

4. VEGETATION, HABITATS AND BIOGEOGRAPHIC CONTEXT

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4.1 Vegetation

The vegetation of the northern Pilbara Region belongs to the Fortescue Botanic District of the Eremaean Botanical Province which covers the whole of arid Australia (Beard 1975, 1980). The predominant vegetation of the two physiographic units are wattle savannas on the Abydos Plain of small trees and scrub with a soft spinifex hummock grass groundlayer, and snappy-gum savanna with two kinds of spinifex grassland on the fold ranges. Traversing these are the major creek lines carrying dense bands of tall gum and paperbark woodland, and dense wattle scrub along tributaries.

The first ecological description of the Abydos-Woodstock area which identified plant associations based on landform and soil characteristics was made by Nancy Burbidge (1959) who pointed out that "variation in the local flora is directly linked with soil character and with drainage". In her survey five major plant habitats were identified viz. (1) large granite outcrops, (2) dykes and non-granitic outcrops, (3) stony rises and low hills, (4) plain and (5) watercourses (consisting of six types).

For ease of reference in correlative studies the vegetation is here first classified on a physiognomic and structural basis, then regrouped in habitats which are associated with particular landscape units.

Plant Communities grouped on a Physiognomic and Structural Basis

(definitions combine African (Tinley 1975) and Western Australian (Muir 1977) terminology).

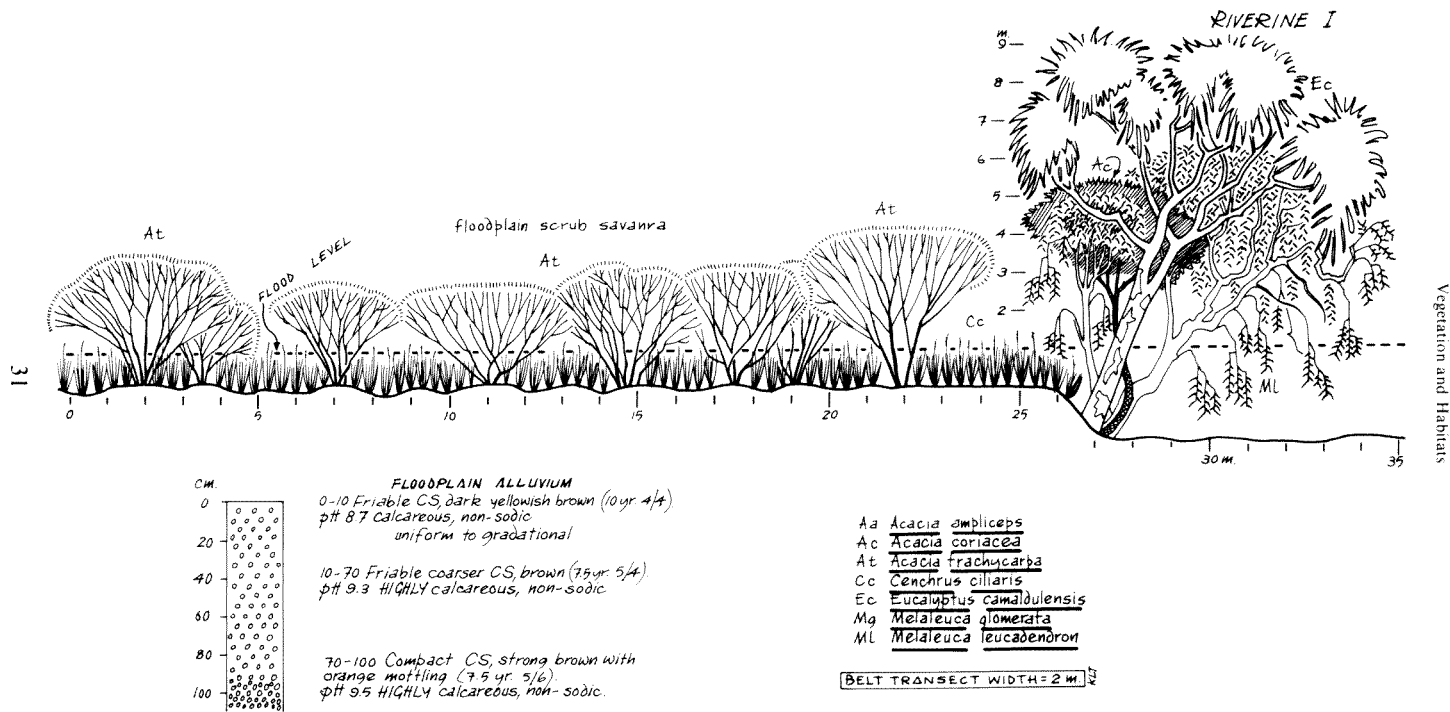
(A) **THICKETS**: usually stratified, very dense tree and/or large shrub community, occurring as a continuous, patchy or clumped cover. Thicket shorter than 5m is referred to as scrub-thicket. In moist areas thicket is seral to forest, and in dry regions it is climax. Most components except the groundlayer are heliophytes.

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|---------------------|------------------|
| (1) Riverine | (4) Tree-base |
| (2) Small Tributary | (5) Rock Outcrop |
| (3) Calcareous | (6) Ravine |

(B) **WOODLANDS**: stratified or single layered stands of trees over 5 m tall with a variable canopy spacemnt from closed to very widely separated (dense = >50% canopy cover, open = 20-50%, sparse = 2-20%). Typically all strata of woodlands are heliophytes as opposed to closed forests whose subcanopy layers and immature stages of canopy trees are sciophytes. Two major physiognomic orders of woodland occur, the true woodlands and the wooded grasslands. The first where the term is in closest accordance with appearance, where all strata are dominated by woody plants (e.g. eucalypt woodlands with heath or saltbush understorey). The second comprises

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Figure 4.1



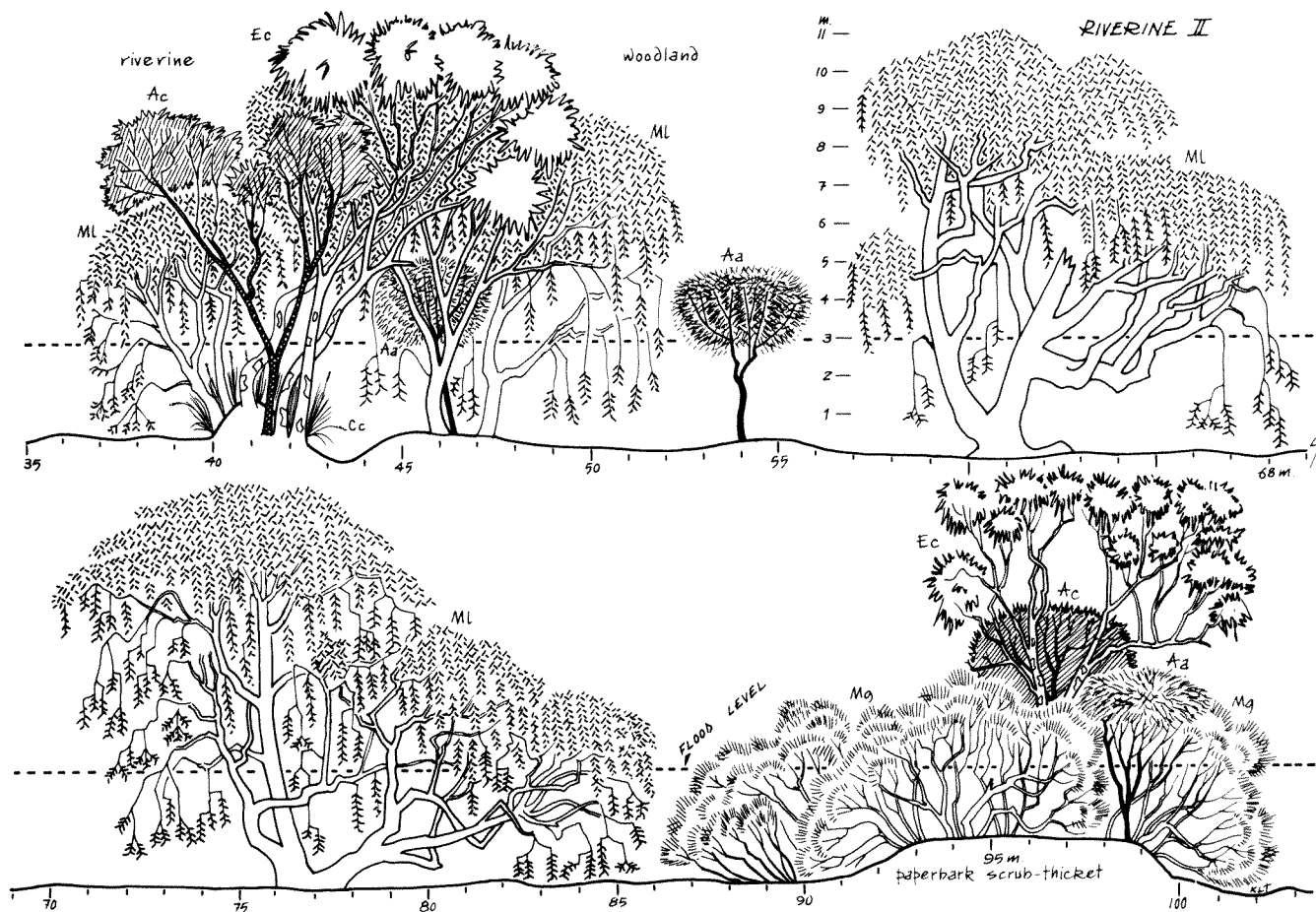


Figure 4.1 Transect to midstream across floodplain and riverine habitats of Coorong Creek.

two major formations, those of montane and temperate climates, and those that lie between the equator and the true deserts which are referred to as savannas (e.g. most of Australia north of the winter rain regions and excluding the steppe-like saltbush country and the tropical rainforests: consisting of Arid, Mesic and Moist Savanna types). As a rule of thumb a casual observer can easily identify two main woodland cover classes, as wooded shrublands or wooded grasslands where the tree cover is sparse (<20%), and as grassed woodlands or shrubbed woodlands where the tree cover is open to dense (>20%).

- (1) Riverine (creek beds and banks)
- (2) Bloodwood-gum Tree Savanna
- (3) Snappy-gum Tree Savanna
- (4) Mulga

(C) SCRUBLANDS/SHRUBLANDS: short woody cover generally less than 5m in height of single stemmed small trees and/or multiple-stemmed shrubs, including the mallee growth form. Canopy spacement classes, and field and groundlayer relationships as described for woodlands. *Scrub* is used where short trees and/or large shrubs over 2-3 m predominate, and *shrub* for a pure shrub cover usually less than 2-3 in height e.g. saltbush, heaths.

- | | |
|--------------------------------|---------------------------------------|
| (1) Floodplain Wattle Scrub | (4) Thorny Ranji Wattle Scrub Savanna |
| (2) Boulder Talus Wattle Scrub | (5) Weeping Wattle Scrub Savanna |
| (3) Rock Outcrop | |

(D) HERBACEOUS FORMATIONS AND COMMUNITIES

1. *Suffrutex and Forb Communities*

- i Rock Outcrops
- ii Minor Gullies
- iii Secondary (disturbed ground)
- iv Soft Herb Communities of Caves and Overhangs

2. *Grassland Formations*: land covered predominantly by grasses. In addition to grasses, graminoids (sedges, rushes), geophytes and forbs may occur, as well as dwarf scrub at or below the grass canopy level. The main growth forms are tufted or bunch grasses, hummock, and mat or lawn forming grasses. The bamboos are woody clump forming grasses which are classed as woodland or open forest.

Resinous Perennial Hummock Grasslands:

- i Plains Soft Spinifex
- ii Dambo Spinifex
- iii Bottomland Spinifex Mosaic

- iv Calcareous Hill Spinifex
- v Non-calcareous Hill Spinifex

Non-resinous Perennial and Annual Tufted grasslands:

- vi Riverine and Floodplain
- vii Dwarf Root-mat Communities on Exfoliation Surfaces
- viii Post-fire succession in spinifex grassland
- ix Post-rain Annual Flora

3. *Aquatic Communities*: these comprise free floating, (submerged and surface), rooted submerged, and emergent plants rooted underwater or in wet soil.
Present, but not differentiated. Aquatic habitats should be classified using the two distinctive attributes of "wetness" and "landform" as detailed by Semeniuk (1987).

(E) HEIGHT/STRATIFICATION CLASSES

<i>Woody Plants (m)</i>	<i>Herbaceous Plants (cm)</i>	<i>Class</i>
a. >25	>300	High
b. 15-25	150-300	Tall
c. 5-15	50-150	Medium
d. 1- 5	15- 50	Short
e. <1	<15	Dwarf

Plant Community Description

The vegetation of the north Pilbara in keeping with the whole of the Australian Arid Zone is predominantly perennial, and evergreen in regard to its woody components. Exceptions to this feature occurs in two situations. (1) Where perennial spinifex grasslands are replaced for three years (Burbidge 1943) by an annual post-fire seral successional phase until the hummock growth-form reasserts its predominance. (2) Where local moister and sheltered habitats such as ravines and rock outcrops provide outlier nuclear sites for deciduous trees and shrubs more typical of the moister tropical savannas in the Kimberley. Of these elements five deciduous woody genera were recorded from the Reserve area, concentrated in the Soansville Plateau and the larger granite rockpiles in the north and northwest of the Reserve, including *Dichrostachys*, *Flueggea*, *Phyllanthus* and *Terminalia*.

Another distinctive feature of the region due to the recurring but sporadic alternation of fire, drought and exceptional rains, is the tendency for the development of even-aged stands of woody plants. This is most conspicuous amongst wattle species where regeneration is dependent on seed. These species mature and become senile or moribund and die back simultaneously, or are killed by fire or drought. The new crop of seedlings all come up together in a particular area in response to an adequate rainfall and develop new even-aged stands (e.g. Figure 4.6: Plate 4). The eucalypts and a few wattles, notably Ranji, the plainsland dominant, recover vegetatively by coppice regrowth after being burnt by fire.

A third distinctive feature of the landscape is the single species dominance in both woody and grass strata over large areas. This appears to be an expression of the huge size of each relatively homogenous physiographic unit. Within this larger overall pattern however, higher biotic diversity occurs wherever edaphic changes result from the junction of differences in relief, rock type, soil and drainage.

The plant communities noted below are arranged in order of most to least heterogenous in vertical and horizontal form and structure i.e. from thickets through the duplex wooded grassland savanna formation to the simplest herbaceous communities. Habitat profile diagrams (bisects) of vegetation and soils were drawn to scale in the field of representative sections for each main plant community. These are depicted in Figures 4.1 to 4.7 arranged in the same order as the text.

[A] THICKETS

(1) *Riverine Thicket*

Formed primarily by one or more of five species of large paperbark or tea-tree *Melaleuca* shrubs, on the main sandy and gravel creeks and their larger tributaries. These thickets are formed on river bank deposits and islands of sand over silt. They usually occur in clumped form though some as on the Turner River have considerable linear continuous canopy cover. The *Melaleuca* thickets attain up to 5 m in height and often have an overstorey of taller wattles which are perch-based bird dispersed species such as *Acacia ampliceps* and *A. coriacea* which form an upper canopy stratum between 6 and 9 m height. Where these have formed around taller river-gums *Eucalyptus camaldulensis* a three tiered leaf and stem structure results (see Figure 4.1; Plates 17, 22, 24).

(2) *Small Tributary Thickets*

These are composed chiefly of dense wattle scrub up to 5 m in height with denser patches where *Melaleuca* clumps occur (Plate 25). Though they form relatively narrow bands of only 2 to 4 m width they have long sectors of continuous linear canopy cover. In the upper Turner catchment and in the Fold Range zone the dominant tributary wattle on stony ground is *Acacia acradenia* (refer to Figure 2.1; Plate 22). The floristic composition of the riverine strip in the hills is mixed, derived from a combination of species from, or more typical of, creeklines, rock outcrops, savanna, perch-based bird dispersed elements, and Moist Savanna Biome elements.

(3) *Calcareous Thicket*

This is a relatively uncommon plant community in the Reserve area and the type example occurs immediately north of the Edgina Tors. The dominant thicket forming species is a tea-tree shrub *Melaleuca bracteata*, which attains 3 m in height and a canopy diameter of 5 m. The main overstorey species are small trees of the bird dispersed riverine wattle *Acacia ampliceps* (see Figure 4.2; Plates 26, 27).

(4) *Tree-base Thicket*

Bush clumps formed around the base of larger trees are composed of bird dispersed species which recur in all perch related situations such as rock outcrops, around fence

posts and near watering sites (Plates 28, 29). These subcanopy bird formed thickets are a salient feature of the Central Desert savannas in Western Australia (Tinley 1986), but are relatively uncommon in the Abydos-Woodstock area. Here they are confined mainly to alluvium along drainage lines in the Fold Hills. Tree-base thickets here are from one to 3 m in height and those noted beneath the canopy of bloodwood-gums were composed of *Acacia bivenosa*, *A. pyrifolia*, *Senna artemisionides* subsp. *oligophylla*, *Crotalaria* spp., *Eremophila longifolia*, *Eremophila* sp., *Rhagodia eremaea*, and *Santalum lanceolatum*. Three wattles dispersed by birds (Davidson 1984) also occur as components of these riverine bush clumps as well as around the base of rock outcrops, these are *Acacia ampliceps*, *A. coriacea* and *A. pruinocarpa* (e.g. Plate 16).

(5) *Rock Outcrop Thickets*

These form around the base of outcrops, on granite tors between boulder piles and in cliff and talus sites. Components comprise some of those noted above and typically the small tree *Mallotus nesophilus* confined to granite tors, with smaller bush clumps of *Atalaya hemiglauca*, *Capparis spinosa* (rare), *Ehretia saligna*, *Flueggea virosa* and the rock fig *Ficus platypoda*.

(6) *Ravine Thickets*

Confined to the Soansville Plateau the thickets are formed by deciduous bird dispersed scandent shrubs *Flueggea virosa* and *Phyllanthus ciccooides*, either alone or close to larger trees (Plate 17). The rock figs which are also bird dispersed occur as lone clumps, some covering a large area, on the sides of ravines and around boulder piles, such as the large multiple-stemmed clump of *Ficus racemosa* near Cajeput Pool.

[B] WOODLANDS

(1) *Riverine and Floodplain Woodland*

There is great variation in the canopy spacement of riverine woodland depending on the width and substrate features of the drainage line. In the fold hills coolibah *Eucalyptus microtheca* occur as isolated large trees along rocky creeks or form part of the outer drier margin of more continuous woodland on large creeks dominated by rivergum *E. camaldulensis* and cajeput *Melaleuca leucodendra*. Typically riverine woodland is composed of a single stratum of large trees up to 12 or 14 m in height with patches of more diverse cover where thickets occur (Figure 4.1; Plates 18-21). On the adjoining floodplain alluvia are single or two tiered short woodlands or scrub of wattles between 3 and 7 m in height with lines of taller river-gum or coolibah along channels crossing the alluvium. The floodplain wattle cover is a savanna system with a tufted grassland groundlayer of the introduced Buffel-grass *Cenchrus ciliaris*, which also tends to form a single species cover particularly where creeks traverse the Plains (Plate 21). In the fold range zone the riverine grass understorey is richer in tussock (bunch grass) species than the plains, including *Dicanthium affine*, *Heteropogon contortus*, *Sorghum plumosum* and *Themeda australis* in addition to the Buffel grass. All of these bunch grasses attain over 100 cm in height when in full inflorescence. Refer to Figure 4.1.

(2) *Bloodwood Gum Tree Savanna*

Bloodwood Gum *E. terminalis* savanna with its ground layer of hard dark green spinifex *Triodia wiseana* are indicators of calcareous soils. The largest area dominated by Bloodwood savanna occurs in the north, Abydos sector, of the Reserve in the upper catchment of the Turner River. Bloodwood occur on plains, riverine, fold hill and plateau summit sites (Figure 4.3; Plates 30-34).

(3) *Snappy Gum Tree Savanna*

Snappy Gum *E. leucophloia* is the dominant hill savanna tree in association with one or other of three spinifex species depending on soil. On the fold hills Snappy Gum is less common and tends to form groves related to escarpment-like outcrops, but forms a more continuous intermediate to sparse upper canopy cover on plateau summits. Here Bloodwood is a subordinate upper canopy component and the trees only attain some 6 m in height, as opposed to 10 m on the plateau's talus slopes. On the Soansville Plateau the Snappy Gum savanna is composed of three strata, an upper canopy to 6 m, a midstratum between 3 and 4 m in height of wattle and hakea scrub and a groundlayer less than 1 m in height of widely spaced spinifex and dense patches of a dwarf form of *Acacia orthocarpa*. Midstratum components recorded were *A. pyrifolia* and *Grevillea wickhamii* (dominants), *A. sclerosperma*, *A. tumida* and *Hakea suberea*. The dominant ground layer is glaucous spinifex *Triodia brizoides* with soft spinifex *T. pungens* in deeper soil pockets and rare occurrences of a dwarf wattle *A. adoxa*. Elsewhere Snappy Gum hill savanna is typically two tiered, trees over grassland as shown in Figure 4.4.

(4) *Mulga*

The mulga *Acacia aneura* woodland formation reaches its northern limit as a whole community on the sediments and valley plains of the Fortescue River (Figure 4.11D), though it does occur further north as disjunct outlier communities in an arc around Nullagine north eastwards almost to Warrawagine on the Oakover River (Ron Johnstone pers. com.). In the Reserve area mulga occurs only as lone tree outliers on cliff ledges and boulder talus of the Soansville Plateau escarpment, and as a widely spaced line of trees on adjacent lava ridges. The position of these outliers related to perch-based sites suggests that mulga are not only dispersed by ants (Davidson 1984) and water, but also possibly by ground feeding doves and pigeons.

[C] SCRUBLANDS/SHRUBLANDS

(1) *Floodplain Wattle Scrub*

Already mentioned in A1 above, the most common alluvial scrub community is formed by a wattle *Acacia trachycarpa* with "mini-ritch" type bark which forms single species even-aged stands of different cohorts in different localities (Plate 21). On minor sandy tributaries another wattle *A. sclerosperma* is locally common also in pure stands with a patchy occurrence of two, spined, legumes with bipinnate leaves, the Chinese Lantern *Dichrostachys spicata* and Mimosa Bush *Acacia farnesiana*. This cover is intermediate to dense (canopies touching) and is generally between 2 and 3 m in height.

The "mini-ritchii" wattle is not confined to riverine sites but also occurs as single or several plants on the granite tors. Refer to Figure 4.1.

(2) *Boulder Talus Wattle Scrub*

The best example of this community dominated by small trees of gidgee *Acacia pruinocarpa* is to be seen beneath Waterfall Bluff on the Soansville Plateau escarpment behind The Buttes. Here gidgee attain about 4 to 5 m in height and form dense stands amongst the boulders. The most common shrub or small tree associated with gidgee in this area is *Atalaya hemiglauca*. Gidgee is most common along the plateau escarpment both above and below the cliffline (Plate 16).

(3) *Rock Outcrop Scrub*

On the granite tors, calcrete mesas of bottomlands and fold hill rocky outcrops where the trees and shrubs are *not* aggregated into bush clumps occur as individuals or as groups of several plants mostly less than 5 m in height with their canopies separate to touching. The component species are the same as those noted in A(5) above and with others showed the following percentage occurrence on 20 different granite tors between Pullcunah and Gallery Hill: *Mallotus nesophilus* 80%, *Acacia coriacea* 50%, *Ficus opposita* 40%, *Ficus platypoda* 40%, *Clerodendrum floribundum* var. *angustifolium* 20%, *Flueggea virosa* 15%, *Dichrostachys spicata* 15%, *Acacia trachycarpa* 10%; less than ten percent *Atalaya hemiglauca*, *Capparis spinosa*, *Ehretia saligna*, and the tree *Terminalia canescens*.

The deciduous terminalia tree is confined to the north and northwest of the Reserve on plainsland tors, and to ravines in the Soansville Plateau where large trees to 7 or 8 m height occur in Bowerbird Gorge. On the tor-capped dome granite inselberg group between the northwest of the Reserve and Mount Tinstone the terminalia is the prevalent tree and forms a sparse to intermediate canopy cover. The species is typical of poor soil, steep slopes or leached sands in the medium to higher rainfall areas of the Kimberley (Petheram & Kok 1983).

(4) *Thorny Ranji Wattle Scrub Savanna*

The predominant vegetation on the Abydos Plain, but also occurring more sparsely on the spinifex dominated fold hill ranges as well. The only thorny phyllodenous acacia in the area, *Acacia pyrifolia* recovers from fire damage by coppice regrowth. Though occurring as nearly pure species stands of small trees 3 to 5 m in height over large areas, another smaller wattle up to 2.5 m in height with emerald green leaves *Acacia ancistrocarpa* often forms a midstratum though it also tends to develop in pure patches. Minor small tree components of Ranji savanna are *Grevillea wickhamii*, *G. pyramidalis*, *Hakea suberea*, and widely scattered occurrences of Lemonwood *Dolichandrone heterophylla* which also occur in the fold hill zone on pediment red earths (Figure 4.5; Plates 41-46).

(5) *Weeping Wattle Scrub Savanna*

The weeping wattle *Acacia orthocarpa* which attains up to 5 m in height forms single species, even-aged scrub savanna over most of the shallow stony granite soils south of the

Yule River, in the centre of the Reserve between Coorong Creek and Tilt Hill, then again in the northern section south of the Abydos Wall between the railway line and the main branch of the upper Turner River. Canopy cover though extremely light due to the fine weeping growth-form of the terminal branchlets and leaves, can be from nearly touching to overlapping over large areas but generally appears to be of intermediate spacing. Typically the community is a two tiered structure with a ground layer of glaucous spinifex *Triodia lanigera*, or soft spinifex *T. pungens*.

Occasionally pure species patches of another wattle *A. maitlandii*, with spine-tipped phyllodes, is encountered within the greater cover of the weeping wattle. On the Soansville Plateau summit area and its footslopes a dwarf form of *A. orthocarpa* which lacks the weeping habit, has short erect terminal twigs and a higher resin content with pine-like scent. A rare shrub component of this community is *Templetonia hookeri* with pale yellow flowers. Refer to Figure 4.6.

[D] HERBACEOUS FORMATIONS AND COMMUNITIES

(1) *Suffrutex and Forb Communities*

i. *Rock Outcrops*

The most common forbs are species of Malvaceae and Liliaceae (see Burbidge 1959). Larger components on granite tors are *Gossypium robinsonii* and *Senna venusta*. In the fold hill zone *Indigofera monophylla* forms pure species patches on outcrops of base saturated rocks such as basalt.

ii. *Minor Gullies*

In the fold hills the most common forb components encountered were *Cajanus acutifolius*, *Dampiera candidans*, and *Indigofera monophylla* again.

iii. *Secondary (disturbed ground)*

Refer to the works of Burbidge (1943, 1959), Suijndorp (1967) and Beard (1975). This includes the flush of annuals which occur following the advent of fire.

iv. *Soft Herb Communities of Caves and Overhangs*

The only component collected of this very interesting small plant community is a small tufted sedge *Bulbostylis burbidgeae* up to 10 cm in height which is common as a pure species micro-community beneath overhangs on granite tors. A more extensive herb community occurs after good rains below the dripline on the floor of Big Cave on the Soansville Plateau escarpment.

(2) *Grassland Formations*

The two major groups of grasses are the resinous perennial hummock-forming species, all of the genus *Triodia* in this area, and the tufted bunchgrass or tussock-forming species which are non-resinous, perennials and annuals.

i-v. *Hummock Grass Communities*

The hummock grasses typically occur in single species dominance on particular substrates over large areas. This is exemplified by the Ranji wattle savanna where soft

spinifex occurs on red earth plains virtually from horizon to horizon (Plate 3, 42). However, this is of course traversed by creeks, bottomland flats and rock outcrops all of which support different spinifex. On the fold ranges two spinifex species clad very large areas of the hills almost to the exclusion of any other cover. Each form pure species mosaic communities on different substrates (Plate 54), a glaucous spinifex *T. brizoides* on base-poor stony red lateritic earths (Plates 2, 35-38), and *T. wiseana* also in a pure cover but on calcareous stony soils (Figure 4.9; Plates 30-31).

A different suite of spinifex species occur as a mosaic on hydromorphic soils. In bottomland sites on calcareous sodic/gypsic soils another glaucous spinifex *T. longiceps* is dominant on columnar clays where the 6 to 30 cm friable topsoil is preserved. Where this is truncated exposing the base saturated columnar clays at the surface *T. secunda* is dominant. Where pockets of deep calcareous loams occur in the bottomlands *T. wiseana* forms part of the mosaic as well. Refer to Figure 4.7; Plates 50, 51).

The remnant dambo-type drainage rising from the summits of convexities on the granite plains support treeless grasslands of a single spinifex species *T. lanigera* (Figure 4.8; Plates 47-49). At first sight it seems surprising that a spinifex common also on shallow stony duplex earths with weeping wattle, and on calcrete mesas should be dominant on a hydromorphic soil which is seasonally waterlogged. However, for the greater part of the annual cycle in the arid zone its likely that dambo soils are xeric.

Tufted (Bunch) Grass Communities

vi. *Riverine and Floodplain Grassland*

The perennial bunch grasses occurring in the north Pilbara are more typical of the mesic to moist savannas, and in the arid tropics are confined mostly to drainage alluvia. These have been noted above in the description of riverine and floodplain woodland communities (see B(1)). See Figure 4.1; Plate 21.

vii. *Dwarf Root-Mat Communities on Exfoliation Surfaces*

Associated typically with granite exfoliation surfaces in both Australia and Africa, are root-mat communities of dwarf plants natural bonsai habitats. In arid to mesic regions these are chiefly small perennial and annual grasses, sedges and other herbs including mosses, ferns and orchids for example, whose interlacing web of roots form a sponge-like mat blanketing the exfoliation surface. Dwarf root-mat communities are however not confined to granite geology but occur on many other kinds of rock type including laterites, where bare surfaces of gentle slope occur.

As the root mat is relatively thin the microcommunity is extremely sensitive to changes in moisture. They are among the first plant communities to show a greening growth response to even light rain because of the runoff received from adjacent steeper rock faces. But they are also the first to go brown and dormant when dry spells occur in the wet and for the duration of the dry season.

In higher rainfall regions these root mats are also colonized by woody plants as illustrated by examples from the dome granites of the higher zone of winter rainfall in the Southwest Region of Western Australia (Wardell-Johnson 1987). Where succession on

root-mats leads to an increasing density of woody plants the weight of the root-mat reaches a critical mass poised against gravity. This point is exceeded by the additional weight from saturation by a heavy rainfall which also provides a fluid interface between mat and rock resulting in massive gravity slides which eliminate part or whole sections of the community. The colonizing and successional process of root-mat expansion then begins all over again.

In the arid savanna environment of the north Pilbara the root-mat communities are less vigorous due to the extreme torrid conditions, and are confined to the flatter exfoliation surfaces where they occur as small patches around the base of granite domes and tors. Here the microcommunity is characterized by the dominance of a dwarf bunch grass *Tripogon loliiformis*, which attains about 10 cm in height when flowering.

In Africa two dwarf grasses *Oropetium capense* and *Microchloa caffra* (syn. *M. kunthii*) are the main components of root-mats. The latter grass is extraordinarily similar in appearance and growth form, including the shape of the inflorescence, to *Tripogon loliiformis*, and provides another example of analogous species pairs occupying the same niche on the widely separated plates of Gondwanaland.

viii. *Post-Fire Succession in Spinifex Grassland*

In spinifex grassland the post-fire successional dominance of annuals for the first three seasons is detailed by Burbidge (1943, 1959) and Suijddorp (1967). See Plates 45, 46.

ix. *Post-Rain Annual Flora*

A rich flush of a diverse annual flora (therophytes) results in the region following exceptional rainfalls which allow them to complete their life cycle, as was witnessed at the end of March 1988 when three-quarters of the total mean yearly rainfall fell in 17 hours. Of this annual flora only some of the grasses were collected, namely *Aristida browniana*, *Dactyloctenium radulans*, *Enneapogon planifolius*, *Eragrostis cumingii*, *E. dielsii*, *Eriachne aristidea*, *Paspalidium rarum* and *Sporobolus actinocladius*.

Neither Compositae or Cruciferae which form the flowering spectacle in overgrazed Mulga Woodland in spring after rain in the Meekatharra region for example, were encountered at Abydos/ Woodstock confirming a salient difference in the north Pilbara flora pointed out by Burbidge (1959).

Due to sporadic occurrence of rainfall in the region it is likely that more than one flush of annuals and associated insect fauna occurs in the yearly cycle, though only one of the opportunistic cohorts may receive sufficient moisture to set seed. There may be different species assemblages or aspect dominance that respond to effective rains in either spring, summer or winter. When effective June or July rains from a far reaching intense polar cyclonic front eventuates it would be valuable to make a special effort to monitor the wetted area and make collections of any annuals that appear in the various habitats.

The Fire Factor

Fire is a natural phenomenon in grasslands, savannas and woodlands which experience an alternation of wet and dry seasons. The arid hummock grasslands in Australia, like the eucalypts, are particularly predisposed to fire due to the presence of

flammable resins in spinifex and of volatile oils in the gums so that they burn like kerosine. It is hard not to conclude that these formations are in fact "fire demanding" for their longterm cycles of regeneration. The response of various wattles and gums to fire in the area is noted above. In summary, all the gums and paperbarks produce coppice regrowth after fire but only a few of the wattle do so; the majority are killed and regeneration is from seed. Here emphasis is given to the dominant herbaceous ground stratum.

Spinifex bear inflorescence stems from several different flowering periods following each fall of rain. Germination of *Triodia* seeds is related to the occurrence of effective soil moisture rather than to any particular time of the year. However only those seedlings which germinate early in the year develop a sufficiently supportive root system to survive torrid summer drought conditions (Burbidge 1943).

Fire or long droughts kill the aerial parts of spinifex and the plants recover vegetatively from buried meristems after the next rain (Jacobs & Chapman 1984). This author states that only very intense fires kill the buried meristems and even then some always survive, though spinifex growing on rocky hills with overdrained xeric soils are the most susceptible to elimination by fire. Regeneration in the latter situation taking place solely from seed.

In the north Pilbara Region spinifex burning experiments by Burbidge (1943), whose findings were later confirmed by Suijendorp's (1967) burning experiments on Abydos-Woodstock, showed a different pattern of response. Inland, all hummocks of spinifex were killed including the ground meristem leaving the landscape bare for most of the year until the advent of rain when re-establishment was solely from seed. On the Pilbara coast which has dews and a much higher year round humidity than inland (see Figure 2.3) only the aerial parts of spinifex were burnt and vegetative regrowth took place almost immediately from the original individual hummock bases.

Timing of burning is thus important from many aspects. Both Burbidge (1943) and Suijendorp (1967) point out that a winter dry season burn inland is the most damaging as the spinifex is killed and the standing seed crop is eliminated, leaving the ground bare for long periods. Topsoil is stripped off and minor sand drifts occur from the strong spring winds during September. Furthermore foliage production in soft spinifex and associated species was drastically reduced to less than 100 kg/ha over a three year period from a winter burn compared with the tenfold increase of 1000 kg/ha three to five years after a summer burn.

The frequency of burning is also a key factor. Annual burns diminish the ground cover progressively each year, whereas burns at three to five year intervals increased the cover where grazing was a minor influence (Suijendorp 1967). Lack of fire plus heavy selective grazing which avoid spinifex resulted in the expansion of spinifex hummocks to the exclusion of most other herbaceous plants. The four year average interval between experimental burns with an absence of grazing pressure (or using controlled deferred grazing) tended to increase the variety of perennial grasses (Suijendorp 1967).

Hence, the evidence from field control burning experiments indicates that the least damaging fire which maintained the highest diversity of perennial grasses in the absence

of grazing pressure for this arid savanna landscape would be close to a five year interval. Total protection from fire results in the development of a homogeneous spinifex grassland which develop moribund centres if they are not killed by long droughts. Ideally such burns should be in the form of many relatively small patch burns in a mosaic pattern, and a mapped record kept to ensure rotation of burnt and unburnt areas.

4.2 Habitats

The habitat of an organism is the place in which it lives, and includes other organisms. Such an area provides the effective environment within which an individual or a population operates. Habitat may also refer to the place occupied by an entire biotic community in which case only the abiotic environment is involved. An ecological niche, by contrast, is the organism's functional role in a community (what it does) and its position in an environmental gradient (Odum 1971).

The most important ecological units on land are drainage basins which are hydrologic ecosystems that traverse a variety of landscapes, climates, soil and vegetation formations and biotic communities between source and mouth linking them into a single process arena whose boundaries are defined by the outline of their catchment divides (watersheds) (Tinley 1986). Across these are other ecosystem units related to physiographic or landscape features such as plains, mountains, inselbergs, rock outcrops, deltas and sand dunes — each system characterised by its particular biophysical make-up. These are most easily recognised by using plant communities or associations as the first means of identifying and separating system units on the basis that vegetation is an integrated expression of the ecosystem.

Whereas ecosystems are the self-contained functional units of biophysical interactive processes, habitats as kinds of living spaces are as diverse as the species of organisms but their association into biotic communities, synusia, trophic guilds etc facilitates a hierarchical classification of habitats. Hence the habitats of the Abydos-Woodstock area noted below must be seen merely as a preliminary framework a first approximation on which to build or modify according to the nature and habits of the organism under study.

The major habitats of the Reserve area coincident with the larger physiographic ecosystems are the thorny Ranji wattle/soft spinifex community of the plains, the Snappy Gum/hard spinifex of upland fold ranges, and the gum and paperbark/ wattle woodlands and bunch grass communities of creek drainage. A plethora of possible habitat combinations and permutations at all scales are available at ecological junctions and across ecotones, which in the Reserve area are highest where plains, tors, ridges, plateaux and creeks are in closest juxtaposition (see Figure 4.11).

Riverine communities too are usually quite distinct in non-forest settings to their surroundings but are dependent on these from near and far for the linear biophysical connectivity and runoff which is intrinsic to their uniqueness. Nevertheless as drainage passes through different landscapes each tract expresses characteristics related to these changes and in this way forms part of the landform and habitat array identifying each

physiographic unit. Hence where drainage systems pass through a particular landscape unit they are treated here as part of that unit's assemblage of associated habitats.

Ecosystems and habitats as they are associated in the Abydos-Woodstock area:

The three major systems are (A) Granite Plains, (B) Upland Fold Ranges, and (C) Drainage Systems.

[A] PLAINS HABITATS

1. Thorny Ranji wattle scrub savanna with soft spinifex on red earths (Figure 4.5; Plates 3, 41-46).
2. Weeping-wattle scrub savanna with soft and hard spinifex on shallow stony earths (Figure 4.6).
3. Emerald-wattle *Acacia ancistrocarpa* scrub community.
4. Spine-leaved wattle *A. maitlandii* scrub community.
5. Lemonwood *Dolichandrone* tree community.
6. Bloodwood tree savanna with *Triodia wiseana* spinifex on calcareous soils (Figure 4.3; Plates 30-34).
7. Dambo treeless grassland (*T. lanigera*) (Figure 4.8; Plates [16\$F47-49]).
8. Annual Communities/Guilds (Plates 45, 46).
9. Bare Ground: — sand, clay, pebble gibber surfaces (e.g. near Ironstone Mesas).
10. Rock Outcrop Habitats: of isolated domes, tors, mesas, razorbacks and dyke walls (Plates 3-6, 56).
 - 10.1 Tree and/or shrub thicket clumps (*Mallotus*, rock figs).
 - 10.2 Wattle *Acacia tumida* groves around base of outcrops.
 - 10.3 Shrublets and Grasses.
 - 10.4 Dwarf Root-Mat Community.
 - 10.5 Soft Herb Cave Community.
 - 10.6 Bare Rock Surfaces — caves, overhangs, ledges, crevices, small cliffs.
 - 10.7 Gnamma Holes.
11. Secondary Disturbed Habitats: — roads, railway, homestead, mining camps, bulldozed and open cut sites.
12. Habitats provided by Plants and Animals.
 - 12.1 Termite hills and mounds (Figure 4.5; Plates 42-45).
 - 12.2 Spinifex hummocks.
 - 12.3 Paperbarks.
 - 12.4 Mistletoe Clumps (confined mostly to riverine and floodplain trees).
13. Riverine Habitats.
 - 13.1 Tall river gum and cadjeput woodland (Figure 4.1; Plates 18-20).
 - 13.2 Paperbark thickets on sandbanks (Figure 4.1; Plate 24).
 - 13.3 Wattle scrub woodland (Figure 4.1; Plate 21).
 - 13.4 Bunch Grass Community (Figure 4.1; Plate 21).

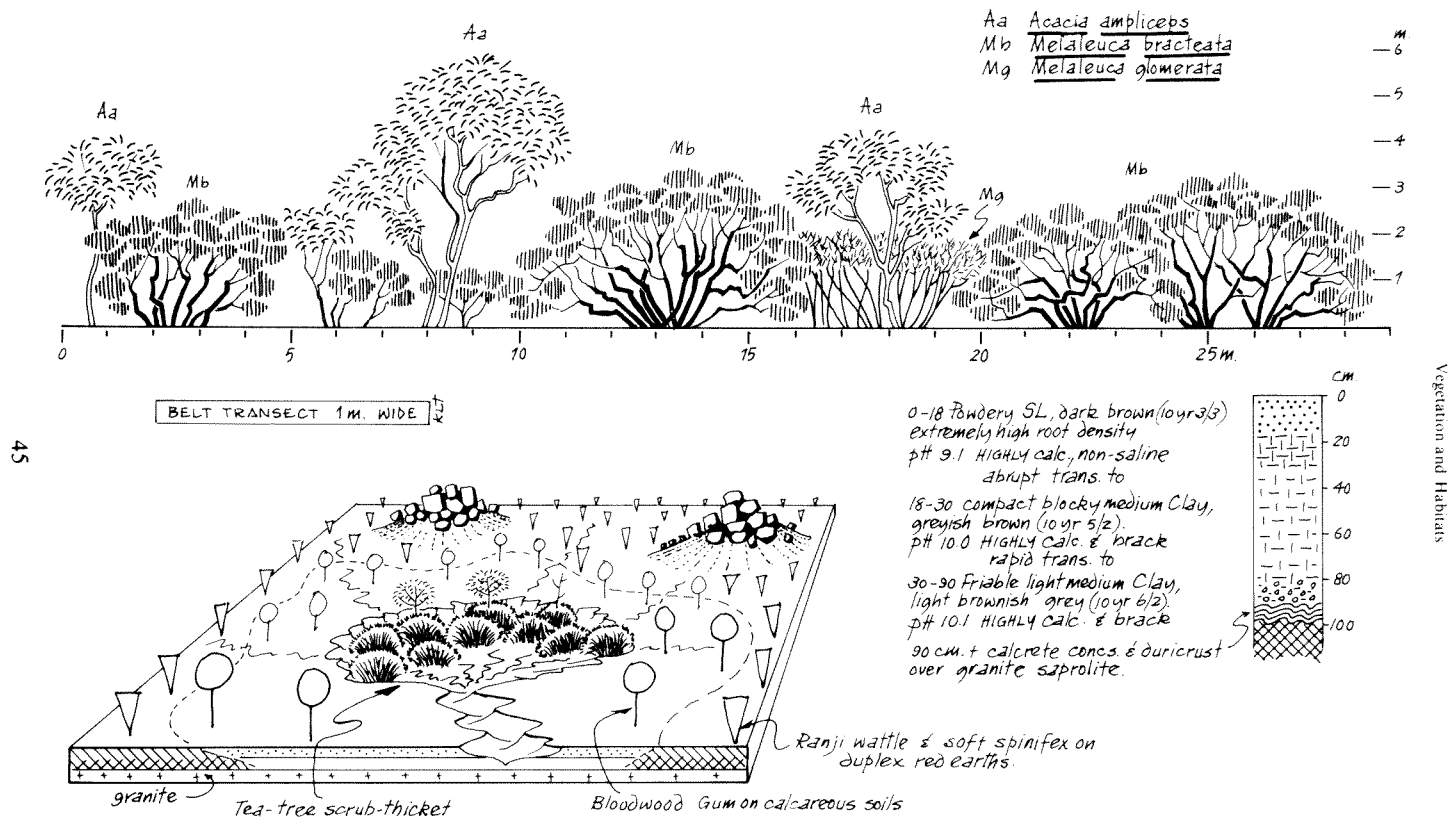


Figure 4.2 Tea-tree Scrub Thicket on duplex pallid calcareous-brack clays of erosion cirque at head of minor tributary.

- 13.5 Sandy Creek Beds.
- 13.6 Scour Pools (Plate 23).
- 13.7 Sandbanks and islands.
- 13.8 Rock outcrops (Plate 23).
- 14. Bottomland Saline Flats: — spinifex grassland mosaic on brown soils (Figure 4.7; Plates 50, 51).
 - 14.1 *Triodia longiceps* on duplex calcareous-sodic clays.
 - 14.2 *T. wiseana* on calcareous loams.
 - 14.3 Sand mounds formed by stoloniferous *T. secunda* over truncated columnar calcareous-sodic sandy clays.

[B] FOLD RANGE HABITATS

- 1. Rock Outcrop Thickets (Plate 55).
- 2. Ravine Thicket (Plate 17).
- 3. Boulder Talus scrub woodland (Gidgee wattle) (Plates 16, 55).
- 4. Snappy Gum tree savanna with hard spinifex grasses (Figure 4.4; Plates 2, 8, 35-40).
- 5. Plateau Summit snappy gum-bloodwood-wattle savanna.
- 6. Wattle *A. tumida* scrub thicket community on cliff ledges and 6\$Faround the base of rock outcrops.
- 7. Dwarf weeping wattle scrub on hillsides.
- 8. Spinifex grassland mosaic (*T. wiseana* on stony calcareous soils, and *T. brizoides* on base deficient stony red earths). Figure 4.9; Plates 2, 35, 38, 52-54.
- 9. Annual Communities/Guilds.
- 10. Bare ground: — exposures of kaolin clays (e.g. White-shouldered Hill), angular stony rubble gibber surfaces (Plate 58).
- 11. Rock Outcrop Habitats: — of razorback ridges, buttes, conical hills; plateaux with planar to rounded summits, cliffed escarpments, talus, scree, caves, overhangs, ledges, ravines (Plates 9, 11, 12, 14-17).
- 12. Secondary Disturbed Habitats: — roads, tracks, homesteads, mining camps, bulldozed and open cut sites.
- 13. Habitats provided by Plants and Animals.
 - 13.1 Spinifex hummocks.
 - 13.2 Termite mounds (uncommon).
 - 13.3 Mistletoe Clumps (confined mostly to riverine trees).
- 14. Riverine Habitats.
 - 14.1 Coolibah and River Gum Woodland or lines of large trees (Plate 20).
 - 14.2 Small Tributary scrub thicket of wattles *A. acradenia* and paperbark clumps (Plates 22, 25).
 - 14.3 Bunch Grass Community on alluvium.
 - 14.4 Calcrete Terraces (Figure 4.9; Plate 8).
 - 14.5 Rocky Creek Beds.

- 14.6 Boulder and Gravel Beds.
- 14.7 Rock pools scour pools, plunge pools of temporary waterfalls (Plates 9, 10).
- 15. Bottomland Saline Flats. Mosaic of bare crusted saline soils with large spinifex hummocks (Figure 4.9).

Concluding Notes

(a) *Thicket Habitats and Fire*

This habitat on rock outcrops would probably be more extensive or larger if there was less fire. Most of the trees and shrubs forming the clumps have been burnt by fire at various times. However both fire and extended drought, which is a normal feature of this region, kill back trees resulting in multiple-stemmed coppice regrowth which thickens up the bush clump habitat but keeps it short.

(b) *Perch-based Thickets*

The perch-based bird dispersed thickets, like the mistletoes, appear to be confined more to creek areas than the intervening savannas. This contrasts with the Central Deserts country traversed by road between Laverton, Warburton, Giles and Ayers Rock where bird-formed tree-base or subcanopy thickets are a feature of the arid savannas in this region (personal observations).

No thicket clump initials related to termite hill perch sites were encountered in the Reserve area. Tall dense thicket clumps develop on termite hills in South America and Africa though the mound-forms usually remain bare. The only place in the whole of Western Australia where termitaria thickets were encountered during low level air traverses of the State was near Kununurra airport on *Eucalyptus pruinosa* poorly drained heavy textured soils.

(c) *The Dambo Habitat*

Dambo drainage of open, treeless, seasonally waterlogged swaths with sharp junctions along the sides to the adjoining woodlands are a common feature in higher rainfall regions such as the Kimberley where they are grass covered, and in the Southwest Winter Rain Region where they support low heaths, sedges and restios. In the higher rainfall settings dambos act as a water store, releasing moisture as base flow to its headwater stream during the dry season and thus support green vegetation when the surroundings have already dried out.

All dambo habitats are vulnerable to extinction from the headward migration of gully nickpoints accelerated or initiated by stock trampling and overgrazing, wrongly sited paths or vehicle tracks, or drying out of their surface from the excessive recurrence of fire. By incising the dambo surface gully heads virtually 'pull the plug out of the system' drying out the high watertable sponge which then allows trees to encroach from the sides. This compounds the drying out process leading to its demise and occlusion of the open habitat by tree canopies (Tinley 1982 and in Walter & Breckle 1986). In countries which recognize dambos as a vital dry season resource special conservation measures are applied to stop or damp the headward erosion of gully nickpoints (Roberts 1988).

The occurrence of dambos in an arid setting make their presence in the Reserve area a particularly special habitat to monitor and protect from erosion. Under arid conditions however dambos will not be recharged fully every season, waterlogging will be for much shorter periods so that a base flow cannot be maintained and they become desiccated down to the impervious horizon.

In the Reserve area there are two types of dambo of different age. The remnants of the higher older granite plain convexities being actively encroached by headward erosion of gullies. A younger set which have reformed after the original dambo was eroded and replaced by a V-shaped valley where the incised drainage subsequently became choked by aggradation from an excess of sediments above the transporting capacity of the drainage flow. These smaller reformed dambos are a landscape feature of the Reserve area south of the Yule River.

(d) *Termite Mounds*

A characteristic feature of the Central Deserts and the mulga country especially conspicuous from the air are the myriads of bare oval patches in high density pockmarking the landscape. These bare patches are composed of subsoil brought to the surface by the low mound building *Drepanotermes* termite. A great many of these oval patches are dead or fossilized mounds cemented by calcrete. In the Reserve area where the same bare oval termitaria soil patches are common as well, most of the mounds encountered were live. Much larger and widely spaced bare oval termitaria patches are also a feature of the subdesert western margin of southern Africa both on plains and upland ranges and in summer and winter rainfall regions between SW Angola and Saldanha Bay north of Cape Town (pers. obs.).

(e) *The Mistletoe Microhabitat*

The distribution of the host-leaf imitating mistletoes of Australia (Barlow 1981), which are dispersed chiefly by the specialist mistletoe-bird (Green 1985), appear to be confined mostly to creek woodlands in the north Pilbara. In contrast mistletoe clumps were widespread on the trees and shrubs of the Central Deserts arid savannas as seen from the road between Laverton and Ayers Rock.

This difference could be an observational error caused by the amazingly similar leaves the mistletoes have to their host tree. With their bird, ant, butterfly and other commensals mistletoe clumps are veritable microcosms on their own (De Baar 1985).

4.3 Biogeographic Context

The northern Pilbara lies in the northwest corner of the Australian Arid Zone (Figure 1.1C), in an ecological junction area falling midway between the southwest end of the moister Kimberley savanna types (the Pindan), the western edge of the Great Sandy Desert psammophytic savannas, and the mulga and mallee formations to the south (Figure 4.11D). The ecological make-up of these adjacent regions is described in the vegetation and wildlife surveys of Beard 1979, Beard & Webb 1974, McKenzie 1981, McKenzie 1983, McKenzie & Burbidge 1979, and Muir 1983.

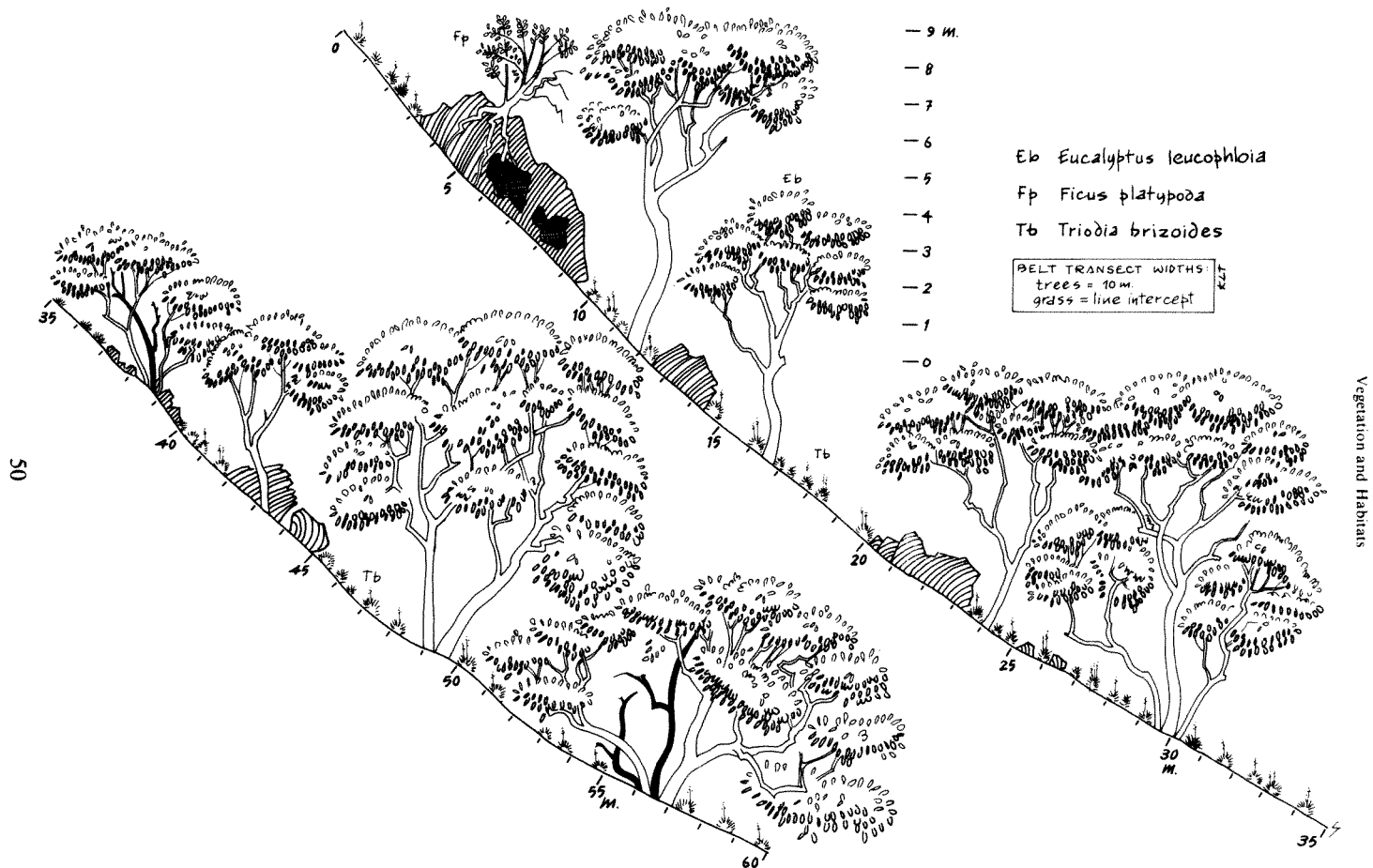


Figure 4.4 Snappy Gum hill savanna with hard glaucous spinifex grasslayer on banded ironstone talus soils.

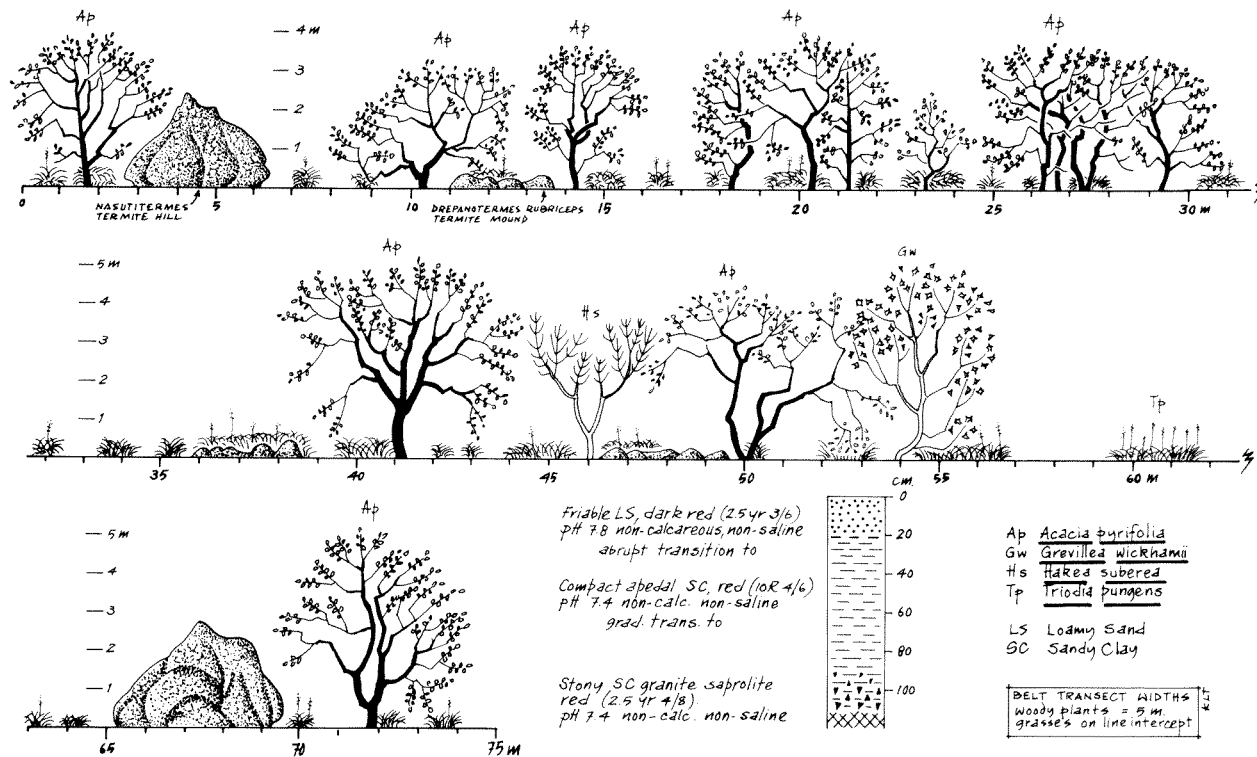


Figure 4.5 Thorny Ranji Wattle scrub savanna with soft spinifex on duplex red earths of granite plains.

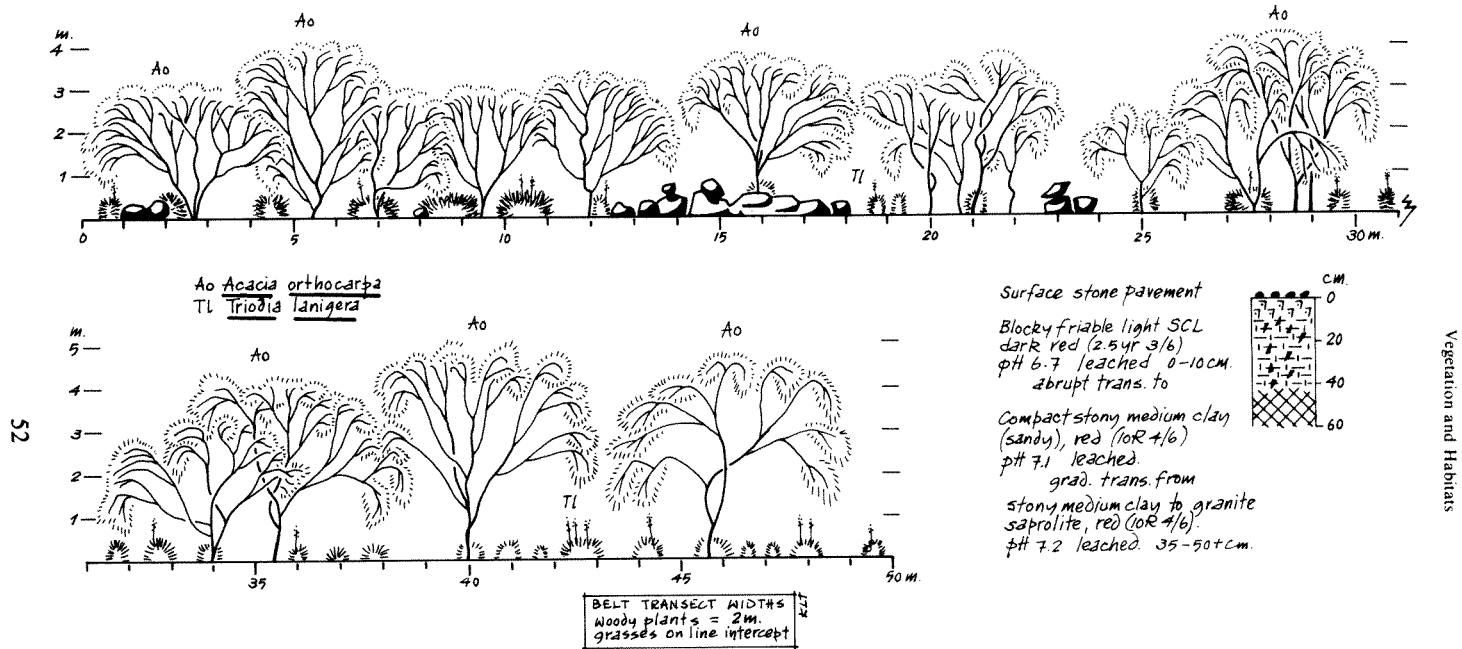


Figure 4.6 Weeping Wattle scrub savanna with hard glaucous spinifex on shallow stony clayey red earths over granite.

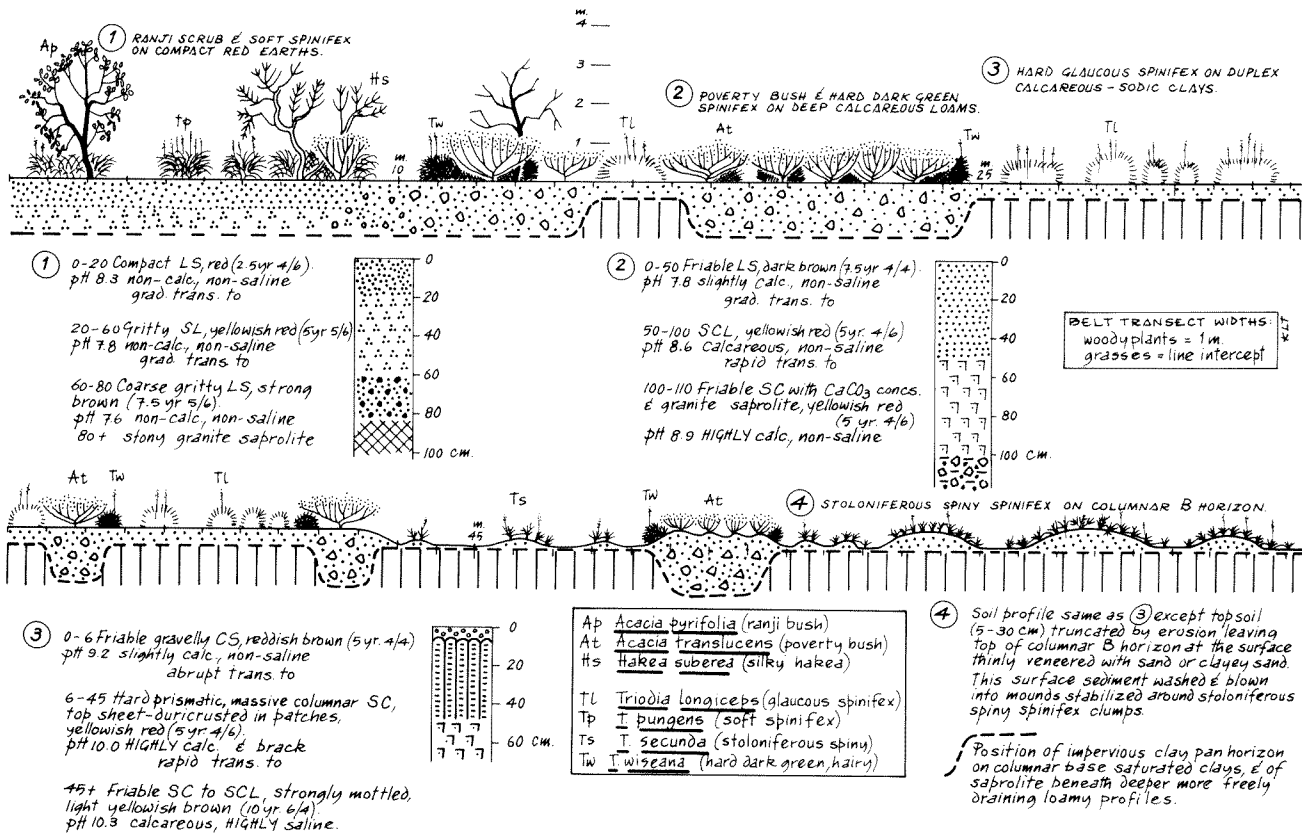


Figure 4.7 Transect across junction of granite plains red earths with bottomland mosaic of base saturated brown soils.

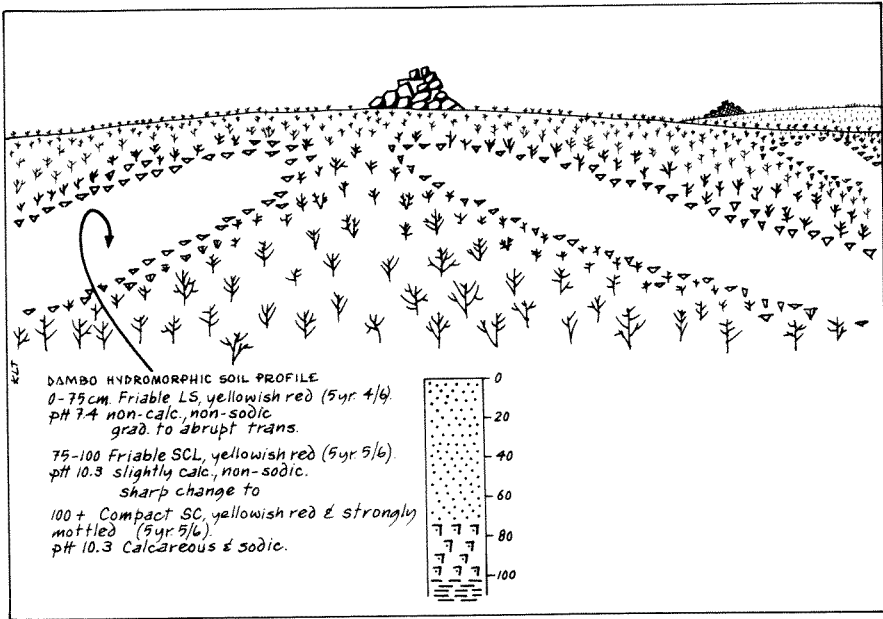


Figure 4.8 Dambo type seasonally waterlogged drainage line grassland radiating from near the crests of convexities on the granite plains.

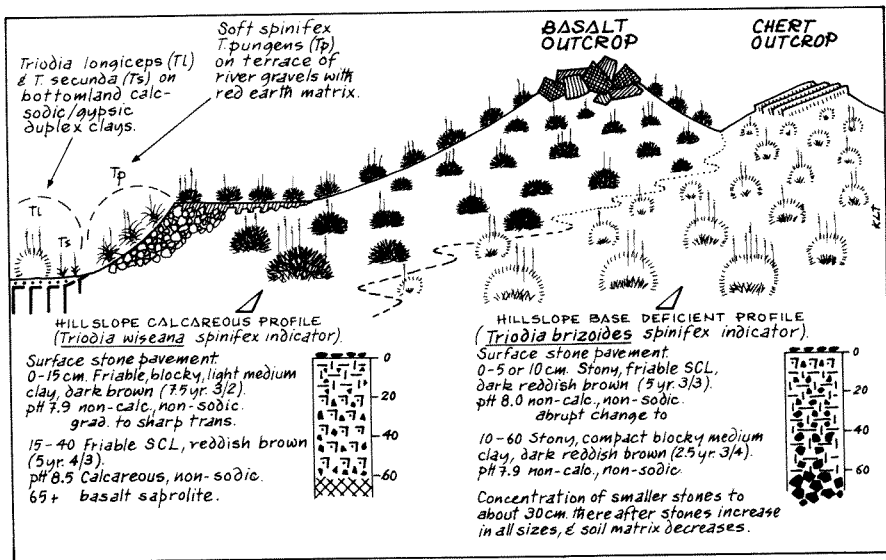


Figure 4.9 Upland fold range soil mosaic pattern related to outcropping of base saturated and base deficient geology.

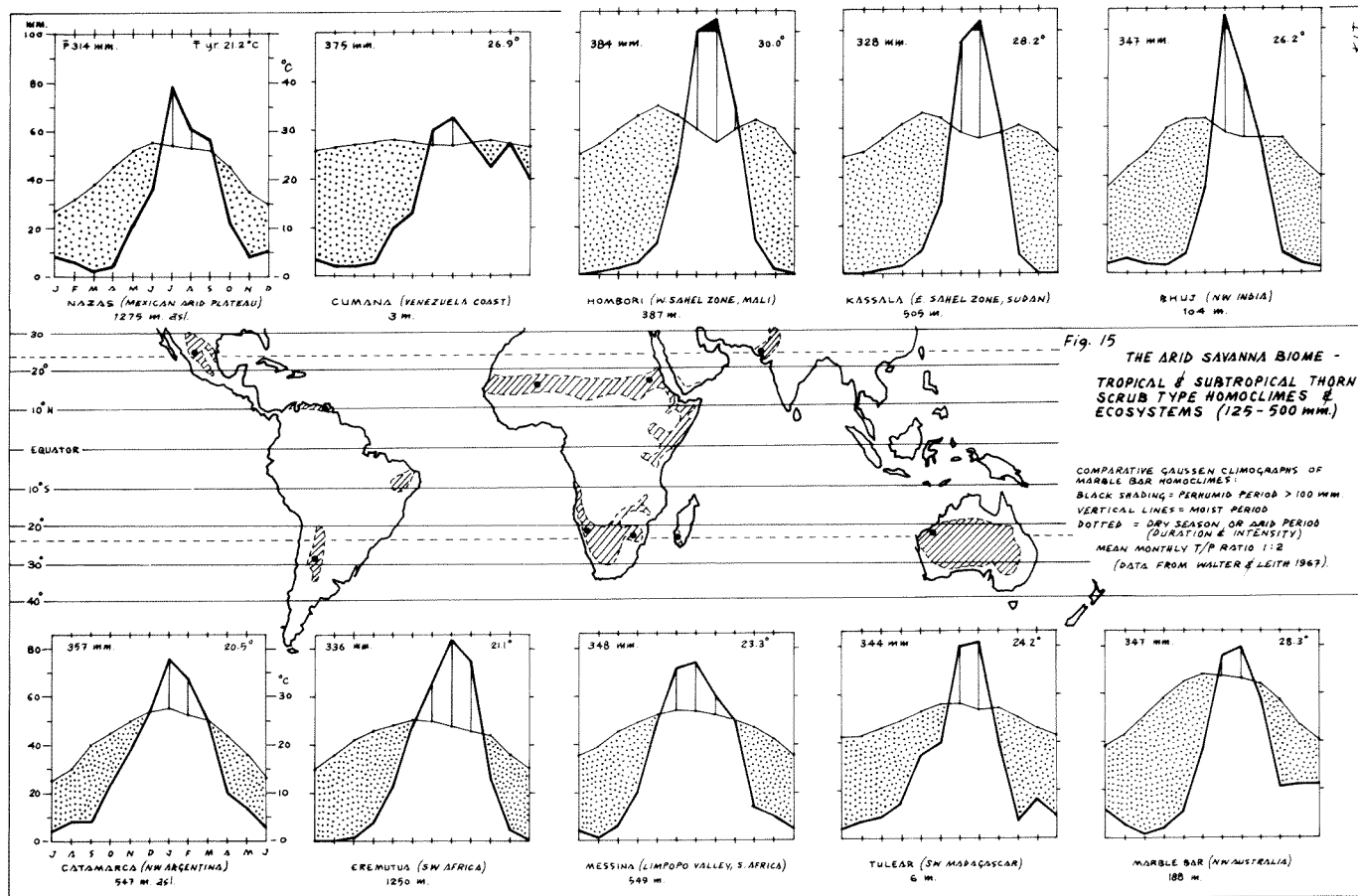


Figure 4.10 The Arid Savanna Biome: Tropical to Subtropical Thorn Scrub Type Homoclimes and Ecosystems (125-500 mm).

The ecological characteristics of the Australian Arid Zone and in turn its continental context has been synthesized by Nix (1981, 1982) for example, for environmental features and Specht (1981a, 1981b) for the vegetation formations and their floristic composition compared with other parts of the world. In the same respect the grasses have been analysed by Clifford & Simon (1981). The outstanding feature is the high endemism to the Australian continent of both the Arid and Winter Rain Biomes. By contrast, the mesic to higher rainfall vegetation in the tropical and subtropical zones contains many shared elements with the Indo-Malayan and African Regions (including Old World and Gondwanan elements). Another unifying characteristic common to grasses of the arid tropical and subtropical regions (e.g. Huntley 1982, Medina 1982) including the arid zone spinifex of Australia (Jacobs & Chapman 1984) is that they typically exhibit the eragrostoid grass response (NAD-ME variant) of the Krantz syndrome or C4 photosynthetic pathway, compared with the Moist Savanna Biome grasses which typically belong to the panicoid grass process (the C4 NADP-ME variant) (Jacobs & Chapman 1984).

Of the many Australian-Indomalayan-African elements those which enter the arid Pilbara Region from the Kimberley, usually on moister sites, include mostly deciduous woody genera such as *Atalaya*, *Capparis*, *Carissa*, *Senna*, *Dichrostachys*, *Ehretia*, *Flueggea*, *Phyllanthus*, and *Terminalia*. Amongst the grasses are bunch-form *Dicanthium*, *Heteropogon*, *Sorghum* and *Themeda* usually on alluvium of creeks with the introduced *Cenchrus ciliaris* which has taken over the drainage lines. In contrast, the Australian Arid Zone is characterized by a predominantly endemic vegetation cover of woody phyllodenous acacias, eucalypts, casuarina, and eremophila (Myoporaceae) shrubs in combination with perennial resinous spinifex hummock grasslands. In biogeography however the similarities are as important as the differences not only in comparing flora and fauna but also for elucidating ecosystem and biome dynamics and evolution — the ecotone of today may become tomorrow's biome and the biome the ecotone.

At the level of biome relationships however there is a great similarity between the Australian Arid Savanna Biome and those of other regions in geographically similar zones north and south of the equator. This similarity is well illustrated even by comparing a single component, the climate, as shown by the examples of Marble Bar homoclimates (Figure 4.10).

Biomes are major ecological regions or life zones in which a variety of ecosystems are linked by similar or shared biophysical features and processes. They are large scale regional units expressing distinct combinations of landscape, climate, soil, vegetation and faunal associations. Biome Types or Zonal Biomes (zonobiomes of Waller 1979, Walter & Breckle 1986) are ecologically equivalent regions within the same geographical zones of the world which have a similar physical environment and analogous biotic elements and communities. Interfacing each biome are large scale ecotones overlap, interzone or transitional areas of various widths and definition.

The misapplication of the term steppe and desert to the to the "thorn scrub type" formations of the tropical and subtropical zones between the 125 and 500 mm isohyets

has masked their real observable identity as the Arid Savanna Biome Type (Figure 4.10). Arid savannas like the Moist Savanna Biome are composed of a mosaic of open and closed habitats whose proportion of dominance will vary from region to region depending on climo-edaphic determinants and their disparate responses to disturbance.

The greater Pilbara Region (Tinley 1986) together with the adjacent Central Deserts is remarkably similar to the arid savanna of South West Africa (Namibia) and the adjacent Kalahari Desert. Each pair is made up of parallel physiographic suites of red earth plains alternating with upland stony ranges on the one side adjoining vast sandridge plains of central deserts on the other. In his study of reptile ecology on three continents Pianka (1986: 19) eloquently describes the similarity between his study area in the Great Victoria Desert and that in the Kalahari. The ecologically equivalent 'look-alike' Biotic Provinces of the Arid Savanna Biome Type, to that of the Australian Eremaean Province and the north Pilbara with similar Marble Bar homoclimes and thorny acacia scrub plains and ridges are the following: (Names of Biotic Provinces as used by Dasmann 1974 and Udvardy 1975)

- NORTH AMERICA — Chihuahuan (southern sector)
 SOUTH AMERICA — (1) Venezuelan Dry Forest, (2) Caatinga (driest area below 500 mm rainfall), (3) Argentinian Thorn Scrub (Monte).
 AFRICA — (1) Sahel Zone, (2) Somalian, (3) Kalahari (including (i) SW Angola, (ii) most of Namibia excluding the coastal extreme desert), (iii) Botswana, and (vi) the two-pronged arid extensions down the broad valleys of the Zambezi and Limpopo to eastern lowlands).
 MADAGASCAR — Malagasy Thorn Forest
 INDIA — Indus-Gujerat (eastern margin of the Thar Desert in NW India).

The Junk Publishers' series on *Biogeography and Ecology* provide a synthesis of the above regions and Australia (Keast 1981) as does the *Ecosystems of the World* series by Elsevier Publishers, the Springer-Verlag Publishers' *Ecological Studies* series and a large number of other works on tropical savannas, hot deserts and arid scrubland (e.g. Barker & Greenslade 1982; Huntley & Walker 1982 and subsequent volumes from savanna symposia).

At the more local level a few generalities may be of use. High plant endemism is correlated with acid soils, particularly leached sands, and a high terrestrial mollusc endemism with calcareous substrates. Conspicuous differences in size, proportion and mass of the same vertebrate species living on calcareous compared with leached habitats is another generality probably best known and documented in the field of stock husbandry. No leached soils were encountered in the Reserve area, but the pattern of base saturated, mostly calcareous, geology is depicted in Figure 4.11B and is related to

the occurrence of mafic and ultramafic rocks and to drainage including valley calcretes and bottomland flats.

The colours of soil samples collected from the Reserve area are recorded in the Habitat Profile Diagrams (Figures 4.1-4.9) as determined by matching colour chips in the Standard Soil Colour Chart (Munsell 1954). The surface samples would provide a basis for elaborating information on cryptic colouration of ground dwelling animals.



Plate 1. Confluence of the Abydos Plain with the pediment off the Fold Ranges in the background below Tilt Hill as viewed from Pullcunah Tor. Ranji Wattle and soft spinifex savanna with termite hills.

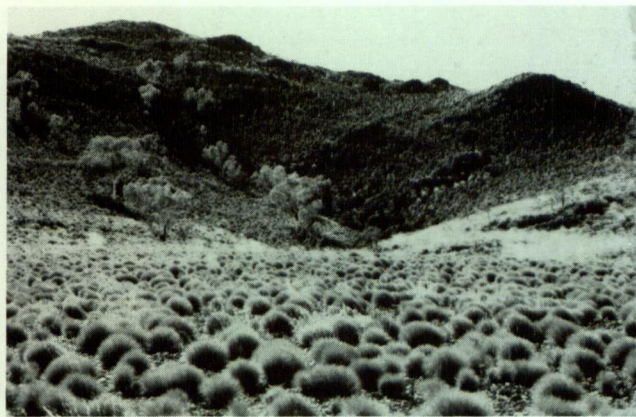


Plate 2. The fold hills covered in hard spinifex grassland on stony overdrained soils with small patches of Snappy Gum, widely scattered wattle scrub, and an abundance of small rock outcrops.



Plate 3. Part of the Abydos Plain to the horizon with scattered or grouped small granite tors. Ranji Wattle and soft spinifex scrub savanna.



Plate 4. Pullcunah Tor viewed from the east side. Note aspect asymmetry from differential weathering (steeper pole-facing and gentler equator-facing slopes); 2.4 m high vehicle as a measure; dead even-aged wattles along the creek edge.

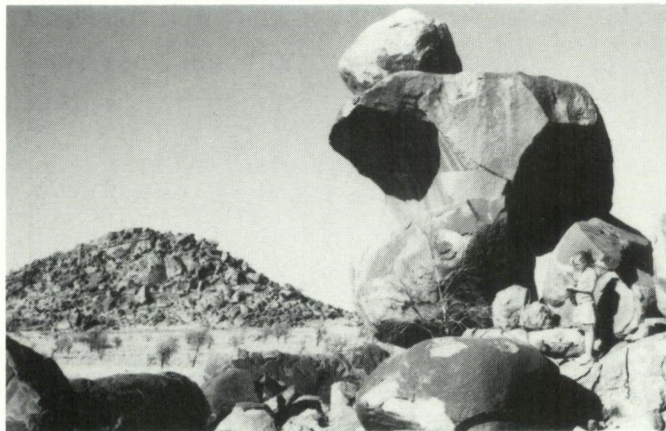


Plate 5. The Gallery Hill tors, with intervening thorny Ranji and soft spinifex savanna on red earths. Spheroidal weathering with angular jointing facets and balancing rocks of granite blockpile.



Plate 7. The Soansville Plateau escarpment viewed from the west.

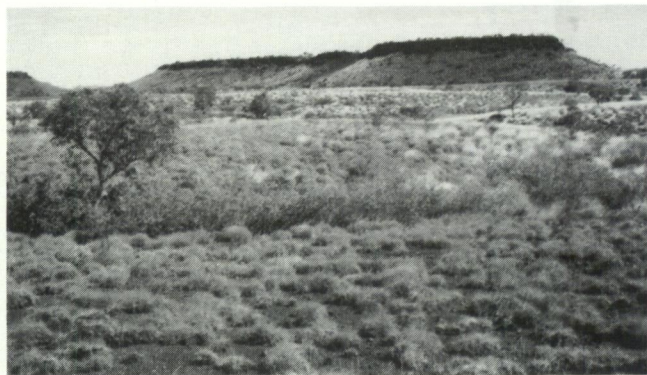


Plate 6. The ironstone mesas in the Abydos sector of the Reserve. Tableland remnants on the incised pediment off the Fold Range belt in the upper Turner River catchment. Pediment interfluves mostly treeless spinifex grassland with dense wattle scrub-thicket and bloodwood emergents along drainage gullies.

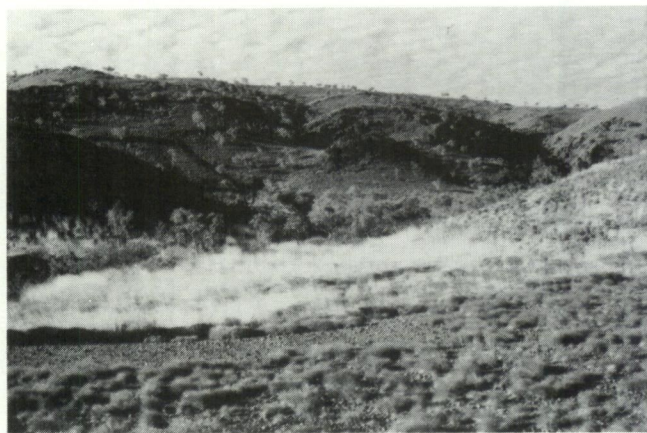


Plate 8. Western escarpment slopes of the Soansville Plateau with Snappy Gum tree savanna, and calcretized river-gravel terrace in the foreground.



Plate 9. Waterfall Bluff on the northern rim of the Soansville Plateau near The Buttes. Cliff and boulder habitats below cliff faces.

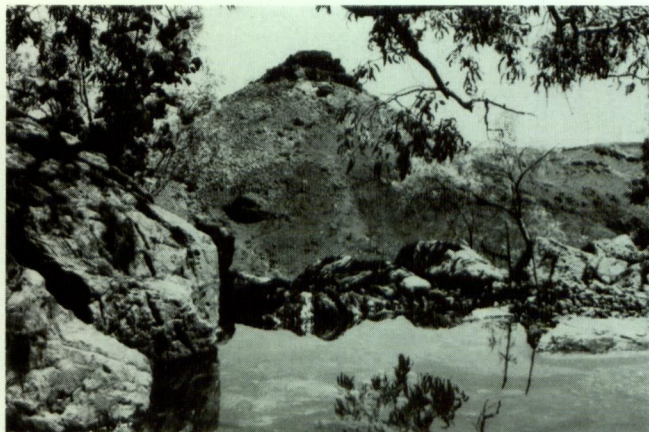


Plate 10. View from the plunge-pool at Waterfall Bluff of the largest of The Buttes.



Plate 11. The Soansville Plateau escarpment near Bowerbird Gorge with bare boulder scree slides below the cliff line.



Plate 12. "Big Cave" near Waterfall Bluff on the northern edge of the Soansville Plateau.



Plate 13. The Soansville Plateau and The Buttes viewed from the N.W. near the Abydos Fine Gold crushing plant. Bloodwood gum tree savannas on calcareous valley gravels between the fold ranges.

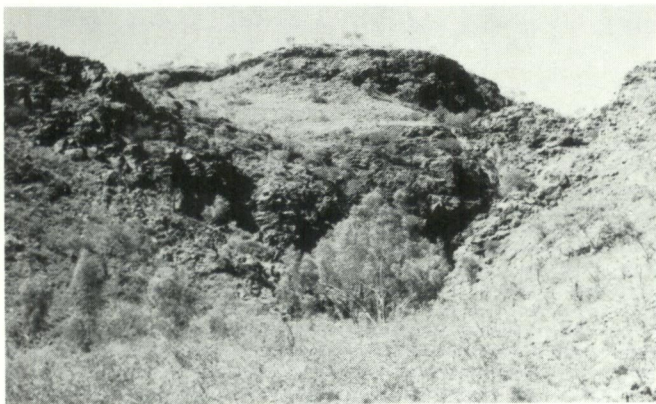


Plate 14. The entrance to Cadjeput Pool gorge on the northern rim of the Soansville Plateau. Coolibah and River Gum with wattles along the creek. Gidgee wattle with a few mulga on the rocky ledges.



Plate 15. Ridge of volcanic agglomerate with mulga trees along the crestline. Near Bowerbird Gorge on the NW corner of the Soansville Plateau.

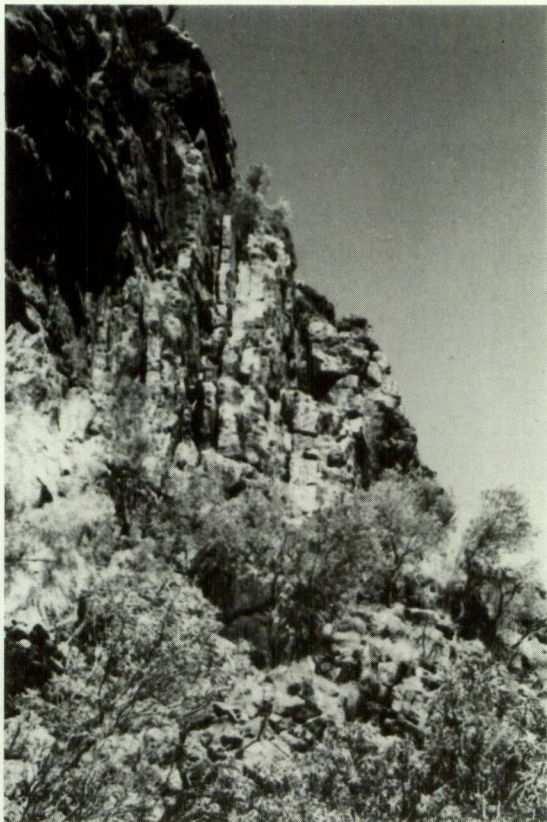


Plate 16. Cliff and boulder talus with Gidgee Wattle woodland at Waterfall Bluff.

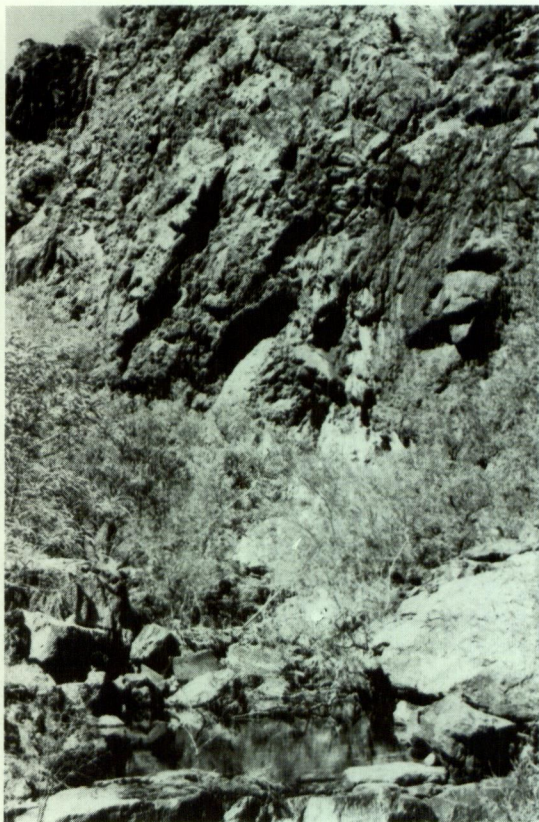


Plate 17. Rock pools, cliffs and ravine thicket clumps in Bowerbird Gorge.



Plate 18. Tall dense canopied riverine woodland of River Gum on an upper Turner River tributary north of Lone Mesa.



Plate 19. Coorong Creek, a broad sandy tributary of the upper Yule River in full flood 30 March 1988, viewed from the windpump at Woodstock homestead.



Plate 20. Riverine habitat of upper Turner River tributary on the northside of the ironstone mesas.



Plate 21. Wattle scrub woodland with tufted Buffelgrass groundlayer on floodplain alluvium of Coorong Creek near Woodstock homestead. Wattles stratified in two layers, upper canopy of *Acacia ampliceps* and *A. coriacea* with *A. trachycarpa* forming the midstratum.

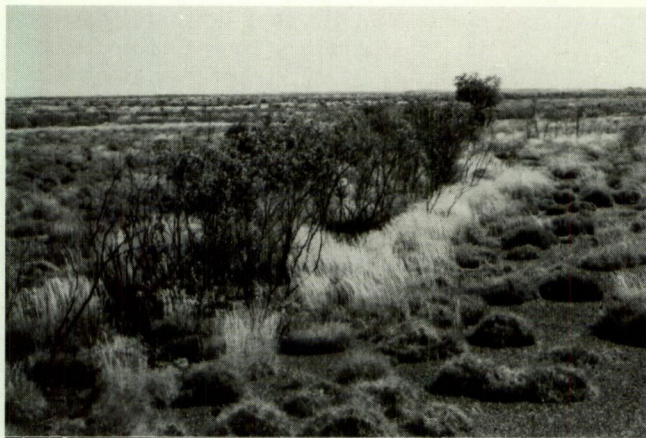


Plate 22. Narrow bands of dense wattle scrub-thicket along minor tributaries of drainage on the incised pediment near the ironstone mesas.



Plate 23. Rock pool in Coorong Creek 2 m at its deepest. Typical of the scour pools through rocky barriers which hold surface water longest.



Plate 24. Riverine thicket formed by dense growth of large paperbark shrubs with an overstorey of River Gum on a sandbank island. Figure is 1.4 m tall.



Plate 25. Riverine thicket composed of two *Melaleuca* species, a paperbark and a tea-tree, on the upper Turner drainage.

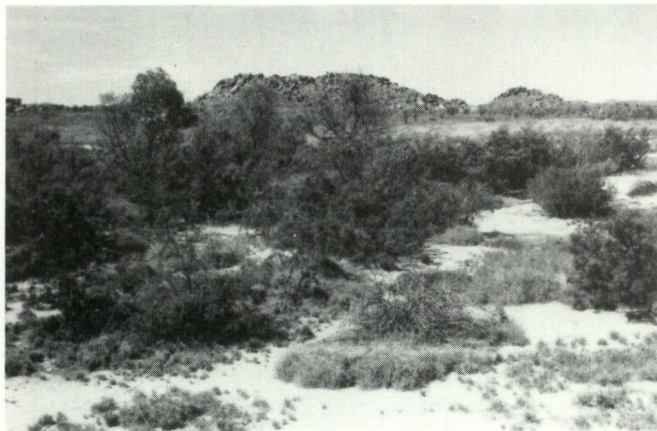


Plate 26. Tea-tree thicket clump community with an overstorey of wattle emergents on calcareous duplex soils with intervening bare patches on truncated soils. Near Edgina Tors.



Plate 27. Two layered structure of tea-tree scrub thicket. *Melaleuca bracteata* forming the bush clumps and *Acacia ampliceps* the overstorey.



Plate 28. Bird-formed tree-base or subcanopy thicket initiates beneath a riverine bloodwood in the fold range zone.



Plate 29. Tree-base thicket beneath a bloodwood on deep red earths of pediment. Figure is 1.4 m tall.



Plate 30. Bloodwood *Eucalyptus terminalis* tree savanna on calcareous loams with groundlayer of dark green hard spinifex *Triodia wiseana*. Small tree layer are fire-induced mallee-form bloodwood.



Plate 31. Bloodwood tree savanna on calcareous clay loams between calcrete mesas in the Coorong Valley.

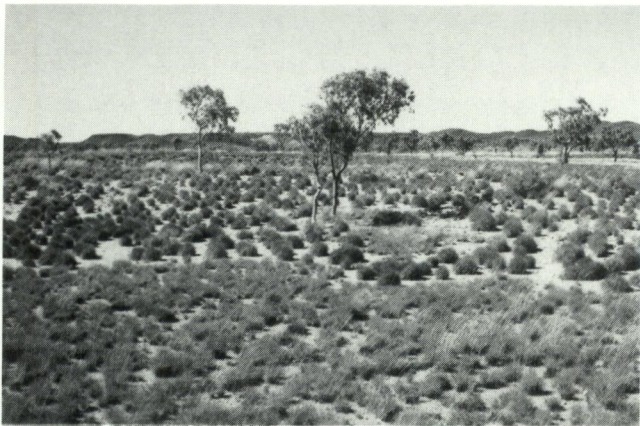


Plate 32. Bloodwood tree savanna on calcareous outwash plains below the fold hill zone. Note sharp junction between two different soils as indicated by change in spinifex species.



Plate 33. Mallee-form Bloodwood clump growing in a deep soil pocket on calcareous stony earths near the ironstone mesas.

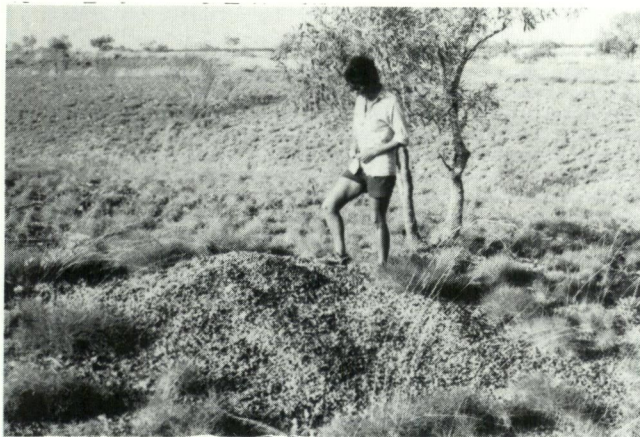


Plate 34. Bloodwood savanna on incised calcareous pediments near the ironstone mesas. Pebble-mound of calcrete rubble brought up from the subsoil.



Plate 35. Hill savanna of Snappy Gum *Eucalyptus leucophloia* trees and the hard glaucous spinifex *Triodia brizoides*.



Plate 36. Snappy Gum tree savanna on the western slopes of the Soansville Plateau.



Plate 37. Snappy Gum on basalt outcrop.

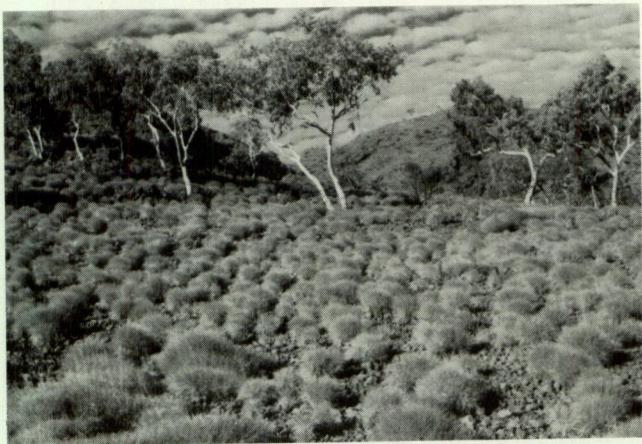


Plate 38. Woodland patches of Snappy Gum with intervening treeless spinifex hummock grassland on the fold ranges.



Plate 39. Snappy Gum tree savanna on incised stony valley calcrete flats between fold ranges. Note gibber surface.

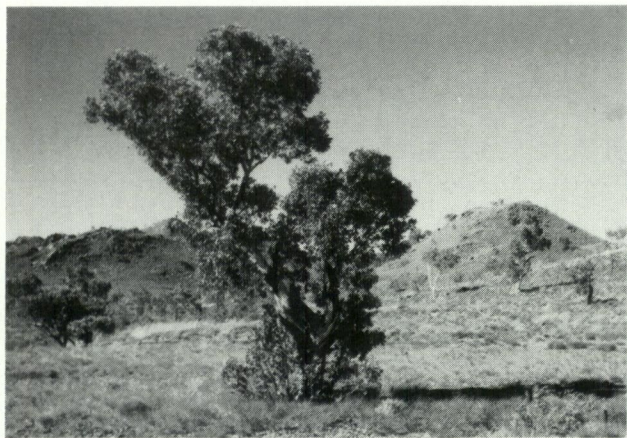


Plate 40. Multiple-stemmed coppicing response by Snappy Gum to fire damage.



Plate 41. Thorny Ranji Wattle *Acacia pyrifolia* scrub savanna with soft spinifex *Triodia pungens* groundlayer on red earths of Abydos Plain; fold ranges in background.



Plate 42. Ranji Wattle savanna with *Nasutitermes* termite hills. View north towards Pullcunah Tor and Tilt Hill (at right). Appearance of spinifex two weeks after flood rains (cf. Plate 43).



Plate 43. Dry season appearance of Ranji Wattle and soft spinifex savanna before the flood rains in late March. Junction of unburnt middle ground with two to three year old burnt foreground. Termite hills with Pullcunah Tor in the distance.

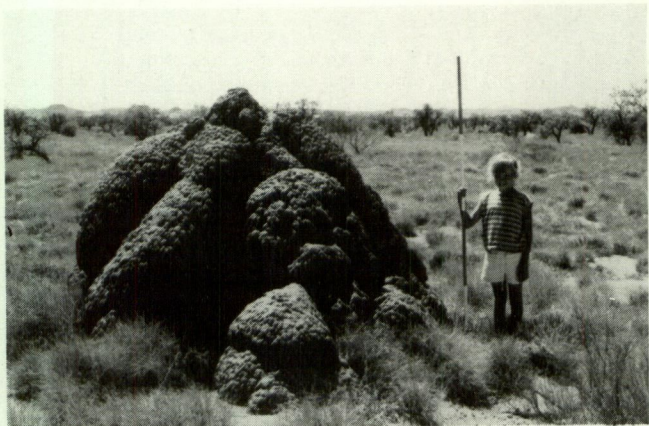


Plate 44. Bare *Nasutitermes* termite hill, a typical feature of the Abydos Plains. Measure is 2 m in height.



Plate 45. Ranji Wattle and soft spinifex on the pediment off the fold range zone in the background. Sharp junction between unburnt and burnt areas the latter with its first season of annuals. *Drepanotermes* termite mound in the foreground.



Plate 46. Abydos Plains south of Pullcunah Tor with first or second year post-fire growth of annuals. Tree-less, unburnt grassland in the middle distance is a dambo drainage.



Plate 47. View down the length of a treeless dambo drainage grassland rising off the crest of a convexity on the granite plains. Spinifex hummock grassland of *Triodia lanigera*. Refer to Figure 13.



Plate 48. Process of extinction of dambo hydromorphic grassland by headward erosion of nickpoint incision moving upslope from local creek base levels.



Plate 49. Leading edge of woody plant invasion of the dambo from its savanna margins as it is dried out by erosion incision.



Plate 50. Bottomland spinifex grassland mosaic on calcareous and/or sodic/gypsic clays. Bare patches are a white sandy silt veneer over columnar clays. See Figure 12.



Plate 51. Junction of bottomland base saturated soil mosaic (foreground and to the right) with granite plains red earths (trees and light grass cover). See Figure 12.



Plate 52. Hill grassland on overdrained stony red earth lithosols of the Fold Ranges. Mosaic dominance of two spinifex hummock grasses. See Figure 14.



Plate 53. Pattern of hard glaucous spinifex *Triodia brizoides* on base-deficient skeletal hill soils.



Plate 54. Mosaic dominance of dark hummocks of *T. wiseana* on base saturated soils and light coloured *T. brizoides* on base deficient hill soils. See Figure 14.



Plate 55. Cliff habitats with overhangs, ledges and block piled talus. Soansville Plateau at Waterfall Bluff.



Plate 56. "Brickwork" rectangular fissures in dolerite dyke forming the Abydos Wall.

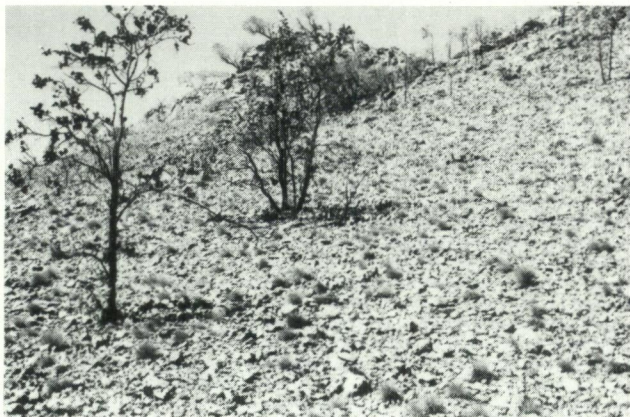


Plate 58. Gibber of angular stone pavement surfacing slopes of Fold Ranges.

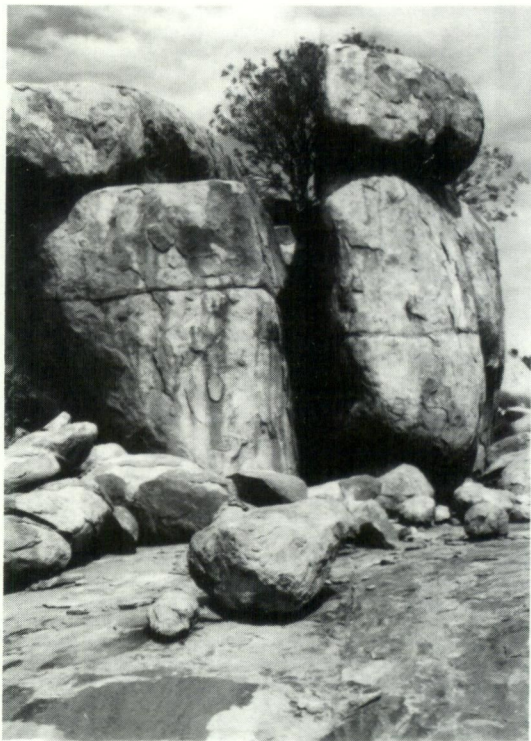


Plate 57. Cliffs and open-ended caves formed by spheroidal weathering of granite tor blockpiles over dome granite with narrow "onionskin" fissures of exfoliating sheets. All are rain shedding surfaces into jointing cracks, talus and the footslope.



Plate 59. Obliquely to horizontally disposed "sandwich" fissures in shales of the Fold Ranges, minimizing penetration by rainwater.



Plate 60. Vertically disposed "sandwich" fissures in shales allowing deep percolation of rainwater.



Plate 61. Site WS4 showing fresh growth after heavy rains of March 1988. Photo: September 1988.

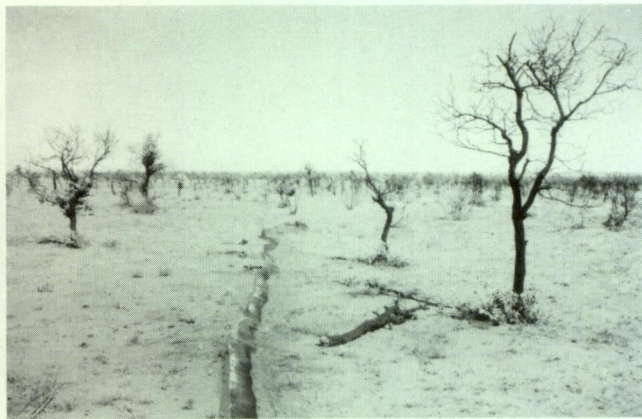


Plate 62. Site WS4 after fire of January 1990. Photo: July 1990.



Plate 63. Site WS6 showing fresh growth after heavy rains of March 1988. Photo: May 1988.



Plate 64. Bilby burrow on creek near site WS4. Photo: September 1989.

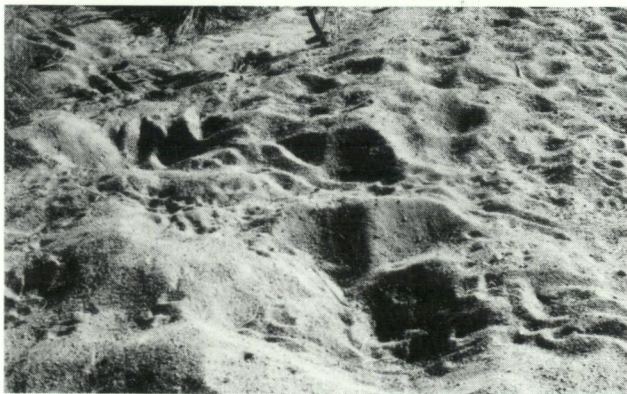


Plate 65. Bilby diggings and tracks in creek near Site WS4. Photo: July 1990.