AN INVENTORY OF *ACACIA PEUCE* (F. MUELL.) STANDS IN CENTRAL AUSTRALIA : BIOGEOGRAPHY AND ECOLOGY

by

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CHAPTER I

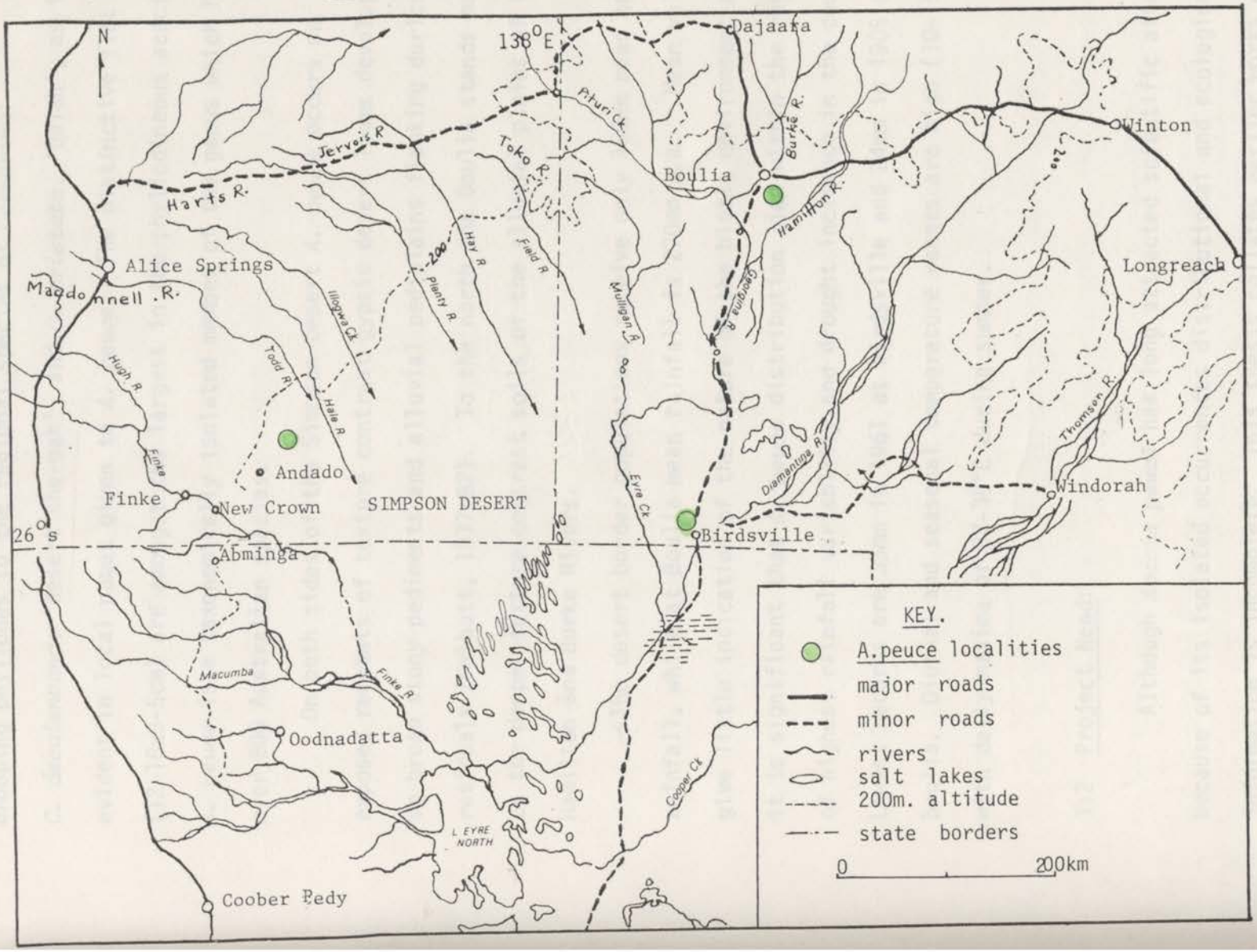
INTRODUCTION

1:1 *Acacia peuce* ('Waddy-wood') is a unique member of the Eremaean flora, (Burbidge, 1960) and an outstanding example of xerophytic adaptation, attaining heights of 15m and stem diameters of 0.5m within one of the most extreme arid environments in Australia. Despite this remarkable ability it is not widespread, being known to occur as isolated populations at only three widely separated locations in Central Australia: on Andado Station, N.T., at Birdsville, Queensland, and near Boulia, Queensland (see map 1). It is unlikely that any other major populations exist, although further scattered groups of trees may occur within the region (see Appendix I:a).

Accepting the hypothesis that this disjunct distribution can be considered relict (Crocker and Wood, 1947:113), the wide potential range of the species indicated by the geographic spread of occurrences suggests an impressive past distribution over much of north-eastern Central Australia.

Acacia peuce is locally abundant within restricted areas of occurrence (<50sq km), and forms pure stands of a distinct open woodland community. These impressive uniform stands with a canopy of 10-14m become conspicuous at Birdsville and Andado in the absence of physiognomically comparable species. Tree form is variable, the narrow linear phyllodes giving erect forms a conifer-like appearance as the botanical name, from the Greek *peuke* = pine, implies (Lothian, 1968:46).

Map.1. Distribution of Acacia peuce. Central Australia



There is a marked resemblance in the mature habit and the drooping phyllodes to the regional species of *Casuarina*: *C. decaisneana*, 'desert she-oak', and *C. cristata*, 'belah', as is evident in local names given to *A. peuce*. The distinctive flat pods (12-18x3-5cm) are amongst the largest in the phyllodineous acacias. *A. peuce* is a taxonomically isolated member of the genus which has over 800 Australian species.

On both sides of the Simpson Desert *A. peuce* occurs on exposed remnants of texture contrast gypsic desert loams developed on broad stony pediments and alluvial pediplains flanking duricrusted residuals (Mabbutt, 1977:82). To the north the Boulia stands occurs on the deeper texture contrast soils of the alluvial plains of the Hamilton and Burke Rivers.

The desert border populations receive only 150mm mean annual rainfall, while at Boulia mean rainfall is 270mm p.a. Mean values give little indication of the nature of the biotic environment and it is significant that *A. peuce* distribution lies within the region of highest rainfall variability and drought incidence in the country. Lowest records are 33mm in 1961 at Birdsville and 24mm in 1905 at Boulia. Diurnal and seasonal temperature ranges are high (10-15°C) with daily maxima of 37-38°C during summer.

1:2 Project Need:

Although *Acacia peuce* has long attracted scientific attention, because of its isolated occurrences distributional and ecological information is incomplete. This thesis collates earlier works on distribution and taxonomy, and provides a census of present populations together with a comparison of the vegetation of *A. peuce* communities and its associated species.

The inventory was proposed to assess the size and extent of the separate populations of *A. peuce* and, in view of its restricted distribution and vulnerable status (Boyland, 1978:257), to obtain information on the population structures and reproductive performance of the species. The Andado and Birdsville populations while well known, had not been mapped, while the extent of the Boulia population was largely unknown. With only 1000 trees in the N.T. stand on the Andado pastoral lease, the N.T. Conservation Commission is negotiating the declaration of a reserve to encompass the main stand at North bore, and has fenced two small areas to exclude stock. Since the size of the Queensland populations, although more extensive, was largely unknown, a total inventory of the species was necessary.

The project is therefore conservation oriented, designed to obtain ecological information on which to base a management policy to ensure the future survival of the species. A detailed autecological investigation was not possible because of the time and access restrictions. However the inventory provides a preliminary assessment of the population dynamics of the stands and brings together available environmental information.

The biogeographic implications of *A. peuce* distribution are investigated through the comparison of floristic associations within the context of regional vegetation patterns. While the disjunction of *A. peuce* populations is explicable in terms of the palaeoenvironmental consequences of Pleistocene climatic and geomorphic changes, its restriction within extensive areas of apparently suitable habitat may reflect both a poor capacity for migration and the deterioration of habitat and climate to conditions marginal for the species.

1:3 Conservation in the Arid Zone:

The justification for the conservation of species lies not only in the ecological and ethical desirability of organismic diversity, but also in the potential human benefits that lie in the products and the knowledge of the unique stage in genetic evolution which each species represents. Conservation policy must give priority to the preservation of representative areas of all major ecosystems, to ensure the persistance of habitats necessary for the survival of most native species (Specht, 1974:2) (Fenner. Ed. 1975).

Within the Australian arid zone the dunefield deserts are well represented within National Parks, while other land-systems and vegetation zones are not, largely because of their greater pastoral importance. Everist and Webb (1975) give the example of the arid tussock grasslands (Mitchell grass) of Western Queensland, and Specht (1974:631) that of the low open shrubland formations (where only 1 of 54 recognised alliances was adequately preserved). The large recently established National Parks in the arid zone, such as Randall River, W.A., Tanami, N.T. and Simson Desert, S.A., Queensland, N.T. are concentrated in the desert zones of largely unoccupied land (Young, 1979:280).

There is a corresponding neglect of pastoral regions in Western Queensland and N.S.W., and in the sheep belt of W.A. Land use in these areas may be in conflict with conservation aims, with selective and often severe grazing and a continuing legacy of soil erosion. Restricted species occurring within pastoral leases may therefore require specific protection policies.

The recognition of any species as threatened or endangered in terms of having critical population levels for continued survival implies a detailed biological knowledge of its:

- taxonomic position
- geographical distribution
- population sizes and dynamisms.

To formulate a balanced management plan for a species thus identified requires an understanding of its ecological interactions within the environment and the nature of the perceived threats. In Australia, 2051 plant species including *A. peuce* are recognised as at risk by the Australian National Parks and Wildlife Service (1979), about 10% of the total flora (Hartley and Leigh, 1979).

Specht (1974:10) outlines categories of rare and endangered species to assist in the recognition of conservation priorities. In the N.T. list (Specht 1974:126) *A. peuce* is considered as (6): 'a species of geographic importance with a disjunct distribution', while in Queensland (p.232) it is considered in addition as (2): 'Endangered, with only small colonies remaining'.

Acacia peuce, with its conspicuously restricted distribution has long been recognised as a vulnerable species. Madigan (1945:122) stated that only about 50 trees remained at the Andado and Birdsville stands and its aesthetic appeal is reflected in his later comment...

> One hoped that a few waddy trees would be allowed to survive. (Madigan, 1946:36)

Crocker (1946:254) and Crocker and Wood (1946:13) point out the restricted nature of its relict populations, while Eardley (1946:147) mentions the likely extinction of the species.

Of the 16 Australian species listed in the data book of threatened plant species of the International Union for the Conservation of Nature and Natural Resources (I.U.C.N.) 1978, *Acacia peuce* is entered and classified as 'Vulnerable' by Boyland (1978:257). This is one of four categories (Lucas et al 1978:25) designated by the I.U.C.N. to allow international cooperation on conservation priorities, and includes taxa, the populations of which are decreasing or depleted, and likely therefore to become 'endangered'.

1:4 Historical:

The historical significance of *Acacia peuce* extends beyond European settlement. This tree features in the mythology of the Aboriginal people whose lands it is found within (Latz, 1980 unpublished).

The Lower Southern Aranda (Strehlow, 1971:621) spoke of the sacred ancient *arēpara* casuarina tree which once linked the earth and sky at Akār Intjota in the Simpson Desert. This was identified at Andado as *A. peuce* (Strehlow, 1971:739). Here *A. peuce* is a significant landmark and the presence of silcrete blades and scrapers at the stands indicates frequent occupation.

The Boulia district was the centre of a complex of trade routes for pituri, ochre and pearlshell (Mulvaney, 1976) and the present township occupies a previous corroboree ground. A monument now marks this site (see photograph); a lone *Acacia peuce* (50cm diameter) which was a landmark for the many Aboriginal groups from surrounding areas.

The first description of *A. peuce* appears in the diary of W.J. Wills from the fated Burke and Wills exploring party in 1861 (Cleland, 1968:47). On January 8th, near camp 88 (23°S 140°E) Wills wrote of a tree quite new to him...

> ...the trunks and branches are like the she-oak, the leaves like those of the pine; they droop like a willow, and the seed is small and flat, in a large flat pod about six inches by three-quarters of an inch.
>
> (Wilson and Mackinnon, 1964:19)

This is unmistakably a description of *A. peuce* and the location corresponds to that of the Boulia stand.

In July 1862 the expedition of A. Howitt and J. Murray made a second journey to find Burke and Wills. In the region of the Cooper Creek and the Diamantina, from camp 74, (25° 52'S, 139° 19'E),

A. peuce at Andado station (N.T.), 15m high. silcrete stone tools are found below tree.

A. peuce at Boulia Monument at north end of Boulia township.

Howitt rode north to near Sampson's Range and on July 23rd wrote...

> In this range I saw a new tree, which resembling a she-oak in appearance - but growing higher and looking disproportional at a distance, like trees seen through a mirage. It bears a flat pod containing several hard black seeds.
> (Grandison, 1980:223)

There is little doubt that the tree described was *A. peuce* as the description accords well with the location of the Birdsville stand. Plants collected by Murray on this expedition were sent to Mueller, and this is the origin of the type specimen labelled by Bentham (1864:323) as from north of Will's Creek (Grandison, 1980:223).

Settlement of Western Queensland in the 1860's (Austin, 1959:216) would have seen the first use of *A. peuce* for timber, since in the Birdsville district it was the only suitable tree for fencing and building. Colson (1940:18) reports that as early as 1879 'waddy' poles were transported from Birdsville for use as survey mile posts along the Queensland - S.A. border. At Boulia local graziers have used *A. peuce* extensively for fencing and posts are still being cut on Montague Downs for this purpose.

It is difficult to assess the environmental effects of European land use on the habitat of *A. peuce*. In this region fire frequency is low (once in 50 years) and is dependent on the build up of ground cover in good years. The cutting of *A. peuce* has affected the separate populations differently: at Birdsville about one third of the population has been affected; at Andado there is evidence of significant removal of trees; while at Boulia only one tree in eight has been cut. No evidence was found to indicate that cutting has reduced the local distributions of the species.

The Simpson Desert Scientific Expedition in 1939, led by C.T. Madigan, crossed the desert from Andado to Birdsville. The 'waddy-tree' became a symbol for the expedition (Madigan, 1946:plate I), occurring both at the beginning and the end of their journey. The North bore stand at Andado was their last outpost of civilization, and after reaching Birdsville they went to the north of the town to see the Birdsville stand (Madigan, 1946:101). Its relict distribution was of considerable scientific interest and may have influenced the interpretations of the age of the Simpson Desert dunefields (Crocker and Wood, 1946:113).

In 1967 Professor L. Pryor compiled a paper on *A. peuce* stressing its performance in an extreme climate, which promoted the distribution of seed to many arid regions of the world. Webb (1973), reporting on planting trials in Iran, found that the slow growth of *A. peuce* limits its use for other than protection purposes (Hall, 1975). A follow up of seed sent to several countries by the C.S.I.R.O. shows that few other plantings have been made (see Appendix I:b).

1:5 Taxonomy:

Infrageneric Classification

Acacia is a very large genus of evergreen woody perennials of the family Mimosaceae (Hutchinson, 1964:223), widespread in tropical and subtropical regions with a major species concentration in the southern continents. The large number of *Acacia* species, about 835 known from Australia alone, (Hopper and Maslin, 1978:63), fall into several morphological groupings based on inflorescence structure and phyllode or leaf characters, which reflect phylogenetic and geographic relationships.

Bentham (1842), (1875) subdivided the genus into six major series which have remained the basis of most subsequent classific-

ations. Vassal (1972) proposed a classification which is broadly compatible with that of Bentham but involves a more cladistic sequence of hierarchical ranking, introducing subgenera, sections and subsections. Vassal's subgenus *Heterophyllum* is largely Australian and includes Bentham's series *Botrocephalae, Pulchellae* and *Phyllodineae*. (see Table 1a.)

A. peuce is a member of the complex section *Phyllodineae* which Bentham subdivided into numerous subseries and further species groups, several of which have been raised to sectional rank. (Pedley, 1978). Recent investigations in chemotaxonomy, pollen morphology and the application of numerical taxonomy have allowed a more systematic consideration of diverse attributes, but while they find support for the subgeneric separation of Vassal, the relationships between and within sections remain obscure.

Pettigrew and Watson (1975:844), using numerical analyses on morphological, anatomical and phytochemical attributes of 171 Australian *Acacias*, found general agreement with Vassal's scheme with species groups consistently separating into the *Heterophyllum (Plurinerves* and *Juliflorae)* and *Uninervea (Phyllodineae* and *Botryocephalae)*.

Pedley (1978:32) presents a currently acceptable classification of the subgenus *Heterophyllum* in which seven major sections and minor sections allied to the *Phyllodineae* and *Plurinerves* are recognised. (see Table 1b.) Several sections show a concentration of species in particular geographic regions, reflecting centres of distribution. The large and widespread sections *Juliflorae, Plurinerves* and *Phyllodineae* have contributed largely to the arid *Acacia* species. Desert species have originated from both the north and south as the presence of identifiable species pairs linking them

Table (1a) Summary of Vassal's (1972) classification of the genus *Acacia* (after Pettigrew and Watson 1975:834)

Genus	Subgenus	Section	Distribution
Acacia	Acueliferum (= Vulgares. Benth.)	Acueliferum Monacanthea	Mostly America, some Africa and Asia
	Acacia (= Gummiferae Benth.)	Acacia	Mostly Africa some America
	Heterophyllum	Heterophyllum (= Plurinerves & Juliflorae)	Australia
	(= Phyllodineae Botryocephalae & Pulchellae Benth.)	Uninervea = (Uninerves Botryocephalae)	
		Pulchelloidea	

Table (1b) Sectional subdivisions of the subgenus *Heterophyllum* and their geographic distribution

Section	Region of Major Species Concentration
Section - *Botryacephalae*	South-eastern N.S.W. and Sthn Qld.
Section - *Phyllodineae*	Widespread
section - *Uninerves*	South eastern
section - *Uninervea*	Widespread, southern
section - *Brunioideae*	Northwestern W.A. & Nthn Australia
Section - *Lycopodiifoliae*	Northern tropical
Section - *Alatae*	Endemic to temperate Sth West W.A.
Section - *Plurinerves*	Widespread, northern, southern and arid
section - *Califormes*	Southern arid
section - *Pungentes*	Southern arid
section - *Heterophyllum*	Widespread Northern tropical
Section - *Juliflorae*	Widespread Northern tropical
Section - *Pulchellae*	Southwestern W.A.
section - *Pulchelloidea*	

to both these regions indicates. It is likely that there have been several separate adaptive radiations within the genus. The widespread *Acacia aneura* ('mulga') and other species with spicate inflorescences are members of the *Juliflorae*, while *Acacia cambagei* ('gidyeah') of north-eastern central Australia is in the *Plurinerves*.

Phytochemical surveys of the hydroxylation patterns of heartwood flavonoid compounds extracted from *Acacia* species by Tindale and Roux (1974), Clark-Lewis and Porter (1972) have shown a general correspondence to Bentham's subdivisions. Tindale and Roux (1974: 838) consider the bipinnate *Botryocephalae* to be the most primitive group, the *Plurinerves* more advanced than the *Uninerves* and the *Juliflorae* to be the most advanced. Taxonomic significance cannot be placed on any single character however as morphological and chemical differentiation may have occurred within sections.

A significant phytochemical finding is the isolation of peltogynoids (Tindale and Roux, 1974:833) in association with the mollisacacidin hydroxylation pair in three apparently unrelated species: *A. peuce*, *A. carnei* (S.A.) and *A. crombiei* (Qld). The compounds which impart a purple colouration to the heartwood are otherwise restricted to members of the Caesalpinaceae (*Peltogyne* Sth. America). The presence of a range of peltogynoid compounds shared variously between these species invites the suggestion of taxonomic affinity, although none appear to have any close relatives.

Bentham's (1875:445) placement of *A. peuce* in the *Continuae* of the *Phyllodineae* was wrong (Pedley, 1978:242), and with the fluid taxonomic situation within the section, these species may have greater affinity than is recognised. All three have the same inflorescence structure, *A. peuce* and *A. carnei* have tetragonous phyllodes which following Black (1924) are treated as being uninerved (Pedley, 1978:89) and the fruits of the rare *A. carniei* bear resemblance to

A. peuce. Pedley, 1978:263). *A. peuce* is a taxonomically isolated species, and its closest affinities with the above species are remote. Pedley (1978:89) considers it may be so distinct as to justify forming a monospecific subseries or even series.

Taxonomic description of *Acacia peuce*

The first botanical description of *Acacia peuce* by F. von Mueller (1863:151) and that of Bentham (1864:323) were based on specimens collected from the Birdsville population near Mt. Lewis by Howitt and Murray in 1862 (Grandison, 1980:223). The type specimen included only pods and the shorter, clustered primary phyllodes, but while Mueller describes the phyllodes as 2-4" long, the tree is accurately described as "...Pini v. Casuarinae imaginem exhibens." (p.151). Bentham's (1875:445) misplacement of the species (Pedley, 1971:242) in his subseries *Continuae* was due therefore to the insufficient specimen material because, while mature phyllodes are articulate, primary phyllodes are confluent on the stem. Bailey (1909:157) gave a brief description and diagram of the pods (p.161), while Black (1929:262), (1957:644) gave the first description of the flowers.

The species is here described taking into account the phenological variation in the phyllodes.

Family:	Mimosaceae (Hutch.)
Tribe:	*Acaciae* (Benth.)
Genus:	*Acacia* (Miller, 1754)
Subgenus:	*Heterophyllum* (Vassal, 1972)
Section:	*Phyllodineae* (Benth.):(Pedley, 1978)
Subsection:	*?Uninerves* (Benth.)
Species:	*Acacia peuce*(F. Muell)

Description:

Habit: Tree to 15m, commonly 10-12m. Form variable from single erect trunk (20-40cm diameter) with short, horizontal branches to a spreading, several-stemmed tree with long, drooping branchlets. Crown narrow, dense, dull green with branchlets ranging from short and close to branches to long (up to 1.5m) and drooping with pendulous phyllodes. Young trees (less than 2-3m), and foliage below this height on larger trees, have a dense arrangement of shorter, erect phyllodes.

Bark: Dark to light grey, fissured to somewhat tessilated, fragments often dark brown with bleached surface (0.5-2cm thick).

Wood: Extremely hard. Heartwood dark purplish-brown (yellow-black).

Stems: Branchlets of mature trees narrow (2-6mm), up to 1.5m long, drooping, glabrous, terete, obscurely ribbed by vasular traces. Branching subunits of shoot growth articulate. Branchlets slightly broader at pulvinus, forming an almost zig-zag pattern in long, unbranched terminal sections, internodes (2-4cm). On juveniles, much branched, internodes rarely 1cm.

Phyllodes: Eglandulose. Mature phyllodes articulate on branchlets, alternate, rigid but fragile, narrow linear to 40cm (commonly 15-20cm) straight or slightly curved. Conspicuously tetragonous with four prominent longitudinal veins, 1mm wide, pendulous, sometimes slightly flattened (i.e. at Boulia). Glabrous, green with surface wax, ending in an acute pungent point, though often deteriorated at tip. Base of phyllodes a short (1-2mm) unwrinkled pulvinus, yellow to orange-brown. Axillary bracts (1-2mm) often present. New shoot growth, soft orange-red (± 30cm long.)

Primary Phyllodes: On juveniles less than 2-3m, on coppice growth and trees below this height. Alternate, eglandulose, confluent on stem, pulvinus absent. Rigid erect, crowded on branchlets, somewhat

more glaucous pale blue-green. Narrow linear 5-12cm long, 1mm wide tapering to an acute, very pungent mucro. Axillary bracts (1m) present.

Inflorescence: Flowers in globular heads, about 30 flowered, 0.8-1.2cm diameter, on solitary axillary peduncles 12-20mm long. Flowers pale yellow, regular bisexual, 5-merous.

Calyx: Five sepals, scarcely 1mm long, divided almost to base. Lobes narrow linear-spathulate, filamentous, ciliolate at tips.

Corolla: Petals five, glabrous, 2-2.5mm long, acuminate, united at base, margins somewhat papilose in bud. Pale yellow with slightly darker spot near apex. Valvate in turbinate bud.

Androecium: Stamens numerous, longer than corolla, filaments 3-5mm long, anthers bilocular.

Gynoecium: Ovary single, superior, 2mm long, glabrous yellow, style single 2-3mm arising at side of ovary.

Fruit: Pods are large and flat legumes to 18cm by 5cm wide, size variable, sometimes twisted. Shortly stipitate, subglaucous. Transversely reticulately veined with more prominent marginal veins. Pale green to pale blue-green, pruinose, with red margins on formation drying to glabrous very pale brown or darker brown to red. Firmly chartaceous to somewhat coriaceous.

Seed: Compressed, circular obovate to elliptical, dark brown 7-9mm, size variable (6.2 - 14 x 3.8 - 8.7mm) swelling to twice this on germination. Aureole small, central, open. Seeds transverse in pods, distant, variable (0-8 seeds per pod). Funicle slender filiform 7-10mm long, unthickened.

Ontogeny: Long root tip with conspicuous collar on germinated seeds. Cotyledons photosynthetic. First leaves a single pair (rarely three) of pinnate leaves 3-4cm long, with three to five, generally four, pairs of pinnae, oblique oblanceolate (1 x 0.5cm) rarely with a term-

inal pinna, Rachis with stipules (± 1m). Followed by indeterminate flat alternate phyllodes, narrow lanceolate apiculate, slightly curved with prominent midrib and vestigial stipules. Finally tetragonous pungent primary phyllodes develop.

Pollen: Circular compressed polyad. 16 monads.

Seedling *A. peuce* in flat phyllode stage at Boulia.

Mature phyllodes of *A. peuce* showing pods and flowers.

CHAPTER II

REGIONAL SETTING

2:1 Geology:

The Eromanga Basin drains a catchment area of 1,300,000km^2 (Wopfner and Tindale, 1967:119) of asymetric internal drainage with Lake Eyre as the centre of subsidence. The geological sequence comprises Cretaceous sediments of the Rolling Downs group (Senior, 1977). The marine shales of the Winton formation were the last of the Mesozoic blanket depositions but are overlain in places by thin Tertiary sandstones.

The Tertiary landsurface was characterised by a long period of aerial exposure culminating in a broad Oligocene planation surface, resulting in deep weathering and widespread silcrete formation (Wopfner and Twidale, 1967:121) (Wopfner, 1978). Since the Miocene the dominant land-form process has been the erosional dissection of uplands, resulting in the duricrusted residual plateaux and undulating pediplains typical of Eastern Central Australia.

The Pleistocene is recognised as having been a period of climatic fluctuations of high frequency and amplitude. During this period an extensive prior Lake System, Lake Dieri (Loeffler and Sullivan, 1979:238) gradually contracted and provided the sediment source for the development of the adjacent desert dunefields. The presence of gypseous sediments in the Eyre region may relate to the drying of this lake system. The extreme aridity of Late Pleistocene glacial maxima coincided with the aeolian deposition of the dunefield deserts. The Quarternary fluviatile sediments below the muds of the present meandering rivers of the Channel Country are predominantly sands, and therefore a relict feature of prior braided stream flow, reflecting

large seasonal discharges (Veevers and Rundle, 1979:13).

The Simpson Desert dunefield is not physiographically uniform, dune spacing increasing linearly from west to east (mean interdune distance from 0.25-1.0km). There is a distinct central dunefield extending for 60km west from Poeppel's Corner of irregular anastomising dunes with stable crests (5 YR) with interdune flats of claypans and salinas, contrasting with the more regular (7.5 YR) parallel dunes to the east and west. (Fatchen and Barker, 1979:647).

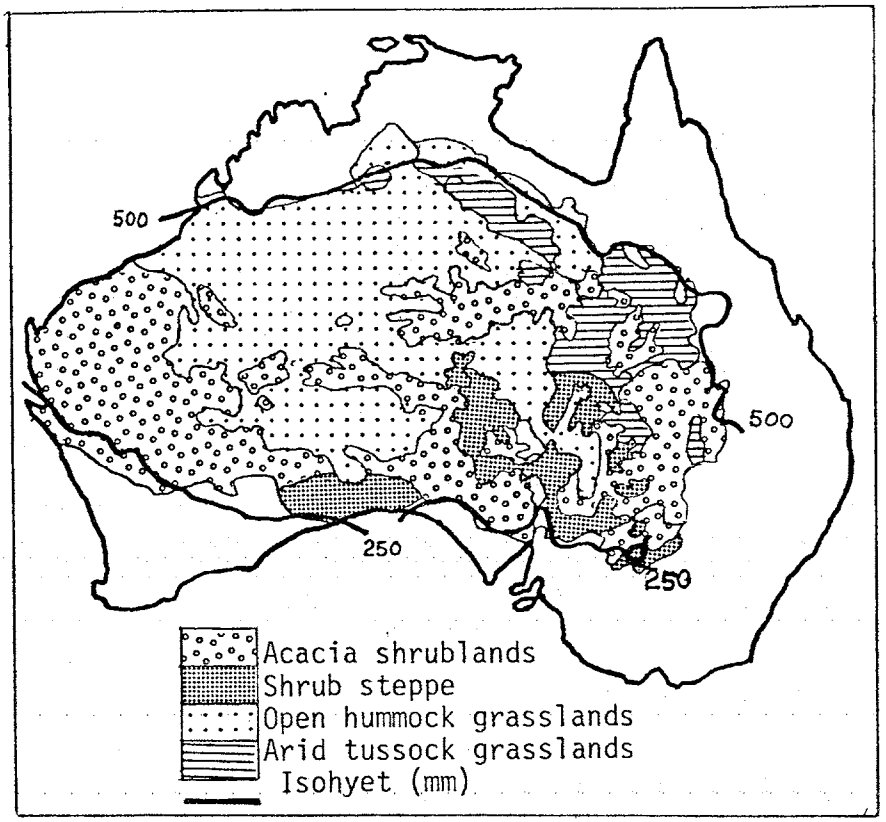
2:2 Vegetation:

The vegetation of Australia's arid zone is dominated by the shrublands and woodlands of the sclerophyllous genera *Acacia* and *Eucalyptus*, and by the arid hummock grasslands of *Triodia* and *Zygochloa*. Significant areas in the south-east are occupied by low open shrublands of the Chenopodiaceae and *Eremophila* species, and in the north-east by xerophytic tussock grasslands of *Astrebla* species (see map 2a).

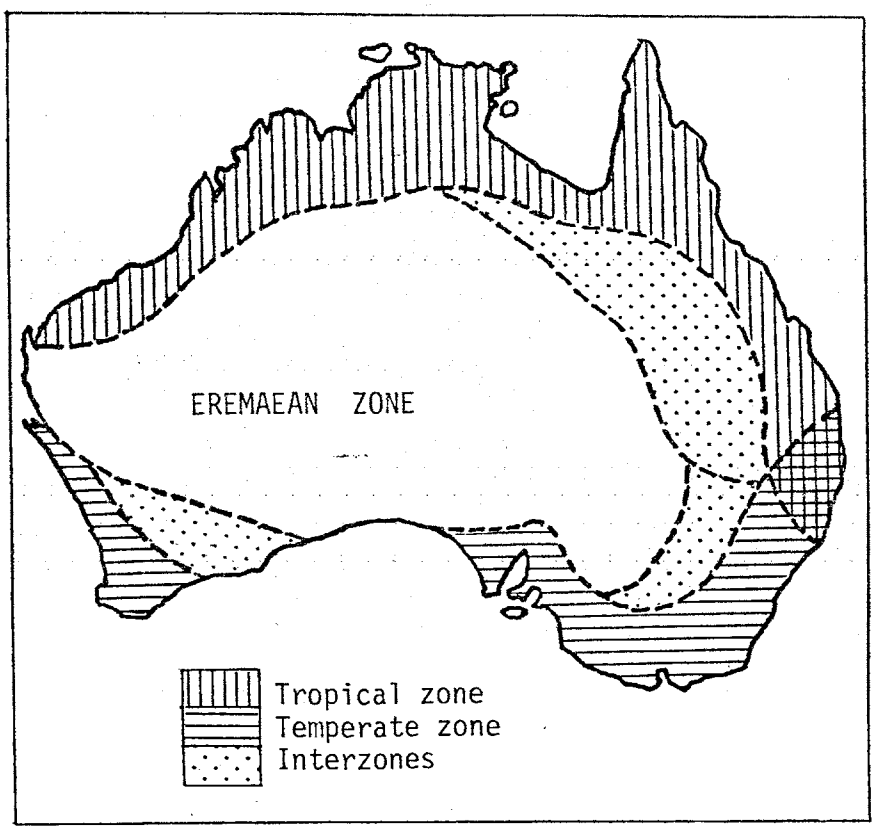
The arid zone as defined by rainfall efficiency (per-arid, 'A', from Gentilli, 1972) is bounded in the north by the 500mm isohyet, and 250mm in the south, and corresponds to the Eremaean floristic zone of Burbidge (1960) (map 2b).

The major vegetation formations of arid Australia and their extent are presented in Table 2.1. While the hummock grasslands occupy large areas of the sandridge deserts they are the dominant association only of the dunes themselves. Carnahan (1976) has mapped nearly all these areas, with an overstory of sparse tall shrubs (see map 2c). *Triodia* hummocks are a frequent understory of increasing densities of shrubs and low trees. The low open shrublands and tussock grasslands maintain a uniform stratum in core areas, but are also understory

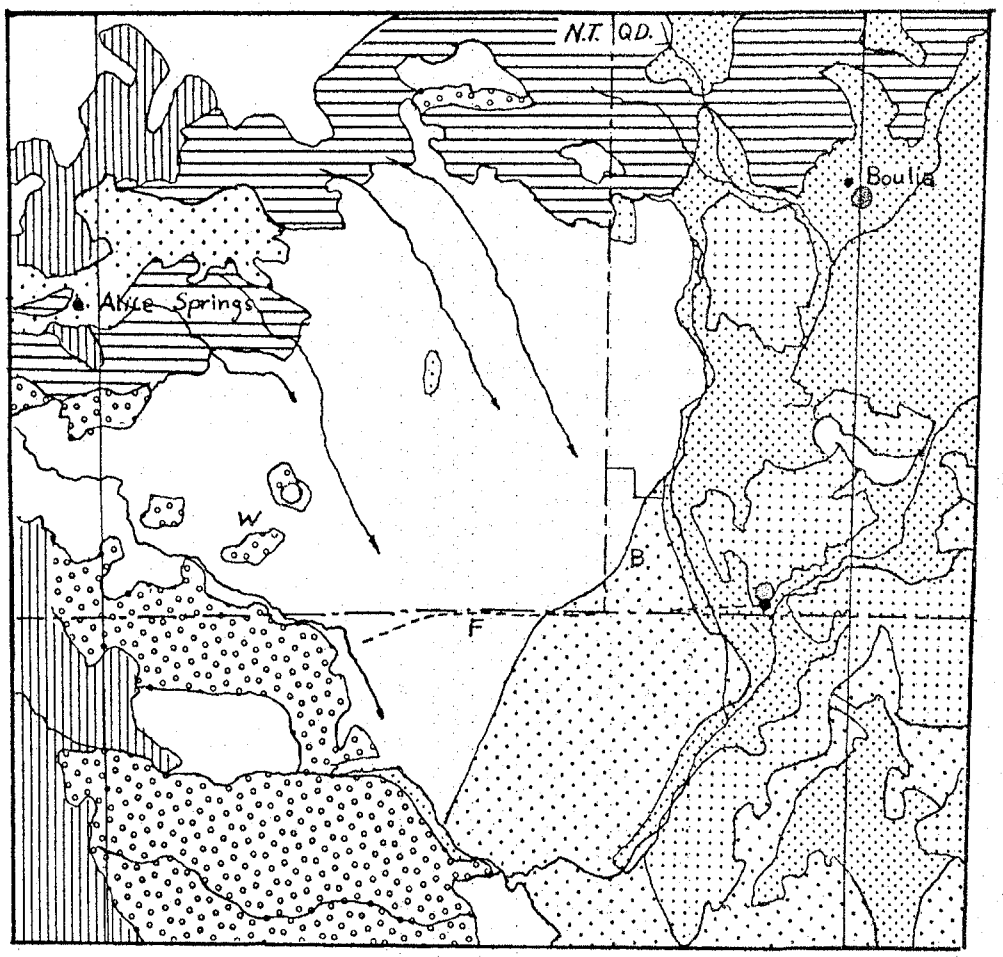
Map 2.a. Major Vegetation formations of arid Australia.
(after Moore & Perry. Leigh & Noble 1969:77).



Map 2.b. Australian Floristic zones. (after Burbidge 1960)



MAP 2:3c Structural vegetation formations of Eastern Central Australia. (after Carnahan, 1976) showing locations of Simpson Desert vegetation studies



Key

- sparse tall shrubs over hummock grassland
- sparse tall shrubs over tussock grasses
- open herbland(forbs)
- tussock grasslands (10- 30%cover.
- low shrublands (10-30% cover)
- sparse low trees over hummock grasses
- tall shrublands 10-30% cover

B Boyland (1970)
W Wiedeman (1971)
F Fatchen & Barker (1979)
O *A. peuce* localities

Acacia woodlands. In the border areas of South Australia and Queensland elements of both these formations, form a mixed open herbfield formation (map 2c). *Acacia* woodlands vary in both canopy height and density from the closed woodlands of *A. aneura* (mulga) groves in Western Queensland and north of Alice Springs, to tall open shrublands elsewhere. Interspersed with these major formations is a complex of drainage line fringing woodlands of *Eucalyptus microtheca* and *Eucalyptus camaldulensis*, as well as floodout areas of *Muellenbeckia* closed scrub or low samphire (Chenopodiaceae) communities. The subdivision of the major formations into local associations for the whole region has been carried out by Specht *et al.* (1974).

The climatic fluctuations of the Pleistocene have, through migrational and selective pressures resulted in a mosaic of spatially discontinuous taxa and heterogenous communities corresponding to present edaphic conditions.

The Simpson Desert dunefields form a regional vegetation unit of open hummock grasslands bordered by *Acacia* woodlands in the north (eg *A. aneura*, *A. estrophiolata*, *A. cambagei*) and by the open herbfield-tussock grasslands of the 'Stony Downs' (ie undulating gibber plains).

Crocker (1946) compiled the first map of the regional vegetation, identifying three major edaphic complexes:

- *Triodia basedowii* - Spinifex *(Zygochloa paradoxa)* on siliceous sands of the dunefield.
- *Astrebla pectinata - Atriplex vesicaria - Bassia* species on duplex soils of the stony tablelands.
- *Eucalyptus coolibah (E. microtheca) - Atriplex mummularia* on clay soils of river floodplains.

Soil properties were considered to be the major factor governing plant distribution in the desert (Crocker, 1946:256). Crocker also provides the earliest description of vegetation patterns within the Simpson Desert dunefields, distinguishing a *Zygochloa paradoxa* ridge crest

Table 2.1 Major Structural Vegetation Sub-Formations of Arid Australia - after Moore and Perry (Leigh and Noble 1968:76)

Formation	Area km^2	Soils (Northcote 1975)	Dominant Genera (Regional associates)
1. OPEN HUMMOCK GRASSLAND	1,700,000 (304,500 Williams 1979:171)	Siliceous sands Uc 1.2	*Triodia, Zygochloa, Plechtrachne* (*Acacia*)
2. OPEN TUSSOCK GRASSLAND	500,000	cracking clays Ug 5	*Astrebla, Aristida Eragrostis*
3. LOW OPEN SHRUBLANDS (SHRUB STEPPE)	308,000	calcareous earths, clays and saline soils Dr 1 Ug 5 Um 5	*Atriplex, Acacia, Rhagodia, Chenopodium, Eremophila, Cassia*
4. ACACIA SHRUBLAND AND WOODLANDS	2,000,000	wide range of lithosols, earthy sands, duplex soils Um 1 Uc 1 Dr 2	*Acacia (Casuarina, Callitris, Heterodendron, Pittosporum, Eremophila, Cassia, Eucalyptus)*

Table 2.2 Associations within the Vegetation of the Simpson Desert National Park, S.W. Queensland. (From Boyland, 1970:5)

ASSOCIATION	DOMINANT SPECIES	HABITAT
COOLIBAH	*Eucalyptus microtheca*	Floodplains and drainage channels
GIDYEAH	*Acacia cambagei*	Interdune flats
SALTBUSH	*Atriplex* spp. *Bassia* spp.	Claypans
SAMPHIRE	*Arthrocnemum* spp. *Atriplex* spp. *Bassia* spp.	Edge of salt lake
SPARSE LOW SHRUB	*Acacia* spp. ± *Triodia basedowii*	Lower stable slopes of dune
CANE GRASS	*Zygochloa paradoxa*	Upper unstable slopes and crests of dunes

association from the *Triodia basedowii* association of lower dune slopes and swales.

More recent studies, Boyland (1970) and Fatchen and Barker (1979a) have found general support for the separation of these associations. Boyland (1970:5) delimited six vegetation associations relating to habitat and soil types in the Simpson Desert National Park in south-western Queensland. (See Table 2.2.2). Fatchen and Barker (1979a:116) applying numerical analysis to species association data for the southern Simpson Desert found that the only two species groups delimited corresponded to the *Triodia* and *Zygochloa* associations. Weideman (1971) assigned species in a crest-swale ranking over a single dune at Andado (N.T.) and concluded that vegetation consists of a dune-interdune continuum of individual species rather than distinct associations. The consistency of the dune crest association across the desert is in part a result of the uniform substrate of unstable siliceous sands, while interdune corridors are a mozaic of earthy sandplains, lateral extentions of dune slopes, and the clays of salinas and floodplains.

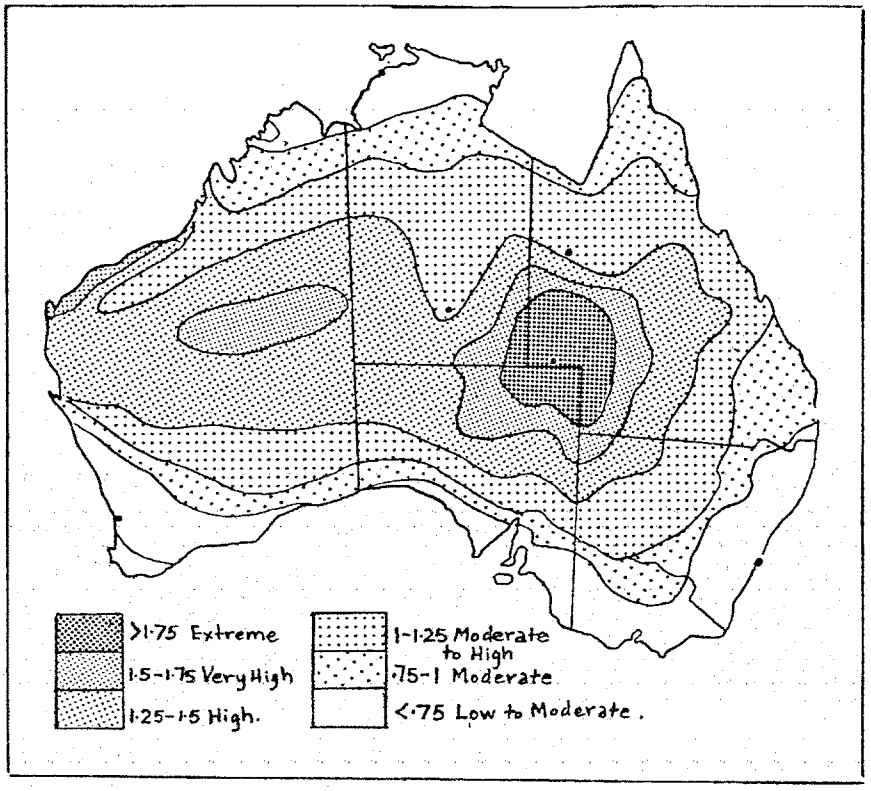
2:3 Climate:

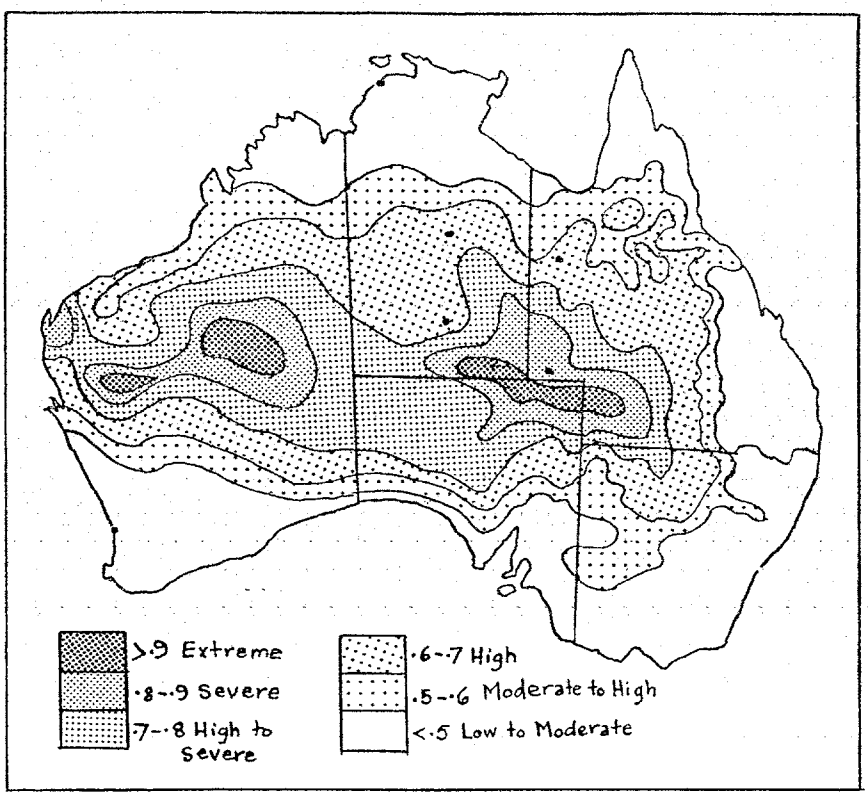
The climate of Central Australia is warm arid [(EB'. Thornthwaite, BWh. Koppen (Gentilli, 1972:36)] with an overall rainfall deficiency. The Lake Eyre region is the most arid centre of the continent (<100mm p.a.). Atmospheric circulation is dominated by the seasonal shift in latitude of the subtropical anticylcones and associated warm dry air masses which cross the continent at 29-32°S in summer and 37-38°S in winter. The major rainbearing wind systems in Central Australia are:

- Tropical cyclones bringing summer storms in the north.

Map 2.3 a. Annual rainfall Variability, Australia.
variability index based on annual rainfall deciles-

$$\frac{90\%-10\%}{50\%}$$





Map 2.3 b. Index of drought incidence, Austr alia.
based on annual percentiles $\frac{50\%-10\%}{30\%}$

- Mid-latitude fronts bringing winter and spring rainfall in the south.
- Inter-anticyclonic fronts, upper level low pressure belts.

(Fleming, 1978:19)

The resultant pattern is one of seasonal drought in winter in northern Australia and in summer in the south, while in central Australia prolonged non-seasonal droughts may last for several years. About 40% of the continent receives <250mm p.a., however rainfall variability in inland Australia is 10% higher than in other arid regions of the world. (Williams, 1979:154).

Rainfall variability in terms of spatial and temporal distribution and intensity is a feature of arid environments. It is this distribution of effective rainfall rather than the total which is of fundamental ecological importance. Temporal variability occurs over daily, seasonal and annual timescales.

Precipitation in short convective bursts is favoured on the low latitude margins of subtropical deserts; the northern part of arid Australia often receives large falls associated with tropical cyclones. The maximum probable one hourly rainfall for the arid zone ranges from 180mm to 280mm at the equatorward margin, except for the Simpson Desert region (Bell, 1979:383). The range of mean precipitation per wet day is consistent with the suggestion that desert rainfall occurs largely as isolated daily falls of <12.5mm. The average number of raindays for eastern Central Australia is <20. The geographically restricted nature of individual storm cells adds to the spatial variability of rainfall events. Eagleson and Goodspeed (1973) studied individual storm cell behaviour in the Alice Springs area and found that convectional storm centres have an effective radius of <32km.

Central Australia has an annual rainfall variability in excess of 30% (mean deviation as % of mean annual), with the highest variability occurring in part of the arid zone with a summer rainfall incidence. The region centred on the Birdsville district experiences extreme rainfall variability and is also the region of severe to extreme drought incidence (see maps 2.3a&b. from Cameron 1978:50 & 60). Foley's (1955) study of residual mass diagrams of cumulative rainfall suggests that trend reversals in longterm rainfall have occurred; rainfall generally decreasing after 1890-1900, and increasing after 1940-1950.

Clear desert skies mean that solar radiation approaches the seasonal maximum for the Australian arid zone, however net radiation is small due to the high terrestrial radiation. Average daily radiation in Central Australia is 600-650 cal/cm^2/day for January and 300-350 cal/cm^2/day for July. Average daily sunshine hours are between 8-10 all year. There is a marked diurnal and seasonal temperature range in Central Australia:

Average daily maxima January 36-39°C. July 21-25°C

Average daily minima January 21-25°C. July 5-6°C

Heat waves, prolonged periods with daily maxima >38°C can be expected in most years while frosts (0°C) occur rarely and only in July. Average annual evaporation ranges from 2800-3300mm (Aust. standard tank) or over 4000mm (class A.pan). Mean relative humidity varies from 50% in July to 30% in January.

2:4 Soils:

The geographic configuration of the major soil groups represented in eastern Central Australia is shown in map 2.4 (Northcote, 1975). These are:

1) Red siliceous sands, Uc 1.23 of desert dunefields
2) Red earthy sands, Uc 521 of sandplains
3) Red firm calcareous sands, Uc 1.43 of elevated sandplains
4) Cracking clays, Ug 5.2 and 5.3 of river floodplains
5) Red duplex soils, Dr 1.33 of the stony downs and tablelands

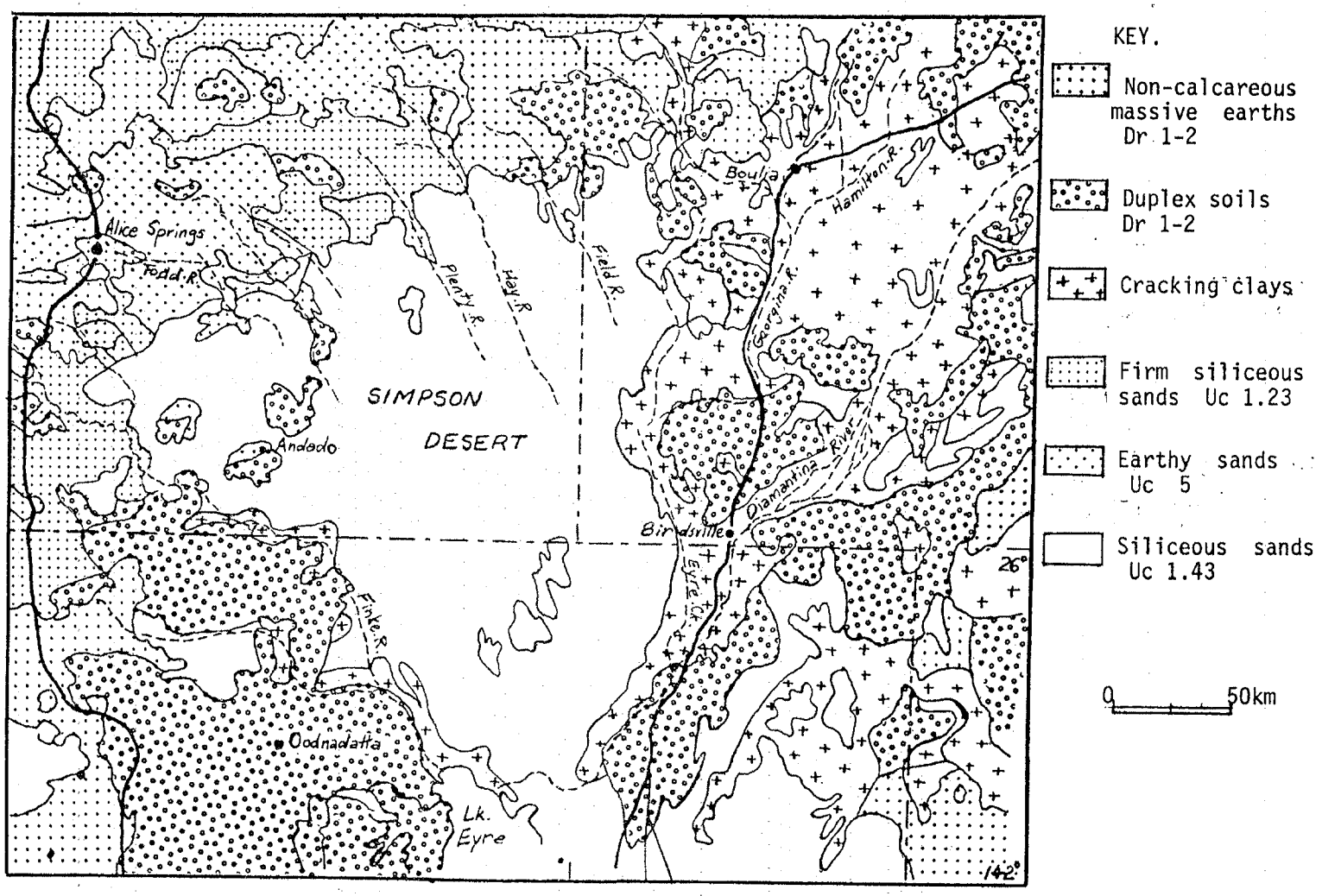
All except the red duplex soils are at least partly late Pleistocene regosols of aeolian or alluvial origin, which have been developed largely in situ (Stace, 1968:61) over alluvium or argillaceous sediments of the Eromanga Basin sequence, and comprise the oldest landsurface in the region. These soils are characteristically associated with stone pavements derived from the widespread Tertiary silcrete duricrust, and formed over an extensive Pleistocene landsurface, surviving as remnants on exposed areas bordering the Simpson Desert. The crusty red duplex soils (Dr 1.33, Northcote 1975:103) are the desert loams (Stace, 1968:60) and were previously known as the stony desert tableland soils (Jessup, 1960a & b, 1961). The great soil group to which they correspond is the orthic solonetz with a gypsic and saline phase (Northcote, 1975:159).

The soils of the Australian arid zone show greater deficiencies of nitrogen and phosphorous than equivalent soils in other continents (Williams, 1979:149). The low N levels may be a resultant of the P deficiency, a characteristic limiting nutrient of the Australian environment (Williams, 1970:323) (Beadle, 1966). The cycling of organic matter is concentrated in the surface horizon, C and N having maximal accumulation in this zone. Microbial activity plays an important role in nutrient cycling, nitrogen availability being linked to pulses of activity by nitrifying bacteria after rains (Charley and Cowling, 1968).

The low accumulation of organic matter in desert soils results from:

a) sparse vegetation cover and low phytomass production (Noy-Meir, 1974:44)

Map 2.4 Major soil types of Eastern Central Australia.(after Northcote 1975)



b) long periods of biological inactivity
c) high rates of oxidation and mineralisation of litter

2:5 Regional Land Systems:

BOULIA: The Burke and Hamilton Rivers converge with the Georgina 40km south of Boulia forming a wide alluvial floodplain overlaying an eroded sedimentary sequence of low relief. The Tertiary sandstones of the Marion and Springvale formations remain only as residual hilltops exposing deeply weathered Cretaceous siltstones and mudstones. A discontinuous shallow blanket deposit of Late Pleistocene aeolian fine sands is superimposed over and partly derived from the floodplain sediments, and in places is organized into linear dunes (eg Coorabulka sandridge).

The dominant alluvial soils are the deep red-brown cracking clays (Ug 5.38) (Northcote *et al.* 1968). Below the confluence of the major channels (<120m alt.) deep brown and grey cracking clays are prominent on flooded country (Ug 5.34, 5.24). On the low rises adjacent to streams gravel strewn loamy red duplex soils (Dr 2.33, 2.43, 2.13) and crusty red duplex soils occur (Dr 1.33).

The Boulia floodplains lie within the major structural vegetation formations of the arid tussock grasslands: mixed communities of *Astrebla, Eragrostis, Aristida* and *Chloris* spp. (5-10% cover). These are interspersed with *Eucalyptus microtheca, Lysiphyllum gilvum & Acacia stenophylla* channel fringing woodlands, and mixed low open woodlands of *Eucalyptus terminalis, E. papuana, Grevillea striata, Owenia acidula* and *Ehretia saligna.*

BIRDSVILLE: Along the eastern edge of the Simpson Desert (139°E) the Birdsville uplift (Wopfner, 1978:94) forms a system of marginally dissected residual plateaux and low stony hills stretching for 300km north of Birdsville. These formations are developed on the Tertiary Marion sandstones and are flanked by broad stone covered

pediments and alluvial plains over argillaceous Cretaceous sediments of the Winton formation.

East of the Eyre Creek the desert sandplain forms a discontinuous deposit over lower areas and longitudinal dunes have extended over the 'stony downs', leaving them exposed in interdune corridors over much of the area north of Birdsville. The dunes in the vicinity of Birdsville show development from an anastomising system along the north bank of the Diamantina to regular dunes of 1-2.5km apart (15m high) over a distance of 5-10km. In places these overly lacustrine sediments of Late Pleistocene age suggesting a recent (<10,000B.P.) origin (Twidale, 1972:77).

The regional soils are the siliceous sands of the dunefields (Ucl.22), the duplex soils of the stony downs (Dr 1.2, 1.3) and the brown and grey clays of river floodplains (Ug 5.3 & Uf 1.3). The stony downs profile forms range from crusty red duplex soils (Dr 1.22, 1.33) to hard pedal yellow duplex types (Dy 2.12, 2.32) and are associated with brown powdery clays (Uf 1.22) in claypans (Northcote, *et al.* 1968). They display a strongly developed 'gypsite' subsurface of gypseous clays (up to 60% powdery $CaSO_4$).

The Birdsville district lies along the boundary zone between two major vegetation formations, the open hummock grasslands of the desert dunefields and the open herbland of the stony downs:

- *Triodia basedowii - Zygochloa paradoxa*, open hummock grassland, dominant west of the Eyre Creek and occurring on longitudinal sand ridges.
- Open herbland formation: this is a unique structural formation (see map 2c) distinct from both the tussock grasslands to the north and the low open shrublands of S.A. It consists of seasonally fluctuating climax communities (generally 10% cover) of perennial herbs (*Bassia, Maireana, Atriplex, Sida* spp.) and tussock grasses (*Astrebla, Aristida* and *Eragrostis* spp.) with a large ephemeral component (Asteraceae) and playas support open succulent shrubland of *Chenopodium auricomum* or *Muellenbeckia cunninghamii*

closed scrub. Scattered low shrubs of *Cassia* and *Eremophila* spp. are common, and along drainage lines, scattered *Eucalyptus microtheca* and *Acacia cambagei* occur.

ANDADO: Positive fold structures form topographic boundaries to the Simpson Desert sandplain, however on its western boundary the Andado Monocline (135°30'E) consists of topographic islands within a wider zone of discontinuous longitudinal dune development. This chain of cuestas, tablelands and low stony hills runs northwards from Andado Station (25°30'S) to the Allittra Tableland (24°30'S, 136°E), leaving wide stony pediments and alluvial plains stretching out on their northern sides. The tablelands are capped by sandstones of the Tertiary Etringimbra Formation, rising up to 50m above the surrounding plains, overlying the Rumbalara shales (Stewart 1968). The major regional soils are the deep red siliceous sands of the desert dunefield (Uc 1.23) and the red earthy sands of the sandplains (Uc 5.12). The latter are prominent on the northern side of the exposed stony plains. The soils of the stony downs are the crusty red duplex soils (Dr 1.23 and Dr 1.33) with a strongly developed 'gypsite' subsoil (up to 75% powdery $CaSO_4$).

The structural vegetation formations dominant within the region are:

- Open hummock grasslands, *Triodia basedowii* - *Zygochloa paradoxa* association.
- Open herbfield formation of the stony downs and tablelands consisting of fluctuating climax communities of tussock grasses (*Astrebla*, *Eragrostis* spp.) and perennial herbs of the Chenopodiaceae and Malvaceae, with an ephemeral component of the Asteraceae. Scattered low shrubs of *Eremophila*, *Cassia* and Chenopodiaceae species occur.

The latter formation is related to the shrub-steppe of northern South Australia (see map 2.2a) by a common substrate and vegetation components, but in view of the structural similarity to the vegetation of

the Birdsville region, the gibber plains north of Andado are best classified as mixed open herbfield. Minor occurences of several open woodland associations are present:

- *Eucalyptus microtheca* as scattered trees along drainage lines.
- *Acacia cambagei* on lower sites in interdune corridors.
- *Acacia aneura* on sandplain to the west and north.

CHAPTER III

INVENTORY

3:1 Methods

Fieldwork: The three known populations of *A. peuce* were visited during two periods of fieldwork in April and June 1980. The extent of local distribution was assessed by ground survey and by available aerial photography (1970, 1:84,000).

Since *A. peuce* occurs in discrete open woodland stands it was possible to identify the largest areas of continuous distribution within which a representative population sample could be investigated. These areas are considered as 'main stands' and may be regarded as high density phases and core populations within wider local distribution areas. Main stands were defined as the area in which random sample plots would contain at least one tree (i.e. mean density of 1/ha) thus avoiding sampling empty plots. The *A. peuce* communities described consist of species occurring within these structurally uniform open woodland main stands.

While this classification proved satisfactory at Boulia where trees occur in a single continuous stand, the density distribution at Birdsville is not directly comparable, trees forming many sparse discontinuous groups. Therefore mean density estimates for Birdsville could be considered as the average maximum density of dispersed stands. The approach is justified however, since obtaining comparative estimates of population structure rather than aggregation patterns was considered the primary objective of the inventory.

Stand measurement: A count plot method of population sampling (Mueller-Dombois, 1974:96) was adopted using the standard forest

inventory technique of recording diameters and heights of all trees. In addition a floristic cover analysis was made for each plot to determine the dominant associations and community composition of each stand.

A systematic location of sample plots was chosen because:

- time and access limitations precluded a truly random sample or a plotless method
- a plotless method ignores other vegetation components
- the full range of habitats over the distribution area could be included
- large scale geographic variations in community structure, and *Acacia peuce* density or population structure over the main stand area could be detected (Westman, 1971:532)

A plot size of 50m radius (0.78ha) was chosen since it allowed a significant tree number and the full size range of *A. peuce* to be represented within each plot. Smaller subsample plots for juvenile trees were unnecessary since the overall low density enabled measurement of all individuals.

At each location data from 25 plots (14 at Andado) were recorded in an attempt to obtain a representative population sample. This represented approximately 1% of the main stand areas and 1% of the population in each case. Total population sizes are estimated from mean density over the main stand area and although outlying individuals are not included they do not, over the limits of accuracy of these estimates, affect total populations.

Within each plot the following data was recorded:

1) Number, height and diameter at 1.2m (D.B.H.) (Carron, 1968) of all trees.
2) Number and height (in 10cm classes) of all juvenile *A. peuce*.
3) Number of stems of *A. peuce* (D.B.H.) at 1.2m and the number which have been cut.
4) Presence and relative abundance of all other plant species recorded as:

- the dominant species in order of abundance. (contribution to biomass)
- numerous individuals
- present

5) Canopy cover of structural components: projective foliage cover (PFC) of tree, shrub and ground layer.
6) Degree of disturbance and agent responsible.
7) Number of dead *A. peuce* and number of cut stumps.
8) Slope, aspect, soil surface characteristics and % area of stone pavement.

Trees were distinguished from juveniles somewhat arbitrarily as those *A. peuce* with D.B.H. <5cm, reproductive aged trees >10cm D.B.H. and canopy dominants as those >20cm D.B.H. Where trees branched below 1.2m the largest of these was recorded as tree diameter. *Acacia peuce* exhibits a general linear relationship of diameter-height (including multi-stemmed trees levelling out towards the upper limit of 12-15m, and showing greatest deviation in the largest sizes due to senile and exceptional trees (see graph 3.2a).

Mean densities were calculated for total main stand populations and for different tree size categories. Population percentages of the separate size classes were also determined. The proportion of living trees which had been cut is given as a decimal index indicating the degree to which the present population is affected and, including cut stumps, gives a total utilization index from which estimates of historical use are made.

The total number of *A. peuce* sampled were ordered into 3cm diameter (D.B.H.) size classes, juveniles separated by height into

those <0.5m and those >0.5m, and a size class frequency distribution histogram constructed for each population. Separation into these size classes (3cm) yields a consistent relationship between frequency scores, and while the size parameter measurements are not continuous between juveniles and trees i.e. height-diameter the resultant histogram form is coherent.

Assuming a general relationship between tree diameter and age, at least for the smaller size classes, the D.B.H. diameter class frequency data allows the inferred age structure of the populations to be assessed. Following the time-specific life table approach (Emmel, 1976:200) of Hett and Loucks (1975) the graphs are taken to represent mortality depletion curves, comparable to the equilibrium age distribution curves for natural tree populations (Leak, 1974). While diameter-age relationships are suggested it is unlikely that the age of any individual tree can be accurately predicted from its diameter. Interpretation and comparison of population dynamics and reproductive performance is discussed in Section 4:1 .

In an attempt to describe the vegetation of *A. peuce* stands accurately and to characterise the associations present, species were ranked according to their abundance (contribution to biomass) in each structural life form. Since the ground cover (PFC) for any species rarely exceeded 5% at the scale of sampling plots, cover abundance scales were not considered applicable. The dominant species in each plot were ranked in order, and those which were consistently dominant over all plots (i.e.>50% plots) are used to define the *A. peuce* communities following Boyland (1974:75). Species lists were compiled for comparison of floristic similarity at the specific and generic level, both between *A. peuce* populations and with other regional floras (Section 4:2:2).

At each location representative soil cores were taken to 3m

depth and described, and samples taken for chemical analysis. Results are discussed in Section 4:4. The bioclimatic influences on *A. peuce* distribution are summarised in Section 4:3.

3:2 Site Descriptions

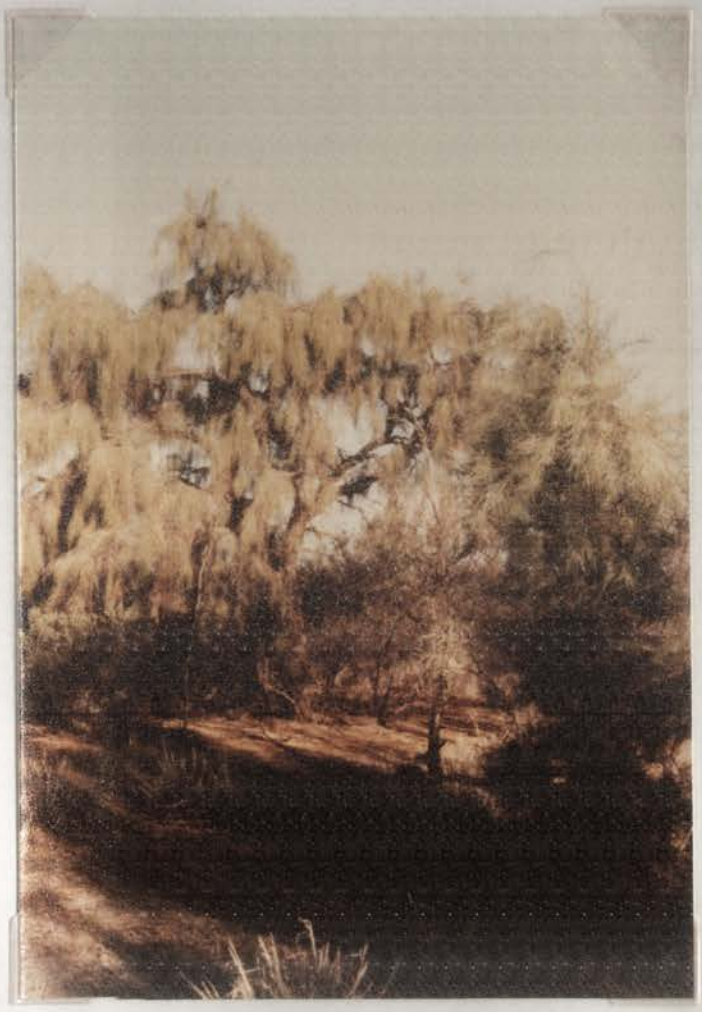
3:2:1 Boulia:

Local names: 'Belah', 'Bull-Waddy', 'Waddy'.

Location: The major stand of *A. peuce* lies 20km south of Boulia and extends for 15km southwest from the old Coorabulka road, north of Mudgeacca Station in a belt 5-8km wide. It occurs on a gently sloping 1:1000 interfluvial rise associated with aeolian sand deposits up to 1.5m thick, and gravel strewn rises and depressions. Trees occur over an altitudinal range of 125-150m.

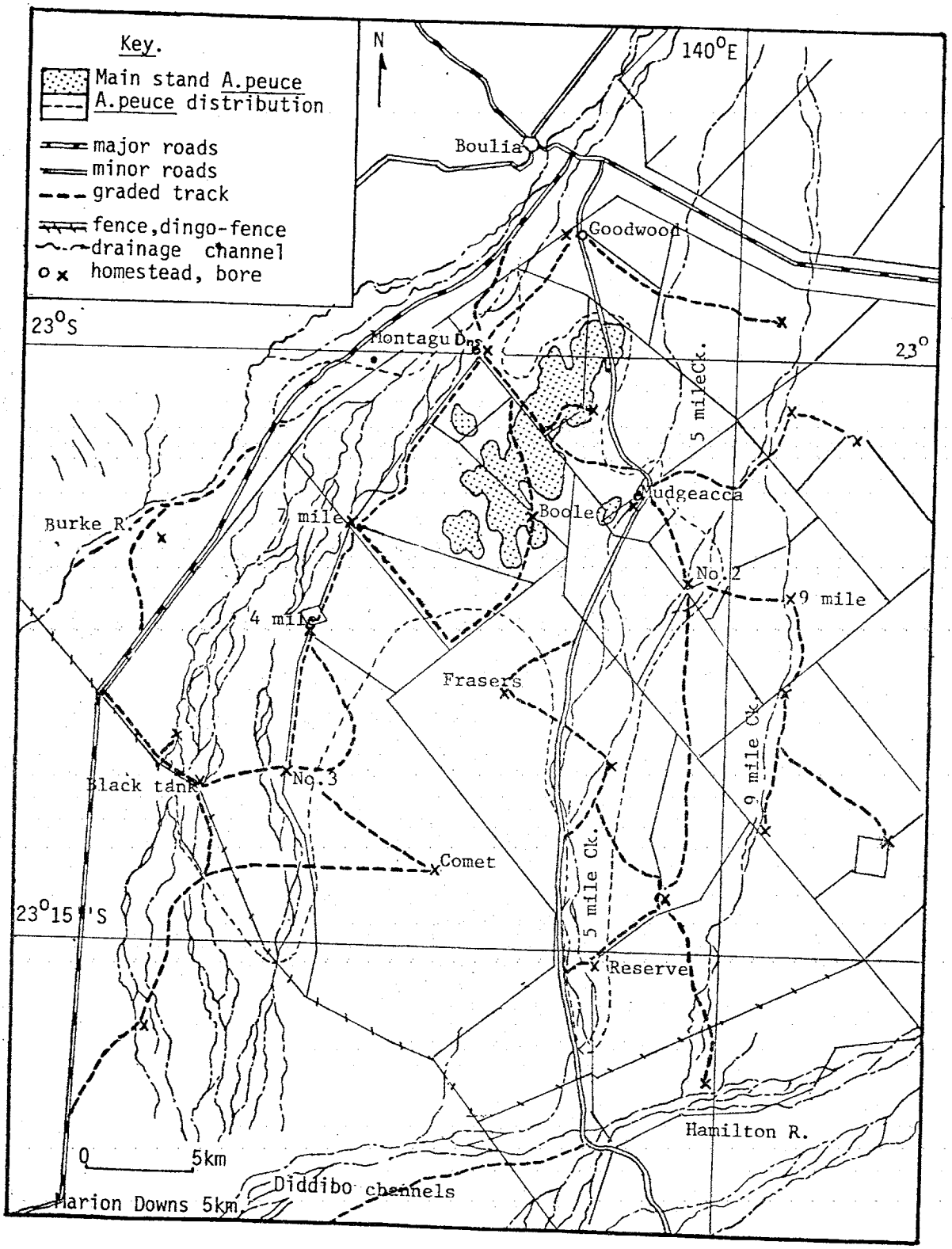
The coordinate boundaries of the stand are 23°00' - 23°07'S, 139°53' - 139°57'E. The main stand covers an area of 25-30 sq km lying largely within Montagu Downs Station and extending into Mudgeacca Station. However the species also occurs more extensively as scattered groups and individuals throughout *Eucalyptus microtheca* and *Acacia cambagei* open woodlands (see map 3.2.1). Scattered trees occur up to 25km south of Mudgeacca homestead, on the Five Mile Creek near Reserve bore, and may be found as far east as the Nine Mile Creek. In the west the main stand is bounded by the floodout channels of the Burke River and scattered groups of trees extend beyond these to the main Bedourie Road near Montagu Downs. Few trees occur along the channels east of this road but scattered groups are found up to 5km south of Black Tank (139°46'E, 29°11'S) on Marion Downs. A feature of *A. peuce* distribution in this area is the presence of isolated

A. peuce, 15m high at Boole bore on Montagu Downs Boulia.



A. peuce along main Boulia-Bedourie road. Juvenile (3m) in foreground, exceptional spreading habit of tree in background.

Map 3.2.1. The distribution of A.peuce in the Boulia district (Qld)



(part of grid sheet SF 54 -14)

Scale outside

outlying individuals. The Memorial tree at the north end of Boulia township and a similar tree on Marion Downs (139°35'E, 23°22'S) indicate an extensive but sparse local distribution.

Soils: The soils of the *Acacia peuce* stand are deep loamy red duplex soils (Northcote, 75:105), Dr 2.1 3, Dr 2.2 3 and minor deep red-brown cracking clays Ug 5.38. The spatial relationship between soils is topographically controlled with duplex soils on higher interfluvial flats and associated with aeolian surface soil deposits. The classification separates these soils largely on surface characteristics: the presence of a poorly structured shallow 'A' horizon; and the development of polygonal surface cracks, a distinction found to be not exclusive in the field.

There is a microtopographic pattern (<30cm) of undulating sandy aeolian deposits and gravel strewn claypans and depressions (10-20m diameter). Lower areas of the main stand are subject to flooding. Collapse holes to 50cm deep and surface cracking are common. The mottled lower horizon >2m and the topographic position of the soils indicates that considerable ground water inputs are experienced.

Vegetation: The main stand of *Acacia peuce* forms a distinct open woodland community within the regional pattern of open tussock grasslands and low open woodlands. The *A. peuce* community varies from open woodland (10-15% cover) with a canopy up to 30% locally in the centre of the main stand, to wooded grassland (5% cover) at the southern end. Trees are associated with an undulating fine loamy sand surface and are absent from areas with a stone pavement cover of >50%. There is a scattered low shrub layer of

Eremophila and *Cassia* spp. over a mixed tussock grassland (5% cover). It is a uniform community although influenced by components of separate low woodland associations in the northern and southern parts of the stand.

The species composition of the *Acacia peuce* community as dominant and common perennial species in each life form is presented as follows:

A. peuce low open woodland.

DOMINANT SPECIES	
Trees	*Acacia peuce*
Shrubs	*Eremophila maculata, Cassia nemophila* sbspp. *Acacia victoriae, Cassia phyllodinea*
Ground Layer	*Eragrostis setifolia, Aristida latifolia Chloris scariosa, Bassia bicornis*
COMMON SPECIES	
Trees	*Eucalyptus microtheca, Atalaya hemiglauca Grevillea striata*
Shrubs	*Eremophila obovata, Eremophila longifolia Enchylaena tomentosa, Rhagodia nutans, Bassia cornishiana, Pluchea tetranthera, Cassia oligophylla, Cassia desolata*
Ground Layer	*Aristida browiana, Eragrostis eriopoda, Chrysopogon fallax, Astrebla pectinata, Eualia fulva, Sida fibulifera, Abutilon otocarpum, Bassia lanicuspis, Frankenia uncinata, Enteropogon acicularis, Enneapogon* spp.

A complete list of species collected within the *Acacia peuce* community is given in Appendix III:2a.

Bounding Communities: Within the northern half of the stand components of a mixed low woodland association of the sandy alluvial plains to the north are found:

Grevillea striata
Eucalyptus papuana, E. terminalis
Ehretia saligna, Owenia acidula, Carissa lanceolata,
Eremophila latrobei

Species associated with sandy sites within the northern stand are:

Eremophila obovata, Ptilotus obovatus
(Trichodesma zeylanicum, Crotalaria eremaea)

On the lower clay flats at the southern end of the stand *Acacia cambagei* low open woodland occurs as scattered groups of trees (5-8m) interspersed with *A. peuce* groves. Elements of these associations are:

Acacia cambagei, Acacia victoriae
Apophyllum anomalum, Eucalyptus microtheca
Eremophila longifolia, Capparis spinosa
Rhagodia nutans

Population: The total population of *A. peuce* in the Boulia district may be in excess of 100,000 plants about 80% of which are juvenile. Tree population is estimated as 25,000 - 30,000 with 8-10,000 canopy dominant sized trees. The mean density of trees over the main stand is 15/ha, while that for the total population is 80 individuals per hectare. Highest density areas in the centre of the north section reach up to 150 plants/ha while in peripheral areas, as few as 3/ha.

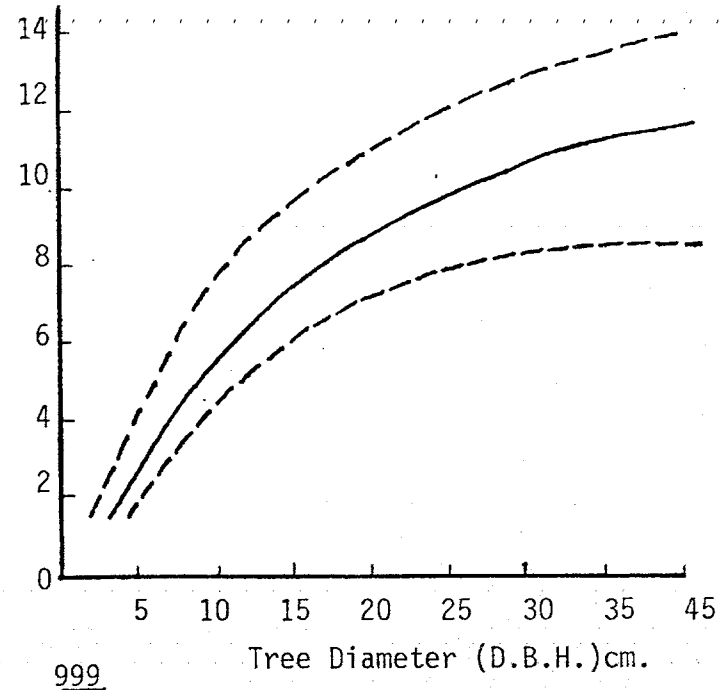
Density decreases gradually to scattered groves of trees towards the southern end of the stand. All plots containing more than 100 individuals occur in the northern half of the stand.
Other tree species comprised 3% of total tree population. There is evidence of local even-aged developed (e.g. plot 24) particularly in peripheral areas, and with the unprecedented number of juveniles <1m high in tussock grassland surrounding the main stand area, it suggests the population may be locally expanding its range. Considerable recruitment during the period since 1972 is indicated by the proportion of juveniles <0.5m, 60% of the total.

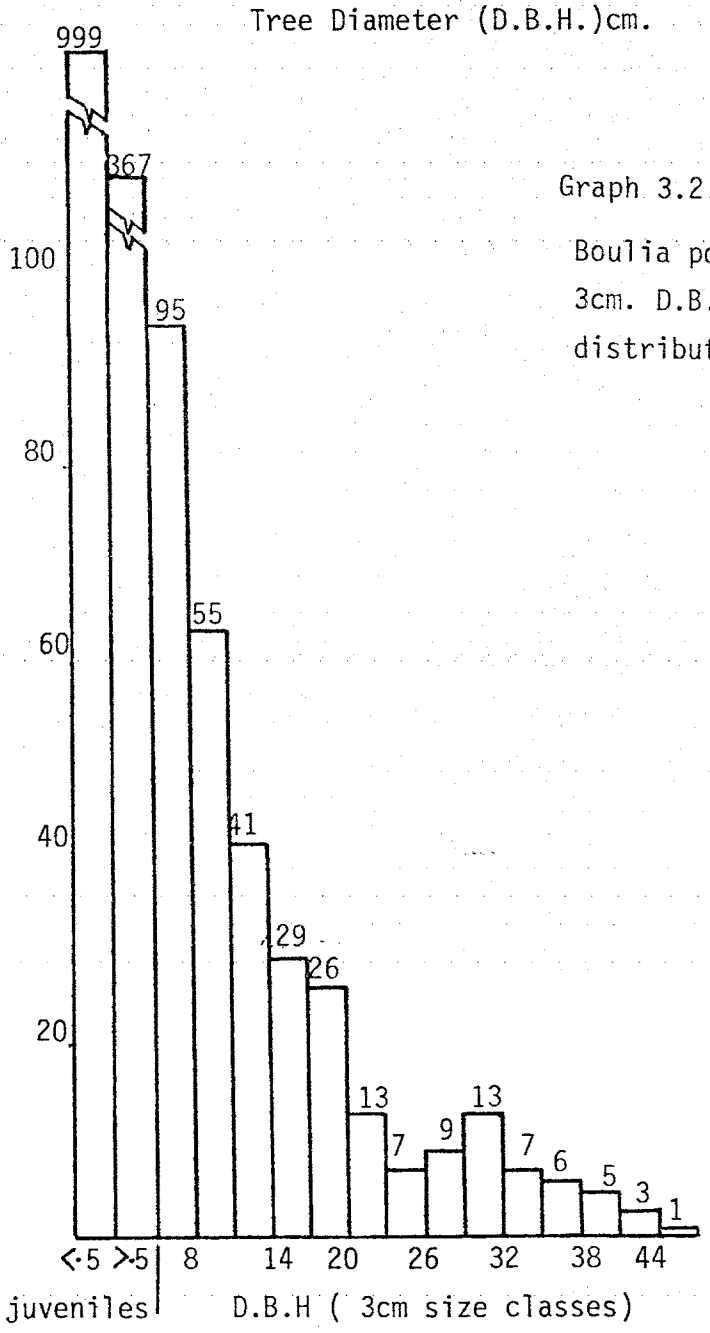
TABLE 3.2.1 Data sheet. Boulia

Plot No.	Total trees	Total *A. peuce*	Juveniles <.5m	Juveniles >.5m	No. measured	Number cut	Number Dead	Mean dia.
1	43	43	21	16	6	3	1	10.55
2	3	3	1	2	-	-	1	
3	47	47	28	6	14	6	6	
4	7	7	6	1	-	-	-	
5	35	18	10	3	5	-	7	
6	43	41	32	2	7	1	1	
7	50	49	34	3	12	1	-	
16	43	43	25	11	7	2	8	
17	12	12	7	5	-	-	-	
18	56	56	46	7	3	-	3	
19	111	109	89	17	3	-	-	
20	45	44	36	6	2	-	-	
8	132	132	80	16	36	4	2	
9	120	120	30	51	37	4	16	
10	122	117	42	72	3	-	2	
11	35	31	26	2	3	2	1	
12	113	112	37	33	42	1	2	
13	54	54	30	6	18	4	2	
14	111	111	77	30	4	2	3	
15	65	64	48	5	11	4	7	
21	125	122	112	3	7	2	11	
22	133	130	18	25	27	5	7	
23	58	51	28	8	11	4	-	
24	77	71	3	31	37	2	10	
25	97	95						
Total	1737	1684	999	367	316	50	90	
mean	69.5	67.38	40.36	14.4	12.64	2	3.6	

Graph 3.2a Height-Diameter Relationship of A. peuce

(all locations) ------90% range.





Graph 3.2.*1*.

Boulia population

3cm. D.B.H. class frequency

distribution histogram.

A frequency distribution histogram of the number of individuals within the 3cm size class (see graph 3.2.2) shows it to be a stable population with continuous recruitment. The large proportion of juveniles <0.5m indicates significant recent regeneration. This may be only a temporary trend however, as large juvenile mortality may equalise fluctuation in seedling numbers.

Condition: Trees are generally in excellent condition, to 15m high with wide dense canopies and phyllodes to 40cm common. Mortality among juveniles <30cm was observed and die-back of major stems of juveniles 1-3m high is common. Senility of mature trees is rare within the adult population but death of large trees by toppling was observed. Localised mortality of a group of smaller trees and juveniles (10-20) was observed but the cause of death is unknown. 30-40% of trees in the centre of the main stand were flowering in April. Seedlings under 1 year old were absent. Seed soil load around trees is large, pods collecting in collapse holes and around obstacles such as fallen trees. Such obstacles create locally favourable germination sites with a build up of reworked loamy sand. Pathological insect activity: scale, *Cerembycidae* (wood beetles) and flower mites were observed and mistletoe (*Loranthus exocarpii*) is present.

Site History: Trees have been used extensively by local landholders for fencing strainer posts, yard construction and even building foundations. While the hardness of the wood limits the use of power tools, posts are still being cut on Montagu Downs. Posts in a yard on Mudgeacca built during the 1920's are still standing. While the proportion of live trees which have been cut is about 1 in 7 (0.136),

the exceptional and continuous recruitment mean the population is not under threat from human utilisation. If the number of cut stumps is included in the utilization index, the figure is closer to 0.2 indicating that 5000 - 6000 trees may have been cut over the time of settlement. An indication of the local use of *A. peuce* is given by Mr S. Halfpenny, owner of Mudgeacca Station, who has used *A. peuce* posts in 150 miles of fencing (i.e. 2,500 posts).

Trampling by domestic stock poses no threat to successful recruitment at Boulia although horses may occasionally eat top shoots, and sheep,the pods. Two photograph recognition points are located within the main stand and a permanent plot in an outlying group along the main road to Birdsville (see Appendix III.2d).

3:2:2 Birdsville

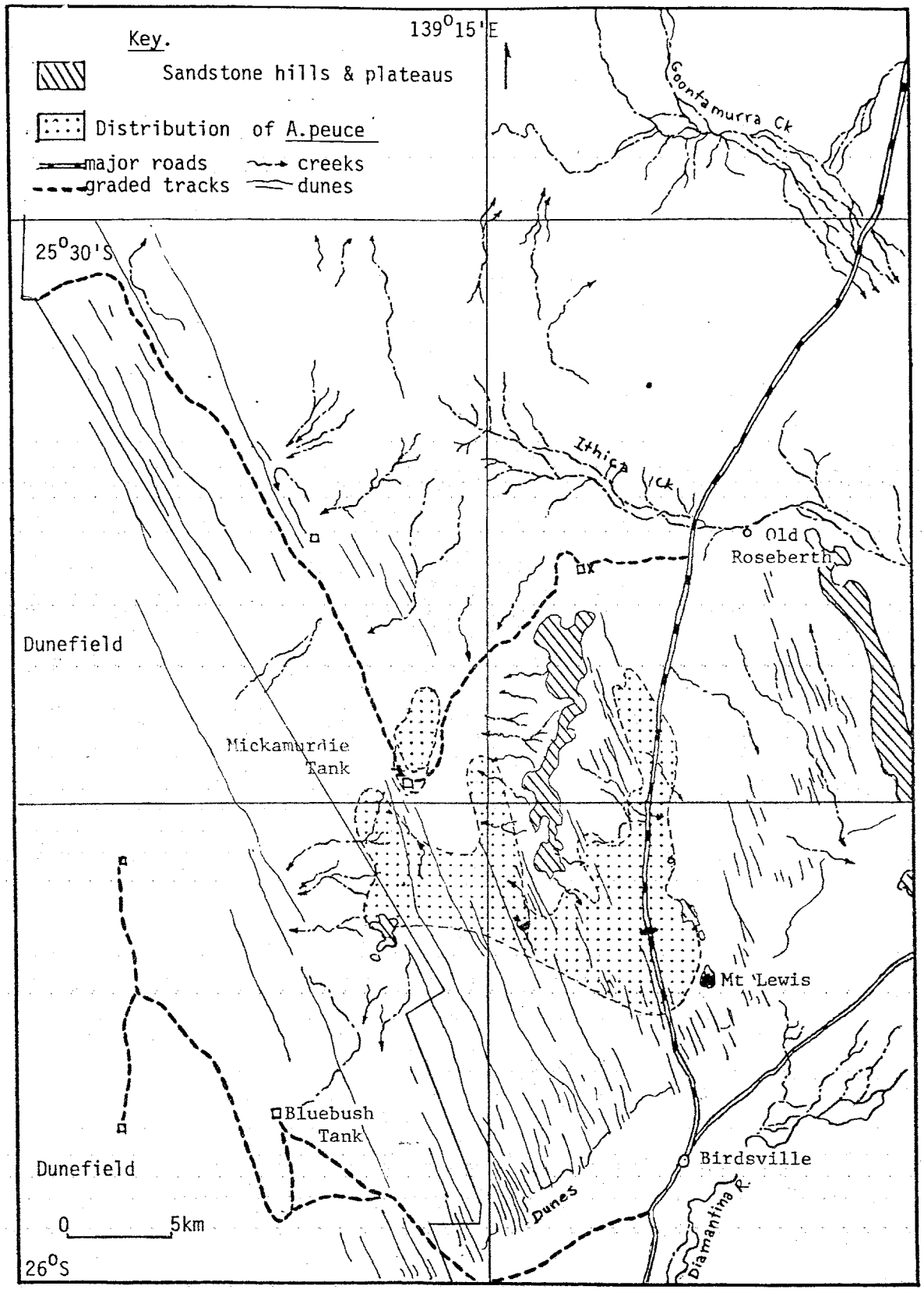
Local names: Waddy-wood, 'Pine' or 'Birdsville wattle', 'Iron wood'.

Location: The major occurrence of *A. peuce* lies 10-25km north of Birdsville along the main road to Bedourie on Roseberth Station. Trees form sparse woodland stands, often organized into continuous bands up to 5km long. The distribution of scattered stands extends for 15km westward, reaching the boundary fence between Roseberth and Adria Downs south of Mickamurdie Tank (see map 3.2.2). From the western flank of Mt Lewis (139°21'E, 25°50'S) these discontinuous stands stretch N.W. for 20km to north of Mickamurdie Tank (25°44'S, 139°12'E) intersected by numerous longitudinal dunes. Stands occur on the broad mantled pediment slopes on both the eastern and western sides of the low range of sandstone hills that run northwards at 139°17-18'E around 25°45'S. The northern limits of this distribution are, in the east, 3km west of the Bedourie road at 25°42'S, and in the west,5km north of the Mickamurdie Tank. The southern limit is

A. peuce along sandy drainage line, at Birdsville, with *Santalum lanceolatum* (foreground)

A. peuce at Birdsville showing localised sheet erosion and gibber pans, with *Hakea leucoptera* and *Cassia nemophila*.

Map 3.2.2 Distribution of A.peuce in the Birdsville district. (Qld)



(part of grid sheet SG 54-5)

about 9km on the road north of Birdsville at 25°50'S. The local distribution covers an area of 100-120sq km but continuous stands cover only about 30km^2. Trees are found over an altitudinal range of 50-100m growing over low stony hills and mesa slopes of up to 4°, over flat interdune corridors and sandy drainage lines. Trees are absent from clay flats, gibber pans and dunes.

An outlying stand occurs some 40km north of Birdsville on top, and on the western apron of a low mesa 25°22'S, 139°26'E. The largest group of trees here numbers 300 (Grandison pers. comm. 1980) on the mesa slope at 25°22'S, 139°24'E. Isolated individuals occur at 139°01'E, 25°42'S and 25°35'S, 139°20'E. It is possible that other small groups of trees occur in the region northwest of Birdsville (see Appendix I:a).

Soils: *Acacia peuce* occurs on texture-contrast desert loams (Stace 1968:60), the duplex soils of the Dr 1 and Dy 2 groups of Northcote (1975). Profiles vary from crusty red duplex soils (Dr 1.3.2, 2.2.1) to yellow hard pedal duplex types (Dy 2.1.2., 2.3.2). Soils have an 'A' horizon with silcrete and limonite gravels forming gibber pans in low areas, and elongated pavements aligned across slope contours. Soils show a strong gypsite development with subsurface profiles of up to 70% powdery flour gypsum. The gypsite horizon appears sharply differentiated at 85cm in low areas below gibber surfaces, and on stony hill slopes gradationally as yellow gypsiferous clays at 1.5m.

Stone size varies from embedded cobbles (10-30cm diameter) on stony hills to a surface layer of gravels (2-10cm diameter) in low areas, indicating an initial origin and lateral transport from residuals. Surface features show a complex pattern of gibber pans

and flats, with intervening areas of sandy clay loam and undulating fine sand deposits. Profiles commonly showed a subsurface stony horizon within or below the clay 'B' horizon (50cm-100cm). Recent localised sheet and gully erosion was observed (i.e. up to 5m removed), and soils on slopes are particularly susceptible to erosion if the surface pavement is disturbed.

Vegetation: *Acacia peuce* occurs as discontinuous stands of open woodland (5% cover) to sparse wooded herbland with a prominent scattered low shrub layer. This is superimposed over the regionally dominant mixed open herbland communities (see below) with a topographically and seasonally fluctuating species composition. Within the *A. peuce* community this sparse ground layer (5% cover) is comprised largely of the Chenopodiaceae (14 species), Poaceae (9 species) and the Asteraceae (13 species). The community is floristically diverse (>100 species) with a large ephemeral component. The scattered low shrub layer (5% cover) achieves a cover of 30% along minor drainage lines. It is a uniform community and in many areas could be described as an *A. peuce - Cassia phyllodinea - Maireana aphylla - Bassia diacantha* association. Several species occur in the vicinity of trees eg. *Enchylaena tomentosa, Rhagodia nutans, Rhagodia spinescens.*

Components of several regional associations are interspersed within the pattern of *A. peuce* woodland over open herbland:

1) *Triodia basedowii - Zygochloa paradoxa* with *Acacia ligulata* confined to sand ridges

2) *Eucalyptus microtheca* association on drainage lines and floodouts with *Owenia acidula, Eremophila longifolia* and *Santalum lanceolatum*

3) *Acacia cambagei* association of drainage lines and lower interdunes

4) Samphire association of claypans, *Arthrocnemum* sp. *Pachycornis* sp.

5) Sandsheet association of epheremal species with *Hakea leucoptera* and *Eremophila macdonnellii*.

The *A. peuce* community is described in terms of the major perennial species of each physiognomic form. A list of all species collected within this community is given in Appendix III:2b.

A. peuce sparse open woodland.

DOMINANT SPECIES

Trees	*A. peuce*
Shrubs	*Cassia phyllodinea, Maireana aphylla, Cassia nemophila* sbspp.
Ground Layer	*Bassia diacantha, Maireana coronata, Aristida contorta*

COMMON SPECIES

Trees	
Shrubs	*Rhagodia spinescens, Rhagodia nutans, Enchylaena tomentosa, Acacia tetragonophylla, Eremophila maculata, Eremophila longifolia, Eremophila macdonellii, Bassia intricata, Bassia lanicuspis, Salsola kali, Cassia desolata, Cassia oligophylla, Atriplex vesicaria*
Ground Layer	*Maireana ciliata, Maireana georgii, Atriplex limbata, Astrebla pectinata, Eragrostis desertorum, Fimbristylis dichotoma*
	Sida fibulifera, Sida pedunctulata, Abutilon otocarpum, Frankenia uncinata, Minuria leptophylla, Tripogon lolliiformis

Population: The total *A. peuce* population in the Birdsville district is 15-20,000, made up largely of established and adult trees. Juveniles make up only 10% of the population. Trees occur in stands with an average maximum density of 11/ha and as scattered individuals peripheral to these groves. Juveniles are sparsely distributed and aggregated around locally favourable sites and actively reproducing

TABLE 3.2.2 Data sheet. Birdsville

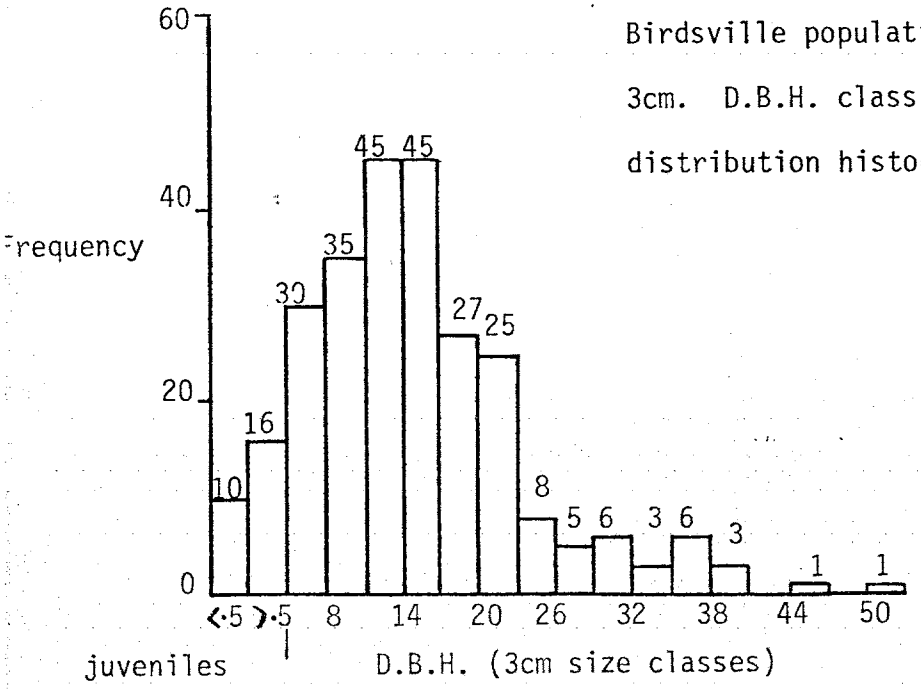
Plot No.	Total trees	Total *A. peuce*	Juveniles <.5m	Juveniles >.5m	No. measured	Number Cut	Number Dead
1	21	13	2	2	9	3	7
2	3	3	-	-	3	1	-
3	18	18	-	-	18	5	2
4	20	20	-	1	19	6	2
5	10	10	-	-	10	1	2
6	2	2	-	-	2	1	1
7	10	10	-	-	10	2	-
8	7	7	1	-	6	3	1
9	22	21	1	8	14	5	5
10	16	15	-	1	14	8	3
11	6	6	-	2	4	2	-
12	7	6	-	1	5	3	1
13	11	7	-	-	7	2	1
14	13	13	-	1	12	3	1
15	6	6	-	-	6	4	6
16	21	21	1	2	19	9	-
17	13	13		1	12	3	1
18	6	6	-	-	6	1	1
19	11	11	3	-	8	-	3
20	13	13	-	1	12	3	2
21	7	7	-	-	7	2	1
22	13	13	-	-	13	6	-
23	4	4	-	-	4	-	-
24	5	5	1	-	4	1	2
25	9	9	1	-	8	5	5
Total	273	260	10	17	232	78	45
mean	10.9	10.4	.4	.68	9.32	3.1	1.8

Graph 3.2.2.

Birdsville population

3cm. D.B.H. class frequency

distribution histogram

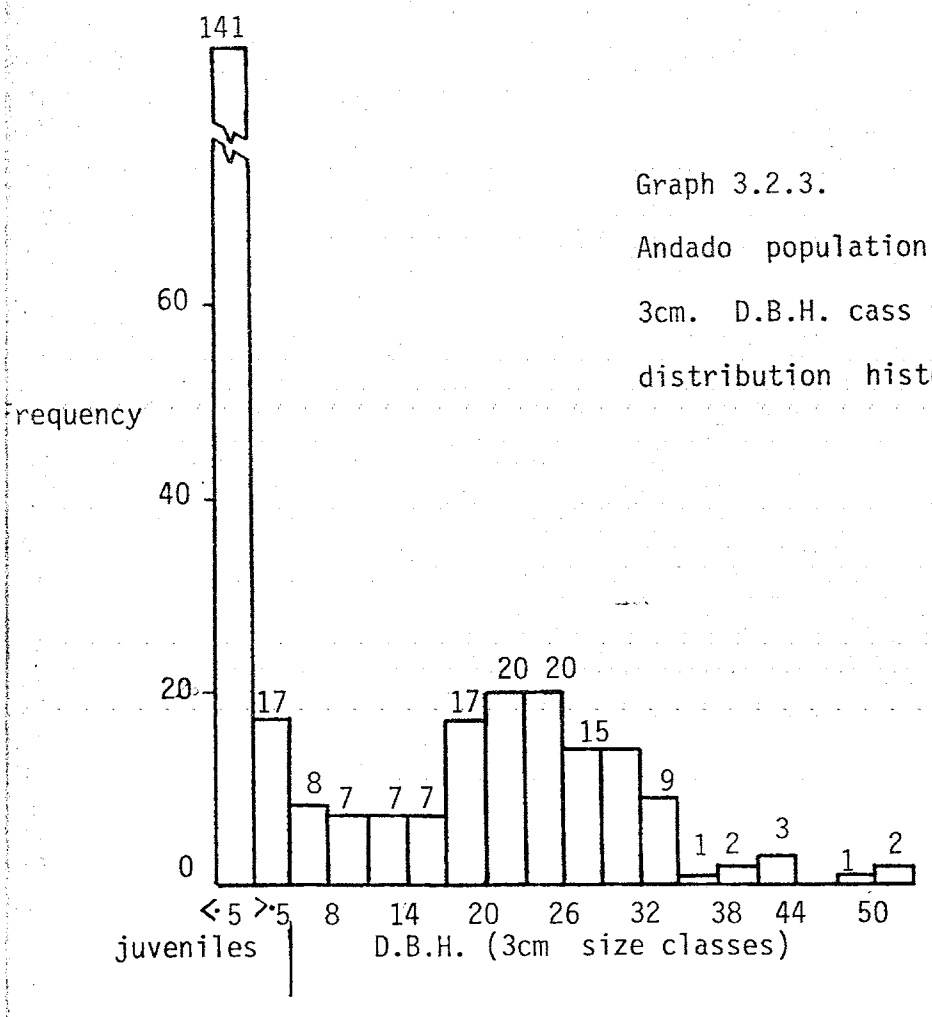


Graph 3.2.3.

Andado population

3cm. D.B.H. cass frequency

distribution histogram



trees. Canopy dominant trees (>20cm) comprise 36% of the population. The distribution of the number of trees per plot suggests a uniform distribution within stands.

At the scale of sampling (.78ha) there was both favourable and unfavourable (stone pavement) sites within most plots, and several distinct habitat types occur within the area:

a) stony hills
b) sandy areas
c) drainage lines
d) gibber pans and flats

Plots frequently overlapped both gibber surfaces (>50% stone cover) and intervening areas with an undulating fine sandy clay surface, indicating the scale of pattern of unfavourable and favourable sites. Trees show little site specificity, occurring in all habitats except gibber pans. To some extent the maintenance of a favourable soil surface may be a product of the presence of vegetation upon it, providing protection from sheet erosion and enhancing aeolian deposition, since the small gibber pans are a residual feature. Trees are often aggregated along sandy drainage lines and younger trees (5-11cm diameter) achieve highest densities here. This pattern may partly be due to root suckering, perhaps initiated by erosional disturbance. Stands are associated with undulating loamy sand to sandy clay loam surface deposits (<1m thick) derived both from the blanket deposition of sand and low dunes, and the aeolian reworking of the present surface.

A size class frequency distribution histogram for all trees sampled is given in graph 3.2.2 showing a convex, bell-shaped depletion between successive diameter classes. The greatest number of trees occurs in the 11-14cm diameter class and adjacent classes, and the low numbers of juveniles suggest that the Birdsville population

is decreasing, recruitment being insufficient to replace mature trees. The exceptional rains over the whole region since 1973 have not resulted in significant juvenile recruitment. The proportion of other tree species within stands is less than 4%, being mainly *Atalaya hemiglauca* in the smallest size classes.

Condition: The proportion of actively reproducing trees is small (10%) but sufficient to produce locally high seed soil loads. No trees were flowering in April or June, but scattered small trees showed fresh shoot growth from over 30mm of rain in late April. Senile trees with diameters up to 65cm were observed.

The general condition of trees is fair, and it was noted that:

a) nearly all mature phyllodes are foreshortened (12-15cm) by degeneration or predation of tips

b) few trees have a well developed canopy or spreading habit, and there is a significant proportion of senile trees.

c) high infestation of *Cerembycidae* larvae on smaller trees, e.g. density of 25 larval chambers of *Chalcobothrya* sp. on a 20x20cm surface of a small (12cm diameter) tree.

Site History: *A. peuce* has been cut extensively in the Birdsville district for fencing, yard building and even shed foundations. At Roseberth a large cattle yard is built largely of *A. peuce* and poles up to 40cm diameter are used as posts for sheds (see photograph).

A utilisation index of the proportion of living trees which have been cut is 0.33, indicating that about one-third of the community has been affected. Since trees <30cm diameter coppice well, the most significant effect has been on tree form. If the number of old cut stumps is included the total use index is 0.4, indicating that up to 5,000

A. peuce at Birdsville on gibber flat with low longitudinal dune in background.

Yard at Roseberth Station built with *A. peuce* poles.

trees may have been cut. Many trees have been cut several times.

Most cutting occurred during the first half of this century and in the last ten years. Mr L. Morton of Roseberth has provided protection from cutting, but although a local ordinance now prohibits cutting, there was evidence, particularly near the main road, of recent tree felling. No evidence was found to indicate that harvesting has reduced the overall distribution of *A. peuce* in the area. The area is used for sparse cattle grazing but grazing pressure is concentrated in favourable areas during growth periods. Therefore it is possible that trampling and grazing could affect germinating seedlings of *A. peuce*.

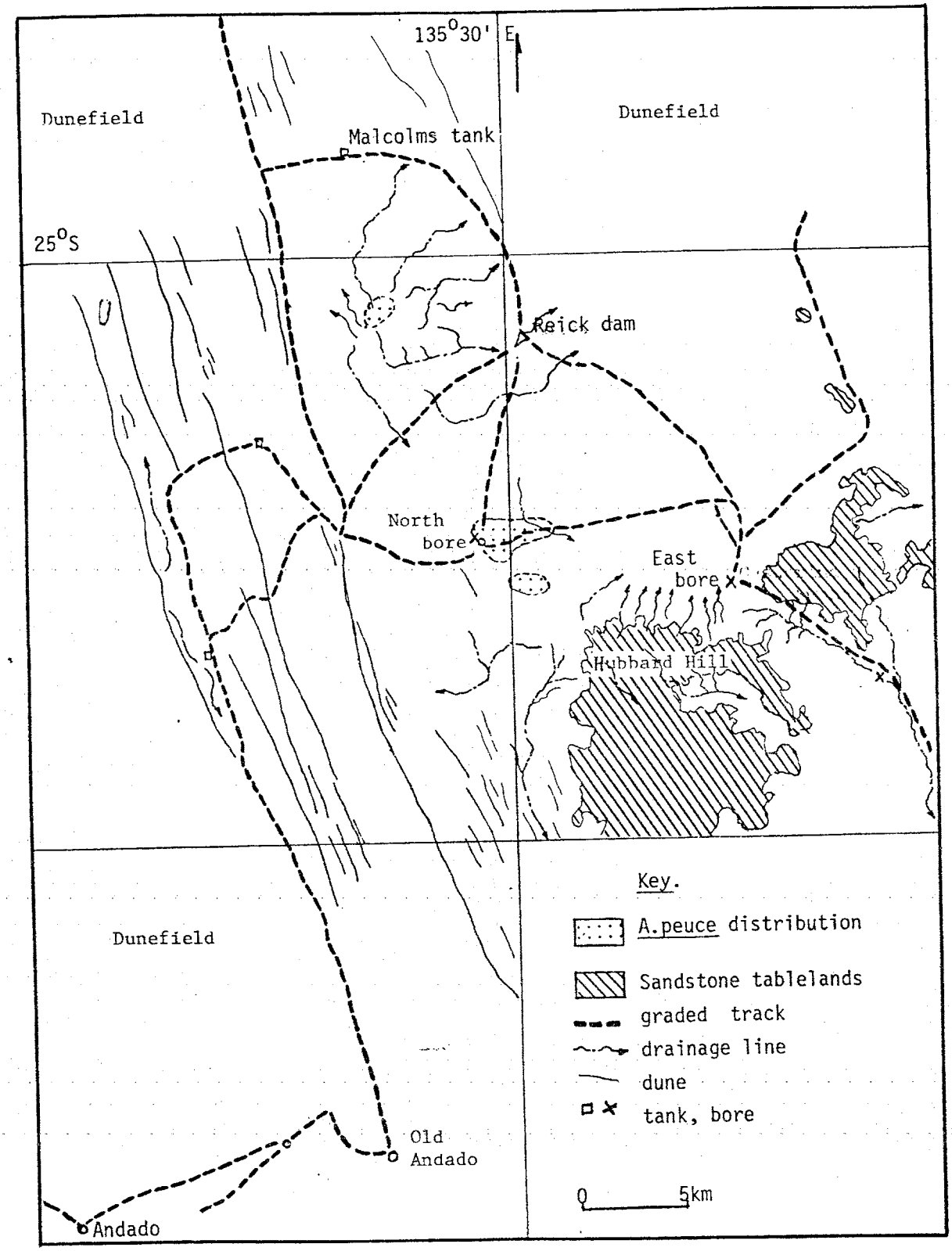
3:2:3 Andado

Local names: 'Casuarina', 'desert-oak', 'waddy-trees'.

Location: The Northern Territory population of *A. peuce* occurs as several small stands within an area of 50sq km on Andado Station, the eastern-most pastoral lease along the South Australian border. The main stand is situated at North Bore 135°29'E, 25°18'S on gently sloping gibber covered alluvial plains, 5km northwest of Hubbard Hill, and comprises several scattered groves of trees. It lies about 40km northeast of Andado Station, but 60km by road. This location lies within an area of exposed, stone-covered, desert loam soils (Stace 1968:60) developed on pediplains and low hills covering an area of 600sq km, stretching northwards for 25km from Hubbard Hill (135°32'E, 25°10'S). This sandstone cuesta is 50m above the main stand at North Bore, (161m).

The scattered groves of trees and isolated individuals extend for 22km in a northwesterly direction from 25°9'S, 135°30'E to 24°58'S, 135°27'E. The main stand consists of two aggregated bands

Map 3.2.3. The distribution of A.peuce on Andado Station.(N.T)



(part of grid sheet SG 53-7)

of trees (and scattered individuals) forming an open woodland covering 10sq km. This stand is largely enclosed within a fenced reserve 9.3sq km in area with 700 trees, and is surrounded by several smaller clumps of trees (see map 3&3). A further 5km south, a group of small groves of trees is enclosed in a smaller south reserve. This narrow east-west fenced reserve covers only 4.6sq km, and contains about 100 trees in three small clumps. The southern limit of distribution occurs as a scattered group of 25 trees outside the south reserve.

Approximately 12km northeast of the main stand, on the top of a stony hill, 3km west of Reicks Dam (240m alt.) a small group (30 trees) is seen. These comprise the total regional distribution of *A. peuce* apart from a pair of adult trees on the plain a further five kilometers north and a small group of trees, now dead, which are found on the track past Malcom's Tank (24°28'S, 135°27'E). Here about 20 young trees, showing evidence of being connected by roots, died during the last five years (see photograph) having been subjected to both inundation in 1974 and subsequent fire. Trees show little site preference, growing over stony hills with slopes up to 4°, broad alluvial flats and within the main stand adjacent to minor sandy drainage channels over an altitudinal range of 80m. Trees are absent from claypans and gibber covered depressions.

Soils: *Acacia peuce* occurs on desert loams (Stace, 1968:60) with a texture contrast between the shallow 'A' horizon and the red-brown clay 'B' horizon, the crusty red-duplex soils (Dr 1.1.3, 1.3.3) of Northcote (1975:103). The 'A' horizon varies from 5-20cm of loamy sand to sandy clay loam with an undulating veneer of loose fine sand and ironstone gravels either scattered throughout the horizon or concentrated into pavements. On the stony hills, soil forms a crusty

surface with embedded sicrete cobbles up to 30cm diameter. The hard setting, pedal 'B' horizon is saline with high exchangeable Na, overlying a strongly developed gypsite subsurface (70% powdery gypsum). A subsurface stony layer occurs at the base of, or within, the 'B' horizon. Profile depth follows a catenary sequence, with the gypsite occurring as a well differentiated zone at 1m on lower sites (i.e. main stand).

These fine textured soils are susceptible to gully erosion on any slope >1° when the stone cover is removed. Evidence of this is seen on graded tracks where channels up to 0.5m have been cut into the 'B' soil horizon. The presence of an undulating wind sorted sandy surface associated with vegetated areas of the main stand suggests that aeolian redistribution of the surface horizon and the development of gravel strewn deflation pans is an active process.

Vegetation: The sparse open woodland stands of *A. peuce* with a tree canopy height of 10-14m over a sparse open herbfield is a unique structural association within the region. The vegetation of the stony plains is sparse herbfield (<10% cover) in which the tussock grasses, *Eragrostis* and *Aristida* are persistent, and with scattered low shrubs of *Cassia* and *Eremophila* spp. Shrub development is generally confined to piedmont gullies and occurs as shrub lines (<3m tall), typically *Eremophila longifolia*, *Eremophila latrobei*, *Hakea leucoptera* and *Acacia tetragonophylla*. On the tableland of Hubbard Hill *Acacia pickardii* exists as a relict population of low open woodland (<5m). *Eucalyptus microtheca* occurs occasionally along drainage lines within the *A. peuce* community.

The complex ground layer of the *A. peuce* community: *Chenopodiaceae* (10 sp), *Poaceae* (16 sp), *Malvaceae* (7 sp) and *Asteraceae* exhibits a mosaic composition related to soil microhabitat. The

A. peuce at Andado looking north from stony hill 3km west of Reicks Dam.

A. peuce at Andado. Group of dead trees near Malcolms tank, 25km north of main stand.

scattered low shrub layer is conspicuous in its association with trees. *Enchylaena tomentosa* is the striking example of this being found consistently at the base of trees.

A. peuce open woodland.

DOMINANT SPECIES

Trees	*Acacia peuce*
Shrubs	*Enchylaena tomentosa, Maireana aphylla*
Ground Layer	*Eragrostis desertorum, Astrebla pectinata, Sida* spp., *Enteropogon acicularis, Bassia parallelicuapis, Aristida contorta*

COMMON SPECIES

Trees	
Shrubs	*Cassia sturtii, Cassia nemophila* sbspp. *Rhagodia spinescens, Eremophila macdonnellii, Pluchea tetranthera, Bassia tricuspis, Bassia intricata, Atriplex vesicaria*
Ground Layer	*Abutilon halophilum, Sida pedunculata, Sida trichopoda, Tripogon lolliiformis, Frankenia planicola, Bassia paradoxa, Bassia lanicuspis, Bassia bicornis, Marsilea exerata, Atriplex limbata, Arthrocnemum* sp., *Heliotropium filaginoides, Aristida browniana, Eragrostis eriopoda, Eragrostis xerophila, Eragrostis falcata, Fimbristylis dichotoma.*

Population: The total *A. peuce* population at Andado is about two thousand, half of which are juveniles <.5m high. Trees occur in distinct open woodland groves with a mean density of 7/ha, while the average maximum density of all *A. peuce* is 17/ha. Juvenile density is 12/ha. The distinctive feature of the population is that mature trees (>20cm diameter) make up a large proportion, 74% of the total tree number, giving stands a uniform open woodland appearance. Juveniles (< 5cm diameter) make up 60% of the population and it is significant that the majority of these (90%) are less than 0.5m high (i.e. 5-8 years old). Juveniles >0.5m high, make up only 0.7% of the total

TABLE 3.2.3 Data sheet. Andado

Plot No.	Total trees	Total *A. peuce*	Juveniles		No.measured	Number cut	Number Dead
			<.5	>.5			
1	22	21	19	-	2	1	2
2	31	31	20	2	7	2	1
3	22	22	3	7	12	4	1
4	8	8	1	-	7	1	2
5	13	13	6	-	7	-	-
6	12	12	6	-	6	11	10
7	23	23	12	3	8	6	6
8	16	16	9	-	7	1	1
9	18	18	16	-	2	-	-
10	5	5	-	-	5	-	-
11	6	6	3	-	3	-	1
12	39	39	29	4	6	-	2
13	21	21	13	2	6	1	3
14	12	12	4	-	8	1	-
Total	248	248	131	18	86	28	29
mean	17.7	17.7	9.3	1.2	6.1	2	2.1

population indicating that only sporadic regeneration occurred prior to 1972. Seedlings are present throughout the main stand area and are locally aggregated near favourable germination sites and successful reproducing trees.

While seedlingsaveraged 10 per plot distribution is variable, the extreme case of localised aggregation being 54 seedlings <20cm within 25x25m. No juveniles less than 1 year old were seen. Trees < 10cm diameter are absent from outlying stands. Mature trees (> 20cm diameter) occur with a mean density of 5.5/ha. Trees of other species are an insignificant component of *A. peuce* stands. Sample plots covered several distinct habitats:

a) stony hills and slopes
b) sandy drainage lines
c) desert loam flats with undulating surface
d) stone pavements in gibber pans

A diameter size class frequency distribution histogram for all trees sampled is given in graph 3.2.3 which shows a convex, bell-shaped population structure, with the large number of juveniles <.5m showing the largest deviation from this pattern. This trend of high juvenile recruitment may be temporary, with the possibility of high juvenile mortality in the future. Most trees (30%) occurred in the 20-26cm size class, indicating a mature and generally decreasing population.

Condition: The proportion of reproductive trees is 40% in the main stand. Fertility is high, and a considerable variation in mean seed size between trees was observed. The general condition of adult trees is good. Askew and Mitchell (1978) report that *A. peuce* has a moderate palatability for stock and is readily eaten when available.

3:4 Inventory: Summary of Populations

The geographic distribution of the disjunct populations of *A. peuce* indicate a wide potential range for the species:

23° - 26°S, latitude
135° - 140°E, longitude
60 - 220m altitude
150 - 270mm (mean annual precipitation)

The three localities are comparable climatically and edaphically, and the *A. peuce* open woodlands over open herbfield and tussock grassland communities are structurally equivalent and floristically related. The Boulia location appears anomalous due to its:

- topographic position on floodplain
- deeper soil profile and the absence of gypsum
- greater summer rainfall
- presence of other, more subtropical tree species.

The demographic characteristics of each population of *A. peuce* is summarised in Table 3.3. Total population sizes and tree size distribution differ markedly between localities, along with the success of recent juvenile recruitment. Life tables indicate that while the Boulia population is stable and possibly increasing, those at Birdsville and Andado are decreasing. The Boulia population shows a continuous logarithmic depletion in frequency distribution of successive diameter classes, while both Birdsville and Andado display a convex depletion curve (see Section 4:1).

The highest frequency diameter classes in these convex graphs are in the 11-14cm D.B.H. class at Birdsville and the 20-26cm classes at Andado, indicating the preponderance of mature trees (65%) in the latter population. The high proportion of cut trees at Birdsville ($^1/_3$), may have altered the diameter distribution. While mean stem density varies between locations (i.e. 12-80/ha) this is largely a result of the different juvenile components in each population. The closer range of tree density (7.5-15/ha) and of canopy dominant trees (2.8-5.4/ha) indicate the more uniform tree distribution within

A. peuce open woodlands.

The juvenile proportion of the populations differs significantly between locations (10% at Birdsville to 81% at Boulia), indicating variation in recent reproductive performance. The size components of juvenile populations show that the exceptional rains in the last ten years has seen significant recruitment at Boulia and Andado. Recruitment prior to this has been continuous at Boulia while at Andado there are very few juveniles > 0.5m high. Juveniles occur outside the main stand at Boulia, suggesting an expanding population. Several factors may be involved in the differential recruitment between the locations:

Climatic - intensity and frequency of rainfall will determine duration of growth periods
- low temperatures may limit growth in winter
- longterm changes may mean the more arid sites are marginal for the reproduction and establishment of *A. peuce*

Edaphic - stability and the erosion-deposition balance of soil surface

Ecological - differential proportions of actively reproducing trees.
- pathogens, predation and grazing pressure.

TABLE 3.

Acacia peuce stands	BOULIA	BIRDSVILLE	ANDADO
Estimated total population	>100,000	15-20,000	2,000
Total tree population	25-30,000	15-20,000	1,000
No. *A. peuce* sampled	1,684	260	320
Juvenile % of total population	81	10	60
Juveniles <0.5m % total pop	59	6	52
% Juveniles >.5m	26	38	11
Tree % of total population	19	90	40
Trees % canopy dominant (>20cm diameter)	20	30	65
Trees % <10cm diameter	47	27	11
% other tree species of total pop.	3	4	0
Highest frequency diameter class	5 - 8cm	11 - 14cm	20 - 26cm
Mean density total/ha.	82.2	12.6	17.6
Mean density juveniles/ha	66.7	1.3	13.8
Mean density trees/ha	15.4	11.3	7.5
Mean density trees >20cm diam/ha	2.8	3.1	5.4
Use index (living trees)	0.14	0.33	0.15
Total use index	0.2	0.44	0.46
Depletion curve	concave	convex	convex
Population status	increasing	decreasing	decreasing

CHAPTER IV

SITE COMPARISONS

4:1 Population Biology

Life Table Analysis of Plant Populations:

A time-specific life table approach to population study, deriving mortality rates from a single observation (Emmel, 1976:200), assumes that populations unaffected by migration and subject to age specific birth and death rates will exhibit a characteristic stable age distribution over time. The difference in the number of trees present in successive age classes reflects the mortality expected during the time represented by the age differences between classes. The nature of the depletion curve generated represents an equilibrium pattern of population structure for that species within a stable climax community.

The time-specific approach is justified if:

a) the area supporting the sampled community type encompasses a complete age distribution of the population.

b) the area has not experienced significant environment change.

(Hett and Loucks, 1976:1029)

The first of these conditions is met by the sampling method for *A. peuce* populations; the second, more difficult to determine, is dependent on the time scale considered and may be reflected by differences in the depletion curves between locations. Environmental change may occur as longterm trends in climatic or geomorphic conditions, or at a shorter timescale as abnormal fluctuations, disturbance, catastrophe or human activity, and is therefore a natural component of many communities (e.g. fire).

The question of what constitutes a natural mortality pattern and population structure for tree populations has been investigated in the field of forestry by the comparison of diameter distributions. de Liocourt in 1898 first recognised the frequent relationship of a continuous percentage depletion between given intervals of diameter increase (Goff & West, 1975).

The resulting inverse 'J' shaped population curve (Leak, 1964a) has been shown to follow a linear model of negative exponential decrease (Leak, 1964b; Bliss, 1964) where the probability of survival remains constant and is therefore independent of age. Upon log-normal transformation this model approximates a straight line equation, the slope of which represents mortality rate.

Hett and Loucks (1975:72) showed that as well as the negative exponential model, a power function model of mortality as a function of age is applicable to tree populations. The power function model also generates an inverse 'J' depletion curve, however mortality is not constant, the probability of survival increasing with age. They found that forest populations of *Acer saccharum* were better described by the power function model and suggest that this is closer to biological reality for long-lived populations since, as individuals age, the probability of survival should increase until senescence.

It is important in plant coenopopulation analysis to consider the seed population as a component. Since 95% of all plant mortalities occur in the seed pool (Hickman, 1978:258) the post-germination population curves for all seed plants may in fact follow a power function depletion.

Recent work indicates that the natural mortality patterns of forest trees may be more complex. Goff & West (1975:1453) suggest that canopy dominant trees will have a greater probability of survival

while the understory is suppressed, thus affecting growth and mortality rates. The resultant equilibrium diameter distribution curve would consist of three indistinct phases approximating a rotated sigmoid form on log.transformation. Hett & Loucks (1976:1042) concluded that cyclic population fluctuations related to climatic variability result in sine wave deviation of residuals from the negative exponential or power function curves.

A further property of population age distributions is that if the population size remains constant, the age distribution will correspond to the equilibrium survivorship curve (Leak, 1975:1451). This theoretical relationship can be used to determine the reproductive performance of tree populations as either increasing or decreasing. If the birthrate increases, a more concave age distribution will result, while a declining population will show a convex or even bell-shaped distribution curve.

The concave age distribution does not necessarily mean an increasing population however, since in the density dependent situation of forests, environmental carrying capacity places limits on tree populations. For a population to increase in such conditions an expansion of geographic range is required. It is however more stable in terms of the capacity to absorb abnormal mortalities, has the potential for migration and is more likely to exhibit the variability to adapt to selective forces.

Methods:

The accurate determination of the age of trees by counting growth rings is difficult even in species with regular seasonal growth and patterns of secondary xylem structure. In arid areas where growth is often coincident with irregular periods of water availability, the

number of rings may bear little relation to tree age in years (Lange, 1965:136). Enumeration of tree age by counting diameter cores is laborious and may be impossible in hardwood species, therefore regression of age against diameter for a counted subsample is the standard inventory method for predicting tree age. Factors which may affect the diameter-age relationship for any tree include:

1) species specific age dependent growth rates.
2) density dependent growth rates in which competition results in unequal growth.
3) climatic variability on both a seasonal and longterm basis.
4) local site variation: edaphic, physiographic or hydrologic.
5) pathogens, predation or damage.
6) genetic variability.

Age dependent growth rate differences are indicated for *A. peuce*. Direct field evidence indicates it is capable of 30cm/year vertical growth. In September 1972 a juvenile at Andado was tagged at 0.75m high (by J. Feehan, C.S.I.R.O. Div. Entomol.) and after seven years of exceptional rains the same tree was measured at 2.85m (3.5.80 see photographs). This corroborates the observations on growth rate by local landholders at Boulia and Birdsville. On the other hand mature trees have been recognised as showing almost no change over the last fifty years (Grandison, 1980 pers. comm).

Lothian (1968:46) first suggested that the growth pattern of *A. peuce* was one of relatively rapid vertical extension after a period of establishment, which he suggested was 35-40 years. This lag period may be as little as 5-15 years as a young tree in cultivation at Alice Springs indicates.

While it is difficult to assess the effects of competition on growth rates because of the low overall density, it is suggested that it is not significant for established trees. There is consider-

A. peuce at
Andado N.T.
juvenile height 75m,
28-9-72 (above) and
2.85m on 3-5-80.

able local site variability at Birdsville and Andado, while Boulia displays a fairly uniform habitat. The incidence and duration of growth periods may differ between locations. Calculations of the soil water budget using climatic data for the last 25 years at Boulia and Birdsville (see Section 4:3) shows that potential growth periods have occurred with a roughly yearly frequency, and have been coincident at both locations. However greater soil storage capacity and occasional flooding at Boulia suggest that growth periods there may be of longer duration and were possibly continuous over several years.

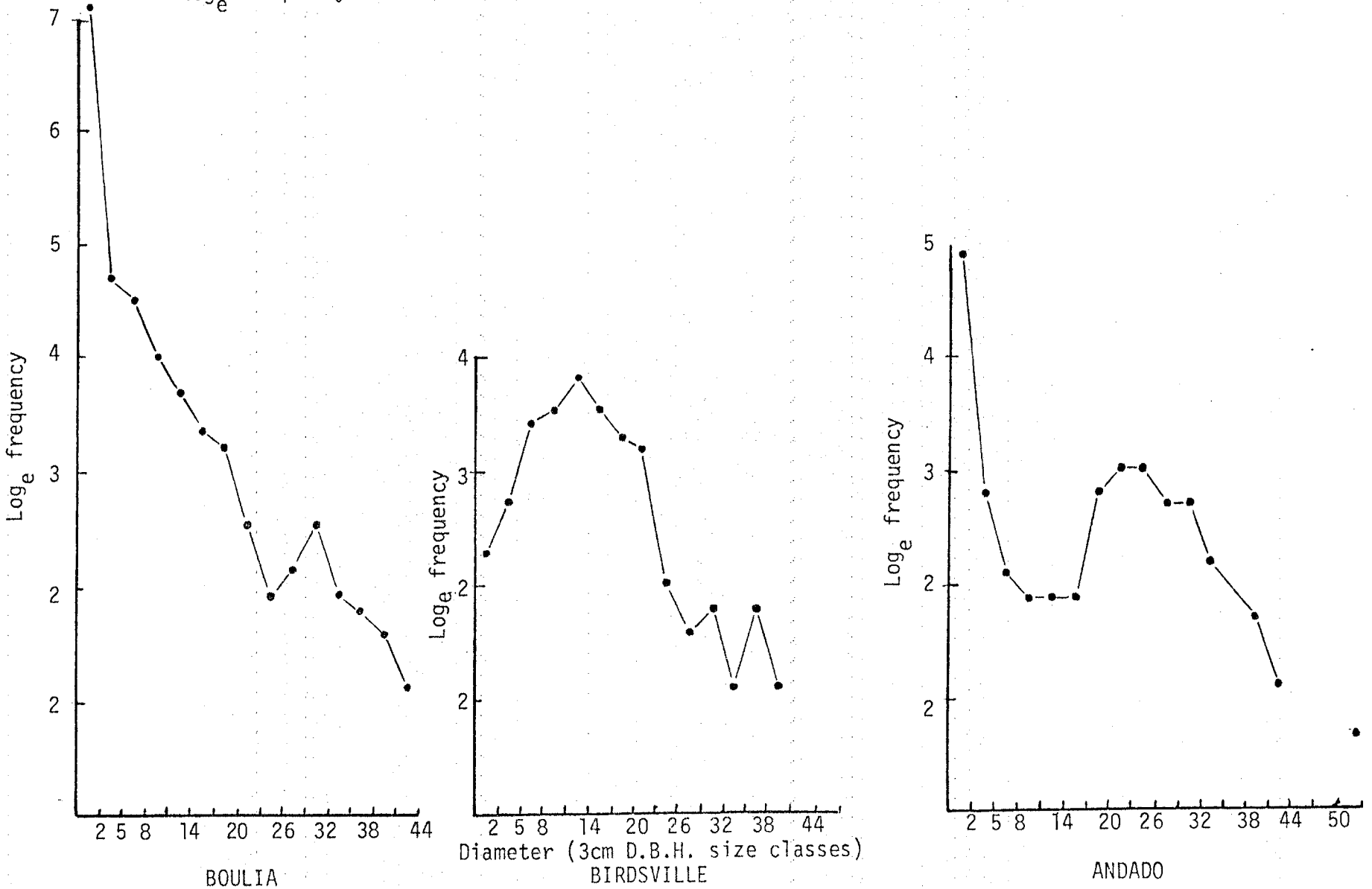
A small sample of recently cut and dead trees at Boulia were analysed for growth rings (see Table 4.1). A radiocarbon age estimate was made available for a sample from an old *A. peuce* to test both the longevity of the tree and the relationship between growth rings and actual age (see Appendix 4:1). Even assuming an annual growth event, the diffuse porous xylem vessel structure, the variation in ring widths and the fact that many rings are not continuous around radii, makes assigning age ranges to diameter classes difficult. For this reason diameter distribution graphs were subjected to log-normal transformation to derive a survivorship curve of negative exponential form.

The frequency distribution histograms for 3cm size classes are taken to represent depletion curves and for the analysis juveniles were reassigned to <2cm and 2-5cm D.B.H. classes (assuming those plants of 1.5m height have a 2cm D.B.H.). Only the Boulia population displays the characteristic inverse 'J' stable population curve while those for Birdsville and Andado are markedly convex. Linear regression of log-normal depletion curve for the Boulia population shows significant correlation to the negative exponential depletion (see Dia. 4.1). The largest deviation occurs in the smallest (< 2cm) diameter class.

Diagram 4:1

Depletion curves for *A. peuce* populations

Log_e frequency values for diameter (D.B.H.) distribution data



The large difference in the form of the depletion curves for the three population of *A. peuce* mean that the interpretations of reproductive performance are not greatly affected by the assumption that a negative exponential depletion is characteristic for the species. The Boulia population approximates well to a stable depletion curve, while the bell-shaped curves of the other populations indicate that they are decreasing. It is unlikely that these are only temporary fluctuations as established plants (< 10cm D.B.H.) are fewer than those they are to eventually replace. The positive deviations in the smallest diameter classes at Boulia and Andado reflect the exceptional rainfall and subsequent regeneration over the last ten years.

Table 4.1 Growth ring count for sample of Boulia population.

Average diameter (D.B.H.)	No. Rings/radius
4cm (basal dia)	8-10
6cm	12-18
7cm	15-19
10cm	17-20
12cm	23-33
14cm	30-33
16cm	24-30
40cm	127-165

Acacia peuce is a long lived species, with tree ages of 200 years being common, and some exceptional trees probably reaching 500 years. Longevity is genetically controlled, having evolved in response to specific environmental pressures, and has important consequences for population dynamics since:

- it allows the maintenance of stable population numbers despite infrequent establishment opportunities.
- most mortality occurs early in the life cycle and survivors remain in the population for a long time.
- significant environmental fluctuations occur during the lifetime of an individual.

(Hamrick, 1978:85)

Long lived populations may be less able to respond to changes in the selective regime and be more likely to retain genetic polymorphism (Levin, 1978:84). In a study on the 'bristlecone pine' (*Pinus longaeva*), a long lived species in an extreme environment existing as relict populations in southwestern U.S.A., it was found that despite the isolation of populations genetic variability was as high within stands as between them (Hamrick, 1979:91). While the genetic features of *A. peuce* are unknown, the similar situation of the two species is worthy of mention. No obvious morphological variation was detected between the separate populations of *A. peuce* although there is variation in some features such as seed size and tree form within the populations.

4:2 Ecology and Floristics

Ecology:

'The outstanding feature of this acacia is its ability to grow in tree form in one of the most severe desert climates in Australia.' (Hall, *et al* 1975). In exception to most other tree species in the area *A. peuce* is not restricted to drainage lines, growing over open stony plains and hills. Physiological tolerance to drought stress conditions is achieved through a combination of xerophytic adaptations.

A. peuce is a true 'sclerophyllous xerophyte' (Walter & Stalelman, 1974:239) and its life history tactics are those of a classic 'stress tolerant' species (Grime, 1977). It is a 'drought evading' perennial (McCleary, 1968:162) with an extensive lateral root system to improve water status.

The desert environment is characterised by extremes of temperature and water input, and a consistently high radiation load. The periodic nature of extreme stresses requires that plants have wide ecological tolerance ranges (physiological adaptation), or be capable of completing a reproductive cycle during the brief and infrequent periods of water availability (reproductive adaptation).

Many attempts have been made to find generality in the morphological features of desert perennials such as root extension and leaf reduction (e.g. Solbrig, 1977:69). Such features effect a balance between high evaporative atmospheric demand and low soil water availability which constitute water stress in plants whose life functions depend on a continuous flux of water within the ecosystem.

Characteristics of *A. peuce* which constitute known xerophytic adaptation to the desert environment are the root system and phyllode structure. Consistent with the shallow zone of water penetration

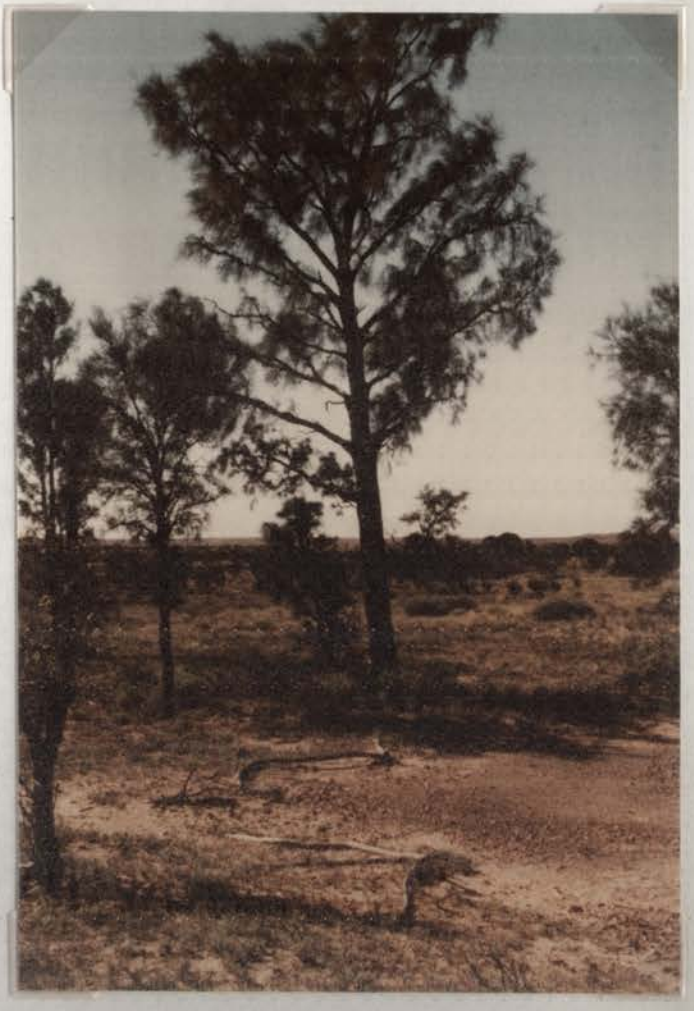
(normal depth of wetting 50-60cm) in arid soils with a high clay content (Williams, 1979:151), *A. peuce* possesses an extensive lateral root system of up to 20m radius from mature trees (see photograph). The sphere of influence of an individual tree is therefore large in relation to the evaporative area of tree canopy, the high root:shoot ratio favouring a continuous extraction from the sandy clay 'B' horizon. This lateral root system comprises long, unbranched porous roots extending from the main tap root 30-100cm below the soil. Secondary rootlets emerge perpendicular to the main lateral. The root cortex is composed almost entirely of large, continuous vessels. The age at which lateral roots are initiated is unknown, established seedlings (20cm high) show a vigorous taproot >5 times seedling height in depth.

The maintenance of leaf energy balance in the presence of a high radiation load but limited opportunities for transpiration demands that energy dissipation from the leaf is maximised by convection. In *A. peuce* the narrow, linear drooping phyllodes have a reflective surface wax and form a well-ventilated canopy, reducing incident light energy and maximizing convective heat dissipation. Phyllodes are rigid and tetragonous with strong sclerenchyma development giving physical resistance to dessication.

With a life span of 200-500 years, and the ability of adult plants to withstand prolonged water stress, *A. peuce* can maintain population levels with only sporadic recruitment. It is likely that successful recruitment occurs during a sequence of wet years with a nearly continuous positive soil moisture balance.

Following the studies of Preece (1971b) with *Acacia aneura* which displays a germination response of the tropic legume pattern (Fitzpatrick and Nix, 1970), it is suggested that mass germination of *A. peuce* is likely to occur during the summer

A. peuce at Birdsville sheet erosion has exposed extensive lateral roots



period when large storms >100mm often occur. The probability of positive soil moisture budget is greater for the winter months however (Fitzpatrick, *et al* 1967), and therefore it is likely that the rainfall of the summer subsequent to germination is the critical factor in the establishment of *A. peuce* seedlings.

The rapid vertical growth phase and the good coppice response of the species as well as the durability and unique qualities of the wood (1450 kg/m^3, Hall, 1975) are ample reasons why the cultivation potential of *A. peuce* should not be overlooked. Although seed fertility is high (85%) and germination response favourable, cultivation history has not been successful. Plantings have been made at the Adelaide Botanic Garden for over thirty years (Grandison, 1980 pers. comm.) yet the oldest living specimen there was planted in 1976. Small plantings have been made in several arid zone centres as well as major cities. The Canberra Botanic Gardens has seedlings (6) two years old. Germinating seedlings show no marked stress tolerance although recovery from partial wilting was observed. It is likely that soil physical and chemical characteristics become important in the establishment of young trees.

The limited ecological knowledge of the reproductive behaviour of *A. peuce* is summarised below:

Flowering:	Faculative in spring and autumn dependent on rainfall September-November, March-April
Time of seed deposition:	Continuous
Seed longevity:	5 years in storage, probably short on average in the field due to fluctuating temperature and moisture, pathogens, and the high germination response on wetting.
Temperature sensitivity:	10°-38°C range

Degree of innate dormancy: None in 50% of seed, up to several weeks.

Germination response: 24-48 hours in fresh seed (30°-35°C)

Fertility: 85-95% (Hall, *et al* 1975)

Reproductive life span: 30- >200 years.

Acacia peuce has particularly large seed in relation to other Australian species. Of the twenty arid zone *Acacia* species tested by Turnbull (1972:535) *A. peuce* has the heaviest seed with only 250 per ounce (9-11,000/kg), while other species including *Acacia aneura* and *A. cambagei* have >1000/ounce. No pretreatment is necessary although scarification improves germination response. The arid species which have the largest seeds are:

	No. seeds/oz	% germination
A. peuce	250	85
A. oswaldii	330	85
A. ligulata	550	90

There is considerable variability in both seed size and shape between individual *A. peuce* trees. Of seed collected from two different trees at Andado the difference in the weight of 50 seeds from each was 3.0 gm - 6.3 gms. The number of seeds developed per pod varies from 0-9, and some trees produce almost wholly sterile pods. As the unit of dispersal the seed pods may be transported some distance by wind and collect in depressions and around barriers.

While many *Acacia* species are adapted to frequent fires, responding with mass seedling regeneration or suckering, certain features of *A. peuce* and the environment in which it occurs suggest it may be an exception:

1) Fire frequency in *A. peuce* areas is on average only once in 50 years (McArthur, 1972).

2) Community structure and sparse ground cover will not support extensive burning.

3) Observation by landholders indicates fires are rare. No fires have occurred at the Boulia stand in the last 50 years.

4) Age to reproductive maturity is >20 years.

4:2:2 Floristics

The total flora of the Simpson Desert depends on the area considered. Eardley (1947) collected 76 species, while Symon (1969) lists 170 for the desert dunefields. The list for the Simpson Desert National Park in southwestern Queensland is 97 (Boyland, 1970:14) and Wiedeman (1971:123) found 124 species within a single dune area on Andado Station.

There is considerable geographic variation in species distribution and habitat type across the desert (Fatchen and Barker, 1979:6) and it appears to have been subject to migration and recolonisation since the last phase of glacial age aridity. Because of the spatial and temporal changes in species composition, particularly of ephemerals, comparison of local floras based on single observations may give little indication of actual differences. Comparison is made between the floristic similarity of species lists for the separate *A. peuce* communities, and with those for other desert sites within the region, (i.e. Boyland, 1970, Wiedeman, 1971, Fatchen and Barker, 1979a) (see map 2c).

This is an attempt to establish that the vegetation of the stony downs landsystems on either side of the desert is floristically related and distinct from that of the desert dunefields, and to show that they contain other species, like *A. peuce*, which are disjunct about the desert.

Comparison is made in terms of:

- species representation of the major families (Table 4.2a and App. IV:2)
- life form spectra (Table 4.2b)

- floristic similarity indices of both Jaccard (1928) and Sorensen (1948) (from Mueller-Dombois, 1974: 214) (Table 4.2c)

The Jaccard index $\frac{c}{a + b - c} \cdot X\ 100$ (where c is the number of species in common, a and b the total numbers in the two communities, is a measure of the ratio of common species to the total occurring in both, while that of Sorensen $\frac{c}{\frac{1}{2}(a + b)} X\ 100$ is the ratio of the common species to the average number, giving greater weight to those which recur in the two test areas.

The representation of the major families in terms of species numbers is similar between all sites, the prominent families being the Poaceae, Leguminosae, Chenopodiaceae, Asteraceae, Malvaceae and Myoporaceae.

The lower floristic similarity indices at the specific level between desert locations and *A. peuce* communities supports the suggestion that the habitats in which *A. peuce* and many associated species occur were maintained during the extreme aridity of the last glacial phase and are now isolated remnants of a more widespread occurrence. It is significant that the *A. peuce* communities at Andado and Birdsville, separated by 350km, show greater similarity to each other than to the dunefield locations only 50km from each (see Table 4.2c).

Species common to *A. peuce* sites but not recorded from the desert dunefields include: *Enteropogon acicularis, Pluchea tetranthera, Fimbristylis dichotoma, Polycarpaea spirostylis, Lawrencia glomeratis, Pterocaulon sphacelatum, Cassia phyllodinea, Eremophila obovata.* At the same time there are species in common between the dunefields and stony downs, several of which are widespread across the desert, e.g. *Enneapogon avenaceus, Salsola kali, Aristida browniana, Sida virgata, Frankenia uncinata, Eremophila macdonnellii,* and several ephemeral species of the Asteraceae.

Table 4.2a The Representation of major Families as number of species present at *A. peuce* stands and other Simpson Desert localities

Family	Number of species recorded					
	Boulia	Birdsville	Andado	Boyland (1970)	Wiedeman (1971)	Fatchen & Barker (1979a)
Leguminosae	16	14	9	17	19	15
Chenopodiaceae	8	18	15	13	6	17
Asteraceae	7	13	6	12	21	6
Poaceae	14	10	12	10	15	10
Myoporaceae	4	4	2	2	5	3
Malvaceae	4	5	6	3	7	5

Table 4.2b Life form spectra for the three *A. peuce* communities

Life form (Raunkier, 1934)	% frequency of species		
	Boulia	Birdsville	Andado
1) Megananophanaeorophytes >8m	1	1	1
2) Mesonanophanaerophytes 2 - 8m	17	4	3
3) Nanaophanaeorophytes 0.25 - 2m	26	25	30
4) Chamaephytes - dwarf shrubs 25cm	22	27	29
5) Hemicryptophytes - perennial graminoids	18	10	14
6) Geophytes - underground buds	0	2	3
7) Therophytes - annuals	13	20	17
8) Parasitic epiphytes	1	1	1

Table 4.2c Floristic Similarity between *A. peuce* stands and other Simpson Desert locations

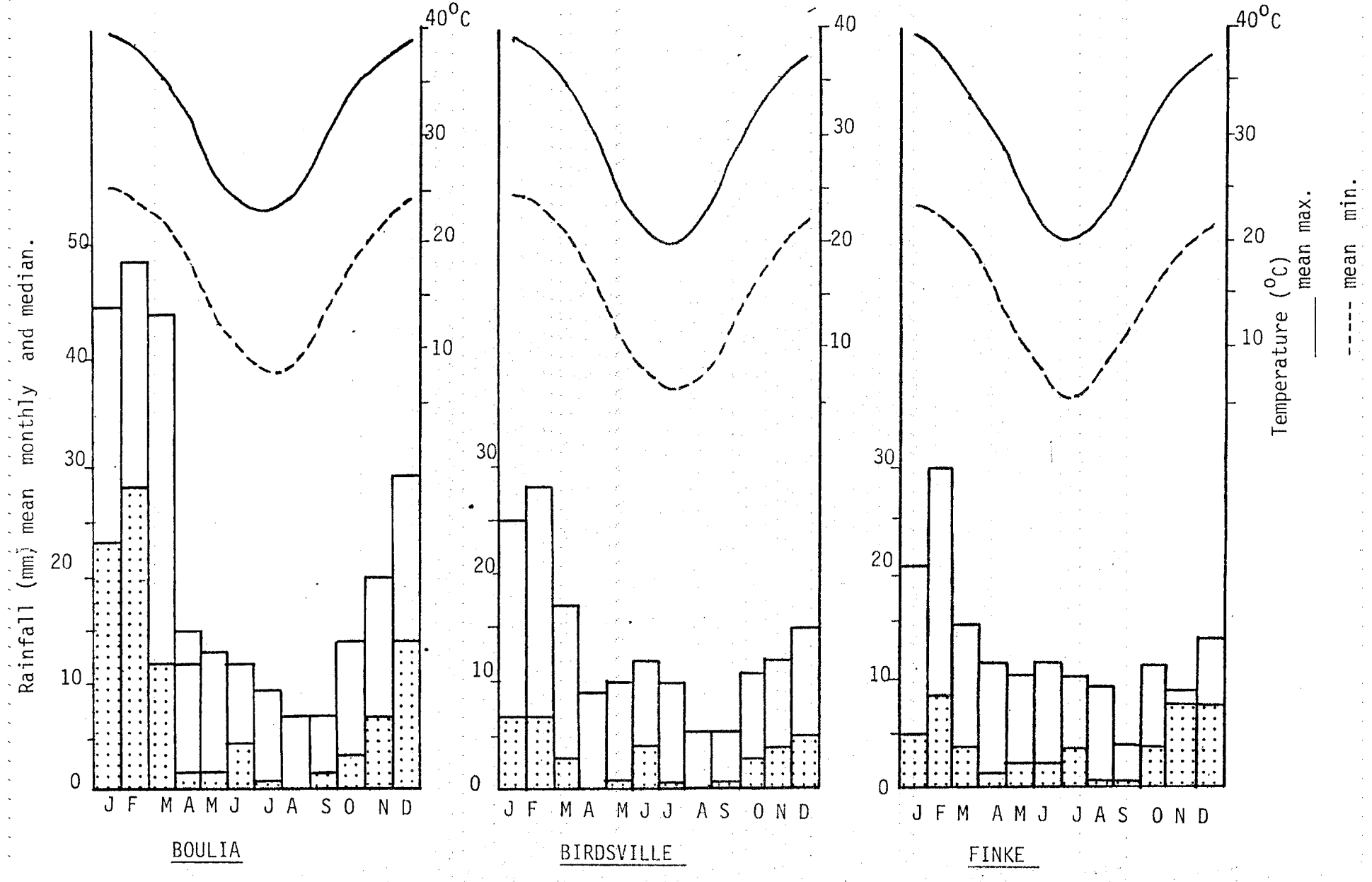
Location	Floristic similarity index Jaccard	Sorensen
Specific Similarity		
Boulia/Birdsville	27	43
Birdsville/Andado	34	51
Boulia/Andado	20	33
Andado/Wiedeman (1971)	11	20
Birdsville/Wiedeman (1971)	13	23
Birdsville/Boyland (1970)	24	38
Generic Similarity		
Andado/Birdsville	54	70
Andado/Boulia	33	50
Birdsville/Boulia	42	59
Andado/Boyland	28	44
Andado/Wiedeman	23	36
Birdsville/Boyland	43	59

4:3 Bioclimate

The high rainfall variability and temperature ranges which characterise the area of *A. peuce* distribution create considerable stresses for perennial plants which must maximise infrequent intervals of water availability and endure stress periods of uncertain duration. The range of 160-270mm mean annual rainfall gives little indication of plant growth periods since precipitation does not exceed evaporation for any month. It is the episodic occurrence of rainfall that allows soil water recharge and limited growth periods to occur.

The general similarity in climatic conditions between the *A. peuce* localities can be seen in the representative climatic data for each (see Graph 4.3a).

The interpretation of climatic data in terms meaningful for plant growth requires a water balance model which takes into account the infiltration and storage characteristics of the soil. Redistribution of precipitation as run-off affects local water status, and in conditions of low vegetative the evapo-transpiration rate is lower than in mesic environments. Temperatures are related to monthly precipitation in that rainfall periods are associated with less than average temperatures, due to evaporation. Fitzpatrick *et al* (1967:399) found that the expected pattern of soil water availability parallels that of seasonal rainfall, but while most rain falls in summer in Central Australia, the probability of positive soil moisture storage is greater in winter due to reduced evaporation. Further, at no site does the probability of the commencement of a growth period of at least 5 days duration exceed 0.5 in any month (see Table 4.3b). At Charlotte Waters (25°26'S, 134°55'E) the greatest chance of a growth period is 0.35 in February. The extreme aridity of this location is shown by the fact that a non-growth period of at least 90 days can be expected in most years. Slatyer (1962) established monthly values for


Rainfall (mm) mean monthly and median.
Temperature (°C)
mean max.
mean min.
40°C
30
20
10
0
50
40
30
20
10
J F M A M J J A S O N D
BOULIA
BIRDSVILLE
FINKE

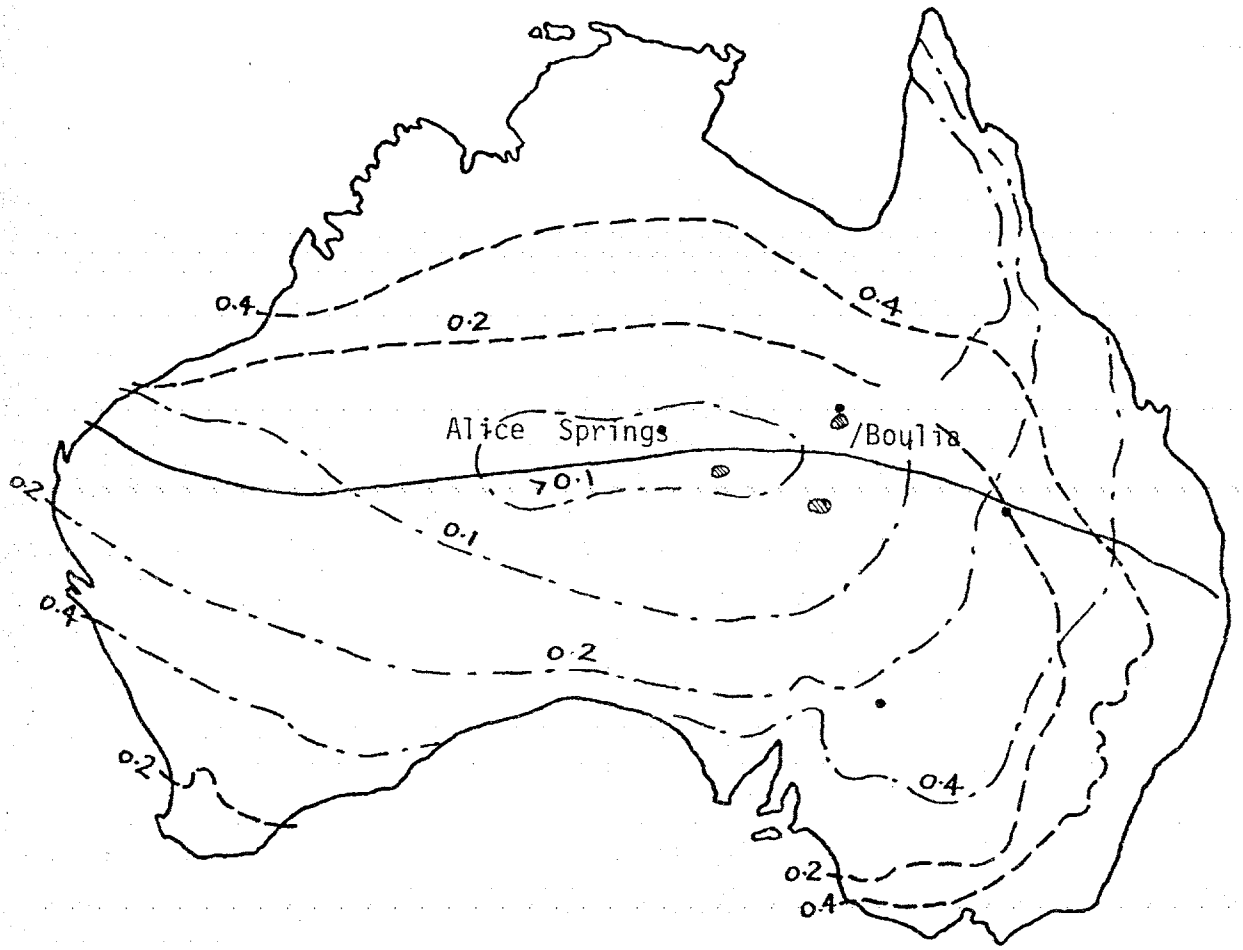
initial effective rainfall and effective carryover rainfall for the Charlotte Waters area, and these are compared to the actual data for the exceptional years 1974-1976 at New Crown Station near Andado (Table 4.3c).

From the water balance model of ratios of estimated actual to potential evapotranspiration (Ea/Et) Fitzpatrick and Nix (1970:11) derived seasonal moisture indices (0-1) for the whole continent. Following the analysis of Nix and Austin (1973) for *Acacia aneura* (Mulga) distribution, it can be shown that *A. peuce* distribution is restricted to an area of very low but continuous moisture regimes (i.e. mean summer index <0.2, winter <0.1) (see Map 4.3). The desert border populations of *A. peuce* lie within the region where summer rainfall does not exceed 50mm 8 years in 10, while no locality receives 20mm in winter with this probability. *A. peuce* distribution lies along the zone of equal summer and winter moisture indices.

Light is not a limiting factor in the region but winter temperatures of <10°C may limit growth. The product of light, thermal and moisture indices provides a multi-factor growth index which takes species responses into account (Fitzpatrick and Nix, 1970:11). The regional bioclimatic analysis of Nix and Austin (1973) for *A. aneura* is based on a thermal response of the tropical legume type assuming an optimum dry matter production at 28-30°C, with upper and lower thesholds of 38°C and 10°C. *A. peuce* occurs in the central arid bioclimatic zone, with no marked seasonality of moisture regimes and where tropical legumes make an important contribution to summer growth.

In an attempt to explain the differential recruitment of *A. peuce* at Birdsville and Boulia in terms of the number and duration of potential growth periods a multifactor growth index was calculated for the last 25 years, using a 'GROWEST' calculator programme designed

Map 4.3 Mean summer and winter moisture indices (E_a / E_t) (Nix & Austin, 1973)



Summer (Nov-Apr)

Winter (May- Oct)

Equal summer/winter moisture index values

Acacia peuce stands

Table 4.3b Expected number of growth and non-growth periods of specified duration occurring seasonally and annually. (Fitzpatrick, Slatyer & Krishnan, 1967:401)

	Alice Springs			Charlotte Waters		
	Oct-Mar	Apr-Sept	Annual	Oct-Mar	Apr-Sept	Annual
Expected number of growth periods equalling or exceeding						
5 days	2.34	1.45	3.79	1.31	1.10	2.41
15 days	1.39	1.09	2.48	0.67	0.77	1.44
30 days	0.74	0.70	1.44	0.17	0.48	0.65
90 days	0.09	0.18	0.27	0.01	0.10	0.11
Expected number of non-growth periods equalling or exceeding:						
30 days	1.32	1.22	2.54	0.96	0.94	1.90
90 days	0.45	0.54	0.99	0.49	0.61	1.10
180 days	0.77	0.10	0.17	0.21	0.37	0.58
365 days	0.00	0.00	0.00	0.09	0.07	0.16

Table 4.3c Effective and Actual monthly Rainfall for New Crown Station 1974-1976 (from Buckley, 1979:7)

Month		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Initial Effective rainfall (mm)		33	31	24	17	11	7	8	11	16	23	28	32
Effective carryover rainfall		65	62	49	33	22	15	16	21	32	46	55	63
Actual New Crown rainfall	1974	158	45	7	100	11	-	4	31	30	87	7	12
	1975	5	77	22	-	-	-	21	69	78	27	22	157
	1976	64	332	94	-	-	-	-	-	-	58	8	4

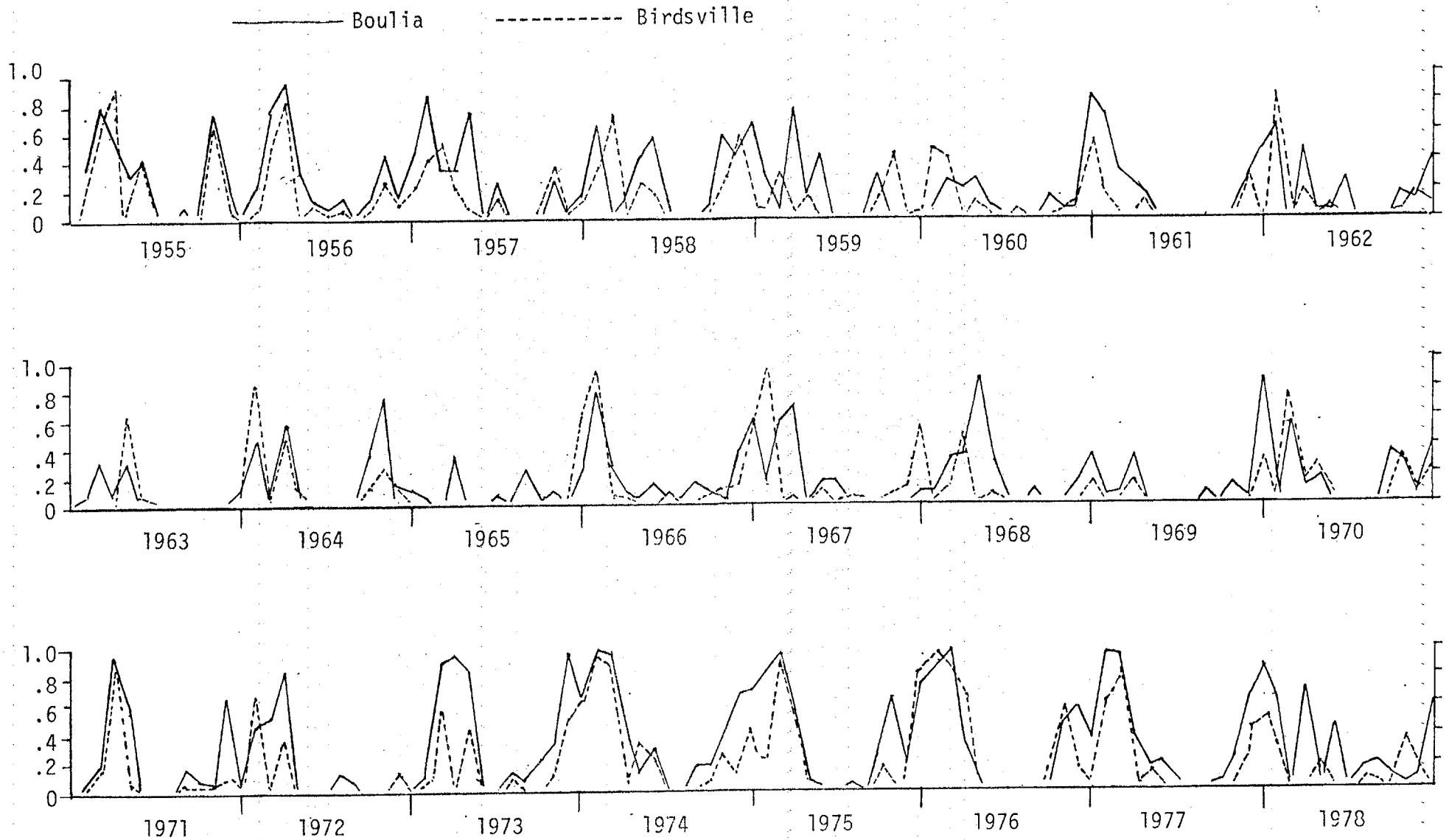
by Dr T. Booth (C.S.I.R.O. Division of Land Use Research). Scalar models of soil water interaction assumed a:

- storage of 100mm
- evapotranspiration (Et) factor of 0.8 (Nix and Austin, 1973)
- extraction factors for a sandy clay loam (Nix et al 1977:10)

A thermal response of the tropical legume type was assumed. Monthly temperatures were defined as $\frac{\text{max} + \text{min}}{2}$. Results are shown in Diagram 4.3. Moisture is the dominant bioclimatic control for *A. peuce* but winter temperatures <10°C may limit growth at Birdsville despite water availability. The number of potential growth periods over the 25 years have been roughly equivalent occurring with a yearly frequency. These results suggest that lack of rainfall is not the reason for reproductive failure at Birdsville. While soils were assumed to be equivalent at the two localities, at Boulia soil water storage capacity is greater (3m deep) and runoff negligible. At the same time the Et factor for the model may be greater than actual considering the low vegetative cover and there is thus no carryover soil storage for any month. These factors will affect the duration of growth periods in terms of soil moisture storage, and it is likely that growth periods may have been continuous at Boulia during 1972-1975.

Diagram 4.3

Estimated potential monthly growth periods over the last 25 years at Boulia and Birdsville (Qld).
(calculated from monthly water balance data using a 'GROWEST' programme)



4:4 Soils

Acacia peuce occurs on texture-constant desert loams (Stace, 1968:60), duplex soils which vary in depth and profile form between localities, but are pedogentically equivalent.

ANDADO: Dr 1.23 - 1.33, crusty red duplex soils (Northcote, 1974)

BIRDSVILLE: Dr 1.22 - Dy 2.11 crusty red duplex to hard pedal yellow duplex soils

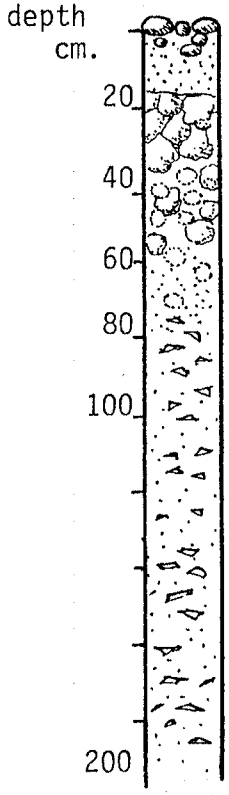
BOULIA: Dr 1.23 - 2.23, deep loamy red duplex soils

Representative soil profiles from each location are shown in Diagrams 4.4a,b and c. The principle profile forms of the Northcote (1974 and 1975) classification emphasize the differences in colour, depth and reaction trend between soils of *A. peuce* localities. The similarity of general pedological features should be recognised however; the characteristic one being the texture contrast between the loose 'A' horizon and the hard pedal 'B' horizon. The 'A' horizon varies in depth from 5-20cm of loamy sand to sandy clay loam (10% clay) commonly forming a surface crust of both physio-chemical and biological origin. The poorly developed $'A'_2$ horizon shows only sporadic bleaching. The surface is typically associated with a stone pavement of silcrete nodules and ironstone pisolites and lag deposits of loose fine sands. Stone may be organised into gibber pavements (80% cover) or be scattered throughout the 'A' horizon. Surface stones have a hydrated 'desert varnish' (Mabbutt, 1977:129) and may have undergone both vertical and lateral movements (Mabbutt, 1977:124).

At the *A. peuce* localities the localised gibber pans are residual features of deflation, while nearby slopes display a continuous stone mantle, suggesting that the sandy 'A' horizon of the former has an aeolin depositional component. On pediment slopes (1-3°) there is a spatially patterned microrelief (< 30cm) of alternating gibber and sandy areas aligned across slope contours similar to the stony 'micro-

Diagram 4.4.b. Representative soil profiles from the A.peuce stand at Birdsville.(Qld)

Site 1. gibber pan



ironstone gravel

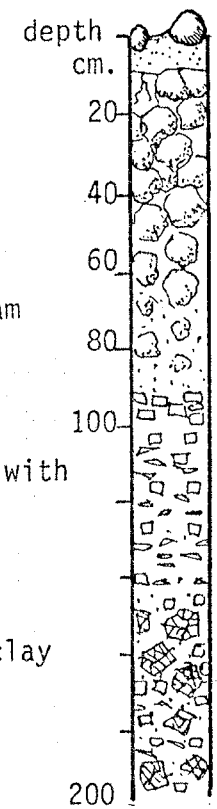
5YR 7/8loose gritty sandy clay loam

7.5YR 8/4dry 7/6 wet.powdery clay with white gypsiferous concretions

7.5YR 8/2 white powdery gypseous clay with occ. crystals (.5cm)

10YR 8/4 pale yellow loamy clay with powdery gypsum and crystals(.5cm)

Site 2.



Embedded silcrete cobbles

7.5YR 4/6 massive crusty sandy clay loam. blocky rough-faced peds.vughs,ando organic matter.

7.5 YR 6/8 loose blocky sandy clay loam with black organic staining.

7.5YR 7/8 sandy clay loam with angular siltstone fragments

crystalline gypsum to 2cm in blocky aggregates with stone fragments

gilgai' of Mabbutt (1977:133). Another common feature is the presence of a subsurface stony horizon within or at the base of the 'B' horizon.

The dominant hard pedal 'B' horizon consists of red-brown medium sandy clays (clay content 35-45%, Mabbutt, 1965:134) with a blocky structure, smooth ped fabric and strong consistence. Aggregations of carbonate and gypsum increase with depth. The horizon is moderately to strongly saline with depth and while calcium and magnesium are the dominant exchangeable cations, sodium may predominate in the lower horizon (> 20% of total). In the areas peripheral to the desert there is a prominent 'gypsite' subsurface of gypseous clays (up to 75% powdery $CaSO_4$) showing a topographically controlled catenary development, appearing at 1m in low areas and only gradually below 1.5m on slopes.

While the soil surface features of *A. peuce* localities are comparable, profiles differ largely in the nature of the sandy clay 'B' horizons (see Table 4:4a) as described below.

Boulia: The deep 'B' horizon of the red duplex soils developed on alluvium, grades from massive brick-red sandy clay to a paler red-brown and slightly mottled lower 'B' horizon below 1m (Dia. 4.4a). Carbonate nodules (1cm diameter) occur below 60cm while gypsum is absent from the 'B' horizon. The profile is strongly alkaline with a reaction trend of pH 8-8.5, and is non-saline, although soluble salts increase below 1m (see Table 4:4a). Ca and Mg are the dominant cations, Ca increasing from 6% in the 'A' horizon to very high at depth, while Mg remains constant at 4.3 - 4.8% of the total. Exchangeable K and acid- and bicarbonate-extractable Phosphorus are very low (< 10ppm).

Birdsville: The hard pedal fine sandy clay of the 'B' horizon varies from pale red-brown (Dr 1.22) to pale yellow-brown (Dy 1.12) grading into a strongly developed gypsite layer at 1-2m on stony slopes or

Table 4.4a Soil Chemical analyses of Representative Profiles from the three *A. peuce* localities (J. Caldwell)

		tot %	AD - basis			exch meq%			
	1:5 pH	calcite	gypsum	halite	1:5 TSS	Na	K	Ca	Mg
ANDADO Site 1.									
Depth 0-20	7.15	nil	.19	.22	.27	2.77	.52	6.16	4.21
(cm) 50-60	7.32	nil	.50	.75	1.14	v.high	.66	7.94	4.42
90-100	7.38	.006	29.9	.59	1.53	v.high	.59	v.high	4.03
150-160	7.20	nil	72.7	.18	1.06	3.00	.51	v.high	3.00
BOULIA Site 1.									
Depth 0-10	6.96	nil	.33	.007	.028	1.17	.30	6.09	4.28
(cm) 20-30	8.08	nil	nil	.015	.018	1.07	.48	7.17	4.69
50-60	8.40	.003	nil	.032	.036	1.10	.44	7.14	4.60
90-100	8.52	3.3	.37	.13	.51	3.00	.52	v.high	4.88
300	8.28	.8	.16	.18	.40	3.29	.55	v.high	4.60
BIRDSVILLE Site 2.									
Depth 0-20	7.95	nil	nil	.20	.20	3.34	.42	8.80	3.84
(cm) 50-60	7.08	nil	.78	.77	1.47	v.high	.50	11.27	3.50
100-110	7.21	nil	10.3	.59	1.62	v.high	.51	v.high	3.38
150-160	7.02	nil	33.0	.59	1.62	v.high	.54	v.high	3.19

abruptly at 1m or less on lower sites (Dia. 4.4b). The 'B' horizon shows a neutral reaction trend (7.0-7.2 pH) below a slightly alkaline 'A' horizon (7.95 pH) and are strongly saline >1% T.S.S. in a 1:5 saturation extract (see Table 4:4). Carbonate ($CaCO_3$) is absent from the profile while gypsum ($CaSO_4$) increases with depth to >30%. Exchangeable Ca and Na increase to very high in the lower 'B' horizon while Mg decreases slightly from 3.8% of total. Acid- and bicarbonate-extractable P and K are very low (< 10 ppm).

Andado: The crusty red duplex soils (Dr 1.23) have a hard pedal red-brown medium sandy clay 'B' horizon, grading into a strongly developed gypsite subsurface (up to 75% powdery $CaSO_4$). Gypseous aggregations are present below 50cm, while Carbonate ($CaCO_3$) is absent from the profile. There is a slightly alkaline reaction trend (7.15 - 7.38 pH) and the 'B' horizon is strongly saline (> 1% 1:5 T.S.S.). The Na proportion of exchangeable cations is very high the 'B' horizon while Ca increases to very high in the lower gypseous horizon.

Those features common to the soils of the three *A. peuce* locations are summarised in Table 4.4b below:

Table 4.4b Soil features common to *A. peuce* localities

Soil Characteristic (X = presence)	Location		
	Boulia	B'ville	Andado
1) Undulating sandy surface deposits	X	X	X
2) Surface stone pavement in microdepressions	X	X	X
3) Crusty loamy sand, 'A' horizon	X	X	X
4) Texture contrast to hard pedal sandy clay 'B' horizon	X	X	X
5) High exch. Ca % in lower 'B' horizon	X	X	X
6) Alkaline reaction trend	X	-	X
7) Stone layer at base of 'B' horizon	-	X	X
8) Strongly saline 'B' horizon	-	X	X
9) Catenary profile depth	-	X	X
10) Powdery gypsum subsurface	-	X	X

Pedological History: Since *A. peuce* occurs on pedogenically equivalent isolated remnants of the desert loams, elucidation of their age and formation may give an indication of the time this habitat has persisted and of its former extent.

The change from of interstadial to full glacial conditions during the terminal Pleistocene corresponded to a change from pluvial to arid conditions in Central Australia. In interpreting the recent sedimentary history of the Lake Eyre region, palaeosols are taken to represent stable conditions when soils formed over the deposits of previous unstable arid phases (Jessup, 1960). Wopfner and Twidale (1967:139) suggest that the removal of the siliceous duricrust was initiated during the Late Pliocene by minor uplifting. Jessup and Norris (1971) recognize the stony tableland soils as part of the last significant soil-forming phase in a complex Cainozoic history.

Jessup (1960, 1961a & b) first placed the 'stony tableland soils' within a proposed Quaternary stratigraphic sequence, identifying two younger calcareous soils overlying them in parts of South Australia. He considered that they had developed on windblown gypseous clays, 'lakulangite' derived from the drying Lake Dieri. He gave as evidence the correspondence of mineral components between Lake Eyre sediments and an adjacent soil (Jessup, 1961:193) and suggested that the profile form of clay over gypsum was the inverse of the deflation sequence of lake deposits, and their occurrence as a blanket deposit over various strata further indicating an aeolian origin. Surface stone was seen as outwash deposits from nearby silcrete residuals maintained at the surface by clay expansion.

On the contrary, Ollier (1961:582) saw the surface layer as a lag deposit resulting from the deflation of an ancient soil profile. In a study of a stony tableland soil at Mt Wilyunpah in the Northern

Territory, Mabbutt (1965) found that the distribution of stone was consistent with an upward displacement, since it was markedly absent from, and reappeared below the 'B' horizon. This does not support formation as lag material after removal of the finer fractions, or as depositional layering of aeolian deposits (Mabbutt, 1965:138). He points out that the sites studied by Jessup and Ollier do not correspond physiographically: the former on low plateaux, the latter on gibber strewn plains (Mabbutt, 1965:132). It was concluded that the stony tableland soils formed as a single residual profile, with the silcrete duricrust as the lower horizon. There was a higher clay content in the 'B' horizon (35-40%) than in underlying rock, but at the same time the distribution of these soils is marked by the geological control of argillaceous sedimentary rocks. presence of an aeolian component in these soils is unresolved.

The high gypsum content in the subsurface of soils peripheral to the desert, in the absence of calcium carbonate, requires further explanation. There are two basic alternatives for the origin of the powdery gypsum subsurface in the soils at Andado and Birdsville:

1) Subsurface deposition from the top of a fluctuating groundwater body saturated in $CaSO_4$.
2) Leaching of windblown gypsum dust to subsurface horizons.

Evidence from North Africa indicates that a fall in groundwater table results in gypsum crystal formation within the soil (Watson, 1979:7). Several lines of evidence suggest that this may have been the source of the gypsite layer in the stony downs soils. These are:

- catenary development within the profile.
- absence of $CaCO_3$ which is less soluble and would be the last compound leached out of the profile
- absence of 'kopi' crystals
- pluvial conditions of the period 45,000-25,000 B.P. (Bowler, 1971, 1976) would have seen high water tables throughout the region

- the presence of extensive Lake Dieri system extending into the Pleistocene (Loeffler and Sullivan, 1979)

In this case the present soils would be neoautomorphic (Kovda, 1979: 440) reflecting the past action of hydromorphic processes of accumulation of compounds through the action of groundwater. On the other hand gypsum is also precipitated at the depth of wetting of a saturated soil solution (Watson, 1979:13). Thus windblown gypsum dust may have been leached to below 1m following its deposition during Quaternary arid phases, its accumulation resulting from automorphic processes.

The desert loams were formed largely *in situ* on aggradational alluvial plains and fine grained sedimentary rocks. The texture contrast is primarily the result of clay illuviation under the influence of colloid saturation by Na ions (Stace, 1968:62). Weathering under high base saturation has concentrated carbonates, gypsum and the more soluble salts in the base of the profile. Solonization, the formation of alkaline soils with a structural 'B' horizon, resulted from erosional dissection of former uplands and the removal of the influence of the water table.

CHAPTER 5

DISCUSSION

5:1 Phytogeography

Joseph Hooker in 1860 first proposed that distinct migrational elements have contributed to the Australian flora and that the continent has itself been a centre of angiosperm evolution. These have come to be known as the Antarctic, Indo-Malaysian and autochthonous elements (Crocker & Wood, 1946:96). Plate tectonics has provided historical biogeography with an elegant explanation both for the disjunctions in the distribution of many southern hemisphere taxa (Melville, 1975); (Beard, 1977) and for palaeoclimatic changes (Kennett, 1977).

It is often difficult to assign a clear origin to certain taxa however, and recently the nature of the recent Indo-Malesian element has been questioned on the evidence of the long history of tropical vegetation in Australia (Kemp, 1978) (Beard, 1976:51) and the presence of primitive endemic rainforest taxa in Northern Australia (Webb & Tracey, 1980); (O'Neill, 1980).

In the case of the genus *Acacia*, the absence of specialised dispersal mechanisms, and the subgeneric differentiation between the southern continents is difficult to reconcile with its mid-Tertiary (Oligocene) appearance in the fossil record (Trusswell, 1980:18). In Australia *Acacia* pollen does not appear until the Miocene (Cookson, 1954); (Martin, 1973:6); (Martin, 1977). The development of seasonally dry subtropical environments coincided with the radiation of the genus. While Axelrod (1970:306) cites *Acacia* as a link between semi-arid regions throughout the world, Raven & Axelrod (1974:606) claim it must have achieved this distribution through long distance dispersal.

Andrews (1914:396) decided that the phyllodinous acacias developed in Northern Australia, and Pedley (1977:2) in a review of the extra-Australian species of the subgenus Heterophyllum, considers the presence of primitive species on islands north of Australia supports such a conclusion. Some strand line species have a conspicuous aril (e.g. *A. cyclops, A. salicina*) suggesting dispersal by birds. *Acacia mangium* in New Caledonia and *Acacia xiphoclada* in the Malagasy may be relict rather than immigrant however. Eastern Australia is also a centre of distribution of sections of the genus.

5:2 Origin of the Eremaean Flora

A review of the Tertiary vegetation history and Late Pleistocene environmental changes in Central Australia is presented in an attempt to establish the conditions and the time limits under which *A. peuce* has existed.

Within the present Australian vegetation floristic provinces corresponding to the climatic controls of major geographic regions were defined by Burbidge (1960) (see map 2.2b). The Eremaean floristic zone is distinguished from the temperate and tropical zones by its prominent and endemic taxa. (see Table 5.2 from Burbidge, 1960:105). The region has floristic affinities with both temperate and tropical zones, and while the majority of genera endemic to it have southern or temperate affinities, most non-endemic genera are related to the tropical zone. (Burbidge, 1960:103).

The structurally dominant taxa of the arid zone display a summer growth rhythm typical of subtropical regions. (Specht, 1972:217). A proportion of the Eremaean vegetation has affinities with arid and warm temperate regions in the northern hemisphere (see Table 5.1) (Burbidge, 1960:181). Specht (1972:205) remarked that in South Australia the 30cm isohyet divides the state into a dry northern

Table 5.1. Genera both endemic and non-endemic to the Eremaean zone but absent from tropical and temperate zones of Australia. (from Burbidge 1960:105)

Family	Endemic	Non-Endemic
Santalaceae	1	
Loranthaceae		1
Chenopodiaceae	15	2
Amaranthaceae	1	
Aizoaceae	2	2
Capparidaceae	1	
Cruciferae(Brassicaceae)	12	
Leguminosae	3	1
Stackhousiaceae	1	
Sapindaceae	1	
Bombacaceae	1	
Sterculiaceae	2	
Violaceae	1	
Myrtaceae	2	
Umbelliferae(Apiaceae)	2	
Apocynaceae	1	
Asclepidiaceae		2
Boraginaceae	3	1
Verbenaceae	4	
Lamiaceae	1	
Solanaceae	2	1
Pedaliaceae	1	
Acanthaceae	2	
Cucurbitaceae		1
Goodeniaceae	1	
Compositae(Asteraceae)	20	1

section showing affinity to the northern hemisphere, largely as a result of the dominance of the Chenopodiaceae, and a southern section in which the Australian genera *Acacia* and *Eremophila* are dominant.

In looking for an origin for the largely herbaceous component of this "pan-xeric" flora it is significant that they are best represented in sandsheet, dune and saline soils. Burbidge (1960) makes a strong case for a coastal origin, (giving as evidence the presence of the herbaceous genera *Ptilotus, Tetragonia, Trianthema, Tribulus* and *Salsola* in coastal habitats in Malaysia,) and the edaphic similarity of sand desert and saline coastal habitats gives support to this hypothesis. During the late Tertiary, a large inland lake system (Lake Dieri Loeffler & Sullivan (1979)), which had oceanic connection during parts of its history (Wopfner & Twidale, 1967:130) would have provided the continuity of habitat for colonization of Central Australia.

If Goodall's (1975:21) hypothesis that deserts, unlike any other climatic zone, have always been isolated biogeographically, then impressive long distance dispersal of taxa, possibly via coastal habitats must have occurred. Eardley (1948:22) gives examples of genera and even species shared between the Simpson Desert and other sandridge deserts of the world. Sarmiento (1976) in a discussion of the Caribbean arid zone mentions several genera also found in Australia; (*Acacia, Cassia, Capparis, Sida* and *Heliotropium*). Subtropical desert regions of the world are dominated by the families Poaceae, Asteraceae, Brassicaceae, Chenopodiaceae and Leguminosae. It is possible that the latter two families may have been present as autochthonous elements within a Tertiary Australian flora (Trusswell, 1980:18). It is therefore not known when or how the genus *Acacia* first arrived in Australia.

Palynology has established that during most of the Tertiary, the continent was dominated by rainforest vegetation with both cool-

temperate and tropical affinities, and in consequence that climates were more humid than at present. Data for Central Australia are insufficient for a regional chronology but for the Eocene at least there is a continent wide representation of sites (Kemp, 1978:184). In attempting to recognise the appearance of xerophytic taxa and zonation of vegetation, the following problems are recognised:

(a) assigning generalized pollen types to present taxa and assuming similar ecological tolerances.
(b) poor absolute dating chronology for Central Australia.
(c) local sedimentary situations give bias to immediate (usually wet) taxa and prolific and widely dispersed pollen producers.
(d) absence of pollen sedimentary situations in arid environments.

The first indication of open vegetation appears in the Eocene of Central Australia, where at Napperby, N.T. (Kemp, 1976) and Hale River (Trusswell & Harris, 1980), *Casuarina*, *Callitris*, some grasses and selerophyll Proteaceae are present. Not until Miocene times did the dominant woodland genera *Acacia* and *Eucalyptus* appear (Martin, 1977) and their rise to dominance is largely a Pleistocene phenomenon. The persistence of rainforest taxa in Central Australia into the Pliocene (Martin, 1973:44) suggests that climates were still fairly humid and that considerable regional zonation of vegetation existed.

5:3 Age and Nature of Aridity in Australia

The Tertiary drift of the continent over 30° of latitude is seen as having climatic consequences at both a regional and continental scale. Firstly, northward drift into mid-latitudes has placed Australia within the high pressure anticyclone belt. Secondly, coincident with the growth of the Antarctic ice-sheet in Miocene times and the initiation of the circum-Antarctic current, the cooling of ocean temperatures would have reduced oceanic evaporation and the development of warm moist air masses (Bowler, 1976:282).

On the basis of the former effect it has been argued that arid climates first appeared in the northwest and subsequently contracted southwards (Beard, 1976:56, Kemp, 1978). Bowler (1976, 1980:21) on the other hand, has argued that the displacement northwards of the Antarctic convergence zone and accelerated southern hemisphere westerlies would have resulted in the compression and northward extension of the anticyclones and the dominance of hot dry airmasses over the continental interior (Bowler, 1976:305).

There is worldwide evidence to indicate the correspondence between glacial maxima and increased aeolian activity. Successive O^{18} peaks are matched by the component of Saharan dust in the Atlantic sediments. (Bowler, 1980:21). Therefore the peaks in oxygen isotope curves for the late Pleistocene (Shackleton & Opdyke, 1973; Emeliani & Shackleton, 1974) may indicate the timing of periods of extreme aridity and desert dunefield formation. Such periods may have preceded the last glacial period of dune mobilisation from 25,000-15,000 B.P., the geomorphic evidence for which may not have been preserved.

While some workers advocate an early Recent age for the Australian dunefields (King, 1960; Twidale, 1972; Crocker & Wood, 1947) sites on which these estimates are based are close to sand source areas and may therefore represent only the most recent and localised activation of dunes. On the other hand dunes of the desert margin overly a stable base (Wopfner & Twidale, 1967:132) on which soil development is evident, and Bowler (1976:303) suggests on this evidence that an organised dunesystem may have been established in Central Australia before 300,000 B.P. Evidence indicates that dunefields were mobilized during the last glacial maximum, and extended far beyond the present limits of aridity. Geomorphic evidence from Eastern Australia indicates the onset of glacial conditions around

35,000 B.P. and a marked change in hydrologic environments from wet to dry around 25,000 B.P. (Bowler, 1980). Assuming that the hydrologic chronology established for the Willandra Lakes in western N.S.W. can be extrapolated to Central Australia, dunefield activity can be placed in the range of 25,000-13,000 B.P. with the height of aridity at 18,000-16,000 B.P. (Bowler, 1971, 1976a). Migration of vegetation zones in response to the expansion of arid environments is seen in pollen cores from the margins of the arid zone.

A retreat of mesophytic vegetation zones during the height of aridity is recorded for the Nullarbor Plain (Martin, 1973a), and indicated in Northeast Queensland (Kershaw, 1972, 1975; Nix & Kalma, 1972). An amelioration in climate by 10,000-8,000 B.P. to conditions similar to or more humid than present is indicated at many sites (Bowler, *et al* 1976), while minor Holocene fluctuations including a mid-Holocene 6,000-3,000 B.P. dune reactivation (Williams, 1973) have occurred.

5:4 Plant Distributions

The Eremaean zone is not a physiographically uniform environment and Mabbutt (1965:106) distinguishes five distinct desert land-surface types for arid Australia:

- mountain deserts
- shield deserts
- stony deserts
- clay and river floodplains
- sand deserts (see map 5.1)

Each of these constitutes a distinct edaphic habitat with a separate geomorphic history, and consequent important bearing on plant distributions. The presence of relict and disjunct species has been given as evidence for previous wetter climates, Crocker and Wood (1947:113) cite the examples of the palm *Livistona mariae* and the cycad, *Macrozamia macdonnellii* isolated in the Macdonnell Ranges.

Mountain ranges and elevated shield areas are seen to have maintained locally favourable habitats for species otherwise eliminated from a former range. The presence of endemics in other mountain and upland areas in the arid zone, indicates that they have acted as refuge areas during the Pleistocene. At the same time these landforms have acted as source areas for subsequent radiation and speciation with climatic amelioration.

Hopper and Maslin (1978) considering the distribution of the 450 *Acacia* species in Western Australia identify mountainous areas in the Pilbara, Kimberlies and Desert region as centres of species richness, within which are found both closely related and taxonomically isolated species. These areas have therefore allowed both the persistence of relict forms and provided the source for recent speciations. The inland margin of the Southwest Province is by far the richest centre of specific diversity and endemicity for *Acacia*, and for this reason Hopper and Maslin (1979:75) suggest that the instability of the semi-arid region during climatic change, rather than topographic diversity has been the most important factor in the adaptive radiation of the genus.

Crocker and Wood (1947:112) identify geographically isolated vicariant species pairs -

Eucalyptus oleosa S.A. - *Eucalyptus gracilis* W.A.
Acacia sowdenii S.A. - *Acacia loderi* N.S.W.

which indicate that environmental stresses over large geographic ranges has resulted in allopatric speciation.

The mechanism of the physical and genetic isolation of populations has been geomorphic as well as climatic, by both erosional and depositional habitat dissection. Crocker and Wood (1947:113) give *Acacia peuce* as an example of a "relic", its geographic distribution and habitat having been reduced by the expansion of the desert dunefield.

Randell and Symon (1977:206) found a correspondence between plant distribution and the configuration of three landsurface types; dunefields, sandplains and stony desert tablelands, giving examples of species disjunctions around the dunefield deserts. They argue for the presence of an arid adapted flora prior to the last major period of dunefield extension. There is evidence that separate eastern and western elements have recolonised the Simpson Desert subsequent to the last arid phase. Species groups which have a widespread, bimodal or transitional distribution across the dunefield at 26° South are identified by Fatchen and Barker (1979b), corresponding to dispersal capabilities and species tolerances to soil instability. They suggest that the Macdonnell Ranges to the north-west have been the major refuge area; and in the east, the floodplains of the Diamantina River would have provided locally favourable habitats during the height of aridity. The occurrence of the Boulia *A. peuce* stand on an interfluvial floodplain would support this hypothesis.

Plant performance during recent droughts indicates that many species would have been eliminated from the dunefield during the height of aridity from 18,000-16,000 B.P. and possibly until after 13,000 B.P., while other species such as *A. peuce* and *A. pickardii* have persisted without migration on the desert margins.

The physiognomy of *A. peuce* suggests that it formed or was a component of a woodland formation of the type now found in less arid areas (e.g. *Acacia estrophiolata* (N.T.), *A. cana,* (Qld) and *Casuarina cristata*) which dominated an extensive Pleistocene aggradational plain across the region. The ecological tolerance and longevity of the species, the maintenance of suitable habitats and the absence of competitors has resulted in its survival at present locations. The extent of former distribution of *A. peuce* is suggested by that of

the desert loam (stony tableland) soils. While this is extensive in South Australia, it may be that *A. peuce* was a subtropical savanna tree of the north-western Eromanga Basin, rather than the Chenopodiaceae shrub steppe.

Because of the complex and oscillating climatic history it is difficult to assess the time *A. peuce* populations have been isolated. It is suggested that this has been at least 17,000 years, and possibly as long as 300,000, the possibility of long distance dispersal by pods being blown across the dunefield appearing remote. The present dunefield must have been established by 17,000 B.P. the height of aridity, but there may have been several arid phases during the Late Pleistocene. The existence of indurated sands with pronounced carbonate segregation underlying sections of the modern dunefield (Wopfner and Twidale, 1967:132) indicates earlier deposition and subsequent soil development. This may correspond to the more stable, pluvial conditions from 45,000 to 25,000 B.P., evidenced in soil formation on the Mungo sedimentary unit (Bowler, 1971, 1976:293) and in the Flinders Ranges (Williams, 1973) or to an even earlier phase extending beyond 80,000 B.P. (the Golgol unit: Bowler, 1971, 1980:8).

It is possible therefore that populations of *A. peuce* were already separated by a dunefield prior to 25,000 B.P. although habitats in which it now occurs would have been more extensive. On the other hand the species may have been present on these stable sandplain soils and exposed interdunes, even extending its range by migration during this more favourable pleniglacial period.

Assuming that opportunities for migration across its distributional range have been minimal since the Pleistocene dessication of the extensive Lake Dieri system (Loeffler & Sullivan, 1979:240), if the species did ever exist in western South Australia it would imply a distribution around this huge lake. On the other hand extensive

alluvial plains in the north of the Simpson Desert may, until after 25,000 B.P., have maintained *A. peuce* in a situation similar to that seen at Boulia with trees on sandy interfluvial rises.

While a considerable age is indicated for the species, and it may indeed be a remnant of a Late Tertiary flora, the absence of any morphological differentiation between present *A. peuce* populations may reflect either a Late Pleistocene continuity of distribution and genetic exchange, or the slow rate of genetic drift and long inter-generational time (100 years) of this conservative species. Late Pleistocene fire regimes may also have played a part in the diminution of the range of *A. peuce* which now occurs on the borders of the distributional ranges of the widespread species *A. aneura* and *A. cambagei*. *A. peuce* is both climatically and geomorphically relict, the deposition of the Simpson desert dunefields having played a major part in the reduction of its range.

5:5 Conclusions

. The distribution of *A. peuce* is of biogeographic significance as a striking example of a relict species signifying the relative age of the Simpson Desert dunefields. The separate populations became disjunct during the Late Pleistocene and have survived the aridity of the last glacial maximum from 18,000-16,000 B.P. as isolated stands similar to those of today. It is a climatically and edaphically relict species, and the present climate and habitat of the desert border populations are marginal for reproduction and establishment.

. *A. peuce* forms structurally similar and floristically related open woodland communities at the three locations. These open woodlands occur over the unique open herbland and tussock grassland formation of the desert loam, stony downs soils bordering the desert. The high floristic similarity between locations in contrast to the dunefield flora suggests that this habitat was maintained during the last glacial arid phase.

. The population structure differs markedly between locations; while the Boulia population is stable and possibly increasing, those at Andado and Birdsville are declining. The unstable, convex population curves at these latter localities justifies the retention of the classification of the species as "vulnerable" (Boyland, 1978:257) as a guide for conservation policies.

. The activities of the pastoral industry do not at present directly threaten the survival or recruitment of the separate populations, indeed at Birdsville and Andado utilization has ceased. Because of the low overall regeneration in the desert border populations, the progress of juvenile recruitment should be monitored at each

location. If the present trend of poor regeneration at Birdsville continues, the fencing of control plots and possible replanting may be justified.

. The last ten years have seen periods of exceptional rainfall over the whole region. At Boulia and Andado this has resulted in significant regeneration. The relative failure of juvenile recruitment at Birdsville must be explained by factors other than total rainfall, such as soil instability or the general poor condition and low proportion of actively reproducing trees.

. The ease of propagation, coppice response, rapid vertical growth phase and unique qualities of the wood, suggest that the cultivation of the tree may have potential. Although unlikely to be an economic plantation species, its aesthetic appeal justifies its introduction for amenity planting in arid townships. Although the overall growth rate is slow in natural conditions, the tree may respond to irrigation, but this would not be necessary once trees are established.

The inventory has allowed population age structures for *A. peuce* to be inferred, and although prediction of age from diameter is tenuous, it is suggested that at Boulia trees may achieve a diameter of 10cm in 20-30 years, and while tree ages of 200 years are common, exceptional trees at other localities may be greater than 500 years old. The size and extent of *A. peuce* populations and growth rates of juveniles in the field is established.

APPENDIX I:b

Overseas trial of *A. peuce*

Letters of enquiry were sent to several countries which had received seed samples of *A. peuce* from the C.S.I.R.O. Div. Forest Research in Canberra. Those from which plantings were verified are:

Iran 1969-73 plantings made, present progress unknown.
D. Webb 1974.

Israel - Tel Aviv seed planted April 1980, for the desert Botanic Garden, Negev
Prof. Y. Waisel Dept Botany Tel Aviv Uni.

Israel - Ilanot. seed received 1968 - (no record)
seed from C.S.I.R.O. -

Planted	Locality	Number	Survival
Jan 78	Yatir	20	0
Dec 78	Lahar	25	8
Jan 78	Nir Yizhaq	25	5
Dec 76	Mahanemiya	28	4

Dr R. Karschon For. Div. Agr. Res. Org.
Ilanot. Israel

Cabo Verde Islands (Cap Vert)
San Felipe & Trindade (217mm p.a.)
Date planted 6.9.78, 120 plants, progress in natural conditions being monitored. de M.H. Aydemir
Charge du Project
Praia Cap. Vert.

Pakistan, Pershawar, some seed planted 1980.
Director Mr M.I. Shiekh
Forestry Research Institute
Peshawar Pakistan

APPENDIX III: 2:a

List of Plant Species collected at the Boulia *Acacia peuce* stand

Amaranthaceae

Ptilotus macrocephalus
Ptilotus obovatus

Apocynaceae

Carissa lanceolata

Asteraceae

Calocephalus multiflorus
Gnephosis foliata
Minuria denticulata
Munuria sp. aff. M. leptophylla
Pluchea tetranthera
Pteroczulon serrulatum
Streptoglossa bubalkii

Boraginaceae

Trichodesma zeylanicum

Brassicaceae

Stenopetalum nutans

Caesalpinaceae

Cassia desolata
Cassia nemophila var. nemophila
Cassia nemophila var zygophylla
Cassia oligophylla
Cassia phyllodinea

Capparidaceae

Capparis spinosa var. mummularia
Cleome viscosa

Caryophyllaceae

Polycarpaea arida

Chenopodiaceae

Atriplex limbata
Bassia anisacanthoides
Bassia bicornis
Bassia cornishiana
Bassia lanicuspis
Enchylaena tomentosa
Rhagodia nutans
Salsola kali

Convolvulaceae

Ipomoea melleri

Ehretiaceae

Ehretia saligna

Fabaceae

Indigofera linofolia
Crotalaria eremaea
Crotalaria medicaginea
Swainsonia campylantha

Frankeniaceae

Frankenia uncinata

Lamiaceae

Teucrium integrifolium

Loranthaceae

Loranthus exocarpii

Malvaceae

Abutilon otocarpum
Sida fibulifera
Sida pedunculata
Sida sp.

Meliaceae

Owenia acidula

APPENDIX III:2:a (cont'd)

Mimosaceae

Acacia peuce
Acacia cambagei
Acacia farnesiana
Acacia stenophylla
Acacia victoriae

Myoporaceae

Eromophila latrobei
Eremophila longifolia
Eremophila maculata
Eremophila obovata

Myrtaceae

Eucalyptus microtheca
Eucalyptus papuana
Eucalyptus terminalis

Poaceae

Aristida browniana
Aristida latifolia
Astrebla pectinata
Chloris scariosa
Chrysopogon fallax
Dactyolenium radulans
Enneapogon pallidus
Enteropogon acicularis
Eragrostis eriopoda
Eragrostis setifolia
Eualia fulva
Sporobolus actinocladus
Sporobolus australicus

Rubiaceae

Dentella sp.

Sapindaceae

Atalaya hemiglauca

Solanaceae

Nicotiana velutina
Solanum esuriale

Nearby *Acacia stenophylla*
Lysiphyllum gilvum

APPENDIX III:2;b

List of Plant species collected at Birdsville Acacia peuce stand

Aizoaceae

Trianthema triquetra
Trianthema pilosa

Amaranthaceae

Amaranthus mitchellii
Ptilotus obovatus

Asteraceae

Calotis multicaulis
Gnephosis eriscarpa
Helichrysum popolepidium
Helipterum moschatum
Ixeolaena tomentosa
Minuria cunninghamii
Minuria denticulata
Minuria leptophylla
Myriocephalus stuartii
Pluchea tetranthera
Pterocaulon sphacetalum
Rutidosis helichrysoides
Senecio gregorii
Sphaeranthus indica
Stenopetalum lineare

Boraginacaeae

Heliotropium sp.

Brassicaceae

Blennodia sp.

Caesalpinaceae

Cassia desolata
Cassia helmsii
Cassia nemophila var nemophila
Cassia nemophila var coriacea
Cassia oligophylla
Cassia phyllodinea

Caryophyllaceae

Polycarpaea spirostylis sbsp. glabra

Chenopodiaceae

Arthrocnemum sp.
Atriplex fissivalvis
Atriplex vesicaria
Atriplex limbata
Atriplex spongiosa
Bassia bicornis
Bassia diacantha
Bassia intricata
Bassia lanicuspis
Bassia tricuspis
Enchylaena tomentosa
Maireana aphylla
Maireana ciliata
Maireana coronata
Maireana georgii
Rhagodia nutans
Rhagodia spinescens
Salsola kali
Salsola kali var. strobilifera

Convolvulaceae

Evolvulus alsinoides

Cyperaceae

Cyperus sp.
Fimbristylis dichotoma

Euphorbiaceae

Euphorbia drummondii

Fabaceae

Crotalaria cunninghamii
Crotalaria eremaea
Psoralea cinerea
Rhynchosia minima

APPENDIX III: 2: b. (cont'd)

Frankeniaceae

Frankenia serpyllifolia
Frankenia uncinata

Geraniaeceae

Erodium crinitum

Goodeniaceae

Goodenia heterochila
Goodenia lunata
Goodenia sp.
Scaevola spinescens

Lamiaceae

Teucrium racemosum

Liliaceae

Bulbine alata

Loranthaceae

Loranthus exocarpii

Malvaceae

Abutilon otocarpum
Lawrencia glomeratus
Sida fibulifera
Sida pedunculata
Sida trichopoda

Meliaceae

Owenia acidula

Mimosaceae

Acacia peuce
Acacia ligulata (*A. bivenosa sbsp. wayii*)
Acacia ramulosa
Acacia tetragonophylla

Myoporaceae

Eremophila latrobei
Eremophila longifola
Eremophila maculata
Eremophila macdonnellii
Eremophila obovata

Myrtaceae

Eucalyptus microtheca

Poaceae

Aristida contorta
Astrebla pectinata
Dactyolenium radulans
Enneapogon avenaceus
Enneapogon polyphyllus
Enteropogon acicularis
Eragrostis desertorum
Eriachne aristidea
Eualia fulva
Iseilema vaginiflorum
Sporobolus actinocladus
Tripogon lolliiformis

Portulacaceae

Portulaca sp. aff. P. oleraca

Proteaceae

Hakea Leucoptera

Sapindaceae

Atalaya hemiglauca

Santalaceae

Santalum lanceolatum

Solanaceae

Nicotiana velutina
Solanum esuriale

Zygophyllaceae

Zygophyllum howittii
Zygophyllum amophyllum

Nearby: *Acacia cambagei*
Zygochloa paradoxa

APPENDIX III:2:c.

List of Plants collected at Andado Acacia peuce stand

Amaranthaceae

Ptilotus obovatus

Asteraceae

Brachycome tesquorum
Centipeda thespidioides
Ixiolaena leptolepis
Minuria sp
Pluchea tetranthera
Pterocaulon sphacetalum
Streptoglossa sp.

Boraginaceae

Heliotropium filaginoides

Caesalpinaceae

Cassia nemophila var. nemophila
Cassia nemophila var. zygophylla
Cassia helmsii
Cassia sturtii
Cassia pruinosa
Cassia phyllodinea

Chenopodiaceae

Arthrocnemum sp.
Atriplex limbata
Atriplex vesicaria
Babbagia sp.
Bassia bicornis
Bassia intricata
Bassia paradoxa
Bassia parallelicuspis
Bassia tricuspis
Enchylaena tomentosa
Maireana aphylla
Rhagodia nutans
Rhagodia spinescens
Salsola kali

Caryophyllaceae

Polycarpaea spirostylis sbsp. glabra

Cyperaceae

Fimbristylis dichotoma

Euphorbiaceae

Euphorbia tannensis sbsp. evemophila
Phyllanthus sp.

Fabaceae

Rhynchosia minima

Frankeniaceae

Frankenia planifolia
Frankenia uncinata
Lamiaceae
Morgania glabra

Loranthaceae

Loranthus exocarpii

Malvaceae

Abutilon halophilum
Hibiscus brachysyphonius
Lawrencia glomeratus
Sida fibulifera
Sida pedunculata
Sida trichopoda

Marsi

Mimosaceae

Acacia peuce
Acacia tetragonophylla
Acacia ligulata

Myoporaceae

Eremophila macdonnellii
Eremophila obovata

Myrtaceae

Eucalyptus microtheca

APPENDIX III:2:c (cont'd)

Goodeniaceae

Goodenia spp

Poaceae

Aristida contorta
Astrebla pectinata
Diplachne muelleri
Enneapogon avenaceus
Enteropogon acicularis
Eragrostis desertorum
Eragrostis eriopoda
Eragrostis falcata
Eragrostis xerophila
Iseilema sp.
Sporobolus actinocladus
Tripogon lolliiformis

Portulacaceae

Portulaca sp. aff. P.oleraca

Sapindaceae

Atalaya hemiglaura
Dodonaea angustissima

Solanaceae

Solanum ellipticum
Solanum quadriloculatum
Solanum tumuticola

Nearby:

Santalum lanceolatum
Acacia aneura
Acacia pickardii
Canthium latifolium
Eremophila latrobei
Eremophila longifolia
Eremophila strongylophylla
Eucalyptus terminalis
Hakea leucoptera

APPENDIX III:2:d

Two photograph recognition points were established within the main Boulia stand.

1. 100m east of Boole bore Montagu Downs. (139°55'E, 23°4'S.) Photos taken at 0°N, 90°E, and 180°S. (see below)
2. 100m at bearing 320° from the northern gate post separating Mudgeacca and Montagu Downs on the track between the two stations (139°55'E, 23°2'S). Photos taken at 0°N, 270°W, 300°. (see below.)

Point I.

90° E

180° E

0° N

Point 2.

0^{o} N

300^{o}

270^{o} W

APPENDIX III:2:d

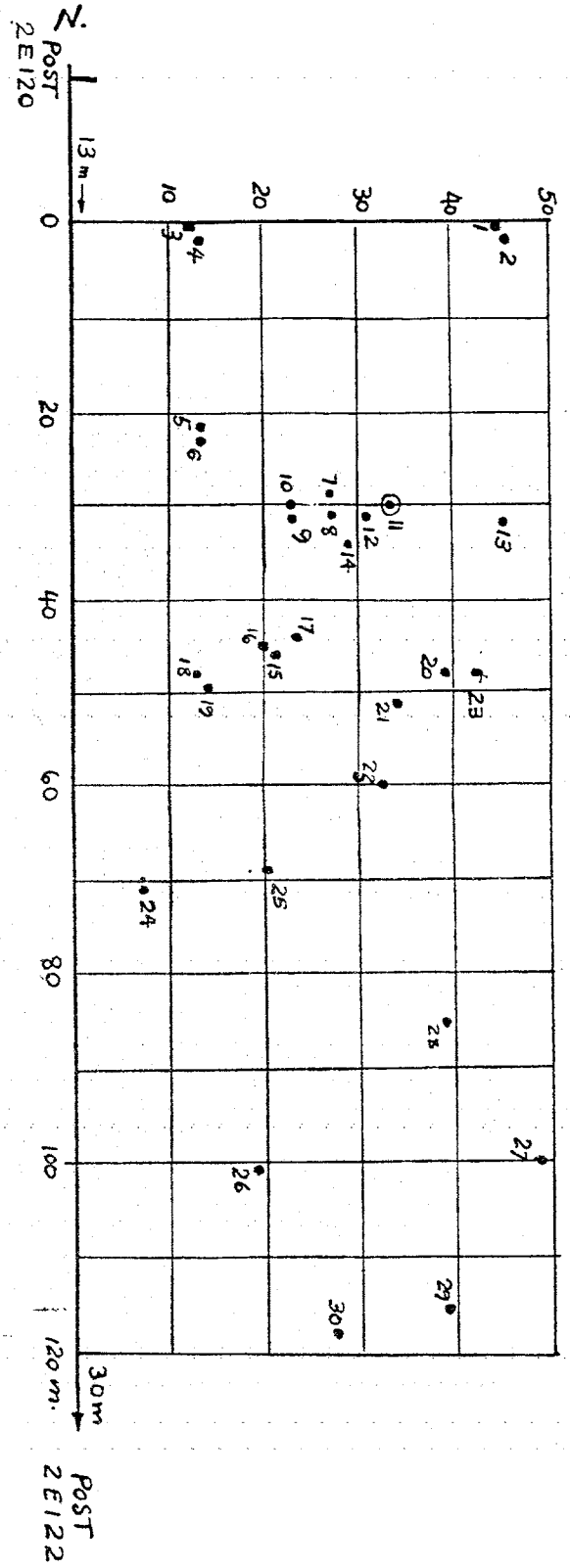
A permanent plot was established outside the main stand along the main road from Boulia to Bedourie, near Montagu downs (23°1'S, 139°49'E). This site is along the telegraph line on the east side of the road 15km north of the dingo fence at the boundary of Marion Downs. A plot was laid out to include 30 trees occurring within 50m east of the telegraph line between the two posts 2E:120 and 2E:122. The plot is 130m long (see diagram below) beginning 13m south of post 2E:120. Within the plot the location and height of all *A. peuce* were recorded.

(see over page)

Permanent Data points at Boulia

point 3. East side of main road to Bedourie telegraph lie between post 2E120 and 2E122 15km north of dog fence.

Tree No.	Height (m)	D.B.H. c
1	3.0	-
2	4.6	11.7
3	.4	-
4	.2	-
6	4.5	-
7	.3	-
8	3.0	-
9	3.8	-
10	2.4	-
11	7.6	22
12	1.3	-
13	3.5	-
14	2.6	-
15	3	-
16	.7	-
17	1.5	-
18	.7	-
19	1.8	-
20	3.5	-
21	4.5	-
22	.5	-
23	4.0	-
24	3.5	-
25	5.6	-
26	1.8	-
27	2	-
28	6.4	13
29	4	-
30	3.5	-



APPENDIX IV:2:a

Distribution of Species within the Families
Represented at *A. peuce* stands

Family	Number of Species		
	Boulia	Birdsville	Andado
Aizoaccae	-	2	-
Amaranthaceae	2	2	1
Apocynaceae	1	-	-
Asteraceae	7	14	6
Boraginaceae	1	1	1
Brassicaceae	1	1	-
Caesalpinaceae	7	6	6
Capparidaceae	3	-	-
Caryophyllaceae	1	1	1
Chenopodiaceae	8	19	14
Convolvulaceae	1	1	-
Cyperaceae	1	2	1
Ehretiaceae	1	-	-
Ephorbiaceae	-	1	2
Fabaceae	4	4	1
Frankeniaceae	1	2	2
Geraniaceae		1	
Goodeniaceae	-	4	2
Lamiaceae	1	2	-
Liliaceae	?	1	?
Loranthaceae	1	1	1
Malvaceae	4	5	6
Marselianceae	-	-	11
Meliaceae	1	1	-
Mimosaceae	3	4	5
Myoporaceae	4	4	2
Myrtaceae	3	1	1
Poaceae	13	12	12
Portulacaceae	1	1	1
Proteaceae	1	1	-
Rubiaceae	1	-	-
Sapindaceae	1	1	2
Santalaceae	-	1	-
Solanaceae	2	2	4
Zygophyllaceae	-	2	-

APPENDIX IV:2 C-14 age determination on *A. peuce*

The age of organic samples can be estimated by radiocarbon dating, using the radioactive half-life of the C-14 isotope (5730 ± 40 years) in equilibrium with living tissues, and assuming that carbon exchange with the environment ceased with the deposition of the sample.

Two problems are involved in estimating the age of a wood sample from a recently living tree by counting C-14 activity in a sample of its innermost rings:

- translocation of younger carbon compounds and chemical fractionation may have occurred radially within the trunk.
- secular variations in the C-14 production rate over the past 200 years with industrial combustion and release of older CO_2, and the Atom-bomb effect of increased atmospheric C-14 concentration since 1950 (Polach 1976:280).

Inconsistencies in the C-14 activity measurements of whole wood and its constituent chemical fractions, and the different chemical makeup of wood between species, have led to the view that the pure cellulose fraction may give the only reliable reading of tissue age (Head 1979). Calibration curves (e.g. Stuiver, 1974) based on multiple samples from well established tree ring chronologies enable the apparent age of a wood sample to be correlated with the secular variations in C-14 concentration to give a calender age, however for certain periods a single C-14 determination may cross this curve at a number of points.

A radiocarbon date was made available to determine the longevity of *A. peuce* by obtaining a count of C-14 activity from the centre of a tree with large diameter. A suitable sample was found at Boulia (40cm D.B.H.) felled in the last 10 years, with the centre of the trunk intact. The sample was prepared by removing a central vertical section containing the innermost (10-12 rings) from a height <.5m,

and submitted to the A.N.U. C-14 Lab. Separate C-14 counts were made on 40 gms of whole wood shavings and on 40gms treated to retain only the pure cellulose fraction. The latter sample was subjected to a series of solvent extractions designed to minimize solvent retention used by Head (1979) involving a:

- 2:1 Benzene-ethanol extraction for 6 hours
- Ethanol extraction for 6 hours
- pure water for 24 hours

This removed the extractives leaving 32.8 grams from the original sample, to a large, 18% extractive component of wood.)

The remainder was further subjected to a chlorite leach, 8gm sodium chlorite in 1 litre of water at pH3 followed by a sodium hydroxide leach to remove the lignin and hemicellulose components leaving only celluloses.

The C-14 counts obtained from these two samples differed markedly, and contrary to expectation the pure cellulose fraction yielded a much younger age than whole wood, although the ages of both are too young to place tight accuracy limits on them.

Results

	C14	
Sample	Apparent age	Calibration age
whole wood	110 ± 20	140 ± 20
pure cellulose	younger than modern	
ring count		127 - 165

There are two alternative explanations for this result. Firstly that contamination by younger carbon did occur during the extraction process, and that the age for the whole wood sample is close to actual, as the ring count would suggest. Thus this sized (40cm D.B.H.) tree at Boulia may be only 150 years old. On the other hand the translocation of peltogynoids into the heartwood suggests a radial

mobility of carbon compounds within the trunk and it is possible that the wood provides storage for carbohydrates during growth phases (Head, 1980 pers. comm.). It is possible that some of these younger compounds may have been retained in the sample during extraction and are present in whole wood, therefore the sample may be considerably older, but probably <300 years.

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