

III Vegetation and Flora

A.V. Milewski and G.J. Keighery

Introduction

In Beard's (1975, 1980a) terms the Edjudina—Menzies Study Area falls mainly within the Austin Botanical District with a small part entering the Helms Botanical District. The main vegetation type in the Study Area is low woodland of *Acacia aneura* (mulga), as seen on the generalised map of Carnahan (1976) where it is depicted as *Acacia* tall shrubland with low shrubs. Trees or shrubs of *Casuarina cristata* (Belah) or *Eucalyptus* spp. (eucalypts) tend to replace mulga where the average annual rainfall is relatively high, as in the south-west of the Study Area, or where a deep friable soil occurs. The vegetation is low and open on shallow or salty soils. Where lime occurs close to the surface, the trees and tall shrubs are scattered and the main plant cover is formed by low shrubs of *Maireana sedifolia* (bluebush). This vegetation is described as lightly wooded succulent steppe by Beard (1975) and is extensive enough on Undulating Plains over basic rocks in the eastern central part of the Study Area to be mapped by Carnahan (1976) as *Acacia* tall open shrubland with low chenopodiaceous shrubs. On Hills mulga persists but is reduced to relatively low shrubs. On Salt Lake Feature the succulent steppe becomes very lightly wooded (Beard 1975) and the low shrubs are *Atriplex* spp. (saltbush). Both the mulga and the saltbush finally disappear on the bare beds of the salt lakes. Sandy soils are covered by *Triodia basedowii* (spinifex), forming a so-called shrub, or tree and shrub steppe (Beard 1975). The scattered shrubs are composed mainly of a *Eucalyptus youngiana* (mallee) and are joined on deep sands in the north-east of the Study Area by scattered trees of *E. gongylocarpa* (Marble Gum). This forms an area extensive enough to be mapped by Carnahan (1976) as shrub or tree steppe. The three main types of vegetation in the Study Area, as mapped by Carnahan, all occur in other Study Areas although his lightly wooded succulent steppe has a relatively limited extent.

The Edjudina—Menzies Study Area lies just beyond the northern edge of the true eucalypt formations of the Eastern Goldfields. However, a considerable number of species of *Eucalyptus* occur here, particularly in the southern parts of the Study Area. Their separation by habitat indicates the main types of vegetation in the Study Area, as follows:

Breakaway: *E. lesouefii* in the south, *E. clelandii* throughout;

Drainage Line: *E. lucasii*;

Granite Exposure: *E. loxophleba*;

Hill and Salt Lake Feature: none;

Sandplain: *E. oldfieldii*, *E. leptopoda*, *E. rigidula*, *E. youngiana*;

Broad Valley: *E. ewartiana*, *E. concinna*, *E. foecunda*, *E. transcontinentalis*, *E. jutsonii*, *E. oleosa*, *E. eremicola*, *E. longicornis*, *E. youngiana*; and

Undulating Plain: *E. oleosa*, *E. clelandii*, *E. celastroides*, and *E. longicornis*.

Vegetation in the Study Area is described hereafter according to the following landform types: Breakaway, Drainage Line, Dunefield, Granite Exposure, Hill, Saltlake Feature, Calcareous Plain, Undulating Plain and Broad Valley.

Breakaway (B): Breakaway consisted of low scarps or erosion bluffs etched into lateritic crusts, the remnant of a previous era of weathering of the bedrock. Such landforms were not particularly common in the Edjudina—Menzies Study Area. Low, poorly distinguished Breakaway in the southern part of the Study Area were developed over banded ironstone formation at places where salt lakes abutted belts of greenstone. Breakaway was formed in this case by back-erosion of the salt lake bed on its lee (north-western) side. The footslopes, including abrupt knife-edges of banded ironstone formation, of Breakaway in the northern part of the Study Area had a very stony and presumably saline soil covered with salt-tolerant chenopods. The steeper slopes and erosion gulleys had a few trees of *Eucalyptus clelandii* and very sparse low shrubs. The level area immediately behind the bluff had very shallow and stony soils separated from bedrock by a calcrete layer. Vertically tilted, pale, soapy bedrock of serpentinite protruded in places. It bore Low Woodland of *Casuarina cristata* over *Maireana sedifolia*. Ephemerals were surprisingly diverse, including *Helipterum tenellum*, *H. fitzgeraldii*, *Calotis hispidula*, *Helipterum maryonii*, *Vittadinia* sp. (AVM 046), *Podolepis lessonii*, *Isoetopsis graminifolia* and *Helipterum battii*. Forty-nine perennial and ephemeral species were listed from one sample site on the near-level mesa of Breakaway of this kind. Other Breakaway were intimately associated with Granite Exposure and had a pale pinkish-grey soil with minor occurrences of lime hardpan. The upper stratum consisted of *Pittosporum phylliraeoides*, *Hakea arida*, *Eucalyptus loxophleba* and some *Acacia aneura* with scattered tall shrubs of *Eremophila alternifolia*, *Acacia tetragonophylla*, *A. acuminata* (particularly along minor dry creeks), *Eremophila oppositifolia*, *Dodonaea lobulata*, *Cassia artemisioides* and *Casuarina cristata*. On the crest of Breakaway grew *Eucalyptus clelandii*. The understorey comprised *Ptilotus obovatus* var. *obovatus*, *Maireana* spp., *Frankenia* spp. (AVM 065), *Atriplex vesicaria* ssp. *variabilis* and *A. inflata*.

Drainage Line (C): The main types of Drainage Line were shallow abrupt channels in Undulating Plain. These were 1-2 m deep and 5-7 m wide. The soil was a deep Loam of alluvial origin over a calcrete hardpan. *Acacia aneura* was dominant, forming 8 m high trees, and was overtopped by scattered *Eucalyptus lucasii* along the length of the creekline. Tall shrubs were *Acacia tetragonophylla* with some *Eremophila longifolia*, *Acacia acuminata* and *Santalum spicatum*. Low shrubs consisted of *Rhagodia eremaea*, *Ptilotus obovatus* var. *obovatus*, *Solanum lasiophyllum*, *Abutilon cryptopetalum*, *Enchylaena tomentosa* var. *tomentosa*, *Cassia nemophila* var. *nemophila*, *C. cardiosperma* and *Maireana triptera*, replacing the *Maireana sedifolia* dominant in the surrounding Undulating Plain. Vines of *Rhyncharrhena linearis*, were characteristic. The main ephemerals were species of *Lepidium*, *Daucus*, *Helipterum*, *Nicotiana*, *Plantago*, **Sonchus*, *Senecio*, *Gnephosis*, *Crassula*, *Goodenia*, *Stenopetalum*, *Erodium* and *Ptilotus*. Some

Drainage Lines had relatively heavy soils and a diffuse creek bed, with some development of gilgai. Here the eucalypt was *E. salubris* (Gimlet) and the vegetation recalled that of Broad Valley in the Kalgoorlie—Kurnalpi Study Area. An example was Site EM2 (Appendix 1).

Dunefield (D): Dunefield were scattered sparsely through the Edjudina—Menzies Study Area, with a concentration in the central southern part of the Study Area. There were two quite separate vegetation types on Dunefield, depending on whether they were upland Dunefield associated with Sandplain, or lowland Dunefield associated with Salt Lake Feature. On uplands, the soil was a yellowish-red Loamy Sand with uniform texture and colour to great depth. Lowland Dunefields had darker soils with considerable calcium especially at depth, and in places slight salinity. Very few plant species were common to both types. Notable exceptions were the ephemerals *Ptilotus polystachys* and *Helichrysum davenportii* which appeared to have a requirement for deep loose soil irrespective of its chemical composition. *Callitris* was the characteristic tall shrub or low tree although various species of *Acacia* were locally equally common in terms of cover. However, *Acacia aneura* and *Melaleuca uncinata*, characteristic of closely related landforms, were generally absent from Dunefield.

Granite Exposure (G): Granite Exposure were scattered throughout the Edjudina—Menzies Study Area, forming islands in Broad Valley, especially adjacent to Breakaway. In common with other landforms in this Study Area there was a strong tendency to calcrete formation wherever some soil had accumulated.

A comparison was made of the vegetation on the bare areas of bedrock and on lime-rich colluvial sheets of soil of the adjacent aprons in the south-western part of the Study Area. Rock-free, hardsetting granitic loam up to 50 cm deep was interrupted by boulders and flat sheets of exposed bedrock. Outcrops of rock were absent from aprons and only a few stones of quartz or granite were strewn on the surface. The gently sloping surface was compact, especially in the vicinity of small dry creeklines. The soil here was a slightly saline gritty, pinkish loam, with few stones or pebbles to a depth of at least 30 cm and probably 50 cm.

Bare bedrock supported tall shrubland of *Acacia quadrimarginea* 4 m high with a very sparse understorey while aprons supported very scattered *Hakea suberea*, *Acacia aneura*, *Pittosporum phylliraeoides* and *Casuarina cristata* over a well-developed understorey of *Atriplex bunburyana* and other species of Chenopodiaceae. Several perennial species were found in small numbers in both areas, e.g. *Ptilotus obovatus* var. *obovatus*, *Solanum lasiophyllum*, *Acacia tetragonophylla* and *Cassia* sp. However, scattered shrubs of *Eremophila* spp. occurred on the rock while they were replaced by *Sida* spp. and *Rhagodia* spp. on the aprons. In both areas a rich community of herbaceous plants occurred, ranging from perennials to ephemerals. Perennial or semi-perennial species included *Cheilanthes* sp. and *Podolepis capillaris* on the rock and *Sclerolaena* spp. on the aprons, with *Eragrostis dielsii* on both. Nineteen ephemeral species occurred throughout, such as *Angianthus burkittii* and *Aristida contorta*. *Chthonocephalus pseudevax*

and *Actinobole uliginosum* were common on the rock only, and other species not found on the aprons were ephemeral species of Aizoaceae, Centrolepidaceae and Urticaceae. *Angianthus tomentosus*, not found on the rock, was the commonest ephemeral on the aprons, together with *Chrysocoryne pusilla*, *Salsola kali*, *Plantago drummondii* and *Senecio glossanthus*. Ephemeral species of *Crassula*, **Bromus* and *Agrostis* were more common on the aprons than on the rock.

Hill (H): The scattered Hill found in the Edjudina–Menzies Study Area were usually small and abrupt, forming the high points of Undulating Plain. The shallow, stony soils were generally underlain by a calcrete coating over the bedrock, except over quartz.

Vegetation on Hill consisted of *Acacia* scrub, the species depending on bedrock type. *Maireana* species, including *M. sedifolia*, were comparatively rare, disappearing where the soil was skeletal and bedrock exposed. Floristically simple *Acacia* aff. *beauverdiana* (AVM 672) Tall Shrubland occurred on the prominent Hill of metabasalt at Mt Percy (Figure 3). The lower slopes bore mixed Tall Shrubland in which no species was dominant although *Cassia* spp. were the most conspicuous. The soil here was stony, dark reddish brown clay loam, up to 10 cm deep. *Cassia nemophila* var. *nemophila*, not found in the *A. burkittii* Tall Shrubland, formed 2 m shrubs. *Acacia aneura* was present as scattered stunted trees. The other main species were *Eremophila angustifolia* (tall shrub) and *Cassia cardiosperma* and *Dodonaea lobulata* (1 m shrubs). Scattered *A. burkittii*, *A. stowardii*, *Rhagodia eremaea* and *Scaevola spinescens* were present, together with occasional *Santalum spicatum*. The understory was sparse, limited to soft low shrubs of *Solanum lasiophyllum* and *Ptilotus obovatus*, herbs of *Sclerolaena patenticuspis* and *S. densiflora*, geophytes of *Wurmbea tenella*, a few grasses, and various ephemerals which covered 10-15 per cent of the surface in season.

The vegetation of Hill of banded ironstone was similar to that of Hill of similar size and shape of granite (e.g. Site EM6, Appendix 1), which protruded from the same plain of *Maireana sedifolia* and scattered *Casuarina*. *Acacia aneura* was the main tall shrub and *Ptilotus obovatus* var. *obovatus* the main low shrub, with *Canthium lineare* forming plants of intermediate height but, as elsewhere, trimmed back to the stems by browsing goats. However, *Dodonaea petiolaris* replaced *Eremophila serrulata* found on granite Hill. Conspicuous ephemerals were *Helipterum maryonii* and *H. battii*, both species characteristic of sheltered microhabitats whether this was under fallen branches or in the lee of rocks. The vegetation of *Acacia aneura* on Hill differed from that of nearby Broad Valley in lacking the ephemerals *Helipterum hyalospermum*, *H. laeve*, *Podolepis canescens*, *Velleia rosea*, *Chthonocephalus pseudevax*, *Isoetopsis graminifolia*, *Calocephalus multiflorus*, *C. skeatsianus*, *Crassula* sp. and *Actinobole uliginosum*, instead having sparse *Lepidium* sp., *Plantago* sp., *Euphorbia drummondii*, *Daucus glochidiatus*, *Vittadinia* sp. and *Ptilotus helipteroides*.

Salt Lake Feature (L): The three main areas of Salt Lake Feature in the Edjudina–Menzies Study Area run parallel to each other in a diagonal alignment. Salt Lake

Feature comprised several distinct landform elements, of which the few extensive Dunefields were considered a separate landform. Soils consisted of very compact, sodium- or magnesium-contaminated loam covered by varying depths of sandy material. The presence of gypsum (CaSO_4) was characteristic although the actual concentrations of this and other mineral elements were low in most areas. All soils in Salt Lake Feature appeared to have poor moisture relations owing to their extreme textural differentiation, aggravated by salinity in places. The soils differed generally from those of Undulating Plain in being duplex instead of gradational or uniform.

As on Undulating Plain, the vegetation on Salt Lake Feature consisted of scattered trees and tall shrubs over a well stocked stratum of low shrubs of Chenopodiaceae. However *Casuarina cristata* and *Maireana sedifolia* were rare and *M. pyramidata* shared its stratum with a number of shrubs of similar form including Asteraceae, Frankeniaceae, Malvaceae and other Chenopodiaceae. *Atriplex* was common over considerable areas. The lower shrubs and herbaceous plants also differed in their composition from those on Undulating Plain. The form of *Acacia aneura* present had broad phyllodes, not narrow or needle phyllodes as on Undulating Plain, and its shrubby associates were *Eremophila miniata*, *Dodonaea viscosa* and *Atriplex* spp., in place of *E. angustifolia*, *D. lobulata* or *D. rigida*, and *Ptilotus obovatus* var. *obovatus*.

A point noted about Salt Lake Feature in the Edjudina—Menzies Study Area was the absence of *Eucalyptus* and *Triodia*, contrasting with Study Areas further south. This presumably reflected the diminished leaching of the soil under a dry climate. Only one small patch of shrubby *Eucalyptus* over *Triodia* was observed on this landform, on an abrupt sandy rise with *Dodonaea viscosa* near Lake Minigwal.

Lakeside depressions immediately adjacent to Undulating Plain (e.g. at Yundamindra) supported a variety of low succulent plants including members of the Mesembryanthemaceae, Chenopodiaceae and Aizoaceae (e.g. *Carpobrotus modestus*, *Gunningsia quadrifidum*, *Halosarcia* spp., *Maireana amoena* and *Disphyma clavellatum*) and gnarled shrublets with small leaves (e.g. *Lawrencia squamata*, *Minuria* sp.) often growing with interlocked canopies. Four succulent species of perennials showed vigorous shoot growth after winter rain when they formed up to 40 per cent of the plant biomass present. The ephemerals included *Helipterum strictum*, *H. maryonii*, *H. tenellum*, *Pogonolepis stricta*, *Calandrinia lehmannii* and abundant *Gnephosis brevifolia*.

Where the soil was unusually deep, loose and siliceous at the edge of a salt lake, shrubs included *Muehlenbeckia cunninghamii*, *Acacia ramulosa* and *Cassia chatalainiana*; the sparse ephemerals showed affinities, in their composition and clumping under trees, with Sandplain and Dunefield. Similar sandy rises at Lake Raeside featured medium-high shrubs of *Jacksonia hakeoides* and ephemerals of *Helipterum manglesii*.

The most conspicuous and characteristic ephemeral of Salt Lake Feature, clearly separating stands of *Maireana pyramidata* here from the *M. sedifolia*

Casuarina cristata community widespread on Undulating Plain, was *Helipterum roseum*. This species grew in definite patches (diameter approx. 10 m) in a way which did not seem to be related to shelter or litter distribution. Gypseous sandy soils were characterised by *Gnephosis macrocephala*, *Senecio lautus* ssp. *dissectifolius* and *Zygophyllum* sp.; where gypsum occurred at the surface as well as at depth, localised patches of the calciphilous *Gnephosis skirrophora* (otherwise restricted to calcareous Undulating Plain) occurred. On the other hand, *Crassula* sp. appeared to avoid gypseous soils although common on calcareous soils in other landforms.

Ephemeral communities of Salt Lake Feature were rich and showed a rapid turnover according to subtle variations in the soil. Detailed notes were taken over a distance of 150 m going from the raised edge of a lake in the south-western part of the Study Area, down through successive bands of vegetation to the bare floor. The soil in the *Maireana* zone was relatively deep and friable (dusky red or dark reddish brown sandy loam, slightly clayier at depth), a compact subsoil being exposed downslope. In the *Atriplex* zone, the friable soil was shallow over a very firm clay. In the *Frankenia* and *Halosarcia* zones the soil was set hard and presumably saline although no salt was visible at the surface. Few perennial plant species occurred, although side by side with *Maireana pyramidata* grew *Cratystylis subspinescens* and individuals of *Scaevola spinescens*, *Ptilotus obovatus* var. *obovatus*, *Rhagodia drummondii* and *Lycium australe*; and *C. subspinescens*, *M. pyramidata* and *Frankenia* sp. extended as occasional plants into the *Atriplex vesicaria* ssp. *variabilis* dominated zone. The flat lake floor was bare except for isolated clumps of *Halosarcia*, of a species different from that at the base of the gentle slope.

Several species of ephemerals were spread throughout this catenary sequence: *Stenopetalum robustum*, *Calandrinia* spp., *Chrysocoryne pusilla*, **Bromus* sp., *Wurmbea tenella*, *Helipterum tenellum* and, in the shelter of substantial shrubs only, *H. maryonii*, **Sonchus oleraceus* and *Senecio glossanthus*. Species of the *Maireana* zone ceasing to grow where *Atriplex* or *Frankenia* entered were *Gnephosis macrocephala*, *Goodenia* sp., *Podolepis* sp., *Ptilotus* spp., *Helipterum* sp., *Calotis hispidula*, *Vittadinia* sp., *Erodium* sp., *Stenopetalum* sp., *Lepidium* sp., *Salsola kali*, *Velleia rosea* and *Plantago drummondii*. In addition it was noted that *C. pusilla* and *Helipterum tenellum* were commonest in the *Maireana* zone and became rare in the more saline zones downslope. Species apparently restricted to the *Atriplex* or *Frankenia* zones were *Chthonocephalus pseudevax*, *Calandrinia* sp. and *Podolepis stricta*; these species apparently required a firm soil but could not tolerate high salinity. Species restricted to the most saline and heaviest soils (*Frankenia* and *Halosarcia* zones) were *Gnephosis pygmaea*, *Gnephosis burkittii*, *Centrolepis polygyna*, *Triglochin* sp., *Swainsona* sp., *Brachycome* sp., *Agrostis* sp. and another unidentified low grass. *Chrysocoryne trifida* was a distinctive species heralding the entrance of *Halosarcia*; others conspicuous and distinctive in the *Halosarcia* zone were *C. polygyna* and *G. pygmaea*. Species penetrating most of the way down the catena from the *Maireana* zone but dis-

appearing where perennial plants became sparse were *H. strictum* and *Sinapis arvensis*. *Crassula colorata* occurred virtually throughout the catena but was commonest in the *Frankenia* zone and extended only marginally into the *Halosarcia* zone.

Maireana pyramidata dominated parts of both Salt Lake Feature and Undulating Plain. The ephemeral communities in these disparate situations were compared using Salt Lake Feature in the south-western part of the Study Area and Undulating Plain in the north-eastern part. Despite their geographical separation and their different landforms and origins, floristic composition was found to be very similar. Approximately 52 species of ephemerals occurred in two sample sites examined and of these only 15 appeared to be restricted to one type or the other. Examples of species restricted to or common only in Salt Lake Feature sites were *Podotheca gnaphalioides*, *Centrolepis polygyna*, *Helipterum roseum*, *Chrysocoryne pusilla*, **Lophochloa pumila*, *Centipeda thespidioides*, *Brunonia australis*, *Waitzia acuminata*, *Velleia rosea* and *Gnephosis macrocephala*. Examples of species restricted to Undulating Plain sites were *Daucus glochidiatus*, *Gnephosis brevifolia*, *Calotis multicaulis*, *Helipterum charsleyae* and *Cephalipterum drummondii*. The differences in the ephemerals appeared to be associated with differences in soil texture as much as soil chemistry. For example *Waitzia acuminata*, *Brunonia australis* and *Velleia rosea* were otherwise characteristic of siliceous sandy soils in Broad Valley and their presence in Salt Lake Feature (they were relatively rare here) possibly reflected the presence of sandy soils relative to Undulating Plain. By the same token, *Cephalipterum drummondii* was characteristic of firm gravelly soils on a variety of landforms.

Calcareous Plain (P): Only one area seen in the Edjudina—Menzies Study Area appeared to represent this landform. It was a small patch of land within Broad Valley, just south-west of Boomerang Lake. Its origin was obscure although it may have been a poorly developed calcrete valley fill, a southern outlier of the type more common in the northern parts of the Eastern Goldfields. Details are given in the section on Goongarrie National Park.

Sandplain (S): Sandplain formed patches throughout the Edjudina—Menzies Study Area, generally where the underlying rock was granite. Where the sand had been piled into actual dunes, the landform was considered separately under Dunefield.

Sandplain in the southern part of the Study Area had similar vegetation to that on lateritic gravelly sands in the Kalgoorlie—Kurnalpi Study Area. *Eucalyptus leptopoda* and *E. rigidula* were equally common, and formed mallees of 4 m and 5 m respectively. *Triodia scariosa* was dominant in the ground stratum but several other grass genera occurred together with dwarf shrubs of *Baeckea*, *Wehlia* and *Thryptomene*.

Shrubs formed a middle stratum of simple composition, dominated by *Acacia* spp. Particularly lateritic areas (e.g. Site EM13, Appendix 1) had topsoils of gravelly yellowish red sandy loam over dense gravel subsoils. The similar but

stunted vegetation here, including *Melaleuca uncinata*, *Acacia aneura* and *Leptospermum roei*, with *Thryptomene aspera* and *Amphipogon caricinus* replacing *Triodia*.

In the eastern part of the Study Area, Sandplain formed the western fringe of the Great Victoria Desert. Soils were loamy fine sand, up to 1 m deep in places but overlying a lime hardpan exposed intermittently on tracks. The vegetation was an open mallee over shrubs of diverse composition over *Triodia*, with variable and blurred stratification owing to the patchiness and range of heights of the species. *Callitris preissii* ssp. *verrucosa* formed the tallest plants at 5 m, with *Eucalyptus youngiana* and *E. concinna* at 3-4 m. Shrubs below 2 m included *Scaevola spinescens*, *Eremophila paisleyi*, *E. pantonii*, *E. decipiens*, *Cassia nemophila* var. *nemophila*, *Grevillea juncifolia*, *G. filifolia*, *Acacia hemiteles*, *A. acuminata*, *A. ligulata*, *A. ramulosa*, *A. longispinea?*, *Dodonaea stenozyga*, *Bursaria* sp., *Prostanthera* sp., *Allocasuarina acutivalvis*, *A. helmsii*, *Alyxia buxifolia*, *Westringia rigida*, *Exocarpos cuppressiformis*, *Daviesia benthamii* ssp. *benthamii*, *Hakea francisiana*, *Cryptandra parvifolia*, *Thryptomene* sp., *Calothamnus gilesii*, *Olearia muelleri*, *O. propinqua*, *Melaleuca leiocarpa*, *M. eleuterostachya*, *Santalum acuminatum* and *S. spicatum*. Where 1.5 m high shrubs were dense enough to constitute a distinct stratum, *Triodia* was sparse. Very occasional shrubs of *Acacia aneura* and *A. tetragonophylla*, species characteristic of Broad Valley, were present. Herbaceous species other than *Triodia* were represented by occasional *Velleia rosea*, *Podolepis capillaris* and *Brunonia australis*, and the parasitic twiner *Cassytha melantha*.

Wherever *Triodia* was dominant, on Sandplain or on nutrient-poor soils in Broad Valley, ephemerals were scarce and had an impoverished composition. *Waitzia acuminata*, *Brunonia australis* and *Helipterum verecundum* were characteristic, together with *Chrysocoryne pusilla* and occasional examples of *Goodenia occidentalis* and *Crassula* sp. Other species occurred locally depending on subtle variations in soil and the presence of litter with its addition of nutrients. Examples were *Velleia rosea*, *Calandrinia polyandra*, *Chthonocephalus pseudevax*, *Calotis hispidula*, *Helipterum maryonii*, *H. fitzgononii*, *H. battii*, *Haloragis odontocarpa*, *Stenopetalum anfractum* and the geophyte *Thysanotus patersonii*. Stunted individuals of some species typical of alkaline soils e.g. *Sonchus oleraceus* and *Plantago drummondii*, were recorded in the most favourable situations in the shelter of fallen branches and the litter of *Santalum*.

A comparison was made of apparently similar stands of *Acacia aneura* on Sandplain and other landforms. Sandplain in the south-western part of the Study Area and Undulating Plain in the north-eastern part both bore dense groves of *A. aneura* to 7 m high, in localised areas accumulating runoff. However the Sandplain had deep sandy soils while Undulating Plain had hardsetting clay loam with occasional patches of cracking clay in depressions (gilgai). The perennial species subordinate to *Acacia aneura* were different, only four sparse species being shared between the sample sites. The main taxa were Chenopodiaceae and Malvaceae on Undulating Plain. Species of *Acacia* and *Eremophila* differed. Not only

did the ephemeral communities differ, but the sample site on Undulating Plain had 26 species versus 12 on Sandplain. *Gnephosis foliata*, replacing *Waitzia acuminata* and *Chrysocoryne pusilla*, was accompanied by various species of *Helipterum*, *Lepidium oxytrichum*, *Senecio glossanthus*, *Cephalopterum drummondii*, *Brachycome* spp., *Daucus glochidiatus*, *Gnephosis pygmaea* and others.

Undulating Plain (U): A special feature of the Edjudina—Menzies Study Area was the extensive areas of Undulating Plain covered with *Maireana* spp. This represented a north-westwards extension into the Eastern Goldfields, of a vegetation type generally associated with the Nullarbor Plain. However, *Casuarina cristata*, which does not occur on the Nullarbor, accompanies *Maireana sedifolia* here. The predominance of *M. sedifolia* no doubt reflected a combination of climatic and edaphic factors, particularly the widespread development of powdery calcareous soils wherever a basic bedrock was subjected to modern-day weathering processes. *Maireana sedifolia* in the Edjudina—Menzies Study Area usually had a sparse overstorey of *Casuarina cristata* which in the north gave way to *Acacia aneura*.

Soils were crusted and slightly cracked at the dry time of year but did not set hard, and consisted of dark reddish brown loam, 20 cm deep over an impenetrable lime hardpan. A noticeable floury texture was probably attributable to their calcareous nature, particularly at depth. Surface pavement was negligible (5% cover of miscellaneous fragments such as quartz and pieces of the lime hardpan) but topsoils contained about 20% of inclusions of gravel size. *Casuarina cristata* was dominant but various lower trees or tall shrubs were also present including *Acacia aneura* (2% cover), *A. stowardii* (1%), *A. tetragonophylla*, *A. enervia*, *Santalum acuminatum*, *S. spicatum*, *Heterodendrum oleaefolium*, *Hakea arida*, *Pittosporum phylliraeoides*, *Eremophila angustifolia*, *E. oppositifolia* and *E. scoparia*. Shrub species subordinate to *Maireana sedifolia* included small numbers of *Cratystylis subspinescens*, *Ptilotus obovatus* var. *obovatus*, *Lycium australe*, *Olearia muelleri*, *Cassia nemophila* var. *nemophila*, *Chenopodium curvispicatum*, *Enchylaena tomentosa*, *Atriplex bunburyana*, *A. nummularia* ssp. *spathulata*, *A. vesicaria* ssp. *variabilis*, *Maireana glomerifolia*, *Scaevola spinescens* and *Acacia erinacea*. Soft, low shrubs or perennial herbs were sparse (*Solanum lasiophyllum*, *Sclerostegia disarticulata*, *Frankenia* sp. and *Sclerolaena diacantha*). The shrubs provided shelter for the tall grass *Stipa elegantissima* and support for the vine *Leichardtia australis*. Ephemerals were abundant in season. However in the dry season the ground was quite bare except for lichens (up to 15% cover) including *Lecidea decipiens*, *L. psammophila*, *Diploschistes ocellatus*, *Parmelia callifolia*, *Acarospora schleicheri*, *Haemotomma puniceum*, *Ochrolechia pseudotartarea* and *Buellia* sp.

In the northern parts of the Study Area, the vegetation was relatively low and simple in floristic composition. Soils were a dark red loam, 30 cm deep over a thick layer of colluvial material, a chalky pink calcareous loam which indicated reddish brown when artificially moistened. *Hakea arida* was characteristic and the only other trees or tall shrubs were scattered *Casuarina cristata*, *Pittosporum*

phylliraeoides and *Acacia acuminata*. Basalt plains and dolerite dykes comprised small rocky outcrops with trees of *Casuarina cristata* and *Acacia aneura* and an understorey of e.g. *Atriplex* sp., *Cassia nemophila* var. *nemophila*, *Solanum lasiophyllum*, *Scaevola spinescens* and *Sida* sp. *Ptilotis obovatus* var. *obovatus* formed the understorey to *Acacia aneura* on one rock type while *Maireana sedifolia* formed the understorey to *Casuarina cristata* on another type. Subordinate species noted on dolerite were *Acacia quadrimarginea*, *A. ramulosa*, *Dodonaea lobulata* and *Eremophila angustifolia*. In small valleys, a few plants of *Eucalyptus salubris*, *Pittosporum phylliraeoides*, *Acacia tetragonophylla*, *Heterodendrum oleaefolium* and *Brachycton gregorii* joined *Acacia aneura*.

Throughout the northern parts of the Edjudina—Menzies Study Area, *Maireana sedifolia* tended to be replaced on low-lying Undulating Plain by *M. pyramidata*. The habitats of the two species corresponded to surfaces distinguished on the geological map, namely colluvial flats of Quaternary age with Calcareous Earths and colluvial flats of Recent age with Sub-saline Soils respectively. Trees and tall shrubs were generally much sparser in stands of *M. pyramidata* type than in those of *M. sedifolia*, their cover even more variable, and *Casuarina cristata* generally absent. In some areas *M. pyramidata* was joined by other semi-succulent shrubs in the Chenopodiaceae, giving way in the lowest-lying parts to *Halosarcia* spp. This recalled Salt Lake Feature though in a quite separate landform at considerably higher elevation.

The ephemeral flora was fairly uniform throughout *Maireana* communities on Undulating Plain although some species were restricted to the *M. sedifolia* type and others to the *M. pyramidata* type. The general ephemeral community consisted of *Cephalopterum drummondii* (where the topsoil had a scatter of pebbles or gravel) or *Helipterum floribundum* (where the soil was smoother and more retentive of moisture, often coexisting with *Maireana sedifolia* and *Stipa* sp.), *Erodium* sp., *Lepidium oxytrichum*, *Helipterum maryonii*, *H. tenellum*, *H. charsleyae*, *H. strictum*, *Gnephosis foliata*, *Goodenia havilandii*, *Zygophyllum* sp., *Senecio glossanthus*, *Daucus glochidiatus*, *Calotis hispidula*, *Plantago drummondii* and **Sonchus oleraceus*. *Helipterum craspedioides* occurred only where topsoils were of the quartz 'gibber' type, and not calcareous. Examples of the first included *Gnephosis skirrophora* (indicating a calcareous topsoil) and *Stenopetalum* sp. Examples of the second included *Gnephosis burkittii*, *Pogonolepis strictus*, *Gnephosis brevifolia*, *Crassula* sp., *Euphorbia drummondii*, *Stenopetalum robustum*, *Swainsona* sp., *Ptilotis aevroides* and *Brachycome* sp. Small washes on Undulating Plain supported relatively tall, dense stands of ephemerals on sandy alluvial material, the conspicuous species being *Cephalopterum drummondii*, *Helipterum charsleyae*, *H. strictum*, *Calotis multicaulis*, **Emex australis*, *Goodenia* sp. (AVM 204), *Erodium cygnorum* and *Brachycome* sp. The species *Calocephalus knappii*, *Waitzia acuminata*, *Actinobole uliginosum*, *Helipterum fitzgibbonii* and *Chrysocoryne pusilla* were present on Undulating Plain only on shallow soils over the relatively siliceous, acidic bedrock of banded ironstone formation. *Podolepis lessonii*, apparently favouring shallow soils, was confined to similar areas.

Although most Undulating Plain in the Edjudina—Menzies Study Area bore *Maireana sedifolia*, banded ironstone formation areas had a different perennial and ephemeral community. The mixed composition of the upper stratum on Undulating Plain (noticeable also in Broad Valley) was well illustrated here. No species clearly dominated and there was no clear stratification; low trees, tall shrubs, low shrubs and herbaceous plants were all present. Most conspicuous were *Acacia aneura*, *A. stowardii*, *Eremophila oldfieldii* ssp. *angustifolia*, *Brachychiton gregorii*, *Casuarina cristata* and *Santalum spicatum*. Chenopodiaceae were rare and no more than three species were recorded per sample site. Mosses and lichens formed a crust over about 40 per cent of the ground, being overtopped by ephemerals in season. Species of ephemerals found on Undulating Plain with *Maireana sedifolia* which did not extend commonly into this type included *Angianthus tomentosus*, *Plantago drummondii*, *Crassula* sp. *Senecio glossanthus*, *Helipterum tenellum*, *H. strictum*, *Vittadinia* sp. and *Gnephosis brevifolia*, their place being taken by *Cephalopterum drummondii*, *Gnephosis skirrophora*, *Helipterum laeve*, *H. maryonii*, *Ptilotus helipteroides* and *Asteridea atrixioides*.

Vegetation on Undulating Plain lacking an understorey of *Maireana sedifolia* and clearly dominated by *Acacia aneura*, occurred only in the northern part of the Study Area. Vegetation of this kind was often localised in groves with surface run-on of rainfall. Soils at Mt Percy were dusky red clay loam, becoming dark red below 30 cm. The surface has a scatter of fragments of quartz and other material less than 2 cm in diameter, covering about 10% of the area. Ten per cent by volume of the topsoil comprised fragments of pebble size and a further 10% fragments of gravel size, the occurrence of both types increasing with depth. At 60 cm a hardpan was encountered. Examination of a nearby dry creek showed that this was a 'pink' or 'brick-red', brittle, lateritic material with carbonate, and containing numerous grains of quartz. The only perennials apart from *Acacia aneura* were a few tall shrubs of *Eremophila angustifolia* and *Acacia tetragonophylla*, 1 m shrubs of *Scaevola spinescens*, *Enchylaena tomentosa* var. *tomentosa* and *Rhagodia eremaea* and low shrubs of *Abutilon cryptopetalum*, *Solanum lasiophyllum* and *Ptilotus obovatus* var. *obovatus*. Ephemerals such as *Gnephosis foliata* were common.

Broad Valley (V): This landform was widespread throughout the Edjudina—Menzies Study Area, occurring wherever the bedrock consisted of granitic rocks mantled with colluvial soil. Broad Valley in the Study Area consisted of loamy soils with a hardpan at depth, often containing lime. However, the topsoils were generally neutral or even acidic. The lime was more prominent in the south than in the north where there was a tendency towards pure silica. The vegetation throughout was characterised by *Acacia aneura* but the composition changed, with an admixture of *Eucalyptus* spp. and other *Acacia* spp. in the southern parts of the Study Area. *Brachychiton gregorii* occurred as an occasional emergent, particularly near Granite Exposure. The topsoil of Broad Valleys tended to be sandy in the Edjudina—Menzies Study Area, and where it was particularly leached

of nutrients a definite understorey of *Triodia* occurred. These areas, transitional to Sandplain, contained several species with restricted distributions found in the Kalgoorlie—Kurnalpi Study Area such as *Olearia exiguifolia*, *Eucalyptus jutsonii* and *Bursaria occidentalis*.

The common ephemerals throughout were *Velleia rosea* and *Helipterum craspedioides*. *Cephalopterum drummondii* was common on soils containing small stones and extended on to Undulating Plain. *Helipterum roseum*, a species typical of Salt Lake Feature and generally absent from Broad Valley, occurred where rainfall accumulated on the surface. *Helipterum charsleyae*, more typical of Undulating Plain, was common in small washes in Broad Valley.

Throughout Broad Valley, ephemerals tended to be concentrated in the litter of trees and shrubs (particularly *Brachychiton gregorii*). *Crassula* sp., *Helipterum laeve*, *Calandrinia polyandra* and *Daucus glochidiatus* were occasional plants encountered only in these microhabitats. In Broad Valley in the northern part of the Study Area, a direct comparison of ephemeral communities was made between patches of *Triodia basedowii* (e.g. EM19, Appendix 1) and areas lacking *Triodia* on the same landforms. Stands of *Triodia* were distinguished by *Myriocephalus guerinae* and *Helichrysum davenportii*, as well as the less common *Ptilotus macrocephalus* and *Helipterum oppositifolium*. These species were replaced in an adjacent area of *Acacia aneura* lacking a definite perennial understorey by *H. hyalospermum*, *H. craspedioides*, *Calocephalus skeatsianus* and the less common *Helipterum laeve*, *Brachycome ciliocarpa*, *Trachymene pilosa* and *Podolepis lessonii*, as well as moderate populations of species which were present but rare among *Triodia* such as *Chthonocephalus pseudevax*, *Crassula* sp., *Actinobole uliginosum*, *Chrysocoryne pusilla*, *Stenopetalum anfractum* and *Goodenia havi-ländii*. Species shared roughly equally between the two sample sites included *Erodium cygnorum*, *Velleia rosea*, *Waitzia acuminata*, *Helipterum battii*, *H. maryonii*, *Podolepis canescens*, *Gnephosis leptoclada*, *Calocephalus multiflorus*.

Vegetation in the southern parts of the Edjudina—Menzies Study Area was dense enough to carry fire, even where *Triodia* was absent. Regenerating areas featured *Codonocarpus cotinifolius*, *Duboisia hopwoodii*, *Acacia murrayana*, *A. ligulata*, *Cassia nemophila* var. *nemophila* and *Solanum orbiculatum* with abundant *Helipterum craspedioides* on the ground. *Acacia hemiteles* was common in the south. The reverse was true for *Eremophila leucophylla* which tended to occur in sandy soils such as small areas of 'wanderrie' country in the north-west where a form of mulga with broad silver phyllodes had an understorey of soft perennial grasses.

Where the soil was relatively shallow and sandy over a lime subsoil in the south-western part of the Study Area, an open stand of *Casuarina cristata* occurred with slightly emergent *Eucalyptus foecunda*. Some of the shrubs here showed links with the alkaline soils of Undulating Plain or Salt Lake Feature, e.g. *Dodonaea viscosa*, *Heterodendrum oleaefolium*, *Acacia stowardii*, *Exocarpos aphyllus* and *Santalum* spp. The ephemerals included sparse populations of a mixture of species of deep sand and alkaline soils rather than Broad Valley,

such as *Helipterum manglesii*, *Stenopetalum filifolium*, *Chrysocoryne pusilla*, *Brachycome ciliaris*, *Helipterum tenellum*, *Lepidium* sp., *Vittadinia* sp., *Ptilotus polystachyus* and *Daucus glochidiatus*.

It was noted that scrub of *Acacia aneura* on colluvial soils derived from banded ironstone formation, though treated within Undulating Plain, was very similar to that on typical Broad Valley sites derived from granite. The two communities shared their dominants as well as several species not usually found in such sites, e.g. *Cheilanthes* sp., *Mirbelia* sp. and *Podolepis lessonii*. Only a few species with minor cover values differed. *Acacia quadrimarginea*, *Minuria* sp. and *Cephalopterum drummondii* found on the banded ironstone formation were replaced on Broad Valley by *Eucalyptus ewartiana*, *Acacia craspedocarpa*, *Maireana villosa*, *Indigofera* sp., *Helipterum pterochaetum*, *Pimelea microcephala* and *Chrysocoryne pusilla*; while *Calocephalus* sp. was common only on the banded ironstone formation and *Helipterum hyalospermum* and several grasses were common only on the Broad Valley. Minor differences were also found among the prostrae ephemeral Asteraceae: *Chthonocephalus*, *Myriocephalus*, *Angianthus* and *Isoetopsis*. The overriding similarities could presumably be explained by the siliceous nature of banded ironstone, setting it apart from the other rocks typical of the 'greenstone' belts.

Goongarrie National Park

Goongarrie National Park consisted mainly of Broad Valley with various combinations of *Acacia aneura*, *Casuarina cristata* and, in places, *Eucalyptus* spp. Much of the area comprised gentle parallel rises about 2 km apart separated by shallow troughs. At the time of field work (July 1981) the area was recovering from a mosaic burn. Fire had affected most of the lower-lying portions but the rises were largely unburnt. Five metre high *Codonocarpus cotinifolius*, a post-fire species, was common throughout the burnt areas, many of which were grassy with regenerating one metre shrubs of *Acacia hemiteles*. In addition to Broad Valley, Goongarrie National Park contained patches of Sandplain with *Eucalyptus leptopoda* over *Triodia*, a few Granite Exposure with *Acacia quadrimarginea* (on rocks) or *Eucalyptus loxophleba* (on colluvial soil), and one patch each of Salt Lake Feature (south-west of the Park) and Calcareous Plain (north-east). A number of sample sites were described in unburnt stands.

One area of outwash plains associated with Granite Exposure bore scattered trees of *Acacia aneura*, *Hakea suberea* and *Eucalyptus* sp., over succulent steppe of *Maireana sedifolia*, some *M. pyramidata* and some *Atriplex*, and occasional *Frankenia*.

A soak on the western edge of Goongarrie National Park was typical of Salt Lake Feature. The gently sloping ground was a crusted loam with significant clay content and probably gypseous at depth. A little salt was visible on the surface. *Atriplex vesicaria* ssp. *variabilis* and *Frankenia* sp. were codominant. The only other perennials were *Maireana* spp. (e.g. *M. glomerifolia*), *Sclerolaena*

spp. (e.g. *S. eurotioides*), *Solanum lasiophyllum*, *Podolepis capillaris* and a few sparse low grasses (*Eragrostis*), with occasional small clumps of *Cassia nemophila* var. *nemophila*, *Eremophila scoparia*, *E. decipiens*, *Cratystylis subspinescens*, *Heterodendrum oleaefolium*, *Pittosporum phylliraeoides*, *Santalum acuminatum*, *Grevillea sarissa*, *Hakea arida*, *Acacia aneura* and *Casuarina cristata* on nearby sandy rises. At least 20 species of herbaceous plants were evident, including the ephemerals *Helipterum roseum*, *Senecio* spp., *Chthonocephalus pseudevax*, *Eragrostis dielsii*, *Maireana carnososa*, *Gnephosis burkittii*, *Erodium* spp., **Bromus* sp., *Crassula* sp., *Stenopetalum robustum*, *Centrolepis polygyna*, **Lophochloa pumila* and *Gnephosis macrocephala* as well as the geophyte *Wurmbea tenella*.

A nearby gypseous dune bore *Acacia aneura* and *Eremophila miniata* with a few plants of *Atriplex* sp. and *M. pyramidata*. Tall shrubs of *Pittosporum phylliraeoides* and low shrubs of *Gunniopsis* sp., *Ptilotus obovatus* and *Salsola kali* were present. *Atriplex* sp. dominated on the swale immediately adjacent with the annual herb *Senecio* sp. and a few tufts of the grass *Monachather paradoxa*. The dune bore a dense carpet of ephemerals despite its loose, sandy surface. *Erodium* and Goodeniaceae were common among these; complemented by *Gnephosis macrocephala*, **Bromus* sp., *Calandrinia* sp., *Ptilotus polystachyus*, *Plantago* sp., **Sinapis arvensis*, *Stenopetalum robustum* and other members of the Brassicaceae, and the geophyte *Wurmbea tenella*.

A small area on the opposite border of Goongarrie National Park, referable to Calcareous Plain, had nutrient-poor but base-rich soil with a scatter of pavement of limestone on the surface, pinker and more compact than the soil of adjacent Broad Valley. The vegetation was dominated by 7-9 m trees of *Casuarina cristata*. *Acacia aneura* was rare and represented by shrubs only, but there was a sparse stratum of tall shrubs noticeably clumped under trees (*Acacia hemiteles*, together with *Scaevola spinescens*, *Cassia nemophila* var. *nemophila*, *Alyxia buxifolia*, *Heterodendrum oleaefolium*, *Exocarpos aphyllus*, *Santalum spicatum*, and *Dodonaea lobulata*). *Maireana sedifolia* was present but uncommon. Low shrubs were confined to *Ptilotus obovatus* var. *obovatus*, *Olearia muelleri* and sparse *Solanum* spp., *Maireana* spp., and *Atriplex vesicaria*. Herbaceous plants consisted mainly of semi-annual *Stipa trichophylla* and a few *Sclerolaena* sp., and the sparse ephemerals were *Zygophyllum* spp., *Crassula* sp. and about 10 other species. This vegetation resembled that on Undulating Plain and Salt Lake Feature in some respects but the dominance of *Casuarina cristata* was distinctive.

Typical of Sandplain in Goongarrie National Park was a site with sandy loam or loamy sand overlain by a patchy crust and a uniform sprinkling of fine grit. Mallees of *Eucalyptus leptopoda* 4 m high and *E. rigidula* 5 m high were equally common. *Acacia aneura* was present in small quantities only. The main ground cover comprised a mixture of *Triodia scariosa* and the relatively soft tuft-grasses *Amphipogon caricinus* and *Eragrostis eriopoda*. An admixture of shrubs consisted of *Acacia* sp., *A. longispinea*, *A. ramulos*, *A. hemiteles*, *Grevillea didymobotrya* and *Hakea multilineata*. Sparse low shrubs consisted of *Thryptomene* spp., *Baeckea* sp., *Wehlia thryptomenoides*, *Keraudrenia integrifolia*, *Prostanthera*

baxteri and a few examples of *Eremophila decipiens*. The only geophyte noted was *Thysanotus patersonii*. *Waitzia acuminata*, found among leaf litter, was the main ephemeral. The only other ephemerals were *Brunonia australis* and a few *Helipterum verecundum*, *Crassula* sp., *Chrysocoryne pusilla* and *Goodenia* sp.

Elsewhere on Sandplain there were local stands of *Melaleuca uncinata* or *Allocasuarina* sp. The south-eastern sector of the boundary track ran through Sandplain at a relatively high elevation, with *Eucalyptus oldfieldii* and *Callitris preissii* ssp. *verrucosa* over *Triodia scariosa* and *Amphipogon caricinus* and patches of trees of *Acacia aneura*. *Eucalyptus transcontinentalis* occupied a few areas on discrete pediments of recently redistributed sandy soil associated with Sandplain.

Typical of Broad Valley in Goongarie National Park was a soil type consisting of loam 40 cm deep over a lime hardpan. The dominant plant, *Acacia aneura*, grew to 6 m with scattered *Eucalyptus longicornis* emerging to 8 m. Shrubs higher than 2 m formed a relatively dense stratum of *Acacia ramulosa*, *A. burkittii* and *A. tetragonophylla*. Shrubs 1 m high consisted of *Cassia nemophila* var. *nemophila*, *Eremophila granitica*, *E. decipiens*, *Scaevola spinescens* and *Dodonaea rigida*, and low shrubs and perennial grasses consisted of *Solanum lasiophyllum*, *Ptilotus drummondii*, *Maireana triptera*, *Amphipogon caricinus*, *Stipa elegantissima*, *Monachather paradoxa*, *Eragrostis eriopoda* and occasional *Triodia scariosa*. Ephemerals consisted of *Goodenia havilandii*, *Velleia rosea*, *Brunonia australis*, *Waitzia acuminata*, *Chrysocoryne pusilla*, *Helipterum craspedioides* and *Chthonocephalus pseudevax*.

A variant of mixed low woodland over scrub, intermediate to Sandplain, was reminiscent of vegetation in the Kurnalpi area to the south. The soil was a Sandy Loam, at least 40 cm deep, with a few pebbles of lime at the surface and terra preta present. The main tree species was tree mallee *Eucalyptus foecunda* (9 m); a second eucalypt was *E. concinna*. Uncommon *Acacia aneura* formed trees 7 m high. Shrubs consisted of *Dodonaea* spp., *Eremophila paisleyi*, *Acacia ramulosa*, and *A. tetragonophylla*. Low shrubs consisted of *Cassia nemophila*, *Eremophila latrobei*, *E. platythamnos*, *Scaevola spinescens*, *Ptilotus drummondii*, *P. obovatus* var. *obovatus*, *Solanum lasiophyllum* and *S. nummularium*. *Maireana* spp. were virtually absent. *Triodia scariosa*, together with less conspicuous grasses (*Monachather paradoxa*, *Stipa elegantissima*) were scattered throughout. Several species of *Olearia*, *Eremophila oldfieldii* spp. *angustifolia*, *Acacia jennerae* and *A. hemiteles* were rare but present. A sprinkling of perennial herbaceous plants comprised *Zygophyllum* sp., *Aristida contorta*, *Podolepis capillaris* and *Ptilotus exaltatus* var. *exaltatus*. Ephemerals were the common *Waitzia acuminata*, and *Brunonia australis*, *Goodenia* spp., *Helipterum fitzgibbonii* and *Chrysocoryne pusilla*, with *Calandrinia lehmannii* on open ground and *Calotis hispidula*, *Plantago* sp. and about five other species restricted to patches of litter. The dwarf ephemerals *Chthonocephalus pseudevax* and *Actinobole uliginosum* were also rare.

Table 4. Relationships between landforms, geology, soils and vegetation in the Edjudina-Menzies study area. Geological surfaces follow Kriewaldt (1970) and Williams *et al.* (1976).

(p) = in part

| Landform | Geological surface | | Position in landform | Soil | Vegetation type |
|-----------------------|--------------------|----------|-------------------------------------|---|---|
| | Edjudina | Menzies | | | |
| BREAKAWAYS (B) | Qrc | Qpy | Whole feature | Gritty loam? | Breakaways complex <i>Eucalyptus clelandii</i> / <i>E. lesoueffi</i> low woodland <i>Casuarina cristata</i> low woodland <i>Sclerostegia</i> low shrubland <i>Callitris columellaris</i> low woodland |
| | Qrc | Qpy | Lower slopes | Colluvium | |
| | Tb, Oqf, T1, Qq3 | Qtn | Mesa top | Shallow calcareous earth | |
| | Qrc (Qrc) | Qpy Qpy? | Footslopes ?Bluff face | Subsaline soil ?Skeletal gritty loam | |
| DRAINAGE LINES (C) | Qpv | Qpv | Narrow creekline | Deep calcareous earth | <i>Eucalyptus lucasii</i> low woodland <i>Eucalyptus salubris</i> low woodland <i>Eucalyptus camaldulensis</i> woodlands |
| | Qrv | Qpv | Broad creekline | ?Deep calcareous earth | |
| | Qpv | Qpv | Major creekline | Variable? | |
| DUNEFIELDS (D) | Qrs, Qple | Qas | Whole feature | Aeolian sand | Dunefields complex <i>Acacia aneura</i> low woodland <i>Atriplex</i> low shrubland mallee <i>Eucalyptus leptopoda</i> mallee or <i>Callitris preissii</i> tall shrubland |
| | Qrc, Qrs | Qas | Swale | Aeolian sand | |
| | Qpk | Qas | Crest | Aeolian sand | |
| | Qps | Qts | Whole feature | Aeolian sand | |
| GRANITE EXPOSURES (G) | Ag | Ag | Skeletal soil sheet and inner apron | Granitic soil | Granite complex <i>Atriplex</i> low shrubland <i>Acacia aneura</i> tall shrubland <i>Acacia acuminata</i> / <i>quadrimarginea</i> tall shrubland <i>Eucalyptus loxophleba</i> mallee |
| | Qpm | Qpm | ?Colluvial flat | ?Shallow calcareous earth | |
| | Qpm | Qpm | Outer apron | Granitic soil | |
| | Ag | Ag | Skeletal soil sheet | Granitic soil | |
| | Ag/Qpm | Ag/Qpm | Outer apron | Granitic soil | |

Table 4 contd.

| Landform | Geological surface | | Position in landform | Soil | Vegetation type |
|------------------------|--------------------------------------|---------------------------------------|--|---|--|
| | Edjudina | Menzies | | | |
| HILLS (H) | Alb, Ald, Alr Ag? | A3v, A3△? Ag? | Lower slope | ?Deep calcareous earth | <i>Acacia aneura</i> low woodland |
| | Alb, Ald, Alr Alb, Ald, Al5 Ag | A3v, A3△ A2k? A3v, A3△, A2k? Ag | Slope and crest Slope and crest Slope or crest | ?Granitic soil Shallow calcareous earth Shallow calcareous earth Granitic soil | <i>Acacia aneura</i> tall shrubland <i>Acacia acuminata</i> tall shrubland <i>Cassia</i> tall shrubland <i>Acacia quadrimarginea</i> tall shrubland |
| SALT LAKE FEATURES (L) | Alb, Ald, Al5 | A3v, A3△, A2k? | Lower slope | Shallow calcareous earth | <i>Casuarina cristata-Maireana sedifolia</i> low woodland |
| | Qrc Qrc | Qrc*, Qas Qrc*, Qas | | ?Aeolian sand ?Aeolian loam | <i>Acacia aneura</i> low woodland <i>Casuarina cristata</i> low woodland |
| | Qrd, Qpf | Qas, Qq3? | | ?Duplex loam | <i>Maireana pyramidata</i> low shrubland |
| | Qrd, Qpf | Qrp | | Aluvium | ? <i>Cratystylis subspinescens</i> low shrubland |
| | Qrm Qrm Qpk, Qrm - | Qak Qrb Qrb, Qak Qqs? | | Subsaline soil Saline soil Variable Deep calcareous earth | <i>Atriplex</i> low shrubland <i>Halosarcia</i> low shrubland Salt lake complex <i>Casuarina cristata</i> low woodland |
| CALCAREOUS PLAINS (P) | | | Plain | | |
| | | | | | |
| SANDPLAINS (S) | Ts, Qps | Qps? | Gentle slope | Aeolian sand | <i>Eucalyptus oldfieldii-Triodia</i> Mallee over Hummock Grass |
| | Qqn, Qps | Qps | Plain | Deep sand | <i>Eucalyptus youngiana-Triodia</i> mallee over Hummock Grass |
| | Tg? Qps | Qts, Qtn? Qps | Plain Plain | Gravelly sand Aeolian sand | <i>Eucalyptus leptopoda</i> mallee <i>Eucalyptus transcontinentalis</i> mallee |
| | Tg? Tg? | Qtg, Qtn? Qtg? | ? ? | ?Sand ?Sand | <i>Acacia ramulosa</i> tall shrubland <i>Acacia coolgardiensis</i> tall shrubland |
| | Qp5 | Qp5 | Slight swale | Colluvial sand | <i>Acacia aneura</i> low woodland |

Table 4 contd.

| Landform | Geological surface | | Position in landform Soil | | Vegetation type |
|-----------------------|--------------------|----------------------|----------------------------------|--|---|
| | Edjudina | Menzies | | | |
| UNDULATING PLAINS (U) | Qqc | Qpa | Colluvial flat | | <i>Casuarina cristata</i> low woodland |
| | Qpv Qqf, Qqc | Qpv Qqc, Qqf | Creekline Rise | | <i>Acacia aneura</i> low woodland <i>Eucalyptus clelandii</i> low woodland |
| | Qqf | Qqf Qtl, Qqc, A2k | Lateritic plain Ridge | | <i>Acacia stowardii</i> tall shrubland <i>Acacia aneura</i> tall shrubland |
| | Qqs | Qqs | Plain | | <i>Maireana sedifolia</i> low shrubland |
| | Qrc | Qpv? | Alluvial flat | | <i>Maireana pyramidata</i> low shrubland |
| BROAD VALLEYS (V) | Qq3 Qqs | Qq3 Qqs | Colluvial flat Colluvial flat | Deep siliceous loam Deep calcareous earth | <i>Acacia aneura</i> low woodland <i>Eucalyptus longicornis</i> low woodland |
| | Qqs | Qqs | Rise | Shallow calcareous earth | <i>Casuarina cristata</i> low woodland |
| | Qpv | Qpv | Alluvial flat | Deep calcareous earth | <i>Eucalyptus salubris</i> low woodland |
| | Qqn, Qps | Qps | Edge of sandplains | Deep sand | <i>Eucalyptus concinna</i> low woodland |
| | Qq3, Qpm | -? | Slightly raised plain | Aeolian loam | <i>Acacia aneura-Eragrostis</i> low woodland |
| | Qq3, Qqn | Qq3 | Plain | Siliceous loam | <i>Eucalyptus youngiana-Triodia</i> mallee over Hummock Grass |
| | Qqc, Qpm | Qqc, Qpm | Gentle slope | ?Granitic soil | <i>Acacia aneura</i> tall shrubland |

* bluffs (skeletal) on W. margins of salt lakes: separate veg type under U or V?

Table 5 contd.

| Vegetation Structure – Floristic dominant (by landforms) | | Landforms | | | | | | | | | | Conservation Status |
|---|--|-----------|-----|-----|-----|-----|-----|-----|-------|-----|-----|------------------------|
| | | B | C | D | G | H | L | P | S | U | V | |
| HILLS (H) | | | | | | | | | | | | |
| Low woodland | <i>Acacia aneura</i> | ... | ... | ... | ... | 22. | ... | ... | ... | ... | ... | . |
| Tall shrubland | <i>Acacia acuminata</i> | ... | ... | ... | ... | 23. | ... | ... | ... | ... | ... | . |
| Low woodland | <i>Casuarina cristata</i> - <i>Maireana sedifolia</i> | ... | ... | ... | ... | 23. | ... | ... | ... | ... | ... | . |
| Tall shrubland | ? <i>Acacia quadrimarginea</i> | ... | ... | ... | ... | 12. | ... | ... | ... | ... | ... | . |
| Tall shrubland | <i>Cassia</i> | ... | ... | ... | ... | 12. | ... | ... | ... | ... | ... | . |
| Tall shrubland | <i>Acacia aneura</i> | ... | ... | ... | ... | 13. | ... | ... | ... | ... | ... | . |
| SALT LAKE FEATURES (L) | | | | | | | | | | | | |
| Low woodland | <i>Acacia aneura</i> | ... | ... | ... | ... | ... | 32F | ... | ... | ... | ... | . |
| Low shrubland | <i>Maireana pyramidata</i> | ... | ... | ... | ... | ... | 23. | ... | ... | ... | ... | . |
| Low shrubland | <i>Halosarcia</i> | ... | ... | ... | ... | ... | 22. | ... | ... | ... | ... | . |
| Low shrubland | ? <i>Cratystylis</i> <i>subspinescens</i> | ... | ... | ... | ... | ... | 11F | ... | ... | ... | ... | . |
| Low woodland | <i>Casuarina cristata</i> | ... | ... | ... | ... | ... | 22. | ... | ... | ... | ... | . |
| Low shrubland | <i>Atriplex</i> | ... | ... | ... | ... | ... | 12F | ... | ... | ... | ... | . |
| Low, variable | Mixed | ... | ... | ... | ... | ... | 12F | ... | ... | ... | ... | P |
| CALCAREOUS PLAINS (P) | | | | | | | | | | | | |
| Low woodland | <i>Casuarina cristata</i> | ... | ... | ... | ... | ... | ... | 12. | ... | ... | ... | P |
| SANDPLAINS (S) | | | | | | | | | | | | |
| Mallee over | <i>Eucalyptus oldfieldii</i> - | ... | ... | ... | ... | ... | ... | ... | 22(F) | ... | ... | P? |
| Hummock Grass | <i>Triodia</i> | ... | ... | ... | ... | ... | ... | ... | ? | ... | ... | P? |
| Tall shrubland | <i>Acacia ramulosa</i> | ... | ... | ... | ... | ... | ... | ... | ? | ... | ... | P |
| Mallee | <i>Eucalyptus leptopoda</i> | ... | ... | ... | ... | ... | ... | ... | 32F | ... | ... | P |
| Mallee | <i>Eucalyptus</i> <i>transcontinentalis</i> | ... | ... | ... | ... | ... | ... | ... | 12. | ... | ... | P? |
| Mallee over | ? <i>Eucalyptus youngiana</i> - | ... | ... | ... | ... | ... | ... | ... | 23. | ... | ... | . |
| Hummock Grass | <i>Triodia</i> | ... | ... | ... | ... | ... | ... | ... | ? | ... | ... | ? |
| Tall shrubland | <i>Acacia coolgardiensis</i> ? | ... | ... | ... | ... | ... | ... | ... | 22F | ... | ... | ? |
| Low woodland | <i>Acacia aneura</i> | ... | ... | ... | ... | ... | ... | ... | 21. | ... | ... | . |

Table 5 contd.

| Vegetation Structure – Floristic dominant (by landforms) | Landforms | | | | | | | | | | Conservation Status | |
|---|-----------|---------------------------------|-----|-----|-----|-----|-----|-----|-----|-------|------------------------|---|
| | B | C | D | G | H | L | P | S | U | V | | |
| UNDULATING PLAINS (U) | | | | | | | | | | | | |
| Low woodland | | <i>Casuarina cristata</i> | ... | ... | ... | ... | ... | ... | ... | 34F | ... | . |
| Low shrubland | | <i>Maireana sedifolia</i> | ... | ... | ... | ... | ... | ... | ... | 34F | ... | . |
| Low shrubland | | <i>Maireana pyramidata</i> | ... | ... | ... | ... | ... | ... | ... | 23. | ... | . |
| Low woodland | | <i>Acacia aneura</i> | ... | ... | ... | ... | ... | ... | ... | 24F | ... | . |
| Low woodland | | <i>Eucalyptus clelandii</i> | ... | ... | ... | ... | ... | ... | ... | 22F | ... | . |
| Tall shrubland | | <i>Acacia aneura</i> | ... | ... | ... | ... | ... | ... | ... | 23. | ... | . |
| Tall shrubland | | <i>Acacia stowardii</i> | ... | ... | ... | ... | ... | ... | ... | 13F | ... | . |
| BROAD VALLEYS (V) | | | | | | | | | | | | |
| Low woodland | | <i>Acacia aneura</i> | ... | ... | ... | ... | ... | ... | ... | 33(F) | ... | P |
| Low woodland | | <i>Eucalyptus longicornis</i> | ... | ... | ... | ... | ... | ... | ... | 12. | ... | P |
| Low woodland | | <i>Casuarina cristata</i> | ... | ... | ... | ... | ... | ... | ... | 23F | ... | P |
| Low woodland | | ? <i>Eucalyptus salubris</i> | ... | ... | ... | ... | ... | ... | ... | 11. | ... | . |
| Low woodland | | <i>Eucalyptus concinna</i> | ... | ... | ... | ... | ... | ... | ... | 12F | ... | . |
| Mallee over | | <i>Eucalyptus youngiana-</i> | ... | ... | ... | ... | ... | ... | ... | 23F | ... | . |
| Hummock grass | | <i>Triodia</i> | ... | ... | ... | ... | ... | ... | ... | ... | ... | . |
| Low woodland | | <i>Acacia aneura-Eragrostis</i> | ... | ... | ... | ... | ... | ... | ... | 23. | ... | . |
| Tall shrubland | | <i>Acacia aneura</i> | ... | ... | ... | ... | ... | ... | ... | 22F | ... | . |

Other areas of Broad Valley featured stands of 9 m *Casuarina cristata*, a species found particularly on the rises in the Park. In one extensive stand of *Acacia aneura* and *Casuarina cristata*, there were few rises but the soil remained compact and lime was present at depth as evidenced by roadside spoil. On the other hand, some relatively sandy surfaces in Broad Valley in the Park were marked by the occurrence of an understorey with *Eremophila leucophylla* and grasses.

Fox (1980) has studied regeneration of vegetation after fire in the Edjudina—Menzies Study Area. His findings relate particularly to Goongarrie National Park since his study was located adjacent to the Park and dealt with the effects of the same fires from which the Park vegetation was regenerating at the time of the present survey.

Acacia aneura normally regenerates by germination of long-lived seed after occasional, torrential rains (Hall *et al.* 1964). Fires are rare in *A. aneura* vegetation owing to its openness and the sparsity of perennial ground cover. However, when burnt, *A. aneura* trees are generally killed and regeneration depends on germination from seeds. Fires may favour successful regeneration of *A. aneura* to some extent by providing a mineral-rich ashbed (Fox 1980).

Suitable conditions occurred for fire in the Edjudina—Menzies Study Area in 1974-1976. Exceptionally heavy rains allowed a dense tall growth of ephemerals which dried to produce flammable ground cover. Fortunately, regeneration of *A. aneura* was favoured by the repetition of good rains shortly after the fires, providing deeply moistened soil adequate for the seedlings (Fox 1980).

Fox (1980) studied a number of sample plots on Menangina Station. On most of these, *A. aneura* regenerated successfully and the plants grew to 50 cm high by five years after the fire. Virtually all of the other species also survived. Species relying basically on vegetative regeneration were the low shrub *Cassia nemophila* var. *nemophila*, sclerophyllous shrubs or trees (*Eucalyptus oleosa* var. *oleosa*, *Grevillea* sp., *Melaleuca* sp.), various plants with relatively soft leaves or short-lived seed contained in fleshy fruits including representatives of rainforest groups *Brachychiton gregorii*, *Exocarpos aphyllus*, *Rhago`a* sp., *Scaevola spinescens*, *Dianella revoluta*, *Canthium lineare*, *Alyxia buxifolia*, and the geophyte *Wurmbea tenella*. Species relying basically on seed, except where fires were very mild, were *Acacia aneura*, *A. tetragonophylla*, *Casuarina cristata*, *Santalum acuminatum*, *Leichhardtia australis* and *Solanum lasiophyllum*, a mixed group ecologically. *Acacia* species were generally intermediate between these groups in their regeneration mode. The emphasis was on vegetative regeneration in *Acacia acuminata*, *A. ligulata*, *A. hemiteles* and *A. ramulosa*, and regeneration from seed in *A. murrayana* (Fox, 1980).

However, a further suit of species (Fox 1980) appeared to be particularly favoured by fire: *Codonocarpus cotinifolius*, *Cassia artemisioides*, *C. pleurocarpa*, *Duboisia hopwoodii*, *Solanum orbiculatum*, *S. oldfieldii* ssp. *plicatile*, *Dodonaea* sp., *Halgania* sp. and species of Malvaceae. These were generally soft-leaved, fast-growing shrubs apparently capitalising on the improved availability of soil nutrients and reduced competition from long-lived plants following burning.

Codonocarpus was a particularly striking example of a 'fireweed' which germinated in this area after the 1974-1976 fires and grew to 6 m in the following five years (Fox 1980). It was still widely evident in Goongarrie National Park at the time of the present survey.



Plate 1: Vegetation type EM1a. Banded Ironstone Breakaway with occasional *Casuarina cristata*, west of Linden, October 1980.



Plate 2: Vegetation type EM3. *Acacia coolgardiensis* Tall Shrubland on Dunefield, 2.5 km north-east of Comet Vale. March 1979.



Plate 3: Vegetation type EM8. *Acacia aneura* Low Woodland over *Muehlenbeckia cunninghamii* on Salt Lake Feature, 5 km north-north-west of Linden. March 1979.



Plate 4: Vegetation type EM9. *Acacia aneura* Low Woodland over *Cratystylis subspinescens*, *Maireana pyramidata* and *Atriplex vesicaria* on Salt Lake Feature between Lakes Goongarrie and Marmion. March 1979.



Plate 5: Vegetation type EM14. *Eucalyptus clelandii* Low Woodland over *Maireana sedifolia* on Undulating Plain, 4 km north-west of Linden. March 1979.



Plate 6: Two-year old regenerating *Acacia aneura* and *Eucalyptus* spp. on Broad Valley in Goongarrie National Park. Ephemerals and grasses (*Amphipogon caricinus* and *Eragrostis eriopoda*) were abundant in October 1980.



Plate 7: Vegetation type EM22. *Eucalyptus concinna* Mallee over *Triodia scariosa* on Broad Valley, 3 km north-east of Comet Vale. March 1979.

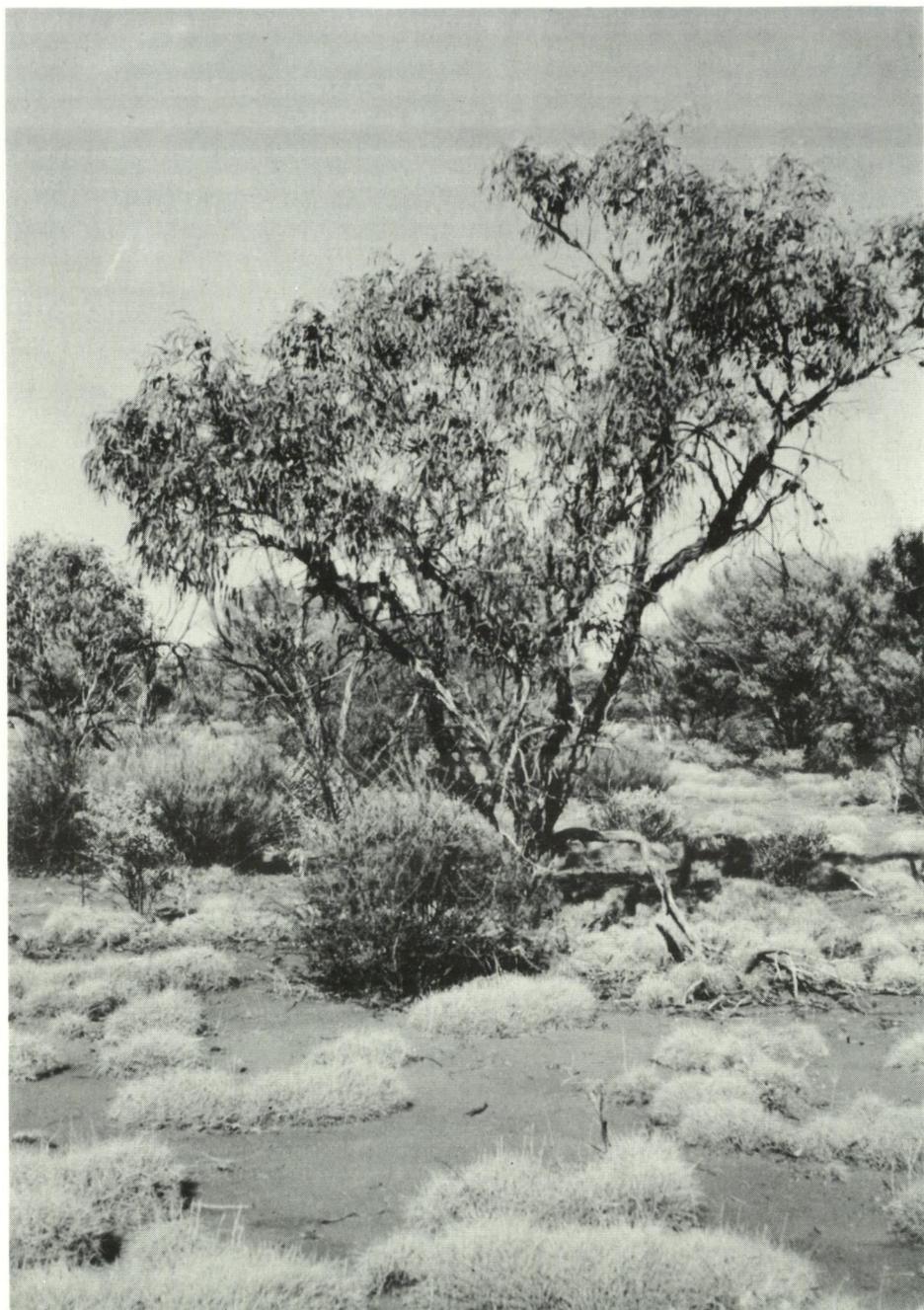


Plate 8: Vegetation type EM19. *Acacia aneura* Low Woodland with scattered *Eucalyptus youngiana* over *Triodia basedowii* on Broad Valley, 10 km south-south-east of Linden. July 1981.