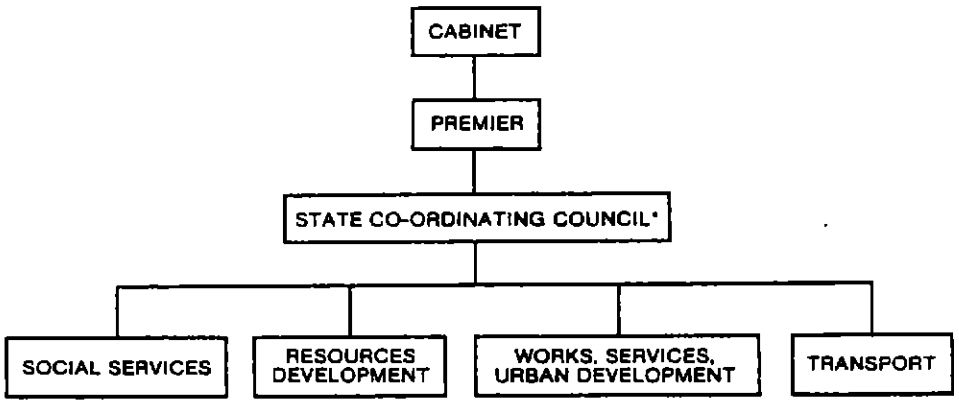


Figure 3. Recommended planning mechanisms: The Gorham Report (1979).

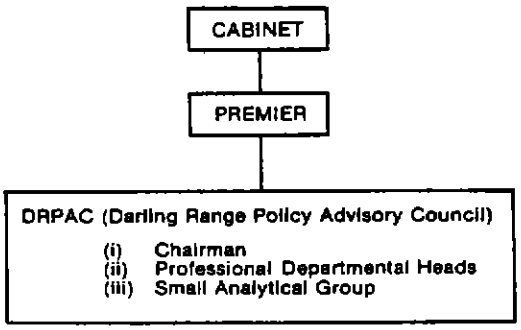


Figure 4. Recommended planning mechanisms: The Stanford Research Institute Report.

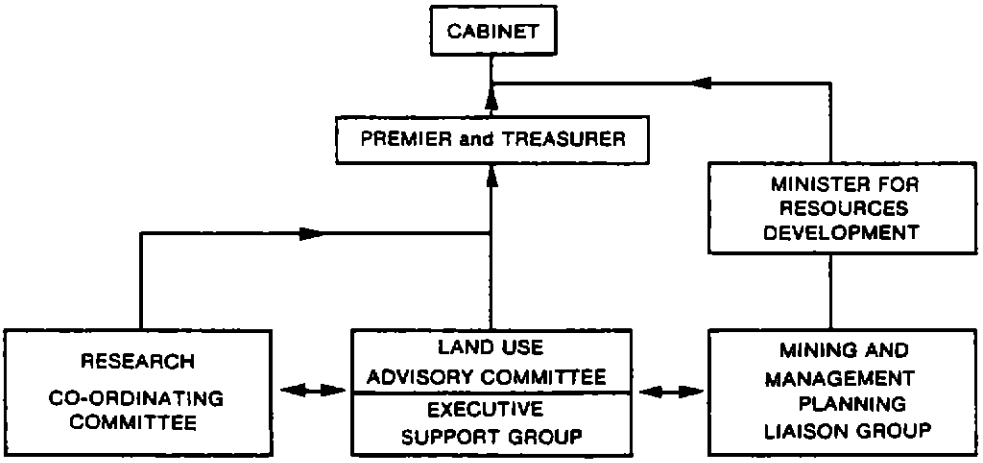
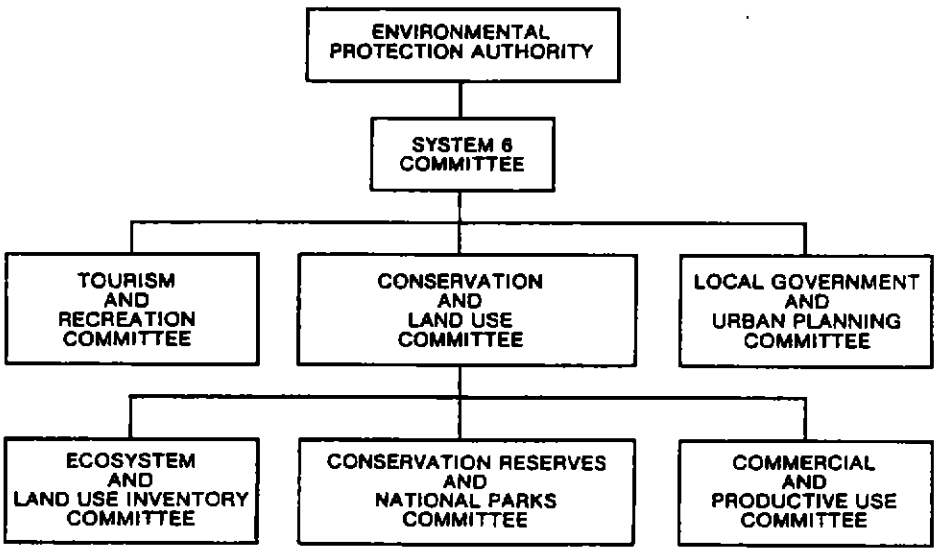
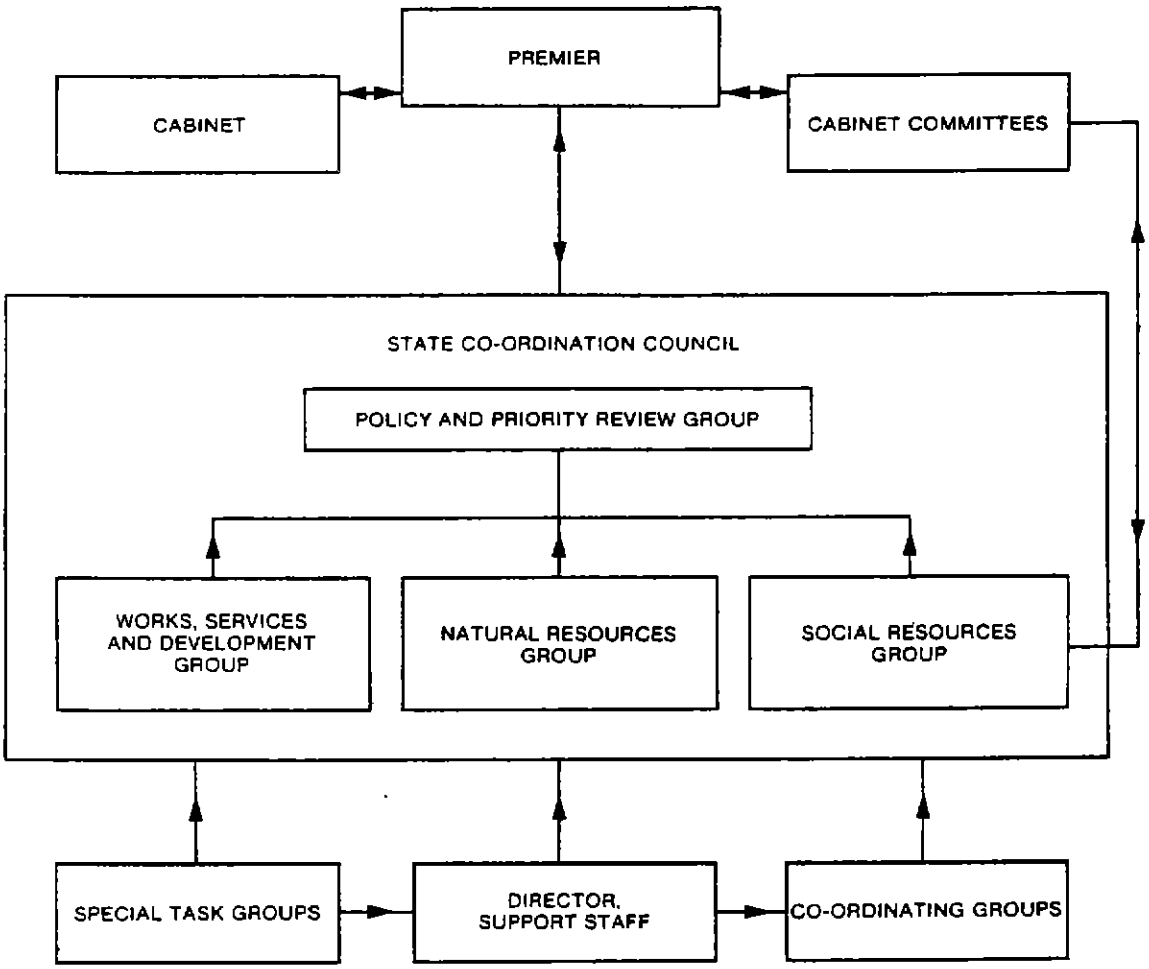


Figure 5. Recommended planning mechanisms: The Darling Range Study Group Report. (Organisational arrangements for Land Use Advisory Committee, Executive Support Group and related committees).



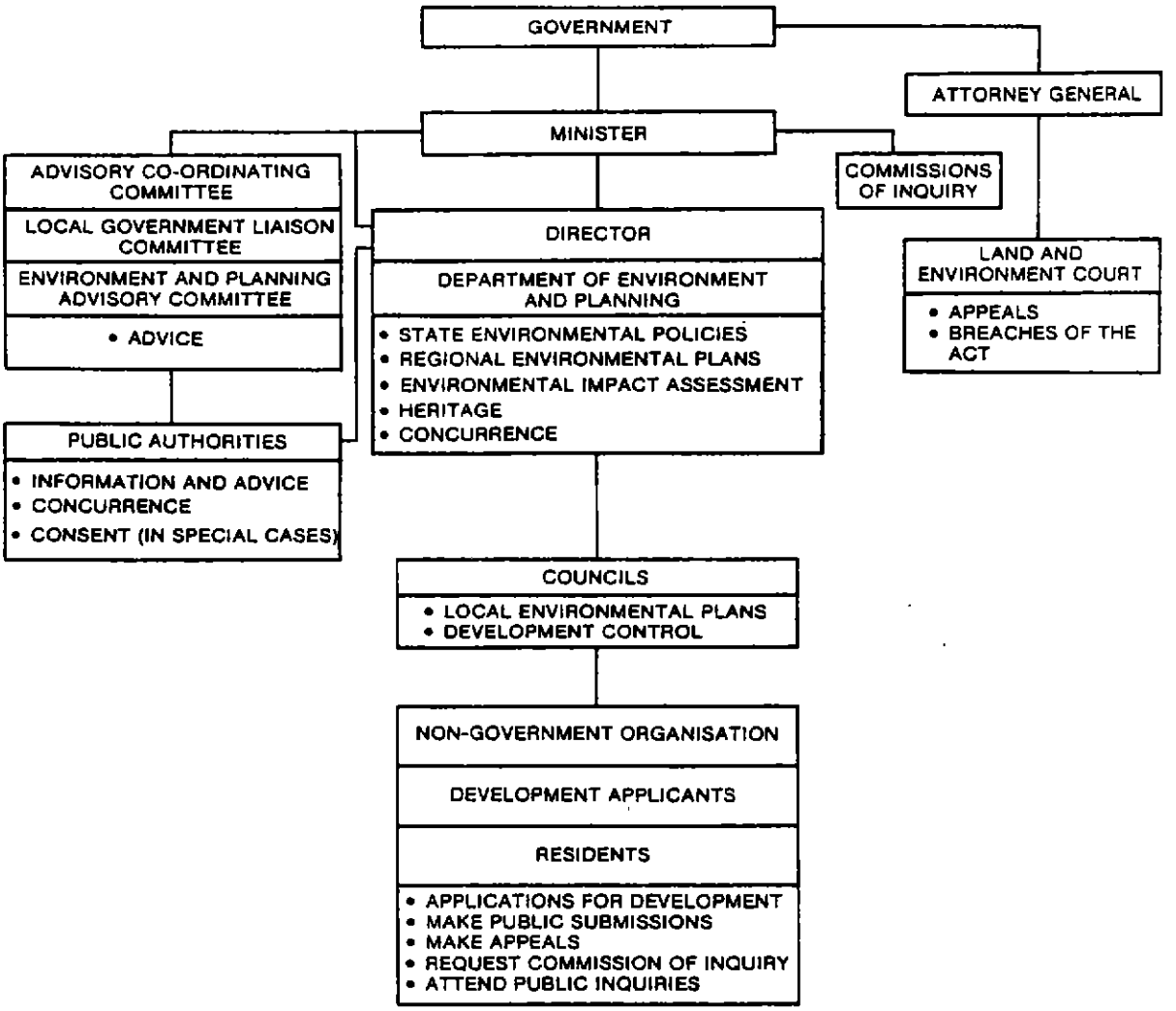
For detail of the committee membership refer to the System 6 Study Report. April 1981

Figure 6. System 6 Study organisation chart.



Source Report of the State Co-ordination Council (1980)

Figure 7. Victoria. Organisational arrangements of the State Co-ordination Council.



Source. Department of Environment and Planning Sydney, September 1980.

Figure 8. Organisational arrangements of the NSW Planning System.

APPENDIX Extract from System 6 Study Report showing information relevant to the Darling Scarp (reprinted by courtesy of the Director, Department of Conservation and Environment).

OPEN SPACE RESOURCES OF SYSTEM 6

6.1 General

In this Chapter major features and regions of System 6 are considered in terms of their value as an open space resource. Specific recommendations for zoning or 'reservation' of land as open space are not made, since, as we have already indicated, these should result from public planning processes by appropriate planning authorities. Instead, broad planning and management goals in respect of conservation and recreation are indicated for certain parts of System 6.

Consequently the considerations presented earlier, particularly the planning concepts outlined in Chapter 5, are especially relevant. We indicate parts of System 6 where, in areas with a mixture of private and public land, there are important opportunities for conservation of natural areas and for their recreational use. These opportunities can be exploited through town and country planning processes. The areas concerned are largely outside the State Forests of the southern Darling Range and northern Coastal Plain. They also include a number of natural features of regional importance where the regional parks concept is applicable. Nevertheless, this Chapter only draws attention to and does not comprehensively review the open space resources of System 6.

Within the Metropolitan Region the MRPA has made significant moves towards providing land for public recreation. Substantial areas have been zoned or 'reserved' for this purpose, and a large proportion of the land has been purchased by the Authority.

The Study has generally endorsed the MRPA's 'reservation' proposals though some modifications and a few recommendations for 'reservation' of new areas have been made. These are detailed in Chapter 10. Outside the Metropolitan Region there are many attractive areas where the opportunity for 'reservation' or zoning exists, but the necessary planning is difficult to implement at present. This is partly because many features, for example river valleys, come under the control of several local and other authorities.

While the areas discussed in this Chapter are not the subject of recommended zonings, they could usefully be considered by planners in the future. They are based on submissions to the Study from such bodies as the Department for Youth, Sport and Recreation, the Department of Tourism, and various individuals and associations, as well as work by constituent committees of the System 6 Study.

6.2 The Darling Scarp

The Darling Scarp is the dominant physical feature of System 6. It is most conspicuous immediately to the east of Perth, where it rises abruptly to a maximum height of about 300 m. The Scarp is extremely important in providing an attractive visual backdrop to Perth. As shown in Figure 6.1, most of the portion of the Scarp under consideration, together with the Avon Valley upstream to

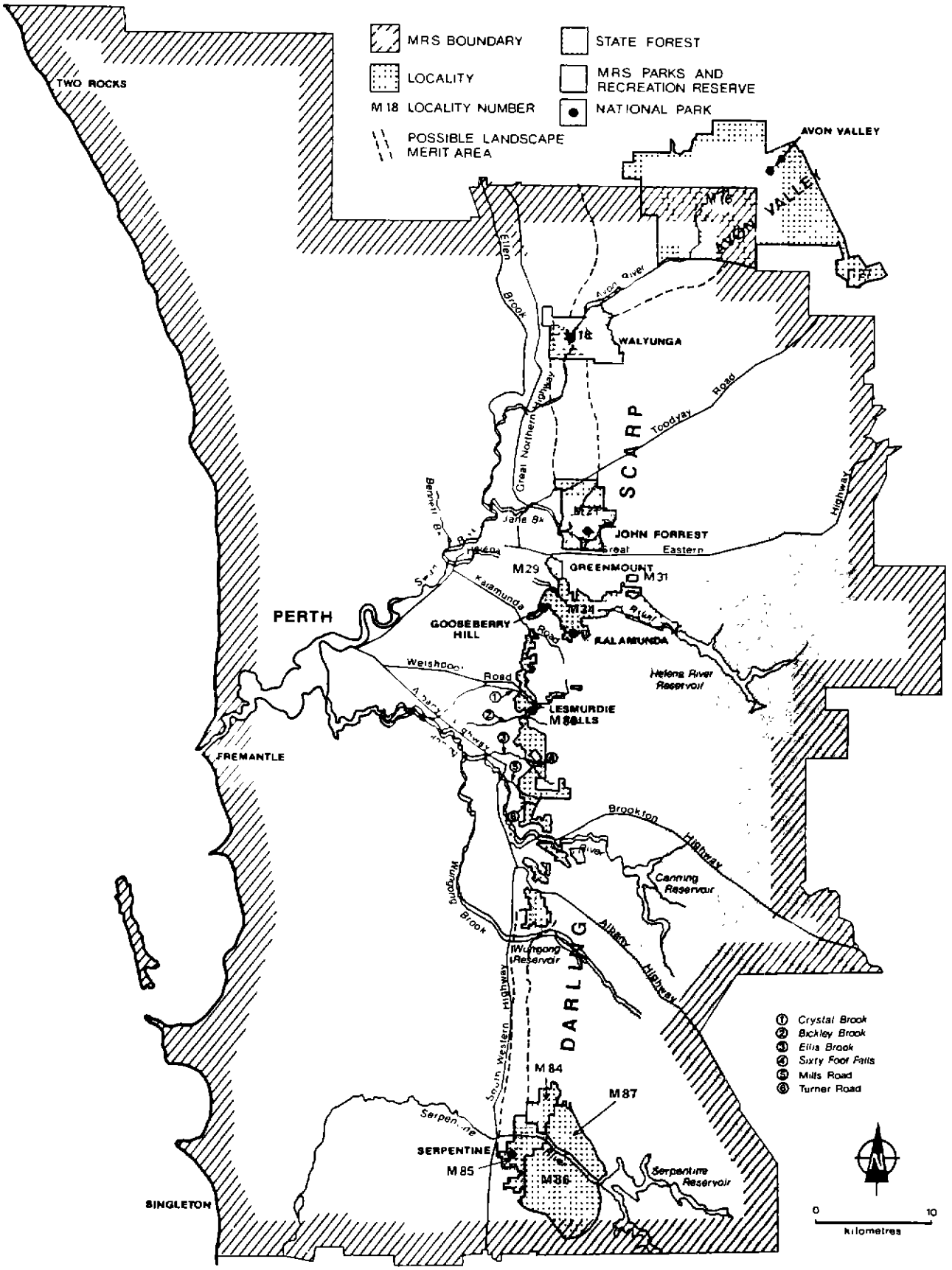


Figure 6.1 Proposals for the Darling Scarp and Avon Valley

Avon Valley National Park, is either 'reserved' for Parks and Recreation under the Metropolitan Region Scheme or has been identified by the MRPA in its submission to the Study as having landscape merit These areas comprise most of the uncleared land on the Scarp, together with some attractive rural areas.

Together, they form an elongated area of potential open space which is almost continuous for roughly 100 km. Several specific localities are the subject of detailed recommendations in Chapter 10 (see Figure 6.1) Major land uses on the Darling Scarp include large areas of residential development and, to the east, orchards and small holdings, and vast uncleared areas of State Forest and water supply catchment. To the west the Scarp is linked to built up areas by open space in the form of narrow river valleys. These include the valleys of the Canning and Southern Rivers (M75)*, Helena River (M33), Jane Brook (M20), and the Swan-Avon River (M19).

The Darling Scarp between Lesmurdie Falls and Turner Road, Roleystone, contains some of the best Scarp bushland remaining near Perth. It includes picturesque scenery on the Scarp itself and within the valleys, and provides vantage points for panoramic views across the Coastal Plain.

Many valleys have a winter-flowing stream and several have attractive waterfalls and rapids. Wildflowers display from August to October, and some areas are still relatively undisturbed and have high value for flora conservation.

The Darling Scarp as a whole supports vegetation and plants found nowhere else, even within the south-west. Due to the variety of landform and rock formations, such as granite outcrops and the edge of the laterite plateau, there is a variety of vegetation types present including heath, forest and woodland. The heath and understorey of the forest and woodlands are rich in shrubs and herbs. A more detailed description of the geology, landforms, soils, vegetation and land use is given in the Darling System Atlas.[6]

Floristically, the most important areas close to Perth are the spur and valley to the south of Crystal Brook; the north side of Bickley Valley; Ellis Brook Valley, where there is an occurrence of the rare *Eucalpytus lane-poolei* above the waterfall, and the spur to the north; and the valley through which Mills Road passes. These areas require further protection and careful management.

The Darling Scarp near Perth is particularly valuable for recreation, due to its ready availability to large numbers of people, especially within the Metropolitan Region. It is suited to non-motorised active uses such as bushwalking and rock-climbing, and contains numerous scenic vistas and potential picnic areas.

The Scarp is also an important source of prime aggregate rock used for building and other purposes. This is an industry which is long established, nearly 50 years old in the case of at least one quarry. The resiting of quarries would cause substantial increases in the cost of aggregate rock. Conceivably, areas from which basic raw materials are secured are useful both before and after extraction for a multiplicity of uses and are not rendered permanently sterile for community use. The Darling Scarp is also subject to pressures for residential subdivision, additional roads, powerlines and other services. All these uses have or would have adverse impacts, reducing the area's conservation, scenic and recreational value.

Quarrying operations may be constrained by other uses, particularly residential development, thus exerting pressures to displace the quarrying into areas of prime conservation or aesthetic value. The Darling Escarpment Aggregate Resources Committee, which is currently investigating quarrying on the escarpment, reports to the Basic Raw Materials Committee of the MRPA.

A number of submissions to the Study discussed the possibility of a scenic drive along the face of the Scarp. As they envisaged it, such a road would cross a number of spurs and valleys, would thus require extensive earthworks and would have a particularly damaging effect in the area described above as being the most important floristically While the majority of submissions opposed the proposal, several agreed with it. The concept of such a scenic drive has not been supported by this Study.

The detailed recommendations in Chapter 10 largely endorse the MRPA 'reservations' and zonings which, with some additions, would provide for the protection of the visual backdrop provided by the Darling Scarp. The long and attenuated shape of the area, and the variety of ownership and priorities of use clearly indicate the need to co-ordinate planning and management in the ways outlined in Chapter 5. The regional parks concept will have particular relevance.

Recommendations

6 (i) Selected portions of the Darling Scarp area, as shown in Figure 6.1, should be classed as regional parks and planning developed according to that concept.

*Reference in parenthesis identifies localities which are the subject of detailed recommendations in Chapters 9 and 10

(ii) The Environmental Protection Authority should endorse the Metropolitan Region Planning Authority's recommendation to 'reserve' portions of the Darling Scarp for Parks and Recreation under the Metropolitan Region Scheme.

(iii) The operators of existing and new quarries on the Darling Scarp should be required to present quarrying proposals, including an outline of options for the final use of the quarries when extraction is complete, to the responsible authorities.

(iv) Further subdivision of land on the Darling Scarp should be restricted.

(v) Detailed land use planning should be carried out for the portion of the Darling Scarp indicated in Figure 6.1. This should aim at minimising the visual and other impacts of quarrying and other land uses on conservation, recreation and scenic values, and on each other. It is recognised that such planning is proceeding with respect to aggregate resources.

M80 DARLING SCARP

The area extends from Kalamunda Road in the north almost to Wungong Brook in the south. It includes the Scarp face itself, portion of the Darling Range immediately east of the Scarp, and portions of the upper slopes and ridges above the south of the Canning River (Figures 150A to 150F)

The area runs north-south for a distance of about 24 km It comprises numerous Land Act Reserves, and freehold land, owned privately and by the MRPA. Most of it is 'reserved' for Parks and Recreation under the Metropolitan Region Scheme. Additional land has been proposed for 'reservation' in the Stage A South-East Corridor Report.

In the area from Kalamunda Road in the north almost to Brookton Highway in the south, the land outside the existing Parks and Recreation boundary comprises: lot 8 (Location 222), lot 5 (Location 300), part of Reserve C12083 (near Albert Road), part of Armadale AA Lots 453 and 467, Locations 450, 451 and land to the north-west of these, Locations 1, 2, 3, 5, 6 and 23 (near Gosnells Road), the western portion of Location 338 and part of a subdivision south of Armadale AA Lots 134 and 135 (adjacent to Brookton Highway) (Figure 150A to D)

Further south, to the east of Armadale and north of Albany Highway is an area often known as the 'Armadale Common', consisting of Reserves C4127 for Common and Timber for Settlers, C25022, C25023, C25024, C25025 and C25026, all for Gravel, all vested in the Town of Armadale; and C33742, for Public Recreation, not vested; lot 4 (Location 31) owned by the MRPA; Part lot 188, lot 189 (Location 31), lots 3 and 91 (Location 631), and Locations 1357 and 2004, privately owned freehold land, (Figure 150F).

Further east from the 'Armadale Common' area described above is an area consisting of the slopes on either side of Churchman Brook. This area comprises lots 10 and 50 (Location 31), part of Part Lots A and 1, lots 1, 3, 4, 10, 11, 12, 36, 37, 40, 41 and 103 and part of lots 1 and 100 (Location 32), all owned by the MRPA; and lot 4 and part of lot 1 (Location 31), part of lot 1 (Location 681), freehold land mostly owned by the MRPA (Figure 150E).

To the south of the 'Armadale Common', in Bedfordale, is Bungendore Park. This area comprises Reserves A4561, for Parklands, vested in the Town of Armadale; C10433 for Gravel, not vested; and vacant Crown land (See Figure 150F).

The Scarp is the most prominent landform in System 6, rising to a maximum height of 300 m. It consists of granite outcrops, ridges, valleys supporting winter-flowing creeks, several 'hanging' swamps, dolerite dykes, laterite screes and the laterite capping of the western edge of the Darling Range.

Most of the Scarp flora is represented in the areas described above. There are open-forests of jarrah and marri, marri and wandoo woodlands, small areas of paperbark, and flooded gums along the creeks There is a stand of the very rare salmon white gum *(Eucalyptus lane-poolei)* above the Sixty Foot Falls on Ellis Brook. The second storey includes such species as bull banksia, rock sheoak and parrot bush. Bungendore Park supports a rare species of dryandra *(Dryandra praemorsa)*. Throughout the area are blackboy and zamia as well as several stands of black gin. The heath and groundstorey are very rich in species, which include hairy jugflower, acacia, Wilson's grevillea, *Grevillea endlicherana*, and an unnamed species of buttercup which is restricted to the top of the Scarp east of Perth. There is a variety of herbaceous plants, including orchids, trigger plants, lilies and small sedges. Bracken is common on the southern slope of Bungendore Park, above Wungong Gorge.

The most important areas floristically are the spur and valley to the south of Crystal Brook, the northern side of Bickley Valley, the Ellis Brook Valley above the Sixty Foot Falls and the spur to the north of this valley, the valley through which Mills Road passes, and the western and southern slopes of Bungendore Park. These areas all require particularly careful management, with the control of bush fires requiring special attention, and they should be managed primarily for conservation, with some provision (e.g narrow walking paths) for recreation activities. The impact of trail-bikes is currently a problem.

The high recreation value of the area stems from the variety of activities for which it is attractive. These include walking, picnicking, sight-seeing, nature study, rock climbing on both natural and man-made rock faces, and the use of trail-bikes in disused quarries. Currently popular areas include Lesmurdie Falls and the Bickley Valley. The rock faces at Churchman Brook provide a valuable resource for rock climbers, both in rescue training and for recreation. The portions of the Scarp under consideration are particularly important in that they provide an almost continuous north-south open space link, adjacent to major residential areas, and within easy access by major roads and by public transport.

Scenically, these portions of the Scarp contrast with other areas which have been partly cleared, developed for residential use, or which are dissected by east-west or north-south roads. The Scarp

forms a natural skyline behind much of the city, and provides panoramic views over the city and the Coastal Plain and even as far as Garden Island. The 'Armadale Common' area provides a visual backdrop to the rural holdings of the valleys to the north and south. From the ridges and spurs along the Scarp there are attractive views into adjacent valleys, for example, Ellis Brook and the Sixty Foot Falls, Mills Road Valley, the Canning River and Churchmans Brook, Neerigen and Carradine Brooks, and the rugged Wungong Gorge

The concept of a 'regional park', as discussed in Chapter 5 of this Report is relevant. The Scarp is extremely valuable to the entire Perth region as a resource for conservation and recreation, and its scenic value is very high As it falls within a number of local government areas, overall co-ordination of management is necessary.

Although much of the vegetation is in its natural state, ground flora has been disturbed or destroyed in places, as a result of clearing, grazing, gravel extraction and rubbish disposal. However, revegetation of some of the gravel pits in Bungendore Park has already begun. Some of these sites may be suitable as picnic areas

There are several SEC powerlines in the area, and more are proposed. The area may also be affected by proposals for a gas pipeline, a tunnel from Wungong dam, which may have its exit within Reserve A4561 (Bungendore Park), and the upgrading of Welshpool Road. Roads in the area should be excluded entirely from the valley south of Crystal Brook and the Ellis Brook Valley and no further roads should be constructed in the Bickley Valley and the Mills Road Valley. Portion of the area is within the Alcoa Mining Lease but has no potential for bauxite mining. There are deposits of white clay immediately south of Bungendore Park. Portions of the Scarp are affected by prime aggregate quarries, the aggregate being important for concrete production, building and road construction. There is currently some pressure by quarry companies to expand, especially into the ridge between Ellis Brook Valley and Mills Road Valley. Although this land is 'reserved' by the MRPA under the Metropolitan Region Scheme, there is some doubt about the legalities concerned. The MRPA's Basic Raw Materials Resources Committee is currently investigating quarrying on the Scarp, for the Minister for Urban Development and Town Planning. In investigating alternative quarry sites the Committee should take into account several criteria including cost of extraction of rock, visibility from the Coastal Plain and from other locations on the Scarp, effect on recreation use patterns and the floristic value of any uncleared land.

The MRPA, following its Stage A South-East Corridor Report, is 'reserving' western and southern extensions to Bungendore Park to include Wungong Gorge, comprising Locations 49, 54, 59, 62, 93, 94, 97, 98, 144, 196, 198 to 202, 239, 291, 307, 309, 538, 553 and 632, all freehold land (Figure 150F). This 'reservation' would enhance the value of the Scarp as a potential regional park, as the valley floor would provide an area suitable for more intensive recreational use than is desirable elsewhere along the Scarp.

The discussion of the Darling Scarp in Chapter 6 is relevant

Recommendations

M80 1 The area within the stippled boundaries shown in Figures 150A to F should be considered as a potential regional park

M80 2 The Metropolitan Region Planning Authority should consider 'reserving' those portions not already 'reserved' for Parks and Recreation under the Metropolitan Region Scheme.

M80 3 The Metropolitan Region Planning Authority, in consultation with the relevant authorities and local land owners, should define management objectives for the area and seek ways and means of achieving those objectives, either through joint management arrangements or, where necessary, acquisition of freehold land. Consideration should be given to:

(a) concentrating recreational activities and vehicular access away from floristically important localities, for example, at the top and base of the Scarp;

(b) ensuring that vehicular access is not continuous north-south along the Scarp and that only non-motorised activities are permitted off any sealed roads,

(c) developing narrow walking paths but not horse riding trails in floristically important areas,

(d) developing disused quarries and gravel pits either for recreational use (e.g. picnic sites) or through rehabilitation of their native flora,

(e) ensuring that no more gravel is extracted from Reserve A4561

M80 4 Until such time as the regional park concept may be incorporated in legislation, a committee for the area should be set up by the Metropolitan Region Planning Authority to advise appropriate authorities and interested parties.

M80.5 The Metropolitan Region Planning Authority's Basic Raw Materials Committee should give consideration to

(a) the high conservation, recreation and scenic values of this portion of the Darling Scarp and the planning and management objectives of the managing body/bodies;

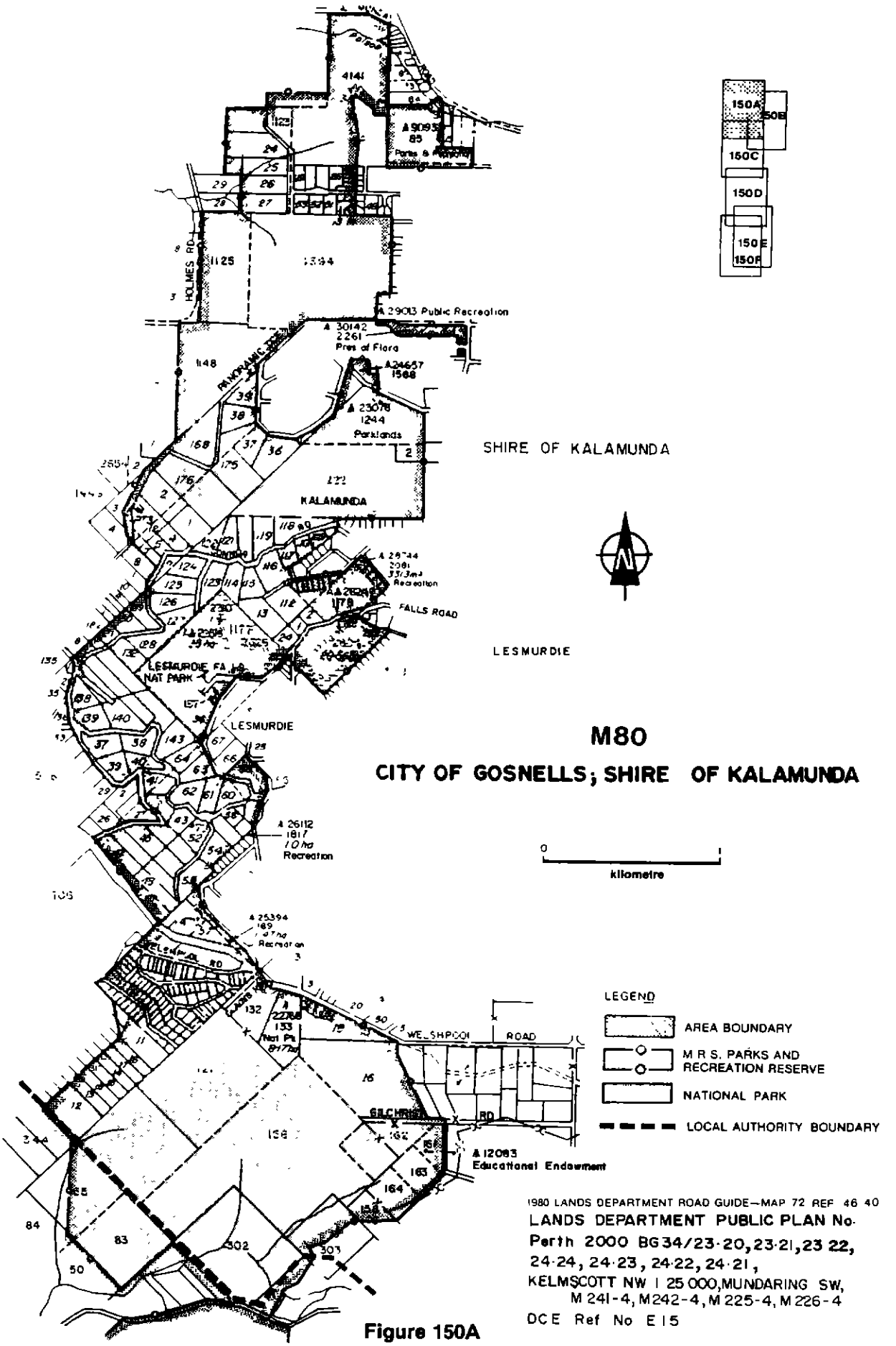
(b) the comparative cost and marketability of aggregate quarried elsewhere on the Darling Scarp,

(c) the need to limit the visual impact of quarrying and other developments;

(d) rehabilitation of quarry sites after extraction is complete

M80.6 The vacant Crown land adjacent should be added to Reserve A4561.

M80 7 The operators of existing and new quarries on the Scarp should be required to present proposals to the responsible authority, outlining options for use of the quarry when extraction is complete, and to implement the option selected in its operation and after closure.

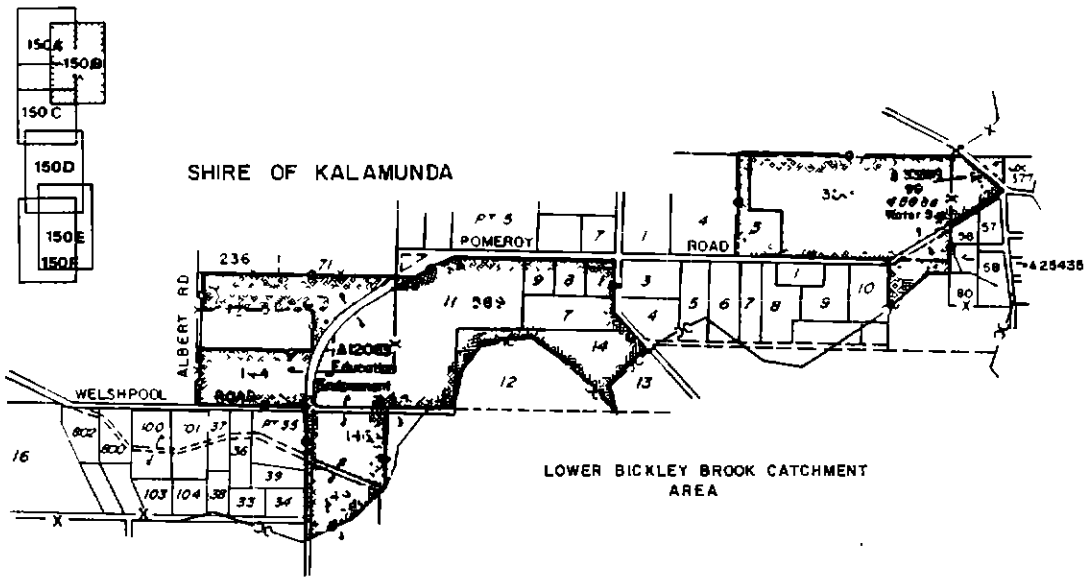


1980 LANDS DEPARTMENT ROAD GUIDE—MAP 72 REF 46 40

LANDS DEPARTMENT PUBLIC PLAN No. Perth 2000 BG34/23·20,23·21,23 22, 24·24, 24·23, 24·22, 24·21, KELMSCOTT NW I 25 000,MUNDARING SW, M 241-4, M242-4, M 225-4, M 226-4

DCE Ref No E I 5

Figure 150A



LEGEND

AREA BOUNDARY

M R S PARKS AND RECREATION RESERVE

M80

SHIRE OF KALAMUNDA

0 — 1

kilometre

1980 LANDS DEPARTMENT ROAD GUIDE—MAP 72 REF 50.36

LANDS DEPARTMENT PUBLIC PLAN Nº
K 2-4, K 1-4, K 18-4,
DCE Ref No E 15

Figure 150B

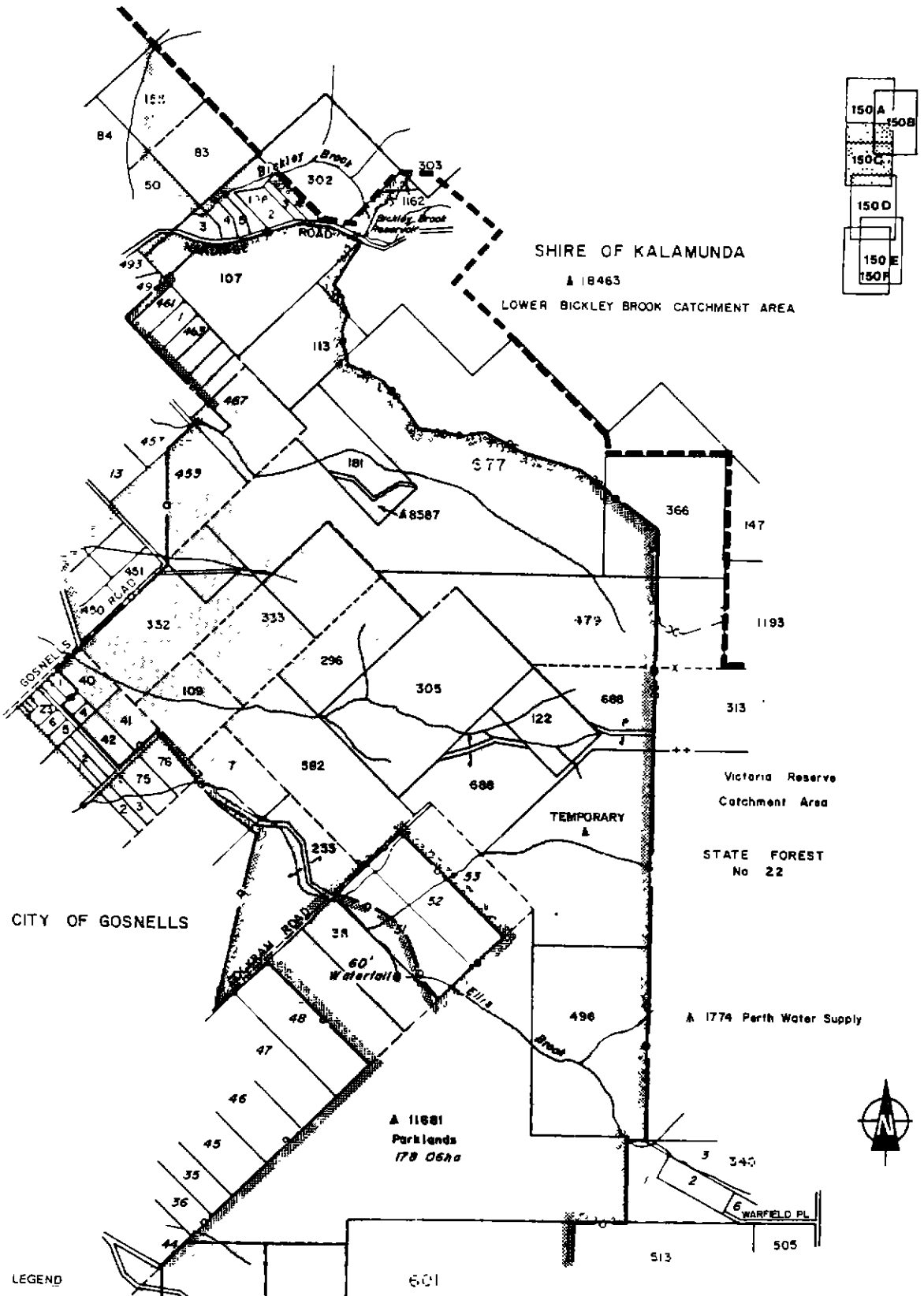
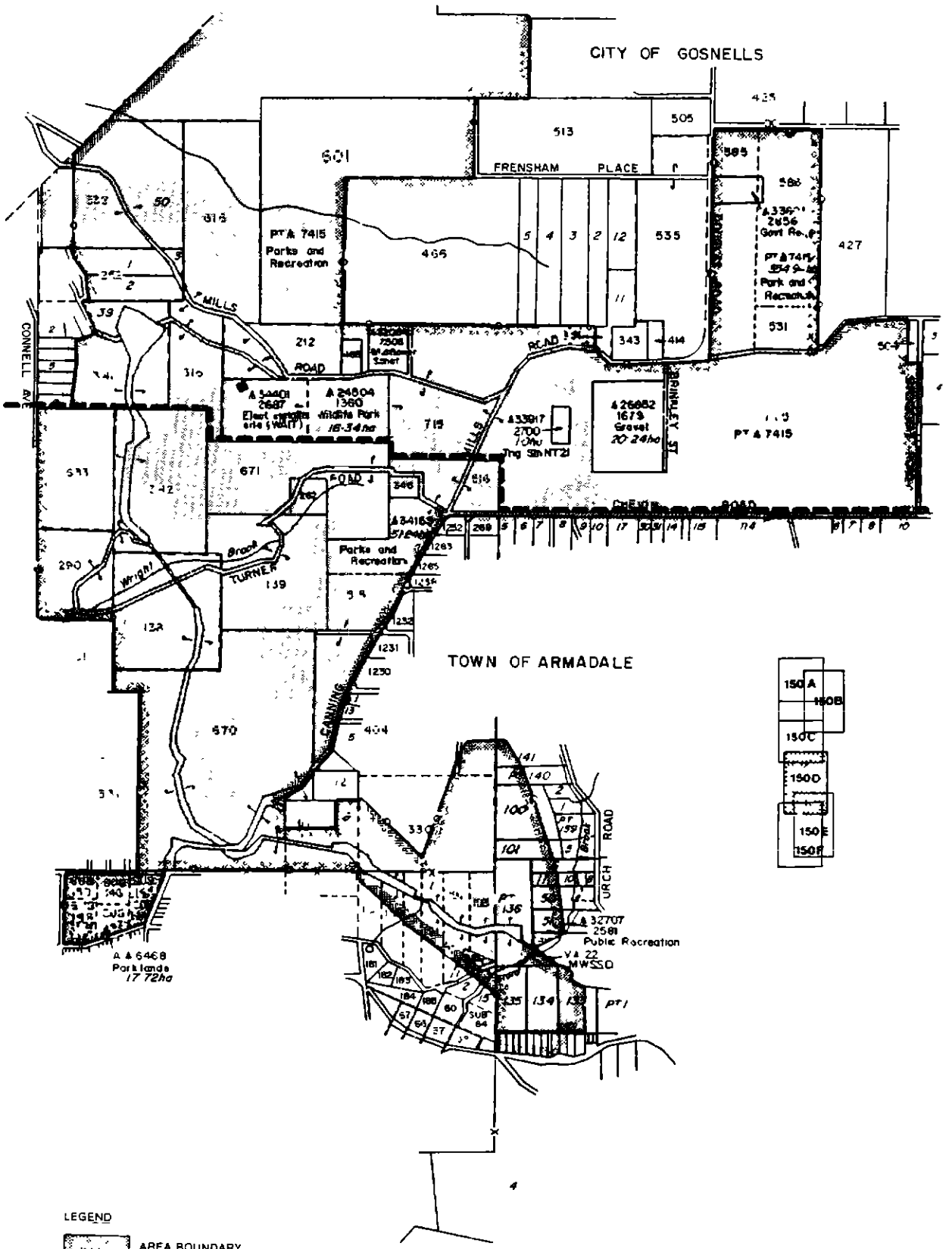

SHIRE OF KALAMUNDA
A 18463
LOWER BICKLEY BROOK CATCHMENT AREA
150A
150B
150C
150D
150E
150F
Bickley Brook
Bickley Brook Reservoir
ROAD
SHIRE OF KALAMUNDA
A 8587
Victoria Reserve
Catchment Area
TEMPORARY
A
STATE FOREST
No 22
CITY OF GOSNELLS
60' Waterlilla
Ellis Brook
A 1774 Perth Water Supply
A 11681
Parklands
178 06ha
WARFIELD PL
GOSNELLS
LEGEND
AREA BOUNDARY
M R S PARKS AND RECREATION RESERVE
LOCAL AUTHORITY BOUNDARY
LANDS DEPARTMENT PUBLIC PLAN No
K50·4, K65·4, K82·4, K18 4, K 34 4
DCE Ref. No E 15
1980 LANDS DEPARTMENT ROAD GUIDE—MAP 82 REF 47 28
M80
CITY OF GOSNELLS and
SHIRE OF KALAMUNDA
0
kilometre

Figure 150C



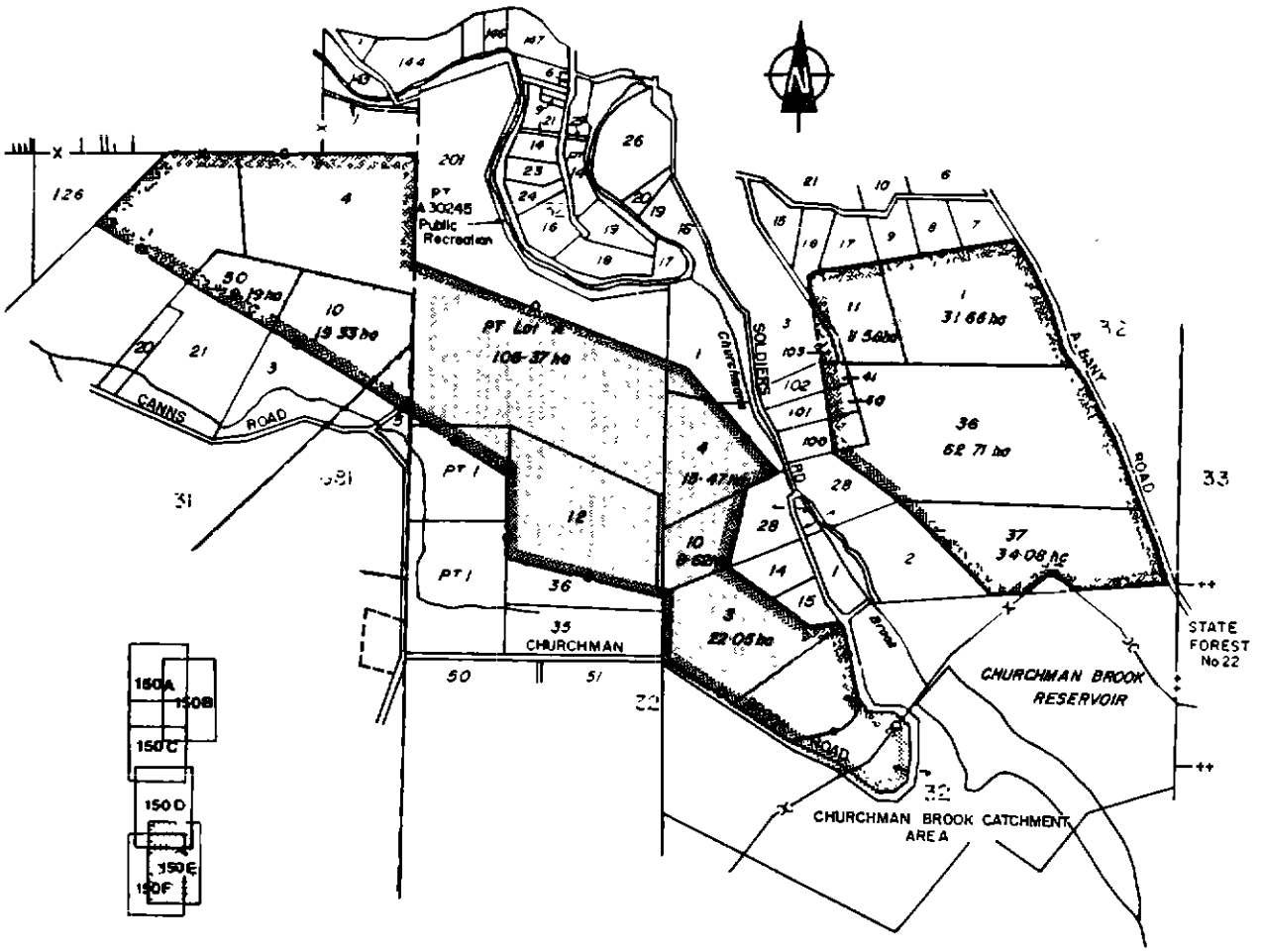
M80

CITY OF GOSNELLS
TOWN OF ARMADALE

LANDS DEPARTMENT PUBLIC PLANS N° K81-4, K82-4, K97-4, K98-4, K99-4, K113-4, K114-4 and KELMSCOTT NW 1 25000
DCE Ref No E15
1980 LANDS DEPARTMENT ROAD GUIDE—MAP 92 REF 48 18

0 kilometre

Figure 150D



LEGEND

AREA BOUNDARY

M.R.S. PARKS AND RECREATION RESERVE

1980 LANDS DEPARTMENT ROAD GUIDE—MAP 102 REF 50 08

LANDS DEPARTMENT PUBLIC PLANS N°
K 131-4 , K 130-4, K 146-4 and KELMSCOTT
S W 1 25000

DCE Ref. No E 18

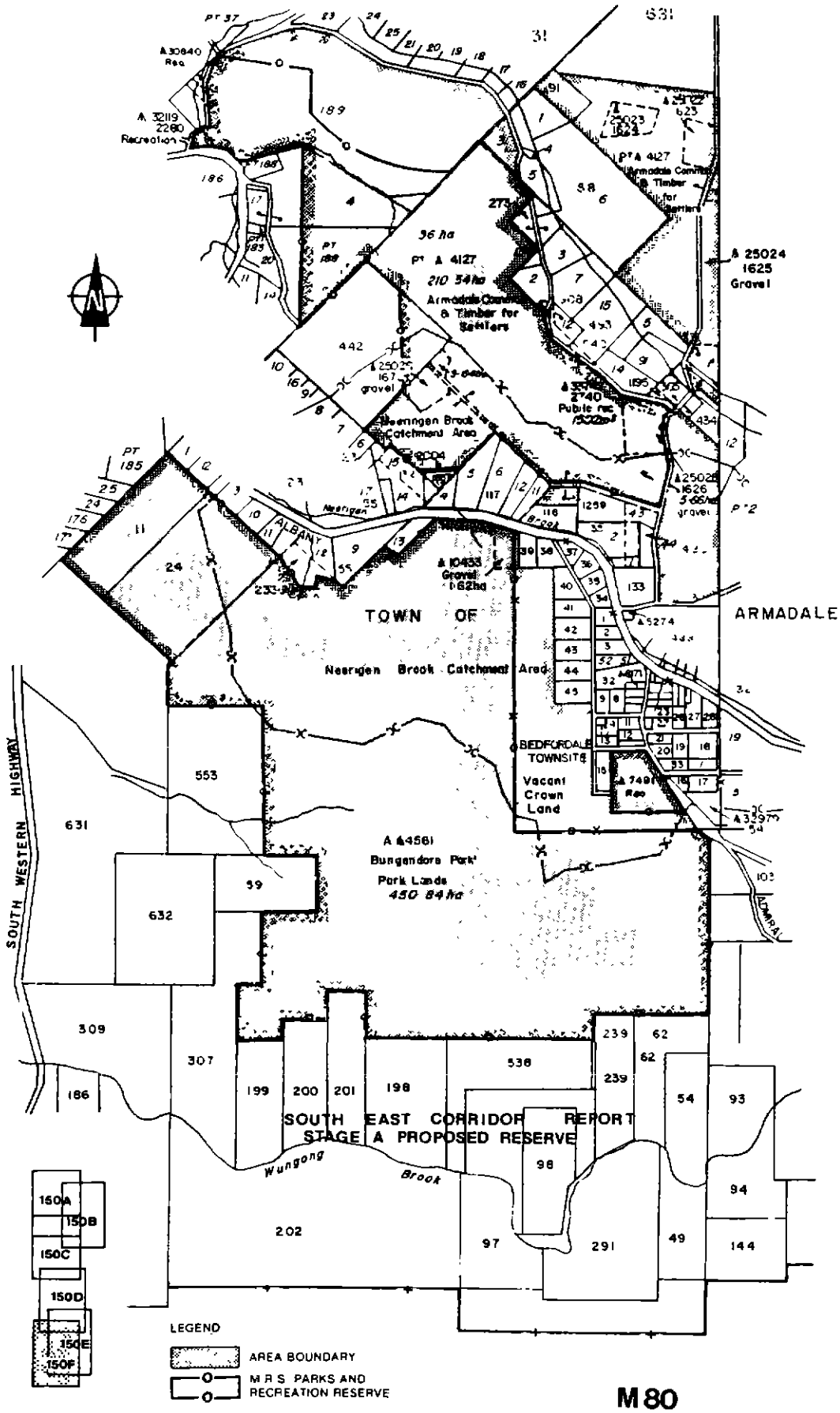
M 80

TOWN OF ARMADALE

0 1

kilometres

Figure 150E



M 80

TOWN OF ARMADALE

0 1 kilometre

1980 LANDS DEPARTMENT ROAD GUIDE—MAP 102REF 46 06

LANDS DEPARTMENT PUBLIC PLAN No K 161-4, K 193-4

DCE Ref No E17

Figure 150F