CONSERVATION STATUS OF UPPERSTOREY MALLEE VEGETATION IN THE WESTERN MURRAYLANDS

Christine A. Jones

CONSERVATION STATUS OF UPPERSTOREY MALLEE VEGETATION IN THE WESTERN MURRAYLANDS, SOUTH AUSTRALIA.

Two volumes

Book One
1.Conservation assessment of Eucalyptus leucoxylon, Callitris preissii and Allocasuarina verticillata.
2. Botanical Lists -
Monarto Native Plantation : Warla and Monarto South
Monarto Conservation Park
Loomooloo Flora and Fauna Sanctuary
Loomooloo Heritage Area
Ferries McDonald Conservation Park

Book Two
1. Fragmentation
2. Regeneration
3. Revegetation
4. Natural Resources Information

First Published 1996
C. Jones
Monarto South
South Australia 5254

ISBN: 1 875949 15 1

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1996

BOOK TWO

BOOK TWO

Part 5 continued

PART 6: Land Use practices

Part 6 continued

BOOK TWO

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EXPLANATORY NOTE

The preparation of this research paper has been wholly self funded. I gratefully acknowledge the assistance provided by the Department of Environment and Natural Resources, Primary Industries SA, and the University of Adelaide for their input and support.

The document is intended to be a valuable resource on the status of upperstorey vegetation in the study area, while also providing background information on land use and capability.

While the data and information compiled on the district is not complete, it does provide sufficient information on the natural resources and offers alternative suggestions towards income diversification, properly planning and land management.

This Research Project has been divided into several parts, comprising two books.

In Book One the project is explained, the area selected, its background given, target species outlined and botanical listing and assessment occurs.

Book Two is a continuation of the assessment process but also provides information on fragmentation, regeneration, revegetation and natural resources.

PART ONE

FRAGMENTATION

Habitat fragmentation impacts on population viability, and may lead to extinction.

Such causes may be human influenced through encroachment and interference, poaching, and introduction of 'alien' species; or may be a natural consequence of particular events resulting from micro-climate changes, genetic defects, or other threats.

A population with density dependent dynamics will experience random fluctuations in population size that may lead to extinction. There will also be an increased risk of greater extinction rates when an area in question is discontinuous. (Burkey,1989:79)

Small and fragmented reserves play an important role in conserving local endemic species (Terborough,1974; Terborough & Winter 1983) particularly those with low area dependency requirements.

NATURE CONSERVATION

Flora

Clearing and grazing of mallee vegetation has had a significant adverse impact on the conservation status of mallee plant communities particularly that of the pinkgum / blugum / sheoak and pine communities.

Fauna

Clearing for cereal crops, grazing by livestock and feral animals and the spread of introduced plants has resulted in the loss and modification of wildlife habitat.(MVMWG 1991) The remaining remnant vegetation provides a very valuable habitat for vulnerable, endangered and rare species. Of particular note is the avifaunal habitat provided for Leiopoa ocellata (malleefowl) in the Hundred of Freeling.

TABLE 1

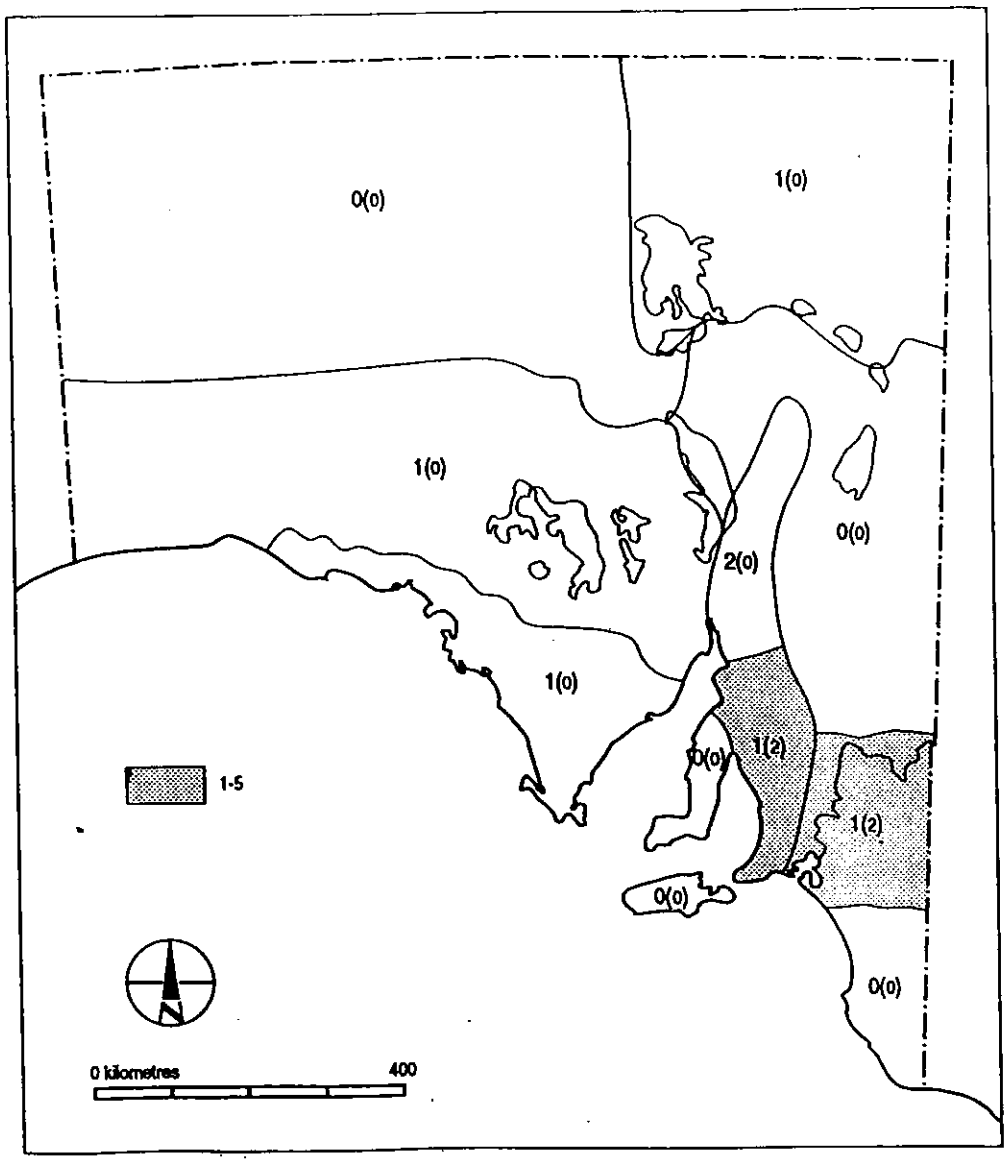
Causes of extinction and threats to endangered taxa in South Australia
Source: Leigh and Briggs (1992)

Threats	Agriculture	Grazing	Low nos.	Roadworks	Weeds	Fire	Recreation	Urban development	Forestry	Mining	Others
Presumed extinct	3	4									1#
Past threats to endangered taxa	16	15		3	4	1		2			3*
Present and future threats to endangered taxa	2	19	6	13	15	2		1			8°

\# 1 Unknown

* 1 Railway maintenance
1 Clearing
1 Stock damage

° 2 Salinity
2 Railway maintenance
1 Drainage
1 Quarrying
1 Stock damage
1 Clearing



MAP 1 *Numbers of plant species extinct in each region of South Australia*
Source: Leigh et al. (1984) and Leigh and Briggs (1992)
Figures from latter source in brackets

PLANTS OF SIGNIFICANCE IN THE SOUTH AUSTRALIAN MALLEE REGION

Species	Status	
Acacia menzelii (Menzel's wattle)	V	
A.pinguifolia (fat leaved wattle)	E	
A.rhetinocarpa (wattle)	V	
A.rhigiophylla (dagger leaved wattle)	R	
Boronia edwardsii (island boronia)	R	
Daviesia pectinata (barb wire bush)	R	
Dodonaea subglandulifera	E	presumed extinct
D.tepperi	E	
Eragrostis infecunda	V	
Haloragis eichleri	R	
Halosarcia flabelliformis (samphire)	V	
Lepidium pseudoruderale	R	
Microlepidium pilosulum	R	presumed extinct
Myriophyllum porcatum (ridged water milfoil)	V	
Phebalium brachyphyllum	R	
Pimelea williamsonii (Williamson's riceflower)	R	
Poa halmaturina	R	
Prostanthera euryboides	E	
Pterostylis sp.3	E	
Senecio macrocarpus	V	presumed extinct
Spyridium spathulatum	R	
Stipa nullanulla (spear grass)	R	
Swainsona laxa (yellow swainsona pea)	V	
Thelymitra epipactoides (metallic sun orchid)	E	
Zannichellia palustris	R	

National rating: rare (R), vulnerable (V), endangered (E)
Presumed extinct within South Australian portion of the mallee region.

Terms defined by Leigh (1981) in accordance with IUCN terminology as follows:
'endangered' - in serious risk of disappearing from the wild state within one or two decades if present land use and other causal factors continue to operate.

'vulnerable' - not presently endangered but at risk over a longer period of time through continued depletion, or largely occur on sites likely to experience changes in land use which would threaten the survival of this species in the wild.

'rare' - not currently considered to be endangered or vulnerable, may include species with large population but very restricted distribution.

Plant Species of conservation significance in the Murray Mallee

Species	Family	Kraehenbuehl/Lang score
Cryptandra uncinata	Rhamnaceae	18
Senecio behrianus	Compositae	18
Stipa mundula	Graminae	18
Caladenia leptochila	Orchidaceae	17
Dodonaea tepperi	Sapindaceae	17
Haloragis eichleri	Haloragaceae	17
Millotia macrocarpa	Compositae	17
Prostanthera eurybioides	Labiatae	17
Acacia rhigiophylla	Leguminosae	16
Boronia edwardsii	Rutaceae	16
Digitaria ciliaris	Graminae	16
Enneapogon clelandii	Graminae	16
Lepidium monoplocoides	Cruciferae	16
Maireana pentagona	Chenopodiaceae	16
Thelymitra epipactoides	Orchidaceae	16
Brachycome melanocarpa	Compositae	15
Calochilus campestris	Orchidaceae	15
Echinochloa lacunaria	Graminae	15
Parahebe decorosa	Scrophulariaceae	15
Phlegmatospermum eremaeum	Cruciferae	15
Senecio megaglossus	Compositae	15
Stipa hemipogon	Graminae	15
Danthonia pilosa var. pilosa	Graminae	14
Phebalium brachyphyllum	Rutaceae	14
Pimelea curviflora ssp. gracilis	Thymelaeaceae	14
Scutellaria humilis	Labiatae	14
Pteris tremula	Pteridaceae	14
Stipa exilis	Graminae	14
Swainsona laxa var.laxa	Leguminosae	14
Trachymene anisocarpa	Umbelliferae	14
Vittadinia cuneata var. murrayensis	Compositae	14
Acacia rhetinocarpa	Leguminosae	13
Atriplex inflata	Chenopodiaceae	13
Dianella laevis	Liliaceae	13
Haeckeria pholidota	Compositae	13
Adiantum capillus-veneris	Adiantaceae	12
Bossiaea walkeri	Leguminosae	12
Eragrostis elongata	Graminae	12
Frankenia uncinata	Frankeniaceae	12
Orobanche cernua var. australiana	Orobanchaceae	12
Stackhousia megaloptera	Stackhousiaceae	12
Trymalium wayae	Rhamnaceae	12

Calostemma luteum	Amaryllidaceae	11
Daviesia benthamii ssp. benthamii	Leguminosae	11
Dodonaea subglandulifera	Sapindaceae	11
Lepidium pseudohyssopifolium	Cruciferae	11
Logania nuda	Loganiaceae	11
Pimelea williamsonii	Thymelaeaceae	11
Vittadinia cuneata var. morrissii	Compositae	11
Christella dentata	Theypteridaceae	10
Eucalyptus cyanophylla	Myrtaceae	10
Psoralea pallida	Leguminosae	10
Ptilotus seminudus	Amaranthaceae	10
Stellaria filiformis	Caryophyllaceae	10
Acacia montana	Leguminosae	9
Bursaria lasiophylla var. albicoma	Pittosporaceae	9
Maireana rohrlachii	Chenopodiaceae	9
Templetonia sulcata	Leguminosae	9
Teucrium corymbosum	Labiatae	9
Acacia lineata	Leguminosae	8
Cymbopogon obtectus	Graminae	8
Geijera parviflora	Rutaceae	8
Glycyrrhiza acanthocarpa	Leguminosae	8
Helichrysum adenophorum	Compositae	8
Hydrocotyle pilifera	Umbelliferae	8
Micromyrtus ciliata	Myrtaceae	8
Millotia tenuifolia var. nudescens	Compositae	8
Pachycornia triandra	Chenopodiaceae	8
Scaveola depauperata	Goodeniaceae	8
Scleranthus minusculus	Caryophyllaceae	8
Thelymitra canaliculata	Orchidaceae	8
Lepidium leptopetalum	Cruciferae	7
Swainsona microphylla ssp. minima	Leguminosae	7
Acacia pinguifolia	Leguminosae	
Acanthocladium dockeri	Compositae	
Brachiaria notochthona	Graminae	
Brachiaria piligera	Graminae	
Brachycome tesquorum	Compositae	
Cryptandra propinqua	Rhamnaceae	
Haloragis odontocarpa forma pterocarpa	Haloragaceae	
Senecio platylepis	Compositae	
Spyridium bifidum var. bifidum	Rhamnaceae	
Westringia dampieri	Labiatae	

FAUNA

Status of native fauna

The Murray-Darling Basin Ministerial Report (1991) has identified a number of key issues relevant to the status and decline of flora and fauna in the region. Agriculture has been identified as the major cause affecting the distribution and abundance of native flora and fauna. Clearing for cereal crops, grazing by livestock and feral animals and the spread of introduced plants and animals has resulted in further significant losses and modification of habitat. The remaining remnant vegetation and revegetated areas now provide valuable habitat for a number of endangered and rare species, along with additional wildlife corridors.

Without doubt mammals have suffered the greatest rate of extinction since settlement (Myers 1982). Small ground living species dependent on native grasses and herbage for food and shelter have had to compete with other herbivores and have fallen prey to foxes and cats. Myers (ibid) recorded some 270 bird species for the region, however one third of these are now classified as being endangered, vulnerable or rare. Some of these include Leipoa ocellata (mallee fowl), Stipituris mallee (mallee emu-wren), Pachycephala rufogularis (red-lored whistler), Manorina melanotis (black-eared miner) and Pedinomus torquatus (Plains wanderer).

Declining native fauna numbers seem markedly opposed to the increasing numbers of feral pests. Agriculture has also been responsible for the increase in numbers of particular native fauna species such as the Western grey kangaroo (Macropus fuliginosus) and seed feeding birds such as galahs, pigeons and corellas, which must affect ecological balance and biodiversity.

The theoretical framework of a fragmentation model for particular areas of woodland and bird species, addresses the areas as islands of habitat in a hostile surrounding grassland. The theory of island biogeography emphasises the importance of area and isolation and predicts that fragments will have fewer species as they become smaller and more isolated. (MacArthur & Wilson,1963; Diamond 1975) This is because bird species on edges of distribution are sensitive to disturbances. Marginal species are therefore more likely to have 'specific habitat requirements and so perceive even the unaltered landscape as fragmented.'(Barrett,Ford & Recher1993:253)

Recognizing and promoting the conservation value of sub-optimal habitat, or disturbed areas between large areas of undisturbed habitat such as nature reserves, state forests and national parks, is a step closer to establishing community based conservation. Landholders can contribute positively to regional biodiversity with sympathetic management of their land towards species diversity. (Barrett, Ford & Recher,1994:254)

BIRDS

There is ornithological concern over declining numbers of birds on a global scale, as a result of habitat clearing and fragmentation. Australia in particular, appears to face widespread decline in woodland bird species of agricultural and pastoral areas. (Howe,1984; Saunders, 1989, 1990, 1993; Robinson 1991 and Garnett 1992.)

Management guidelines for landowners are necessary to protect and enhance species richness. Barrett and Ford (1993) summarized some necessary guidelines for landowners interested in attracting woodland birds to their properties. These included:

1.Maintain or replant existing understorey.
2.Maintain a mixture of local tree and shrub species.
3.Exclude grazing stock from some areas to allow native grasses and legumes to develop.
4.Tolerate moderate levels of mistletoe, as they attract many species, especially honeyeaters.
5.Maintain a range of tree age classes. If large old trees are absent provide nest boxes.
6.Leave fallen trees and large woody debris to break down naturally.
7.Protect or establish vegetation beside creeks and rivers.
8.Link larger, healthy patches of woodland with strips of native vegetation that are as wide as possible.
9.Give management priority to remnants that are 20 hectares or larger and where lacking increase the size of smaller wood lots by encouraging regeneration or planting around boundaries.

Similar recommendations were provided by Recher (1993) for the restoration of degraded ecosystems. Minimal effort is required, yet goals are achievable and compatible with sustainable agricultural practices which provide long term economic benefits to the landowner and community. (Breckwoldt,1986; Davidson & Davidson 1992, Hobbs et al. 1993)

The retention of large existing patches of scrub or woodland by landowners, and the increase in size of others will allow balancing of conservation efforts. This will accommodate for the inevitable losses that occur. Landowners should aim for the retention of about 10% of tree cover for sustainable land management. (Bird et al,1992)

Community co-operation is possible, with co-operative efforts of adjoining landholders and integrated management plans. Management should be broadscale focussing not only on rare, endangered of threatened species but also on common native species, as all are subject to decline. (McIntyre et al,1992)

Authorities and landowners should work towards the integration of management for nature conservation purposes.

Birds of conservation significance in the Murray Mallee.

Scientific Name	Common Name	Rarity score	Habitat dependence
Manorina melanotis	Black-eared Miner	1	Heavy
Pachycephala rufogularis	Red-lored Whistler	2	Heavy
Stipiturus mallee	Mallee Emu-wren	2	Heavy
Pedionomus torquatus	Plains-wanderer	2	Moderate
Leipoa ocellata	Malleefowl	3	Heavy
Polytelis anthopeplus	Regent Parrot	3	Heavy
Burhinus grallarius	Bush Thick-knee	3	Moderate
Neophema splendida	Scarlet-chested Parrot	3	Moderate
Coturnix australis	Brown Quail	3	Little
Lophoictinia isura	Square-tailed Kite	3	Little
Ninox connivens	Barking Owl	3	Little
Philemon citreogularis	Little Friarbird	4	Heavy
Psophodes nigrogularis	Western Whipbird	4	Heavy
Amytornis striatus	Striated Grasswren	4	Heavy
Ardeotis australis	Australian Bustard	4	Moderate
Certhionyx niger	Black Honeyeater	4	Moderate
Certhionyx variegatus	Pied Honeyeater	4	Moderate
Coracina papuensis	White-bellied Cuckoo-shrike	4	Little
Emblema bellum	Beautiful Firetail	4	Little
Lichenostomus fuscus	Fuscous Honeyeater	4	Little
Neophema chrysostoma	Blue-winged Parrot	4	Little
Oriolus sagittatus	Olive-backed Oriole	4	Little
Petroica phoenicea	Flame Robin	4	Little
Turnix pyrrhothorax	Red-chested Button-quail	4	Little
Acanthiza iredalei	Slender-billed Thornbill	5	Heavy
Cacatua leadbeateri	Pink Cockatoo	5	Heavy
Caprimulgus guttatus	Spotted Nightjar	5	Heavy
Cinclosoma castanotum	Chestnut Quail-thrush	5	Heavy
Corcorax melanorhamphos	White-winged Chough	5	Heavy
Entomyzon cyanotis	Blue-faced Honeyeater	5	Heavy
Pachycephala inornata	Gilbert's Whistler	5	Heavy
Plectorhynchus lanceolata	Striped Honeyeater	5	Heavy
Sericornis brunneus	Redthroat	5	Heavy
Climacteris affinis	White-browed Treecreeper	5	Moderate
Coracina maxima	Ground Cuckoo-shrike	5	Moderate
Neophema elegans	Elegant Parrot	5	Moderate
Stipiturus malachurus	Southern Emu-wren	5	Moderate
Struthidea cinerea	Apostlebird	5	Moderate
Turnix varia	Painted Button-quail	5	Moderate
Calyptorhynchus funereus	Yellow-tailed Black-cockatoo	5	Little
Emblema guttatum	Diamond Firetail	5	Little
Acanthiza nana	Yellow Thornbill	6	Heavy
Lichenostomus cratitius	Purple-gaped Honeyeater	6	Heavy
Chrysococcyx osculans	Black-eared Cuckoo	6	Moderate
Geopelia placida	Peaceful Dove	6	Moderate
Lichenostomus plumulus	Grey-fronted Honeyeater	6	Moderate
Myiagra inquieta	Restless Flycatcher	6	Moderate

PART TWO

NATURAL REGENERATION

Venning and Croft (1983) suggested that the essential requirements for the establishment of natural regeneration are low grazing pressure, lack of weed competition, above average rainfall and a natural remnant setting. They noted the coincidence of high rainfall patterns and regeneration.

My own study and the trends of regeneration however do not entirely support this theory.
On our own property, and others on poorer, sandy, calcrete, non-wetting soils, natural regeneration has been occurring over the past thirty years. There has been some grazing pressure due to invasive stock, but this has ceased on our property entirely in the past five years. With the cessation of grazing came a higher incidence of weed growth, particularly around the edges of the property adjacent to pasture lands.

The central core area had very little weed growth, naturally regenerating understorey, healthy plants, and a diversity of fauna and avifauna species. The most noticeable weed was that of Asclepias, and the odd South African daisy introduced from a neighbouring property by wind and birds. The insect life was rich, reptiles were abundant, and a diverse range of rare flora and orchids were present. It could be said that it was in a balanced state. This central core area has changed only slightly with the further intrusion of pasture weed species, and the natural senescence of some species.

Regeneration has been occurring and is evident particularly with Callitris, Eucalyptus leucoxylon, Acacia, shrubs, compositae species, understorey plants, grasses and orchids. Pasture weeds have also increased in variety. On previously cleared areas regeneration with understorey species has occurred. Our rainfall patterns have been reducing with a good year of 500mm rainfall followd by five years of drought of less than 250mm rainfall per year. Regeneration may be assisted by good falls, however it has been progressing well with reducing amounts of rainfall per year.

Some older species however have not been able to cope with increasing salinity and reduced rainfall levels. I have noted the death of isolated mature Eucalyptus species, particularly E.fasciculosa and E.odorata, Acacia and Exocarpus. This finding has also been borne out with other mature vegetation in other parts of the Western fringe zone.

Prolific regeneration of eucalypts and acacias does occur from time to time, and may or may not be related to higher rainfall. More importantly regeneration does occur when rabbits are controlled, the use of vehicles and human impact is minimal, and there is an absence of stock.

In the five years of drought, we have had minimal rabbit damage (1 active warren over 40 ha.), and a plethora of natural and unnatural conditions which may or may not have affected regeneration, or the balance of natural ecosystems. These include:

1. higher numbers of mice, snakes, snails, rabbits, feral cats
2. higher numbers of native fauna population
3. higher incidence of disease - Murray Valley encephalitis, kangaroo blindness
4. higher incidence of insect infestation- borers, sawflies, moths, galls
5. controlled use of 1080, Fox-off and strychnine for vermin control
6. limited use of weedicide
7. reducing rainfall, high winds, temperature extremes- daytime 45 degrees and up over a period of weeks; overnight temperatures below zero, early morning frosts,
8. controlled burning in patches
9. increased human impact- seed and flora collection
10. introduction and removal of bee hives (introduced bees)
11. increased aerial traffic from nearby gliding club

Regeneration has occurred in all areas regardless of level of human impact, with no observable differences.

Neighbouring paddock regeneration has occurred since the removal of stock, with a proliferation of such species as Dodonaea, Melaleuca and Callitris over the past two years. However weeds have increased particularly Salvation Jane, Skeleton weed, Innocent Weed, Evening Primrose and Dandelion, and hence the increased number of species into our own property. Measures of control are aimed at the edge.

Our own practices of control give credence to the principles of Breckwoldt (1983) and others (Siepen 1983, Venning 1984) outlined for regeneration of native species to occur. These are that:

* grazing by rabbits and livestock must be excluded, and
* weed competition for soil moisture and nutrients must be minimised.

Appreciating that weeds are aggressive colonisers of disturbed sites, we can expect that weed numbers will increase particularly as revegetation and direct seeding has occurred around the edge. The use of fertilisers in cropping systems by adjoining owners will also tend to increase the weed cover and infiltration rate. However some effects may be negated by our revegetation efforts. Increased rainfall may assist the native species over the weeds providing hand pulling of weeds occurs. Ongoing management will be necessary. Regeneration should occur given these factors, and allowing for the progression of time.

REGENERATION OF ARID ZONE TREES IN WESTERN FRINGE ZONE MURRAY MALLEE

The study concentrates on the following arid woodland tree species - Callitris, Casuarina, and Eucalyptus species. The predominant vegetation is Callitris, Eucalyptus leucoxylon / odorata / porosa / calycogona , Melaleuca lanceolata, Acacia halliana, Allocasuarina verticilllata.

These species have been determined for the purposes of this study, as being the natural composition of the associated communities. These were determined by reference to relatively undisturbed examples and regeneration characteristics. These were determined through:

* Assessment of germination characteristics
* Assessment of the effects of disturbance
* Assessment of regeneration within exclusion plots.

Outcomes

Assessment of reproductive strategies in the field indicate that despite the age and senescence of many of the remaining trees, flowering and fruiting is prolific with large quantities of seed produced in most years. The seed viability and high production ensures the availability of viable seed when soil conditions are suitable for germination. Stock grazing and pressure from persistent defoliation effects young seedlings dramatically.

I have found that clearing of trees in an attempt to increase pasture growth and collection of mallee roots for firewood has modified the vegetation. Regeneration is particularly prolific where there has been no major soil disturbance over a period of years.

Implications

The long term survival of these communities is under threat unless steps are taken to modify grazing levels to allow regeneration when there is suitable climatic events. Regeneration can take place alongside moderate stock grazing provided grazing pressures from rabbits, hares and kangaroos can be kept at a low level.

There is clear documented evidence of other sites showing recovery of tree dominants and woody species when protected from grazing.

POLLINATION REQUIREMENTS of native plants

Mutualistic relationships, such as those occurring between plants and their native pollinators, are very sensitive to perturbance. Such relationships may be questioned when native plants fail to set their full complement of seed. Are there a lack of pollinators, or perhaps some other reason, to explain these events.

Paton (1993) suggests that in most instances there is a lack of pollinators, and:

> the populations are no longer able to survive in or recruit into patches of vegetation in adequate numbers at appropriate times to fully service the plants. (Paton,D.1993)

Some relevant hypotheses for questioning then include:
(1) Does plant species X need to be cross pollinated to set seeds?
(2) Which animals are important pollinators of plant species X?
(3) Do these animals provide adequate pollination services, or does the plant fail to set a full complement of seed?
(4) Do honeybees add or detract from the plant's ability to set seeds?

Population structure (size classes) of native trees

Age structure has altered dramatically in the remnant vegetation, and natural change has become an adaptation to events and time. In the woodland, species were planted over a period of 5-6 years, with losses being re-planted with alternative species. Today the plantings are about 20 years old. Selective cutting, loss of young seedlings due to rabbit, hare and kangaroo foraging, horse riding and dog trials, stock and changing soil conditions have had an impact. The use of the woodland for a variety of purposes including recreation and research may have also contributed to loss of species or individual plants. Rural dieback and a combination of factors such as exposure, grazing, altered water tables, ground water recharge, all contribute to tree decline.

Some hypotheses would include:
(1) What are the proportions of the different sizes of individual trees of species Y that remain on rural properties?
(2) Does the average size of the trees vary with topography or aspect?
(3) Are there any seedlings present? If not, why not?
(4) Do the sizes of the trees for Species Y vary between scrub and paddock locations?

In all of my investigations in the woodland, dominant species are predominantly locally endemic species that have adapted to changing conditions, soil structure, land use etc. The majority of surviving trees are doing well, even though they have been subjected to insect infestation, weed and feral pests. Most trees maintain healthy heights in association with remnant stands. Some plants on poorer soils however are struggling, and many have succumbed in the past. Those struggling face competition from weeds and the stronger more well established species that have suckered or regenerated freely, particularly certain Acacia species and Pittosporums. Mistletoe remains a large problem suggesting that bird numbers are high and assist in pollination of plants, however in uncontrolled infestations the mistletoe does cause death of the tree .

On rural properties, dominant species tend to be the mallee eucalyptus, and callitris species which have been used predominantly as windbreaks, and shelterbelts. Where these plantings represent a considerable tract of land, and have been fenced off from stock and paddock useage, regeneration is occurring of native species both understorey and Callitris pines.

Mallee eucalypts tend to set and drop large amounts of seed, however it is only just prior to the parent tree collapsing or dying that juvenile trees can be found. These juveniles tend to be uniform in height, size and development further emphasising the emergence as the season prior to the death of the parent tree. This was also apparent in parts of the woodland where particular Eucalypt species had large numbers of juvenile trees ready to take the place of a collapsed and dying tree.

This was different to the Callitris, which had a particular number of trees germinate each season. Structured layers ranging from 15 cm to 4 metres were evidenced, with parent trees being quite old and large. Deaths of callitris tended to be in smaller trees growing close together, or in transplanted/ revegetated sites. Major disturbances evidenced contributing to tree decline were predominantly rabbit warrens with multiple holes, and echidna diggings.

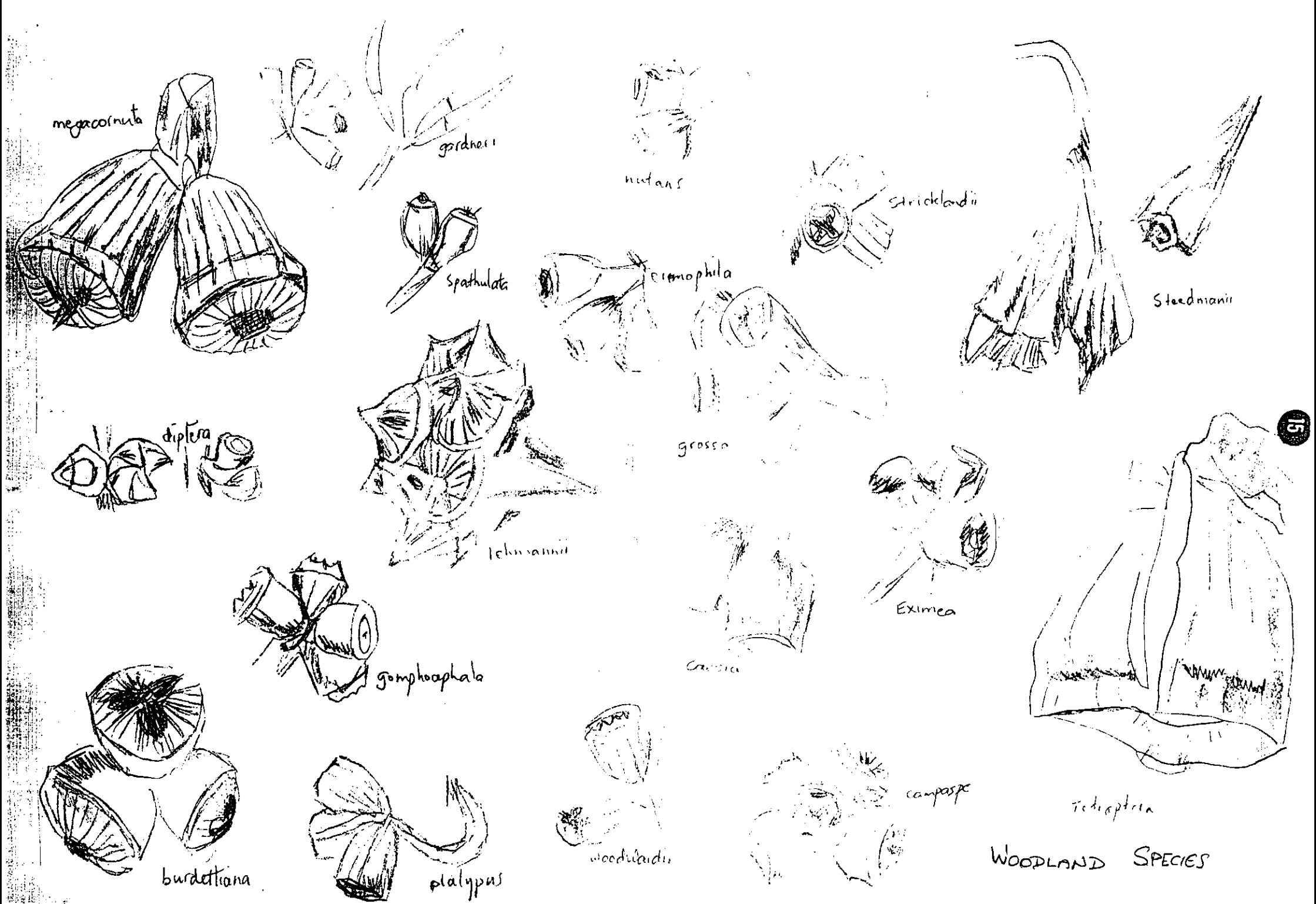
Particular insect scale and discoloration was evidenced on particular trees in the Woodland. Orchids which are noted to be pollinated by insects were absent from the Woodland this season, yet occurred in remnant areas.

PART THREE

MONARTO WOODLAND EUCALYPTUS FLOWERING TIMES

The following flowering periods have been recorded during this study for the Eucalyptus species planted in the Monarto Woodland.

Eucalypt Name	Flowering period
anceps	Jan - Feb.
angulosa	Aug - Dec.
baxteri	Feb - mar
brachycalyx	Oct - Nov
calycogona	Nov - Dec
camaldulensis	Dec - Jan
cladocalyx	Jan - Feb
cneorifolia	Mar - Apr
conglobata	Nov - Feb
diversifolia	Sep - Nov
dumosa	Jun - Feb
fasciculosa	Dec - May
flocktoniae	Feb - Mar
foecunda	May - Jul ; Dec
gillii	Aug - Oct
gracilis	Apr - Aug
incrassata	Sep - Nov
intertexta	May - Jul
lansdowneana	Aug - Nov
leucoxylon	May - Dec
macrorhyncha	Feb
microtheca	Feb - Jul
morrissii	Nov - Dec
odorata	Mar - Aug
oleosa	May - Sep
oxymitra	Jul - Aug
pachyphylla	May - Jun
pileata	Nov - Dec
pimpiniana	Jul- Sep
porosa	Dec - Jan
pyriformis	Jul - Nov
rugosa	Jan - Feb
websteriana	May - Aug



WOODLAND SPECIES

It is relevant to point out some of the discrepancies in regard to choice and selection of species used in the Woodland which may also account for poor survival rates, growth patterns and seed yields. The species suggested for the plantings have a variety of site specific conditions, which are not entirely within the range of the Monarto sites. Some species requiring 450mm rainfall, have understandably been trialled with varying results.

It is worth pointing out to the intending tree planter that the outer limit of normal rainfall for the Pallamanna - Monarto - Hartley - Brinkley - Langhorne Creek - Murray Bridge areas is 400mm. The Bureau of Meteorology records indicate that the region receives between 250 and 400 mm rainfall per annum, and is subject to cyclic fluctuations in weather patterns, and tendencies to drought, wind and temperatures. While these conditions may have become more obvious since the area was planted, many of the species selected were better suited to areas above 450 mm rainfall. By comparison the hills escarpment and valley areas regularly receive falls in excess of 450 mm and may be as high as 800 mm.

The sites selected as buffer plantings along the S-E Freeway and Adelaide - Melbourne railway line consist of poorer leached soils, composed of sand over calcrete deposits with or without clays and loams. At the time of planting these soils were severely deficient in minerals and organic matter from extensive land clearance and cropping systems. These factors should have influenced the process of species selection.

While some local species were utilised, more extensive use and selection of indigenous plants was warranted. Selections appeared to be based on a handful of local species with more emphasis placed on hills vegetation types rather than Lower Murray and Coorong sand dune vegetation. Plantings could have included greater use of mallee tree species, such as Eucalyptus socialis, E.incrassata, E.fasciculosa, E.leptophylla, shrubs such as Melaleuca uncinata, M.acuminata, Leptospermum coriaceum, Hakea muelleriana, a range of locally indigenous Acacia species and other attractive understorey plants. A higher ratio of indigenous species to introduced species would have been more practical overall. Trial sites and species could have continued to provide details regarding potential uses and areas, and applicable planting ratios, and optimum growing conditions.

In relation to the species trialled and information supplied, it would have been practical to select more arid and semi-arid tolerant species, able to withstand minimum rainfall, higher temperatures and frost. From the records some tropical and subtropical species were planted, with many species requiring in excess of 450mm rainfall. These species have struggled to survive, and many have died.

Of particular note for Mónarto Woodland plantings locations 3-13 are the conditions required for the following species:

1974 and 1975 plantings

Species :	rainfall amount required/other conditions
Eucalyptus nicholii	650mm
Melaleuca linariifolia	650mm tropical/sub-tropical
Acacia pycnantha	600mm+
Eucalyptus astringens	500mm
Eucalyptus camaldulensis	500mm
Eucalyptus cneorifolia	500mm
Eucalyptus largiflorens	500mm
Acacia retinodes	450mm not calcareous soils
Acacia saligna	450mm
Agonis flexuosa	450mm
Brachychiton populneum	450mm
Callistemon citrinus	450mm
Casuarina cunninghamiana	450mm
Eucalyptus intertexta	450mm
Hakea laurina	450mm
Hakea multilineata	450mm
Melaleuca armillaris	450mm
Melaleuca nesophila	450mm
Pinus brutia	450mm

1976, 1977, 1978 plantings

Species :	rainfall amount required/other conditions
Acacia mearnsii	600mm
Eucalyptus cladocalyx	550mm
Platanus hybrida	550mm
Eucalyptus macrocarpa	500mm
Koelreuteria paniculata	500mm
Acacia sophorae	450mm
Eucalyptus cladocalyx nana	450mm
Eucalyptus fasciculosa	450mm
Quercus ilex	450mm
Acacia salicina	requires seasonal watercourses

Trial Species 1973- 1978

Species :	rainfall amount required/other conditions
Eucalyptus cinerea	700mm
Eucalyptus eximia	650mm
Acacia verniciflua	600mm
Eucalyptus sideroxylon	550mm
Eucalyptus falcata	500mm
Eucalyptus rhodanthe	500mm
Albizia lophantha	500mm
Eucalyptus lehmannii	450mm
Eucalyptus microtheca	450mm
Fraxinus oxycarpa	450mm

TREES WITH TENDENCY TO COLLAPSE in the wind with roots exposed

Eucalyptus brockwayii
Eucalyptus eremophila
Eucalyptus gardneri
Eucalyptus nutans
Eucalyptus platypus
Eucalyptus salubris
Eucalyptus sargentii
Eucalyptus spathulata

TREES WITH TENDENCY FOR LIMBS TO BREAK DOWN
Note: these are generally healthy trees heavily laden with seed and fruits.

Eucalyptus astringens
Eucalyptus cladocalyx
Eucalyptus forrestiana
Eucalyptus megacornuta
Eucalyptus pachyphylla
Eucalyptus pyriformis
Eucalyptus stricklandii
Eucalyptus transcontinentalis
Eucalyptus youngiana

TREES AND SHRUBS THAT ARE STRUGGLING
These trees and shrubs struggle in the existing soil and climatic conditions

Eucalyptus caesia
Eucalyptus desmondensis
Eucalyptus gilli
Eucalyptus lansdowneana
Eucalyptus macrocarpa
Eucalyptus orbifolia
Eucalyptus pyriformis
Eucalyptus tetraptera
Eucalyptus websteriana
Hakea petiolaris
Hakea grammatophylla
Hakea decaissneana
Hakea calcareana

TREES WITH NOTICEABLE LACK OF SEEDS
Eucalyptus microtheca

TREES AND SHRUBS WHICH PERFORM WELL
many would be ideal for garden plants

Most successful: (local species)
Callitris preissii
Allocasuarina verticillata
Eucalyptus leucoxylon
Eucalyptus camaldulensis
Eucalyptus incrassata
Eucalyptus socialis
Eucalyptus conglobata
Eucalyptus leptophylla
Eucalyptus fasciculosa
Eucalyptus calycogona
Eucalyptus porosa
Eucalyptus odorata
Eucalyptus gracilis
Eucalyptus rugosa
Eucalyptus oleosa
Eucalyptus cneorifolia
Melaleuca lanceolata
Leptospermum coriaceum
Leptospermum laevigatum

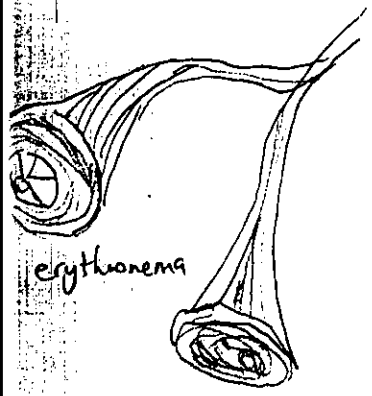
SUCCESSFUL SA species
Eucalyptus brachycalyx
Eucalyptus calcareana
Eucalyptus cladocalyx
Eucalyptus diversifolia
Eucalyptus gamophylla
Eucalyptus intertexta
Eucalyptus largiflorens
Eucalyptus microcarpa
Eucalyptus microtheca
Eucalyptus morrissii
Eucalyptus oxymitra
Eucalyptus pachyphylla
Eucalyptus peeneri
Eucalyptus pileata
Eucalyptus pimpiniana
Eucalyptus pyriformis youngiana
Eucalyptus transcontinentalis
Eucalyptus websteriana
Eucalyptus yalatensis
Eucalyptus yumburrana
Acacia murrayana
Acacia aneura
Myoporum platycarpum

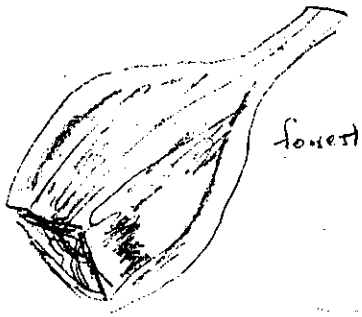
MOST SUCCESSFUL introduced species

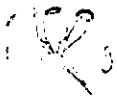
all Pinus species
all Casuarina species
all Melaleuca species
all Callistemon species
Eucalyptus burdettiana
Eucalyptus campaspe
Eucalyptus megacornuta
Eucalyptus nutans
Eucalyptus stricklandii
Eucalyptus steedmanii
Eucalyptus torquata

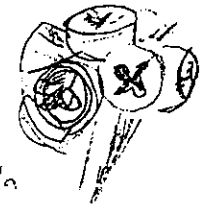
SUCCESSFUL introduced species

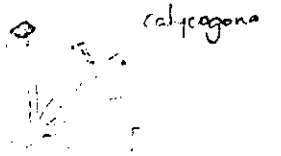
Eucalyptus astringens
Eucalyptus brockwayi
Eucalyptus dundasii
Eucalyptus erythronema
Eucalyptus erythrocorys
Eucalyptus gilleni
Eucalyptus globulus
Eucalyptus grossa
Eucalyptus kruseana
Eucalyptus lehmanii
Eucalyptus macranda
Eucalyptus microcarpa
Eucalyptus microtheca
Eucalyptus platypus
Eucalyptus pterocarpa
Eucalyptus redunca melanophloia
Eucalyptus salmonophloia
Eucalyptus salubris
Eucalyptus sideroxylon
Eucalyptus 'Torwood'
Eucalyptus woodwardii

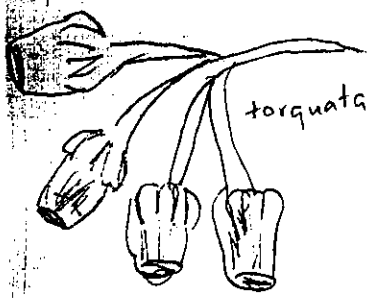


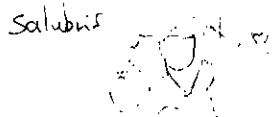


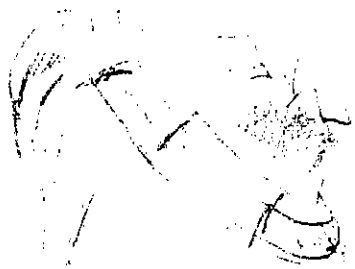












MONARTO WOODLAND SPECIES

PART FOUR

REVEGETATION PRACTICES

Over the past decade there has been a dramatic increase in tree planting programs both by individuals and community groups. Tree planting projects are more effective when appropriate species and provenance (seed sources) are used. (P.Bulman pers.comm)

Using the right species for the right area reduces failure rates because there is a pronounced reduced use of species beyond their range, more extensive revegetation stimulated by more successful projects and increased numbers of suitable species considered for a project.

Overall this assists increased total farm productivity by improving shelter from taller windbreaks, increasing life span and service from plantings because of better species selection. Plantings are located to protect crops, stock and land, and hence reduces costs with increased benefits and provides more reliable results for the same investment in revegetation. (Bulman,pers.comm)

Re-establishment of Native Vegetation

There are two methods for the re-establishment of Native vegetation. These are regeneration and revegetation, and the study area provides examples of both. The cost of revegetation of cleared land however may be up to 100 times more expensive than retaining the natural vegetation. (Cooke,pers.comm.; Jones 1995)

Regeneration refers to the natural process of re-establishment of a substantial cover from the remaining on-site natural vegetation. This is by way of the seed source or through a process of suckering. Regeneration may be assisted by the land manager by minimizing grazing pressure (reducing or eliminating stock), fencing off areas and weed control.

Revegetation refers to the practice of planting seedlings or direct seeding sown on site. Often additional species are included, as soil conditions have altered. The modified state of natural systems may be unable to support the original locally indigenous species. Such an example is evident where saline patches have been planted with salt tolerant species, which may or may not have occurred in the natural state. Another is the planting of nitrogen fixing species to add to the soil's depleted mineral reserves from previously cropped or grazed lands.

In either practice, seed viability and germination rates are infrequent. One of the main reasons for this is the removal of seed from soil by ants and other arthropods. Seedling establishment after germination is often doomed due to competition from other vegetation for soil moisture.

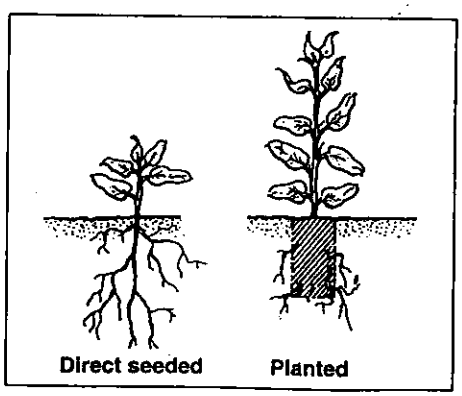
Direct seeding is a quicker method of establishment of vegetation but may not necessarily be a cheaper alternative. Direct seeding of trees and shrubs involves sowing seeds directly into the site where they are intended to grow, and is an alternative to planting nursery grown seedlings.

The practice allows for a much greater area to be mechanically sown in a shorter time frame. Direct seeding is generally estimated to cost as little as 10% of the cost of establishing nursery grown plants. Seeds are cheaper and easier to collect and sow than seedlings are to grow and plant. Direct seeding is the preferred alternative when large areas or large numbers of plants are required (eg.2-6000 plants per hectare).

However other costs may negate these benefits. These include the large scale disturbance of soil which may predispose a site to increased soil erosion or weed invasion, if germination rates are poor, and the increased volume of seed needed. The light covering of topsoil which is placed over the seed may be blown away, leaving the seed as an added food source for native fauna and feral pests further exacerbating the problem of soil and wind erosion.(Jones 1995)

Smaller or rocky areas can still be hand direct seeded using a fire rake, however regardless of direct seeding method light winged and fine seed cannot be sown. Understorey plants and that seed which cannot be utilised in a seeder must still be propogated and grown.

Tubestock growing while more costly in relation to water consumption and chemical use, is often a more viable option with a greater plant success rate. This is particularly the case in areas with poor or lightly textured soils or where there is limited soil moisture. (Jones 1995) Where only small areas of remnant vegetation exist and seed source is scarce, it is more practical to grow tubestock. This will assist in retaining the genetic stock until an adequate seed supply is built up.



▲ *In the early months direct seeded plants have better root systems than planted seedlings*

GROWTH FACTORS

The following growth factors have been taken from control sites at Loomooloo. Initial plantings 1985, other plantings 1990, 1991, 1993, direct seeding 1995. Tree growth patterns have been influenced by site conditions such as non-wetting sands, calcrete, drought (less than 250 mm rainfall pa.), and herbivore grazing. There is no access to mains water and trees planted are reliant upon rainwater.

1.The rate of natural tree development (ie. without watering) is slow.
Seedlings grow at a rate of 20-50 cms a year and average 2m in height after 5 years.
2.The rate of tree development with limited watering (ie. 2L a week for a period of up to 6 months) remains slow but with a 50% improvement in survival and 30% improved growth rate. Seedlings average 2m in height after 3 years.(Statistics from Loomooloo on planted tubestock with minimal watering)
3.The rate of tree development with ongoing or irrigated watering from mains would be considerably higher, however losses may also be higher due to the composition of water salts. Seedlings survive best on rainwater.

The purpose of the plantings at Loomooloo were:
1.to provide timber for fuel, craft and construction as a means of primary production income;
2.to provide materials for floral trade;
3.to provide seed materials for primary production diversification including propogation of plants;
4.to provide a means to arrest sand erosion (sand-drift) and to reduce increasing area levels of salinity ;
5.to provide wind and dust reduction;
6.to provide a corridor refuge for fauna increasing diversity through existing reserves, heritage and sanctuary areas;
7.to screen property and provide privacy,from open areas;
8.to reduce weed invasion from neighbouring properties;
9.to increase area's visual landscape and aesthetics ;
10.to reduce noise from nearby quarrying operations, small bore rifle and clay shooting, and aerosport clubs.

Trial species selected
Eucalyptus leucoxylon megalocarpa
E.occidentalis
Melaleuca uncinata

Reasons for selection of species
1.predominance of local dominant species, with introduced E.occidentalis which is found to perform well under local conditions.
2.species were suited ecologically to site
3.to include a relatively narrow range of species to achieve desirable landscape effects for particular purposes as mentioned above.

REVEGETATION PRACTICES

Weed control is necessary in any revegetation practice, to assist germination and survival rates. Each particular area will have site specifics in regard to species, rainfall, amount of seed and herbicide rates and application. However it is a far better practice to adapt the approach and routine to suit the conditions at each site.

A number of different methods and practices of revegetation have been trialled over the past 2 years on our own property and in the National Park with varying success rates.

Particular conditions would appear to be:

1. Weed control work must be done prior to planting and be part of the total revegetation plan.
2. Weed control should occur over the immediate 12 months prior to planting to reduce weed control work after planting. This includes treatment of particular weeds and a broadleaf spray. It should ideally occur within a month prior to any planned revegetation effort, not after.
3. Direct seeding and planting tubestock should occur after opening rains. Mixed success rates have occurred from plantings between May and July and between July and September. Each site is different.
4. Direct seeding has been attempted by grading away the topsoil, by ploughing the weed layer under, by drilling, by ripping, using a Rodden seeder, and by hand using a fire rake or scattering the seed.
5. Fine and winged seeds should not be machine direct seeded.
6. Direct seeding mixes should combine a variety of naturally occurring species - we have utilised treated acacia and cassia seeds, dodonaea, bursaria, eucalyptus species, melaleuca, leptospermum, casuarina and callitris for broad coverage, with hand seeding of understorey species and grasses.
7. Propogation of plant species should use only locally collected seed, watering by rainwater and be planted on edges of direct seeding and fencelines or in areas where direct seeding is not possible such as in rocky sites.
8. Plants must be watered in after planting.
9. Tree guards should be used to protect planted out species from attack by herbivores, or alternatively species planted within a fenced exclosure.
10. Ongoing management needs to occur, in relation to watering of tubestock, and removal of weeds.
11. Where weeds need to be resprayed shield plants.

TRIALS IN MONARTO CONSERVATION PARK

Direct seeding Methods

1. Ploughed
2. Disc harrows
3. Rodden Seeder
4. Fire rake - hand direct seeded
5. Fire rake -seed hand scattered

TRIALS AT LOOMOOLOO

1.Hand raised tubestock planted out
2.Fire rake hand direct seeding
3.Fire rake- seed hand scattered

TRIALS AT FERRIES -McDONALD C.P.

1.Tubestock planted only.

TRIALS AT MONARTO NATIVE PLANTATIONS

1.Hand and machine planting after ground preparations.
Such means included:

i) ripped
ii) chisel ploughed
iii) disc ploughed
iv) furrowed
v) bowling

2. Direct seeding by Rodden Treeseeder

ESTABLISHMENT PRODUCTIVITY

Operation	% Component cost
Vermin control	5%
Ground preparation	10%
Planting	40%
Mulching/guards/ weed protection	30%
Watering	10%
Maintenance/supervision	5%

Administration and overhead costs are additional

Value can be added to any rural property by providing for wildlife and maintaining and protecting vegetation. Additional benefits of such an action include natural pest control and protecting the environment particularly against land degradation processes. Other benefits include contributing to the conservation of our native flora and fauna.

The most valuable wildlife habitats are those that exist in their natural or semi-natural state. Therefore the protection and conservation of remnant vegetation is of high priority. These have a unique and special value as natural ecosystems, contributing to the maintenance of biodiversity through the intricate web of life that exists (upper and middle canopy of vegetation, the understorey, the soil microflora, the range of fauna and flora the area supports, and even invertebrates.)
Some important components of habitat are often destroyed because of a lack of understanding of conservation values. These include logs, branches, ground litter and rocks which are important in the ecosystem.

Fencing off remnant areas of vegetation is a sensible and practical move, because these areas are generally areas of marginal farming lands. They may also be small areas which are vulnerable to disturbance, and which would then suffer the effects of windthrow during storms, weed or feral pest invasion, introduced animals, or spraydrift from chemicals.

Where land has been partially cleared, revegetation is an option worth pursuing. Revegetation improves farm habitats for wildlife and contributes to land protection. Existing remnants can be enhanced to improve conservation value, by increasing the possibility of natural recolonisation of species. Revegetation may attempt to provide:
a) a buffer zone which protects remnants from edge effects,
b) corridors that provide continuity of habitat and movement of fauna between natural areas,
c) additional habitat to increase the size of the remnant and maximise opportunities for natural regeneration of trees and understorey.
Wider corridors and larger blocks of vegetation are more practical and better for conservation.

Protect, regenerate, revegetate are three key words applicable to property planning with conservation in mind. Remnant native vegetation retaining natural diversity of ground flora should be a high priority for management. Revegetation and remnant protection will assist in maintaining habitat and species diversity.

Species selection
Locally indigenous species are the best choice for local conditions. These plant species have adapted over many hundreds of years, and have an inbuilt system for survival and self-perpetuation.

CORRIDORS

> 'The loss of a species is irreversible. It is the responsibility of all people to ensure the survival of all species, and to preserve their habitats.' (Hussey et al,1989:3)

It is necessary to conserve existing remnants, regenerate further areas and maintain and establish corridors linking remnants to avoid fragmentation or islands of vegetation. Corridor plantings or linear linking features have reached wide public acceptance. However a corridor should not be strictly linear, but more a linking zone which connects the surrounding vegetation to at least two areas of natural vegetation which were once linked in historical time.

Linear corridors have tended to include roadsides, railway reserves, ridgelines, streambanks and drainage lines which consist of linear strips of natural vegetation. They may also incorporate areas planted as windbreaks and shelterbelts on and off farms. To function as a corridor, that is, to enable the movement of native biota, then it is important that these areas are managed properly to retain and enhance their function and purpose. Therefore more rounded or oval shapes are probably more appropriate in the long term than linear plantings.

Value of corridors

Corridors are generally remnants of a pre-existing vegetation community, or a regional representation of the vegetation associations which were present prior to development. They often represent significant areas of conserved land and contain populations of rare or endangered flora or fauna species.(Hussey et al,1989:6)

In the study area a corridor exists between both conservation parks through retained scrub lands and heritage areas. The Monarto Woodland if looked at in its entirety also provides a corridor between the hills area and other conserved sites, railway and water reserves. These corridors provide habitats for many different fauna and avifaunal species, and also contain several rare and endangered plant species.

Benefits of Corridors

The benefits of corridors include their ability to combat land degradation, soil erosion and control of dryland salinity. In doing so the corridor impacts upon the general appearance and productivity of the landscape. It provides shelter and shade for stock, and protection for endangered understorey species.

Negative effects of Corridors

Corridors may channel species into areas of increased risk of predation or mortality. As corridors are often disturbed areas and subject to weed invasion, they may also provide habitat for feral animals such as foxes, rabbits and cats which then compete with native species and contribute to the increased stress of native species and fragmentation.

Linear strips can be difficult to manage because of their vulnerability to outside influences and the different landuses which occur adjacent to them. Management should concentrate on maintaining habitat, principally by minimizing disturbance and degradation practices.

Management

Enhancement can occur by revegetation practices which includes using local native species to create an approximation of the original vegetation. Regional conservation plans and local action and property plans must also ensure protection and active management of such areas.

Management may include fencing, replanting or regeneration, minimizing external influences and encouraging private landholders to protect and manage potential corridor vegetation.

SHELTERBELTS

Observed values to rural landowners:

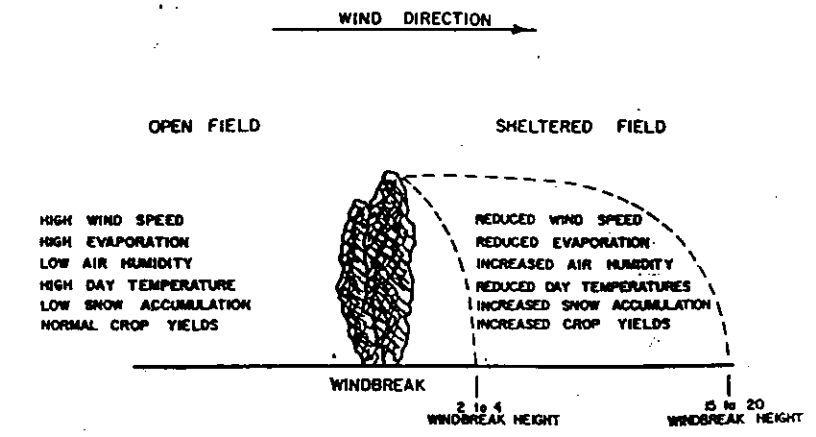
1. windbreaks
2. reduced soil erosion
3. shelter for stock
4. improved crop gains
5. reduced stock and crop losses
6. improved property planning and management
7. aesthetic value

General Values

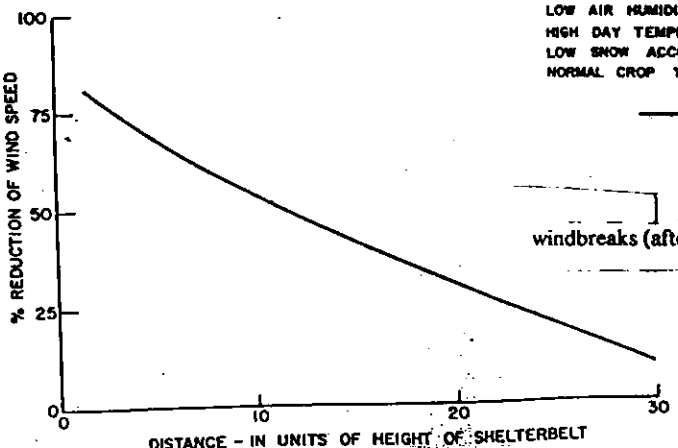
The purpose of shelterbelts or windbreaks is primarily aimed at deliberate weather modification, by reducing wind pressure and speed, and hence the occurrence of soil erosion. Their effectiveness suggests Griffiths (1976) is dependent upon the degree of constancy of the 'undesirable' wind. A shelterbelt will reduce the speed downwind, and can generate a reversal in wind direction. The most efficient windbreaks are those with a 40-50% coverage in the vertical plane, opposed to total coverage. (Jensen 1954)

A windbreak also modifies radiation effecting air and soil temperatures, and precipitation. The most significant induced change is in evaporation and transpiration with rates reduced at lower wind speeds. In a zone 1.5 to 12 times the height of a barrier, downwind yield can be increased up to 50% , with decreased yields evident immediately adjacent to the barrier. Dew deposition is also influenced by shelterbelts - the amount within 2 to 3 times the height of the break being about twice that in the open. (Steubing 1952).

The changes in the micro-climate are illustrated in the accompanying diagram (Read 1965).



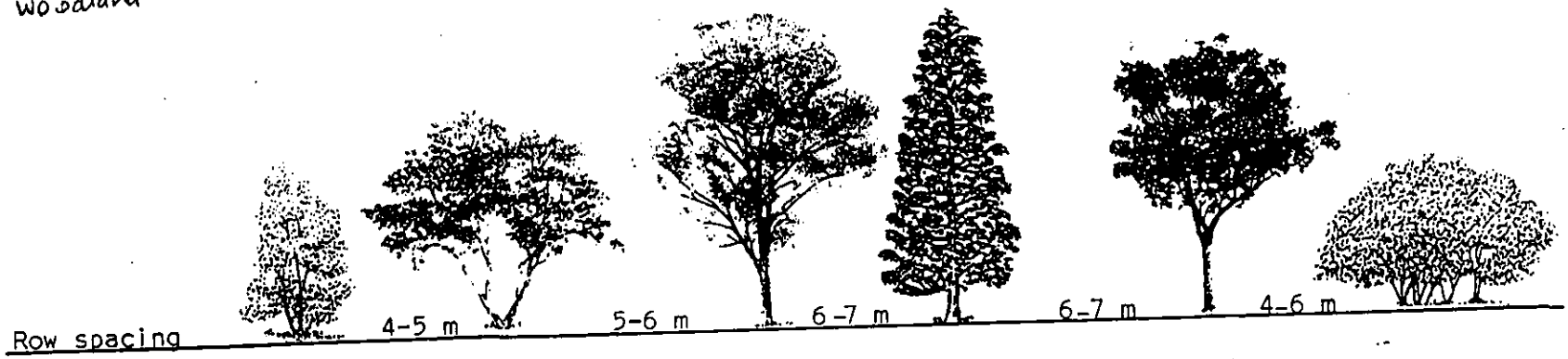
Local climate of open fields compared with that of fields affected by windbreaks (after Read, 1965)



Effect of shelter belt in reducing wind speed

Mallee Woodland

Diagrammatic Windbreak Design



	Shrubs	Mallee	Tall Trees	Medium Trees	Shrubs
Native species	*Acacia brachybotrya* *A. calamifolia* *A. liqulata* *A. microcarpa* *A. montana* *Geijori parvifolia*	*Eucalyptus anceps* *E. calycogna* *E. foecunda* *E. gracilis* *E. porosa* *E. socialis* *E. eneorifolia* *E. erythronema* *E. redunca*	*Callitris preissii* *Eucalyptus fasciculosa* *E. leucoxylon* *E. odorata*	*Acacia pycantha* *Casuarina stricta* *Pittosporum phyllireaeoides* *Santalum accuminatum*	*Baeckea behrii* *Bursaria spinulosa* *Melaleuca lanceolata* *M. uncinata* *Myoporum montanum*
Introduced species			*Brachychiton populanum* *E. astringens* *E. brockwayi* *E. dundasi* *E. intertexta* *E. largiflorens* *E. salmonophloia* *E. salubris* *E. woodwardii*	*A. sowdeni* *E. caesia* *E. erythrocory* *E. gardneri* *E. sargentii* *E. spathulata* *E. stricklandi* *E. torquata* *Tamarix articulata*	*Melaleuca armillaris* *Myoporum platycarpum*

PUBLIC BENEFITS OF WOODLAND AREAS

Bishop (1992) suggests that there are a number of observable public benefits from woodlands. These are:

1.Conservation- the retention and creation of wildlife habitats.

2.Educational- the woodland environment acts as a living outdoor classroom.

3.Leisure- opportunities to enjoy a multitude of leisure and recreational activities.

4.Timber and allied production- opportunities to utilise woodland for timber, cut Christmas trees, or honey production with economic benefit to the region.

5.General environmental enhancement- the creation of a sustainable landscape which acts to reduce atmospheric and noise pollution, contributes to the reduction of global warming, reduces climatic extremes (wind and temperature), promotes economic development, and an aesthetically pleasing environmental landscape.

PART FIVE

HISTORICAL BACKGROUND

A significant area of South Australia receives between 300 and 400 mm rainfall annually, with a sub-humid to semi-arid typical Mediterranean climate, and winter rains. This is typical mallee country and representative also of the study area.

Historical searches indicate that the early explorers described the semi-arid country as being of grasslands with open low woodland, merging into tall savannah woodland of the ranges. This led to long narrow belts of woodland trending south - north in the mid-north and Flinders Ranges areas of the State where the vegetation was associated with the Precambrian and Cambrian geological strata. Low mallee woodlands were described east and west of the mid north region. (Behr 1847; Eyre 1846; Specht 1972; Westgarth 1848; Diels 1906; Lange and Lang 1985, Wood 1937.)

Vegetation differences have been examined (Canning 1921; Crocker and Wood 1947) through the different geological time periods. Differences result from edaphic conditions that influence soil depth, texture and soil droughtiness, and reflect the impacts of the Pleistocene interglacial high sea levels and the subsequent migration of species during the Holocene period. (Boardman,1986; Crocker & Wood 1947.)

Settlement patterns of the emigrants led to the expansion of land clearance and cereal crop production and the push further northwards into non viable grain growing areas. (For an account of this period refer to Menge's 'Margins of the Good Earth'). Unfortunately drought took its toll, and the mallee lands provided a more reliable rainfall pattern than beyond Goyder's Line. These lands were soon cleared and planted with cereal crops. By the 1970s records indicate that 80% of the mallee lands had been cleared mostly for cereal production.

Present problems

Two persistent problems have resulted from this transformation of the land. The first is top-soil erosion compounded by severe duststorms. The second affects the sub-soils with increasing soil and stream salinity following clearing. Salting and other mineral accumulations (eg.lime and boron) affect crops. Excess drainage of ground water percolating through sub soils increases the leaching effect and raises the water table.

C L I M A T E

Specific weather phenomena occurring and having a marked change upon the study area are discussed. These include duststorms, fogs and mists, frost, temperature extremes and rainfall. Supporting information has been obtained from the Bureau of Metweorology and the Department of Environment and Natural Resources publication 'Greenhouse News', with personal observations and records made.

Duststorms

Duststorms tend to occur more frequently during periods of drought, and may re-occur during the same season. A duststorm occurs when horizontal visibility is reduced to less than one kilometre by the presence of dust. Most duststorms experienced in the study area, indicate that very thick dust is raised by strong northerly winds ahead of a southwest wind change. In the southerly parts of the study area dust is combined with sand, with visibility reduced to less than two metres and resulting in severe stinging to the eyes.

The Bureau has records of two severe duststorms in the Murray Bridge area in the winter of July 1969 and August 1972. Personal records indicate the Monarto South / Hartley area experienced severe duststorms during May and June 1994 and again in 1995. Severe duststorms have a tendency to occur over large areas, and this was shown with the May 1994 duststorm which was recorded as a natural disaster for South Australia. The 'Advertiser' (May 25,1994:5) reported a combination of many rain-free months, followed by fierce winds and a blinding duststorm which covered the whole of the State's grain belt. Resulting from a low pressure system in Western Australia strong north-westerly winds were forced across South Australia. Farmers on Eyre and Yorke Peninsulas, in the Mid North and the Murray Mallee all reported similar conditions. Exceedingly dry agricultural conditions with less than 20 percent of normal rain in the preceding three months was reported by the SA Department of Agriculture. The storms whipped up an estimated 22 million tonnes of dust including valuable topsoil from agricultural lands, transporting it to distant parts of the State. The later duststorm which whipped up topsoil and sands reduced visibility to a few inches, depositing soil along fencelines.

The area continues to experience strong wind / dust / sand storms because of continuing below average rainfalls over the previous five years. Much soil damage has occurred, with many farmers recognising the benefits of retaining vegetation as shelter belts. Sand drift remains a problem throughout the region, and serves as a reminder of the ferocity and damage of winds and duststorms.

Fogs and mists

The differences between fogs and mists is one related to visibility. A reduction in visibility by small water droplets occurs during fog, when visibility is reduced to less than a kilometre. With the phenomena of mist, visibility is greater than one kilometre.

Overnight mists and fogs are a regular occurrence at Monarto South when radiation heat loss at or near ground level cools the air to below saturation temperature. Starting from late March through to September, night temperatures may drop considerably low, and the incidence of fog increases. Temperatures recorded at Loomooloo during this time are often below zero. Morning fogs occur because of cold drainage patterns along the Murray Valley, combined with evaporation from the relatively warmer river and lake surfaces. The fog extends for some distance, and at least on one occasion per quarter exists for most of the day. Evening time from 1600 hours onwards is noticeably cooler and on nights of extremely low temperatures (below 4 degrees) fog may be evidenced within a few hours. Mists on the other hand because of their shallow nature, dissipate within a few hours of sunrise.

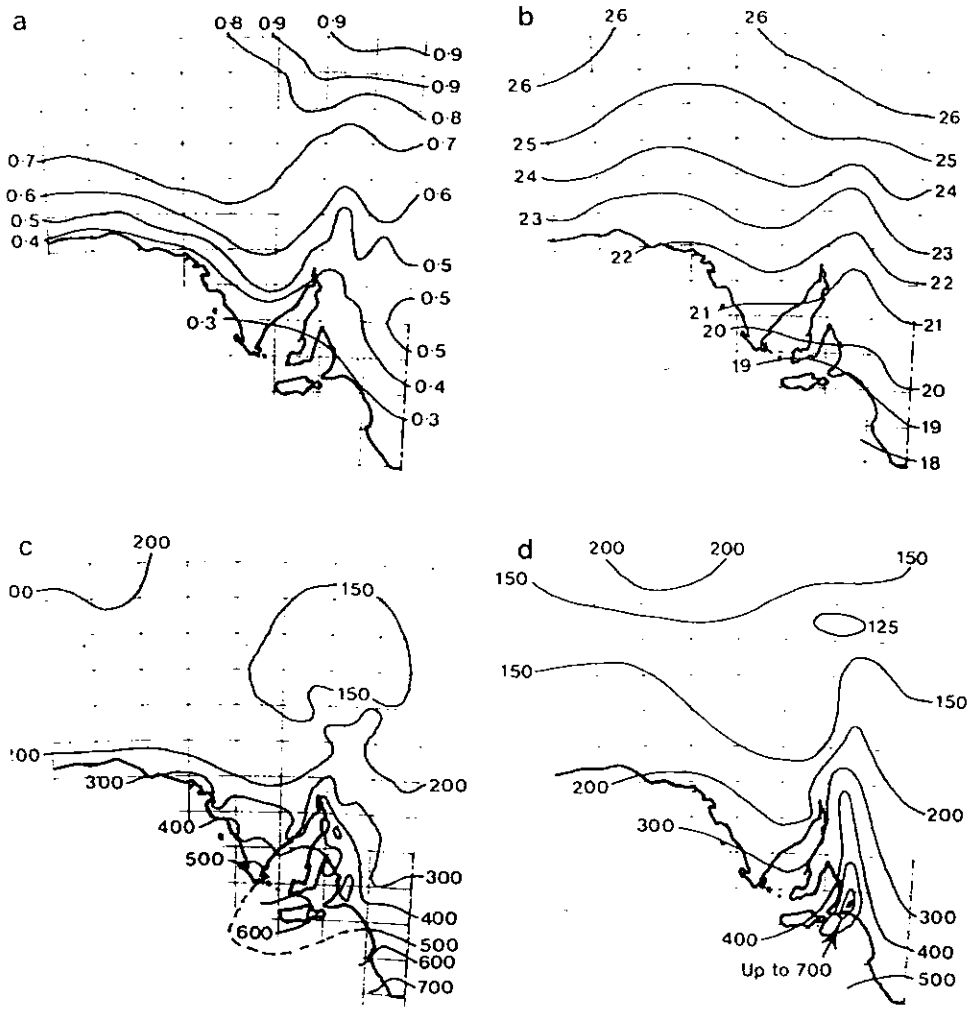
Morning mists and fog tends to occur in low-lying areas of Monarto South - Mosquito Creek more frequently than Monarto, or the Warla - Monarto South area. The fog prone areas of Monarto appear to be parts of the Rocky Gully Creek, east of 'Kalibar', and an area south of 'Lylo.' The fogs in these areas tend to be shallow, dispersing rapidly, occasionally reducing to mist and then haze. They occur early morning from 0400 hours dissipating a few hours after sunrise.

Frost

The frost period appears to commences mid to late March and ceases late October. Heavy frosts occur during the winter months, and when temperatures are less than 2 degrees, mild to moderate frosts may be experienced. When temperatures drop below zero, heavy frosts are indicated.

Temperature extremes

Temperature extremes personally experienced include long spells of 40- 48 degrees plus during the daytime in Summer, with evening temperatures less than 15 degrees. In Winter the daytime temperature may remain at 8-10 degrees and drop at night to several degrees below zero. These also tend to occur over an extended period of 7-14 days.



MAP 2. Some climatic factors in South Australia:

(a) Drought index, $I = \frac{50\% - 10\%}{30\%}$ rainfall percentiles.
Lines of equal droughtiness of site at the present day.

(b) Lines of equal global radiation kj/cm²/year.

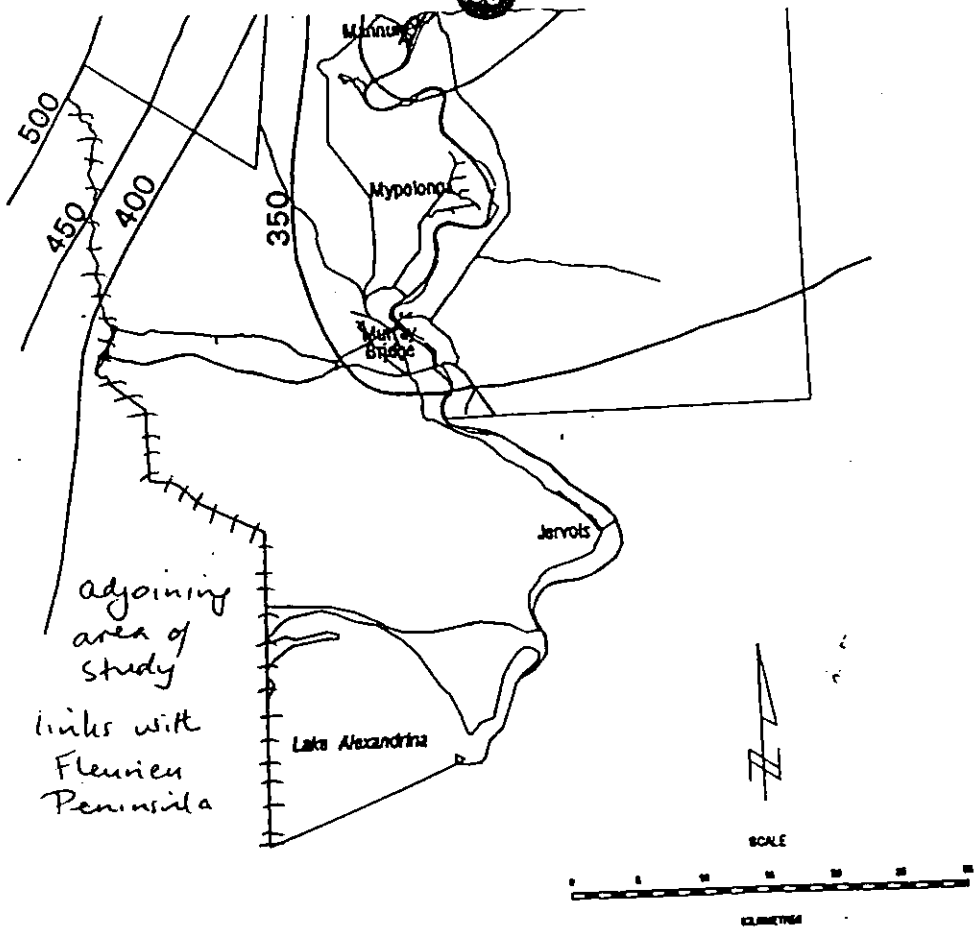
(c) Average annual rainfall isohyets present day (mm).

(d) Average annual rainfall isohyets estimated for the period when sea level was 100 m below present sea level.

Bureau of Meteorology

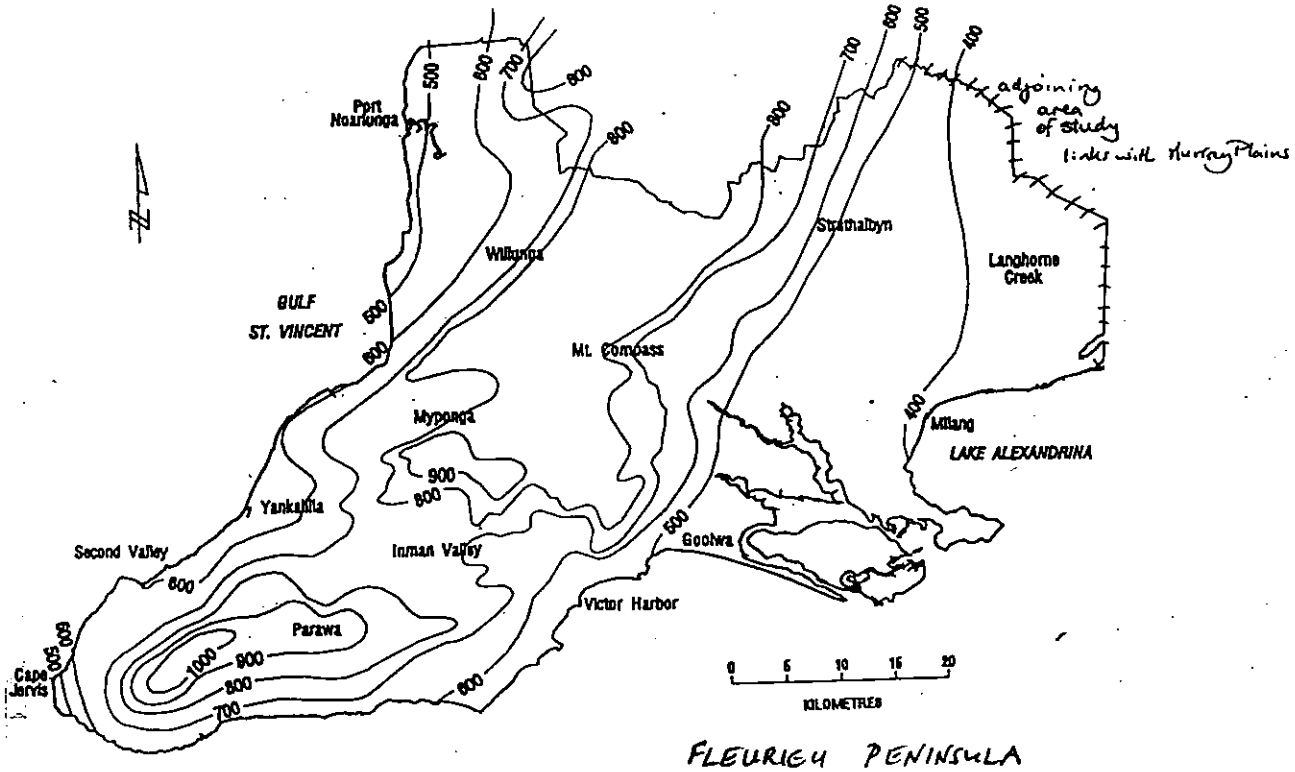
EFFECTS OF DRY SPELLS

Local dry spells have considerable impact on micro-climates and soil structure. Once soil is depleted of moisture, and exposed to direct radiation and continuing temperature fluctuations (hotter during day, colder at night) for an extended period, there is an imbalance of heat. Rapid physical changes occur including disintegration of larger soil particles and greater erosion hazard potential of the soil.



MURRAY PLAINS **Average annual rainfall isohyets**

Map 3. AVERAGE ANNUAL RAINFALL



FLEURIEU PENINSULA

TABLE 2.1
RAINFALL AND EVAPORATION

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN RAINFALL (mm) - (1)	20	18	20	30	39	42	42	44	41	36	24	21	377
MEAN NO. RAINY DAYS - (1)	3	3	4	6	10	12	11	12	10	8	5	4	88
DECILE 8 RAINFALL (mm) - (1)	31	28	35	46	54	61	63	63	57	54	39	30	561
EVAPORATION (mm) - (2)	230	205	190	125	75	65	65	70	90	140	180	235	1670

NOTES :

(1) From rainfall records for Callington (Station 024508), for the period 1883 - 1988, as advised by the Bureau of Meteorology.

(2) From Class A Pan Evaporation records for Murray Bridge, bird guard corrected, as advised by the Bureau of Meteorology.

TABLE 2.2
TEMPERATURE - (1)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
AVERAGE DAILY MAXIMUM (Deg C)	27.9	27.1	25.2	22.5	18.3	16.3	14.9	15.8	17.8	21.0	23.6	25.0
AVERAGE DAILY MINIMUM (Deg C)	13.2	13.3	11.7	9.7	7.6	6.0	5.6	6.0	6.6	8.3	9.9	11.8

NOTES :

(1) From temperature data for Strathalbyn, as advised by the Bureau of Meteorology.

TABLE 3

WIND ANALYSES

MURRAY BRIDGE POST OFFICE. STATION 024521. 15.0 m ELEVATION. 20 YEARS OF RECORDS

	TIME 09:00 HOURS									TIME 15:00 HOURS								
	WIND SPEED km/h:			WIND DIRECTION							WIND SPEED km/h:			WIND DIRECTION						
	<5	5-20	>20	N	NE	E	SE	S	SW	W	NW	<5	5-20	>20	N	NE	E	SE	S	SW	W	NW
JAN	35	52	13	10			20	21	20			14	50	36				12	33	25		
FEB	42	49	9				21	20	22			16	55	29				15	32	23		
MAR	38	51	11	11			17	19	19			17	57	26				13	31	19		
APR	48	41	11	18					14	13	12	21	58	21	12				20	20	12	10
MAY	53	40	7	17					15	14	20	24	56	20	14				14	19	12	16
JUN	58	33	9	18					12	12	21	26	53	21	16				16	15	14	18
JUL	47	41	12	19					11	15	30	14	56	30	16				11	18	19	22
AUG	32	49	19	20					17	13	26	13	50	37	12				11	20	18	25
SEP	26	51	23	20					24	12	17	11	49	40	12				16	25	15	18
OCT	18	59	23	16					22		12	12	52	36	10				21	25	14	12
NOV	32	53	15	11					25	10		13	55	32				10	24	30		
DEC	31	54	15	13					25			12	53	35				11	27	28		

TABLE 4

RAINFALL 1996

4.1 Callington

Yearly average	376
Totals to end Feb	49.0
Totals for March	13.8
Totals to end March	62.8
Totals for April	23.1
Totals to end Apr	85.9
Totals for May	19.6
Totals to end May	105.5
Totals for June	80.4
Totals to end June	185.9
Totals for July	48.6
Totals to end July	234.5
Totals for Aug	90.8
Totals to end Aug	325.3
Totals for Sept	66.2
Totals to end Sept	391.5
Last years period end Mar	65.2
Last years period end Apr	91.4
Last years period end May	156.8
Last years period end June	156.8
Last years period end July	200.8
Last years period end Aug	
Last years period end Sept	312.9

4-2

Loomooloo Monarto South

Month	Fall	This time last year
July 1995	78.5	22
August	18.0	18.5
September	8.25	34.0
October	46.5	0
November	8.0	49.0
December	13.0	3.0
January 1996	19.0	37.0
February	11.0	2.5
March	5.5	5.5
April	26.5	28.5
May	18.5	34.0
June	39.0	13.0
TOTAL Year	291.75	247.0

Jan-June 1996	119.5mm	previous year: 120.5mm
January 1996	19.0	37.0
February	11.0	2.5
March	5.5	5.5
April	26.5	28.5
May	18.5	34.0
June	39.0	13.0
July 96	62.0	78.5
August	76.0	18.0
September	51.0	8.25
October	18.0	46.5
November		8.0
December		13.0
		291.75

4.3

Langhorne Creek	
Yearly average	388
Totals to end Feb	73.2
Totals for March	8.6
Totals to end March	81.6
Totals for April	27.2
Totals to end Apr	108.8
Totals for May	31.0
Totals to end May	139.8
Totals for June	40.0
Totals to end June	179.8
Totals for July	48.0
Totals to end July	227.8
Totals for Aug	67.0
Totals to end Aug	294.8
Totals for Sept	65.8
Totals to end Sept	367.8
Last years period end Mar	54.4
Last years period end Apr	91.2
Last years period end May	136.2
Last years period end June	136.2
Last years period end July	162.2
Last years period end Aug	
Last years period end Sept	256.6

4.4.

Murray Bridge	
Yearly average	340
Totals to end Feb	21.0
Totals for March	6.0
Totals to end March	27.0
Totals for April	19.4
Totals to end Apr	46.4
Totals for May	15.0
Totals to end May	61.4
Totals for June	63,0
Totals to end June	122.6
Totals for July	74.8
Totals to end July	197.4
Totals for Aug	64.6
Totals to end Aug	262.0
Totals for Sept	62.0
Totals to end Sept	324.0
Last years period end Mar	54.4
Last years period end Apr	91.4
Last years period end May	120.2
Last years period end June	120.2
Last years period end July	153.2
Last years period end Aug	
Last years period end Sept	238.6

43 Table 5

Low rainfall aggregates

Low rainfall aggregates (mm) - Murray Bridge. Lowest value, first decile, second decile and third decile of rainfall totals cumulated for periods from 2 to 12 consecutive months commencing in the month at the head of the column.

(Period of record 1886-1970)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2 Consecutive Months												
Lowest	*	2	5	11	14	19	19	16	11	10	5	*
Decile 1	5	4	12	25	25	39	40	38	35	25	9	10
" 2	11	9	23	37	44	49	50	47	41	32	22	13
" 3	15	14	28	44	55	55	57	54	48	39	27	21
3 Consecutive Months												
Lowest	2	4	15	18	27	26	33	19	16	13	7	2
Decile 1	15	19	35	46	63	64	68	58	49	33	20	16
" 2	19	29	46	66	79	80	77	71	61	49	31	22
" 3	28	40	60	74	86	87	84	79	69	59	43	32
4 Consecutive Months												
Lowest	9	23	22	31	41	40	35	48	19	13	15	5
Decile 1	28	41	48	73	87	92	90	78	59	42	31	25
" 2	41	65	83	95	110	104	102	88	77	58	43	37
" 3	54	76	92	107	121	117	110	96	95	70	55	46
5 Consecutive Months												
Lowest	24	33	34	66	54	43	77	50	45	27	20	16
Decile 1	47	72	83	103	113	116	108	91	72	59	45	47
" 2	70	90	109	130	138	134	121	104	83	74	57	67
" 3	87	106	121	141	151	143	135	122	104	87	70	73
6 Consecutive Months												
Lowest	43	45	69	80	57	84	88	74	63	43	27	29
Decile 1	80	103	116	133	141	134	121	101	84	65	69	67
" 2	96	116	145	156	158	156	141	114	104	94	81	91
" 3	120	134	156	172	177	170	161	128	113	102	96	106
7 Consecutive Months												
Lowest	56	80	89	82	99	96	90	77	73	52	40	48
Decile 1	110	139	146	157	163	150	128	119	91	92	92	101
" 2	132	156	173	186	179	177	150	130	122	108	111	125
" 3	145	172	184	202	198	194	170	149	129	124	126	133
8 Consecutive Months												
Lowest	91	100	105	103	106	98	93	80	91	58	60	80
Decile 1	143	158	168	173	181	159	150	126	115	116	123	122
" 2	164	185	202	206	193	187	167	148	136	144	139	149
" 3	180	198	217	222	227	209	183	160	155	156	165	164
9 Consecutive Months												
Lowest	111	117	106	110	112	101	96	107	103	93	90	100
Decile 1	177	177	185	196	190	171	163	144	145	152	141	155
" 2	191	217	224	226	218	205	177	164	171	175	170	184
" 3	211	232	233	249	237	224	197	187	182	189	190	203
10 Consecutive Months												
Lowest	128	117	114	137	115	103	123	125	124	123	110	132
Decile 1	189	200	212	203	203	186	180	169	182	179	172	195
" 2	223	233	244	243	236	210	211	196	194	202	210	216
" 3	241	252	257	257	253	235	222	215	214	228	221	233
11 Consecutive Months												
Lowest	128	124	144	140	118	130	146	152	149	143	142	152
Decile 1	215	222	216	230	212	204	210	210	207	205	212	211
" 2	245	257	256	259	243	240	235	231	225	231	238	244
" 3	255	272	265	271	263	254	250	245	251	256	261	265
12 Consecutive Months												
Lowest	135	155	163	143	145	170	175	174	174	175	160	179
Decile 1	233	237	245	236	229	235	244	229	234	238	233	239
" 2	266	267	272	264	268	267	262	259	265	277	267	258
" 3	278	283	288	289	289	290	301	280	285	289	292	284

Map 4 Frost in S.A.

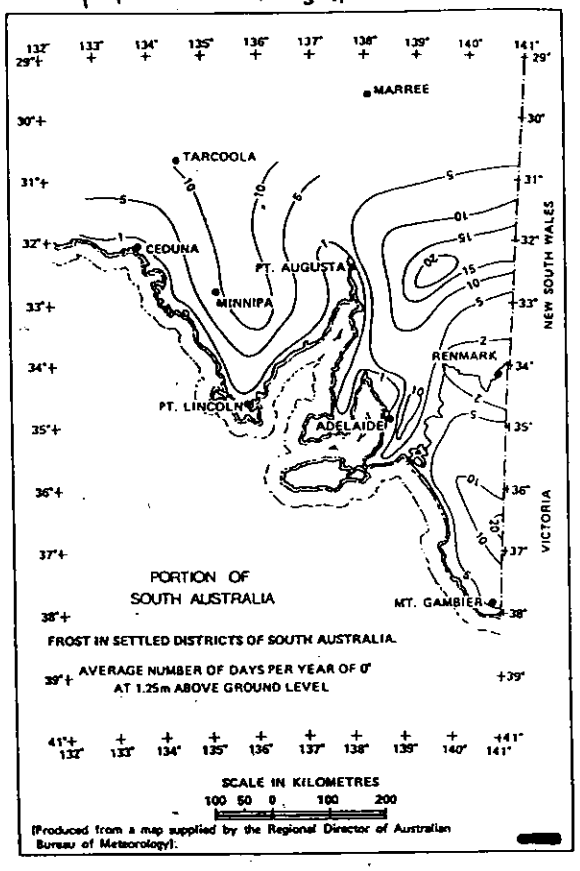


TABLE 6 - METEOROLOGICAL DATA

Reading	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept	Oct.	Nov.	Dec.	Year
RAINFALL													
Median (mm)	10	11	11	23	32	35	31	34	32	30	21	16	333
Lowest on Record (mm)	0	0	0	1	2	7	1	4	2	2	0	0	135
Highest on Record (mm)	189	129	169	189	112	88	103	117	93	94	79	115	546
TEMPERATURE													
Average Daily max.	29.4	28.3	26.2	22.2	18.4	16.4	15.6	16.6	18.9	21.7	24.7	27.2	22.1
Average Daily min.	14.2	14.1	12.3	10.0	7.8	6.1	5.0	5.6	6.9	8.9	11.0	12.9	9.6
SUNSHINE													
Est. Average hours	300	250	230	180	160	140	150	170	180	220	240	270	2,500
EVAPORATION													
Mean (mm)	330	275	220	145	80	60	65	80	120	210	240	300	2,125
EVAPOTRANSPIRATION													
Mean* (mm)	260	215	165	100	55	40	40	50	85	160	190	240	1,600
FOG FREQUENCY													
Days	0	0	0.2	0.2	0.4	0.9	0.6	0.4	0.4	0	0	0.1	3.2
FROST FREQUENCY													
Days	-	-	-	-	1	4	5	4	2	-	-	-	16

Notes: The data is for Murray Bridge and is therefore not precisely applicable to the Monarto site. However, the trends for Murray Bridge are expected to be applicable to the site area.

*Estimated for well irrigated short grass.

Source: Bureau of Meteorology Report on Climate at Monarto

CLIMATIC CHANGE

The nature and distribution of individual plants and floral associations may be influenced by climatic change. From the maps shown we can determine that precipitation plays a dominant role in the structural composition and appearance of the vegetation along decreasing rainfall gradients from coastal areas inland.(Kershaw,1981:231)

Climatic events and patterns of climatic change may not only influence changes in distribution patterns and composition but may also assist in the development of new community types and vegetation associations.

Conservation and heritage areas therefore needs to be retained in order to preserve maximum floristic diversity and suitable habitats for existing species. This would seem even more appropriate in areas that have been changed by agricultural or forestry practices.

THE EFFECTS

Although increases in temperature and carbon dioxide concentration cause the productivity of plants to increase, this can only be accomplished under conditions of adequate moisture and nutrient supply. The increases in productivity postulated to occur with enhanced CO_2 fertilisation and conservation of water-use, included by Booth and McMurtrie (1988) have been applied to native hardwood systems. In this respect CO_2 will only act in full as a fertiliser when it is the limiting nutrient; should some other nutrient become limiting inter alia, then this will determine the extent of the gain

Productivity actually realised in natural ecosystems is determined predominantly by the length and constancy of the growing season.

TABLE 7.1

Mean annual net primary production typical of native trees - t/ha/y - assumes mid-20th century ambient CO_2 concentrations

LOCALITY	Late 20th C.	Mid 21st C.	Difference	% Change
Mount Crawford	11.4	14.6	+ 3.2	+ 28
Mount Burr	13.2	15.4	+ 2.2	+ 17
Myponga	11.4	14.1	+ 2.7	+ 24
Bundaleer	8.9	9.8	+ 0.9	+ 10
Adelaide	9.1	9.75	+ 0.65	+ 7
Georgetown	8.1	7.8	- 0.3	- 4
Snowtown	7.4	5.3	- 2.1	- 28
Lameroo	6.8	5.3	1.5	- 22
Yongala	5.75	1.0	- 4.75	- 83
Monarto	5.8	<1.0	- >5	- >85
Hawker	3.2	<1.0	- >3	- >95

Assumptions:
- sites with adequate depth of drained soil and optimum nutrient supply.

7.2

Mean annual net primary production typical of native trees - t/ha/y - doubled CO_2 concentration photosynthesis enhanced by 50%

LOCALITY	Late 20th C.	Mid 21st C.	Difference	% Change
Mount Crawford	11.4	16.5	+ 5.1	+ 58
Mount Burr	13.2	17.4	+ 4.2	+ 32
Myponga	11.4	16.0	+ 5.4	+ 47
Bundaleer	8.9	11.1	+ 2.2	+ 25
Adelaide	9.1	11.0	+ 1.9	+ 21
Georgetown	8.1	8.8	+0.7	+ 8
Snowtown	7.4	6.0	- 1.4	- 19
Lameroo	6.8	6.0	- 0.8	- 12
Yongala	5.75	1.2	- 4.55	- 79
Monarto	5.8	1.0	- 4.8	- 82
Hawker	3.2	<1.0	- >3	->95

Assumptions:
- sites with adequate depth of drained soil and optimum nutrient supply.

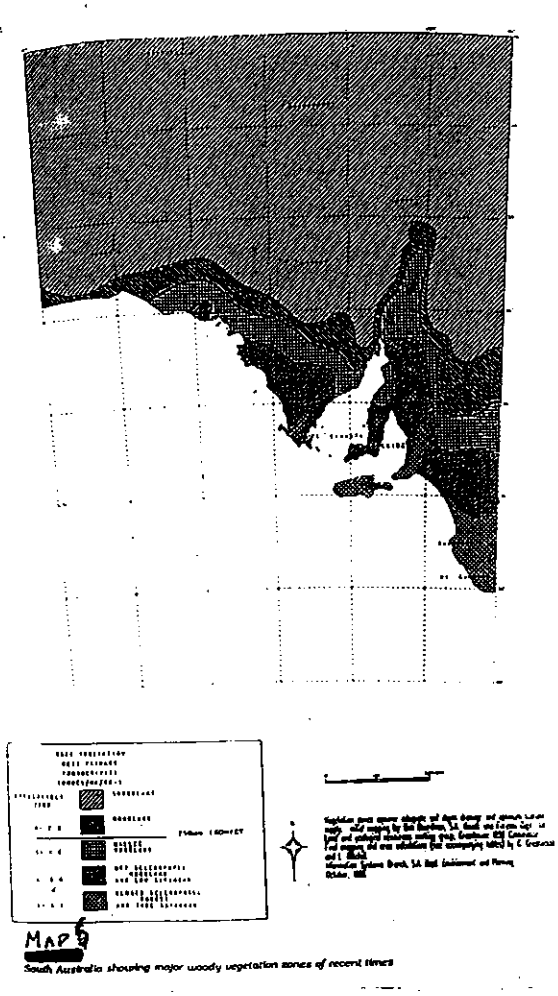
7.3

Mean annual net primary production typical of native trees - t/ha./y - doubled CO_2 concentration - Photosynthesis enhanced by 50% + stomatal resistance increased 30% to enhance water use efficiency

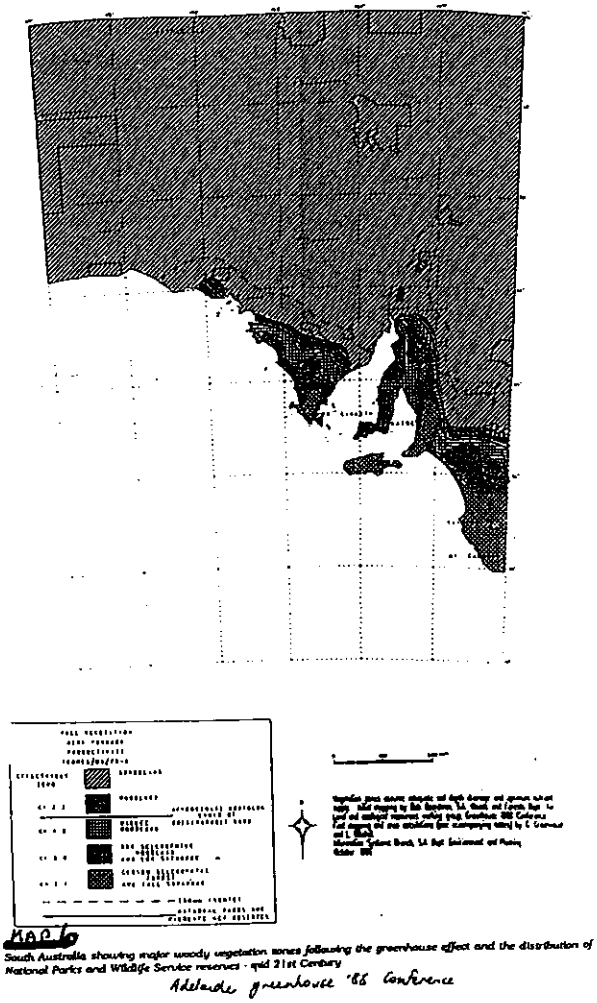
LOCALITY	LATE 20TH C.	MID 21ST C.	DIFFERENCE	% CHANGE
Mount Crawford	11.4	18.7	+ 7.3	+ 64
Mount Burr	13.2	19.6	+ 6.4	+ 48
Myponga	11.4	18.0	+ 6.6	+ 58
Bundaleer	8.9	12.6	+ 3.7	+ 42
Adelaide	9.1	12.5	+ 3.4	+ 37
Georgetown	8.1	10.0	+ 1.9	+ 23
Snowtown	7.4	6.8	- 0.6	- 8
Lameroo	6.8	6.8	0.0	0
Yongala	5.75	1.4	- 4.35	- 76
Monarto	5.8	1.1	- 4.7	- 81
Hawker	3.2	<1.0	->3	->95

Assumptions:
- sites with adequate depth of drained soil and optimum nutrient supply.

Adelaide greenhouse 88 Conference



MAP 9
South Australia showing major woody vegetation zones of recent times



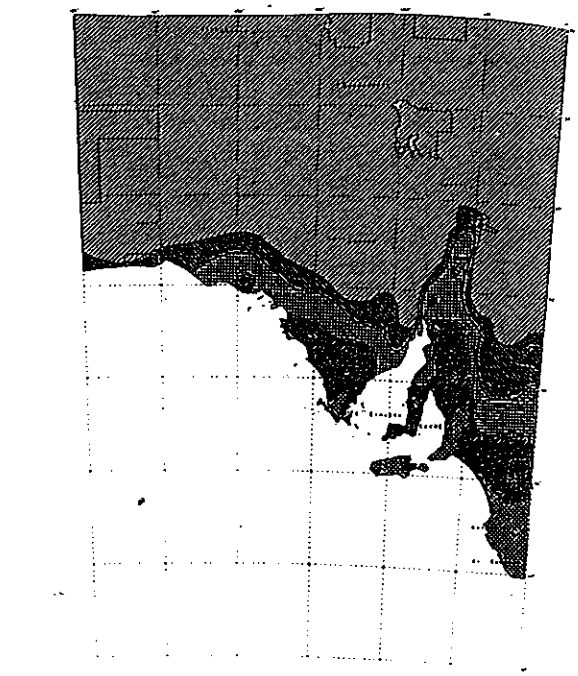
MAP 10
South Australia showing major woody vegetation zones following the greenhouse effect and the distribution of National Parks and Wildlife Service reserves - qvd 21st Century
Adelaide greenhouse '88 Conference

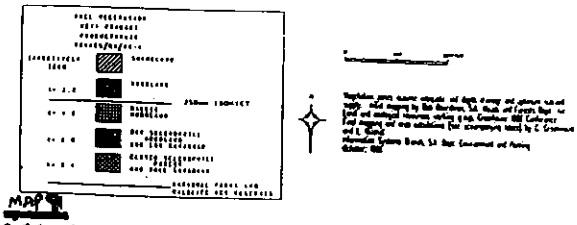
IMPACTS OF GLOBAL WARMING

The generalisations of global warming and the inference for particular areas, states and nations.

Without doubt human indulgences have made a major impact on global warming. As a rich nation, we have compounded an existing problem with our demands on energy consumption levels and increased pollution.

In the study area at Warla, pollution is most evident, as the freeway and Adelaide to Melbourne railway line are in close proximity. Transportation methods and technological revolutions have made enormous social progress but in doing so, have over burdened our natural systems. The amounts of chemical and noise pollution does affect our natural resources, particularly land, air and water. Buffer zones and plantings effectively screen the area and reduce noise levels from traffic.

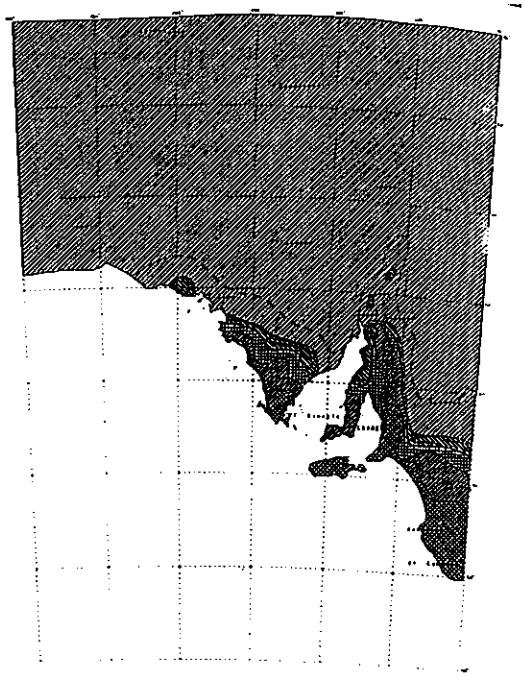


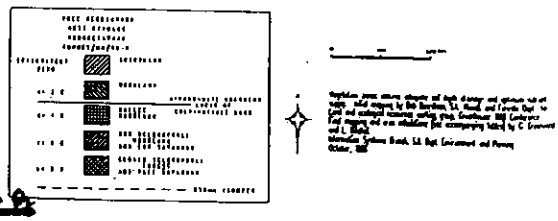


MAP 1

South Australia showing major woody vegetation zones of recent times and National Parks and Wildlife Service reserves

Adelaide Greenhouse '88 Conference





MAP 2

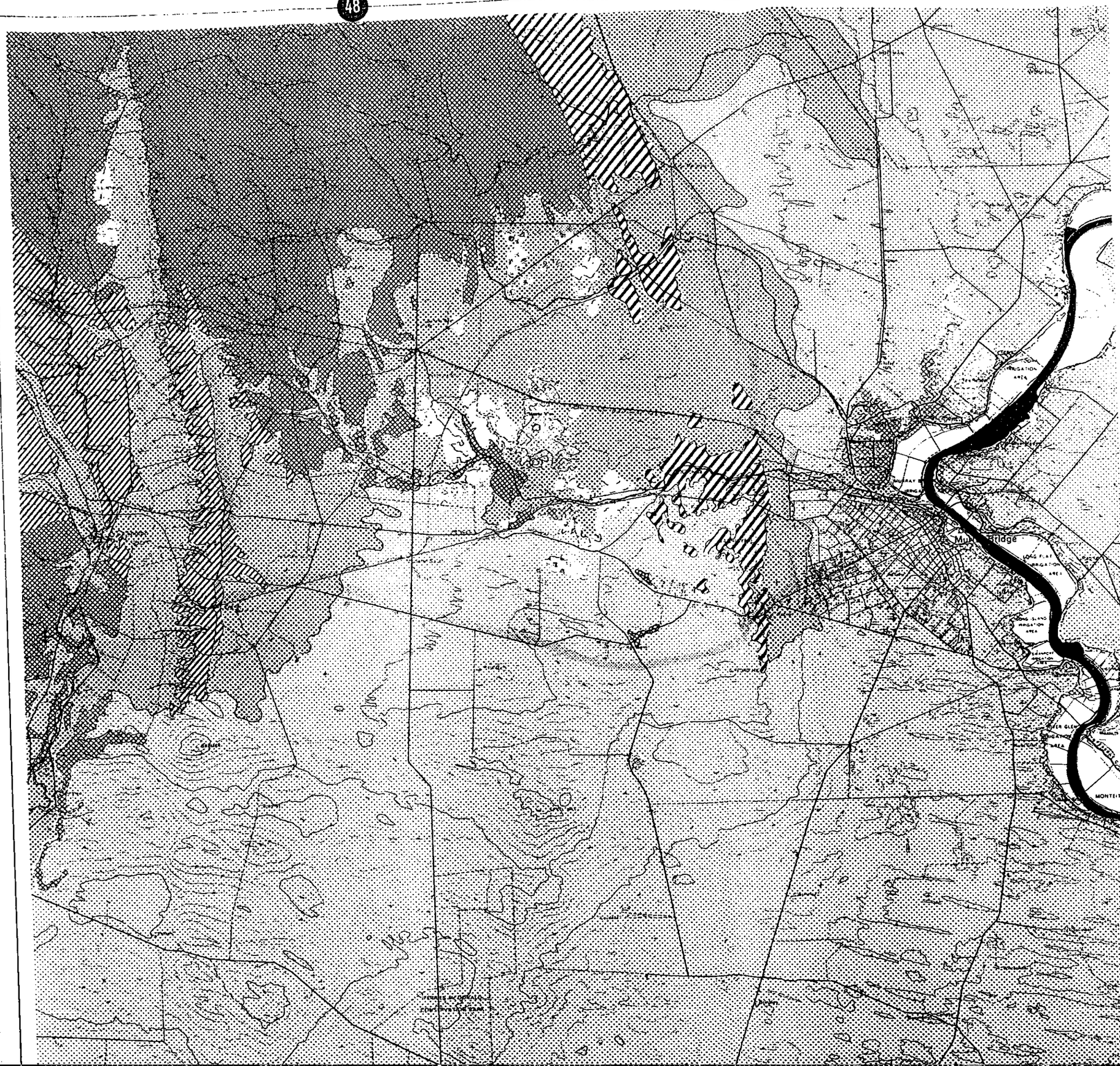
South Australia showing major woody vegetation zones for the mid 21st century following postulated climatic changes resulting from the greenhouse effect

Adelaide Greenhouse '88 Conference

In discussions with local landholders situated on salt lakes and swamps, near Lake Alexandrina (immediately south of the study area) there is a very real concern about the greenhouse effect and global warming. Here it is more than just a temperature rise, and higher lake levels. Many of these property owners are situated below or just above sea-level. Any rises in levels would spell disaster for their land and livelihood. They are very conscious of building levee banks, retaining and re-creating wetlands, and the value of tree planting on properties and roadsides. This is action on a local level, but measures also need to be taken on a regional and national level.

In the South Australian Greenhouse News, April 1996, it is suggested that the major impact of global warming on ecosystems, will be dependent on the economic circumstances and institutional infrastructure of countries. This will be observable by the nation's capacity to deal with problems arising from the vulnerability of human health and socio-economic systems. This infers that South Australia and Australia must reduce their greenhouse emission levels and take positive steps to reduce the global problem and speed of damage. It is essential that the richer nations do all that they can to offset the climatic changes, before land becomes useless, and because poorer nations are in no position to effect any significant changes.

One very practical solution that everyone can assist with, is the planting of more trees. It is by no means the only measure, but it is a positive example with so many benefits.



ALLUVIUM OF THE RIVER MURRAY CANYON

SHALLOW ALLUVIAL DEPOSITS OF CREEK CHANNELS AND FLOOD PLAINS

AEOLIAN DEPOSITS. SILICEOUS DUNE SANDS AND KUNKAR OF THE MURRAY PLAINS.

PISOLITIC LATERITES

NORTH WEST BEND FORMATION - LIMESTONE, SANDS, SANDSTONE EXPOSED IN CLIFFS NEAR TAILEM BEND

MANNUM FORMATION - FOSSILIFEROUS MARINE LIMESTONES, CALCARENITES TYPICALLY EXPOSED IN MURRAY RIVER CLIFFS; GRAVELS AND GRITTY LIMESTONES AT BASE.

EVEN GRAINED GREYWACKES, QUARTZ-MICA-FELSPAR-SCHISTS.

MICA SCHISTS, DARK GREY SHALES, KNOTTED ANDALUSITE SCHISTS; GREYWACKES.

MIGMATITES, SCHISTS, GNEISSES AND AMPHIBOLITES. ZONE OF MIGMATIZATION.

MURRAY BRIDGE GRANITE

MONARTO "GRANITE"; ADAMELLITE

SOURCE: DEPT OF MINES MOBILONG SHEET

0 1 2 3 4 5Km

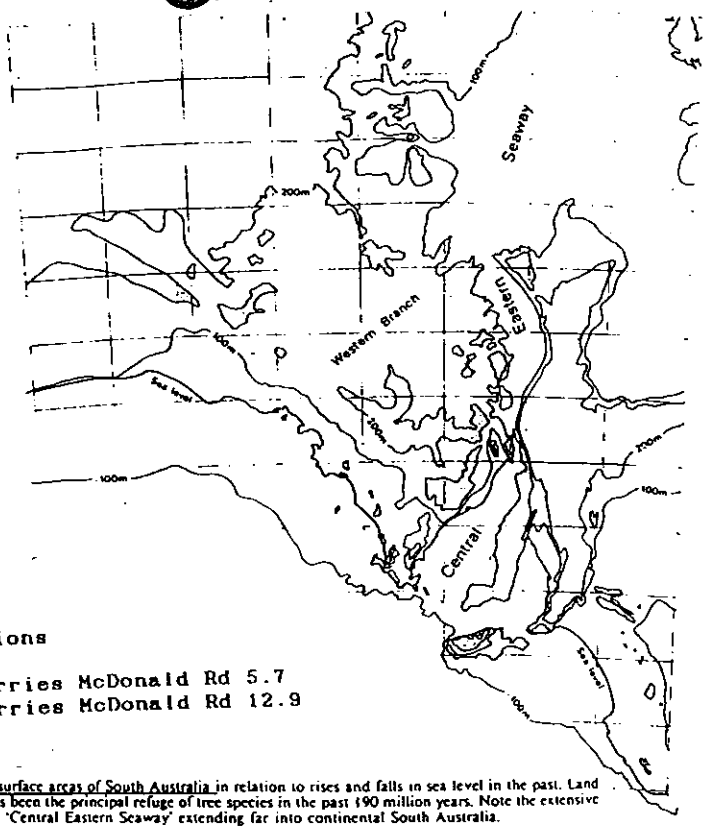
GEOLOGY OF ENVIRONS

MAP 9

MAP. 9

LAND SURFACE

SOUTH AUSTRALIA



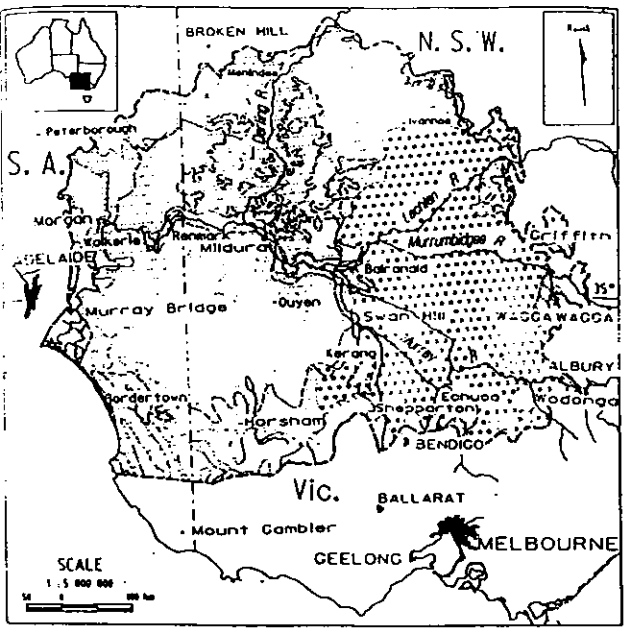
BEDROCK

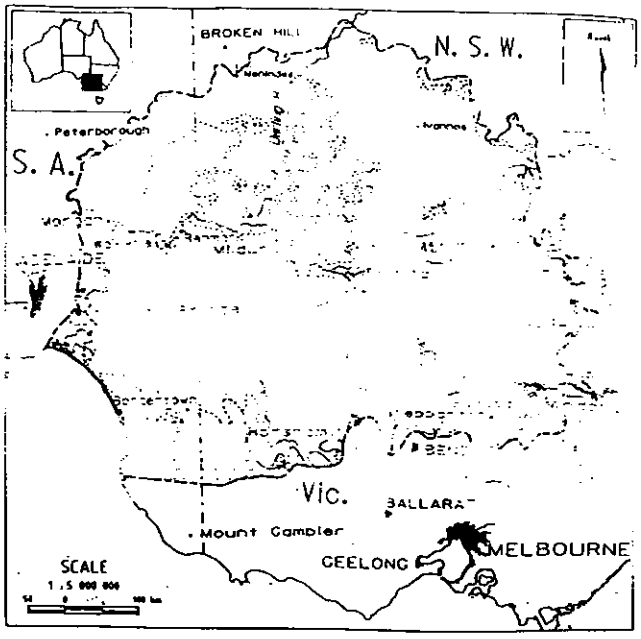
Depth to bedrock at key locations
Warla 4.8m
Monarto South western side Ferries McDonald Rd 5.7
Monarto South eastern side Ferries McDonald Rd 12.9

Land surface areas of South Australia in relation to rises and falls in sea level in the past. Land over 200 m has been the principal refuge of tree species in the past 190 million years. Note the extensive 'Central Eastern Seaway' extending far into continental South Australia.

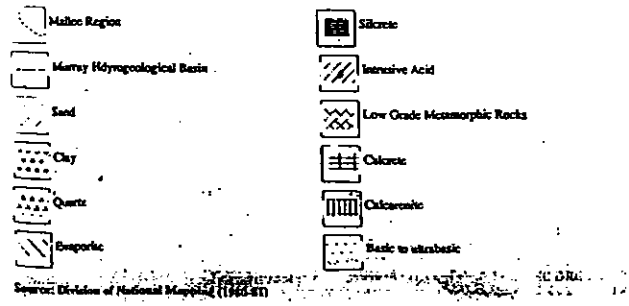
Map 10 GEOLOGY MURRAY DARLING BASIN LANDFORM MAP. 11

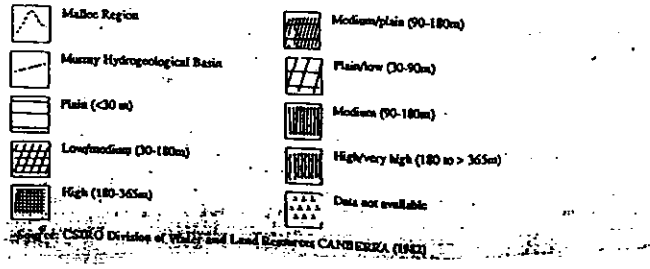
Surface Geology - MURRAY - DARLING BASIN





Landform-Relief - MURRAY - DARLING BASIN





GROUNDWATER

Research confirms that extensive native vegetation clearance for agriculture has resulted in the development of dryland salinity in all parts of the mallee. It has also resulted in loss and modification of wildlife habitat, soil erosion and accelerated recharge of groundwater aquifers. (MVMWG:1991) Consequently increased discharges of saline groundwaters to rivers and low lying lands have increased dramatically.

In the area under study (the western fringe zone) river salinity from the River Murray and upstream, and hence from the entire Murray Darling Basin, is an increasing concern amongst landholders. At the southern extreme of the area reviewed, the fringing wetlands and backwaters of Lake Alexandrina (West Creek catchment, Mulgundawa, Boggy Lake and Mosquito Creek) have a salinity rate of three times that of the sea.

Investigations have demonstrated that groundwater recharge rates increase as much as 100 times after vegetation clearance, and rising local and regional groundwaters result forcing more salinity to flush to the surface. Without immediate action by landholders, some of this above ground salinity will find its way back into the sub artesian basin unless corrected. It is also a concern that waters currently being drawn from the aquifer are in fact millions of years old. It is vital therefore to address the issue of groundwater recharge and dryland salinity immediately as the positive results of such an action will probably take decades to correct.

A better understanding of hydrogeology and accelerated recharge of groundwater systems is vital, if landowners are to relate the causes and effects of native vegetation clearance, land salinisation and river salinity. Farmers need to appreciate the importance of putting trees back into the ground, and the positiveness of such actions for future generations.

Groundwater Recharge and Native Vegetation

Mallee eucalypts with their often extensive root systems are extremely efficient at extracting soil water. Documented and oral evidence from Aboriginal sources suggest that mallee roots particularly that of Eucalyptus incrassata could provide several litres of potable water. More recent research indicates that the roots of Eucalypts have been found at a depth of 28 metres. (Nulsen et al 1989)

Other research findings for South Australian systems (Allison et al 1985) indicates that recharge under sand dunes covered with mallee vegetation is less than 0.1mm/yr, whereas in similar cleared sand dunes recharge rates of 13 to 14mm/yr had been observed. Investigations at Borrika and Wanbi suggest recharge rates may be as high as 40mm/yr, giving credence to the extraction rate and use of water by native vegetation. (Cook et al,1989)

Irrigated agriculture and horticulture increase the magnitude of the problem by adding a further 30% of the total annual drainage (about 700mm) to groundwater. (Cole,1985)

Barnett (pers.comm) through hydrogeological monitoring indicates that dryland salinisation will become significant in the study area as the regional watertable rises rapidly over the next 30 years. It will continue to rise for a period of 150 to 200 years and work towards a steady state over the millenium. Therefore over the next thirty years those areas of land below 20m AHD (Australian Height Datum) will be severely affected. Higher rainfall patterns will advance the losses of land from agricultural production. In the Lake Alexandrina area where the land is lower than the sea level, land loss from recharge states will be more advanced, and will be the first land to be affected (Barnett,1989;1990; Prendergast 1989). Technical correction methods to avert this would involve expensive engineering structures such as barrages or wells near Wellington. Other methods would relate to increased plant water usage.

Modification of current pasture and cropping practices is indicated as a key component of any land management option. This can be achieved with the use of deep rooted perennial species (eg.lucerne- Medicago sativa). Lucerne is a low cost practice and has the added advantage that it is capable of reducing sandhill seepage (Cooke pers.comm.)

Re-establishment of indigenous mallee vegetation and other tree species on previously cleared land is a desirable outcome supported by the MVMWG (1991). The benefits include groundwater management, habitat reconstruction, treatment of land degradation and more efficient farm production.

MALLEE

The word "mallee", is recognised as being an Aboriginal word used to describe eucalypt species which have many stems arising from a specialised underground stem (lignotuber). Mallee species range from one to eight metres in height with multiple, flat-topped or domed crowns. Stunted or whip-stick mallee communities occur in the more arid areas, where trees assume lesser heights often only up to about three metres. These communities are representative of the harsher climatic conditions, and the shallow or poor soils.

In the Western fringe zone of the Murray mallee, the mallee community ranges from trees of four to six metres, with a typical understorey comprising layers of halophytic shrubs (eg.Chenopodeaceae), xeromorphic shrubs (eg.Proteaceae, Myrtaceae), grasses (eg Triodia,Gahnia) and predominantly annual grasses (eg.Stipa). (Beadle 1981; Jones 1994) The South Australian mallee region has been mapped by Carnahan (1976).

Clearing has been identified as having the most profound impact upon the status of mallee vegetation. Other significant and degrading influences identified by the Murray Darling Basin Commission include:

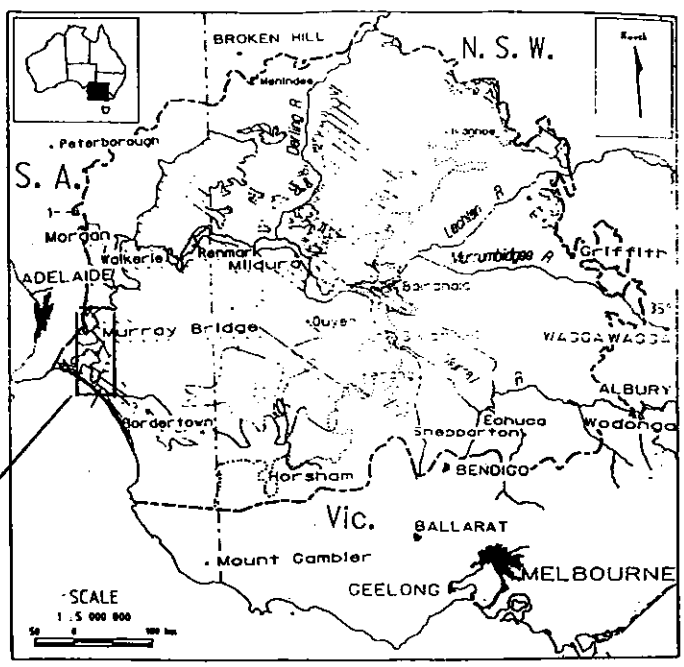
- grazing (livestock, introduced and pest species)
- pest plant invasion
- fire both prescribed and wild
- dryland salinity
- waterlogging
- broombush harvesting
- fuelwood harvesting

MAP: 13 MALLEE REGION

MURRAY DARLING BASIN

FRINGE ZONE

The Mallee Region - MURRAY DARLING BASIN



Mallee Region

Murray Hydrogeological Basin

Boundary between the Mallee (West) and Riverine Plains (East) Hydrogeological sub-Basins.

1 Eucalyptus tall shrubland (Mallee) *

2 Eucalyptus tall open scrub *

3 Eucalyptus tall open shrubland *

* From Carnahan (1976)

Mt Lofty Ranges Hard Rock Aquifer

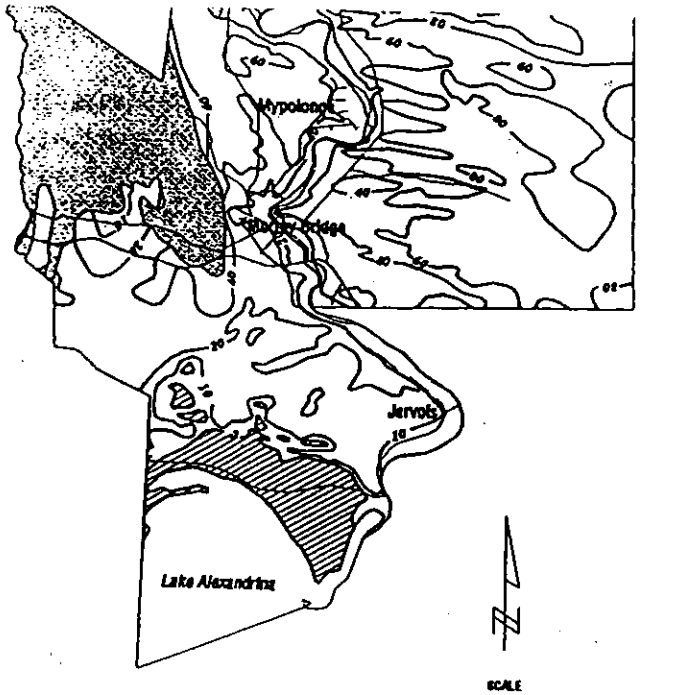
Direction of flow.

Contours show watertable depth in metres above sea level.

MURRAY MALLEE PLAINS

MAP 14

WATER TABLE CONTOURS



Mt Lofty Ranges Hard Rock Aquifer

Risk Area

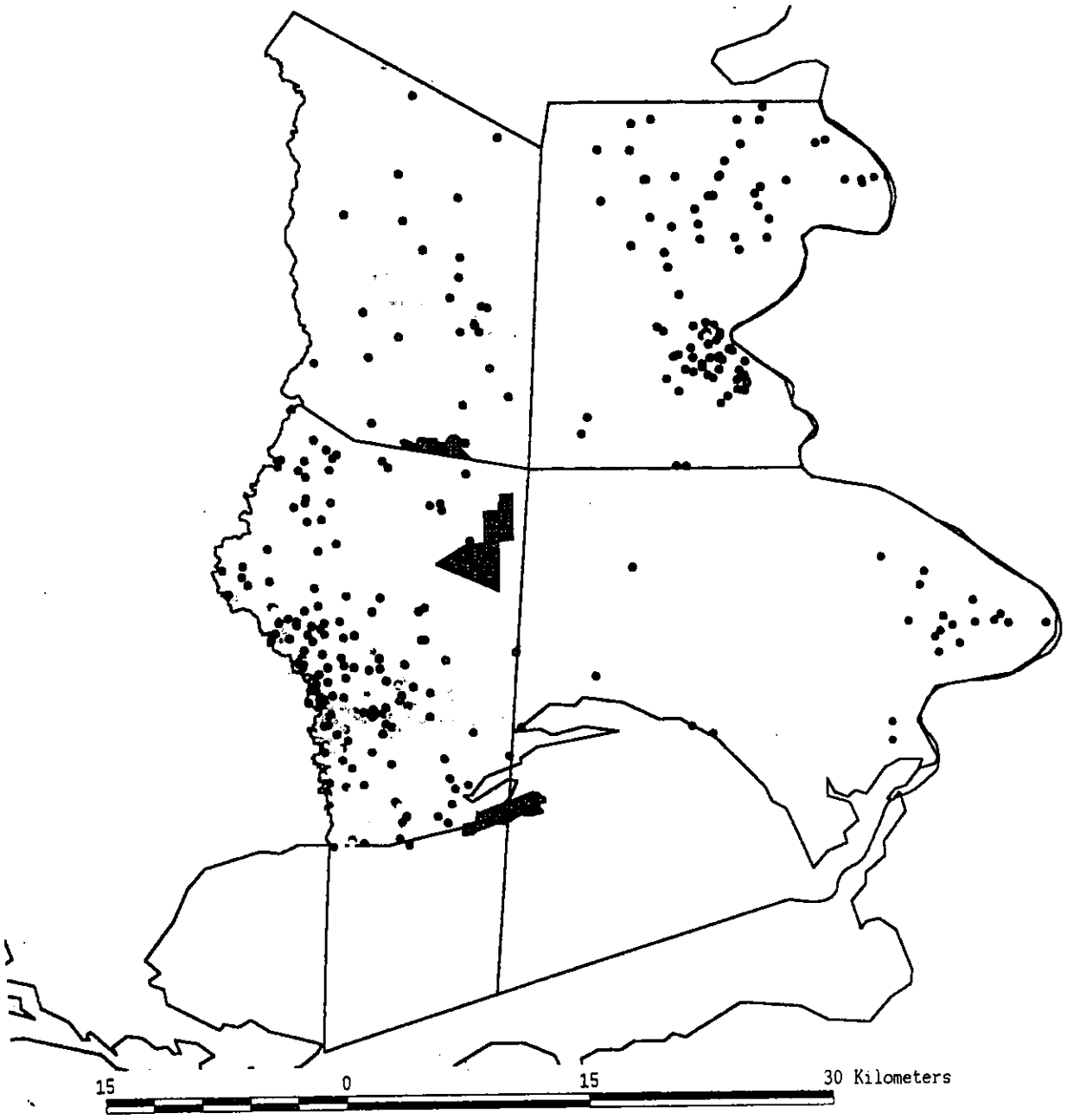
Values show depth from ground surface to water table in metres.

MURRAY MALLEE PLAINS

MAP 15

WATER TABLE DEPTH

DEPTH TO WATERTABLE



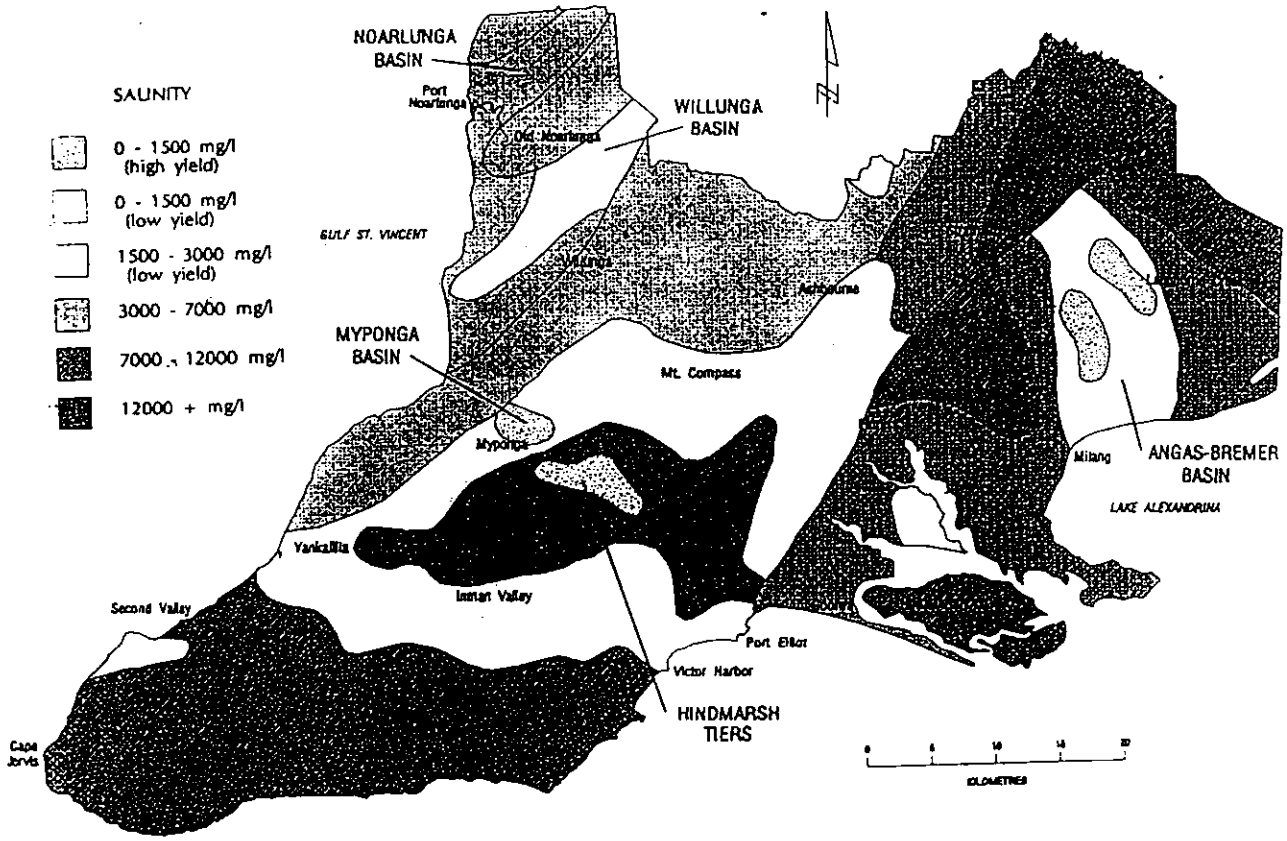
N

Hundreds
Depth to watertable (m)
0 - 3
3 - 10
10 - 20
>20
NPWS - Parks & Reserves etc
Coastline

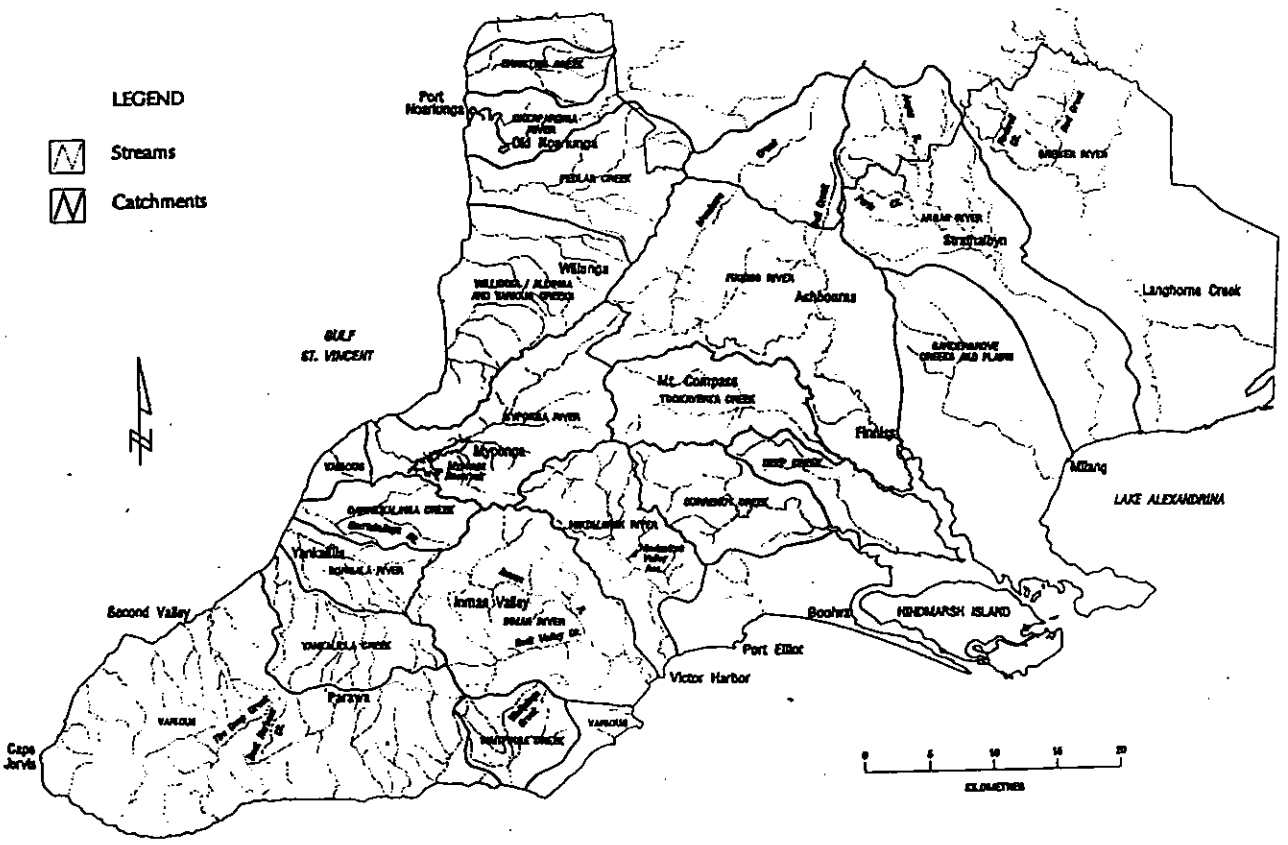
Map 16

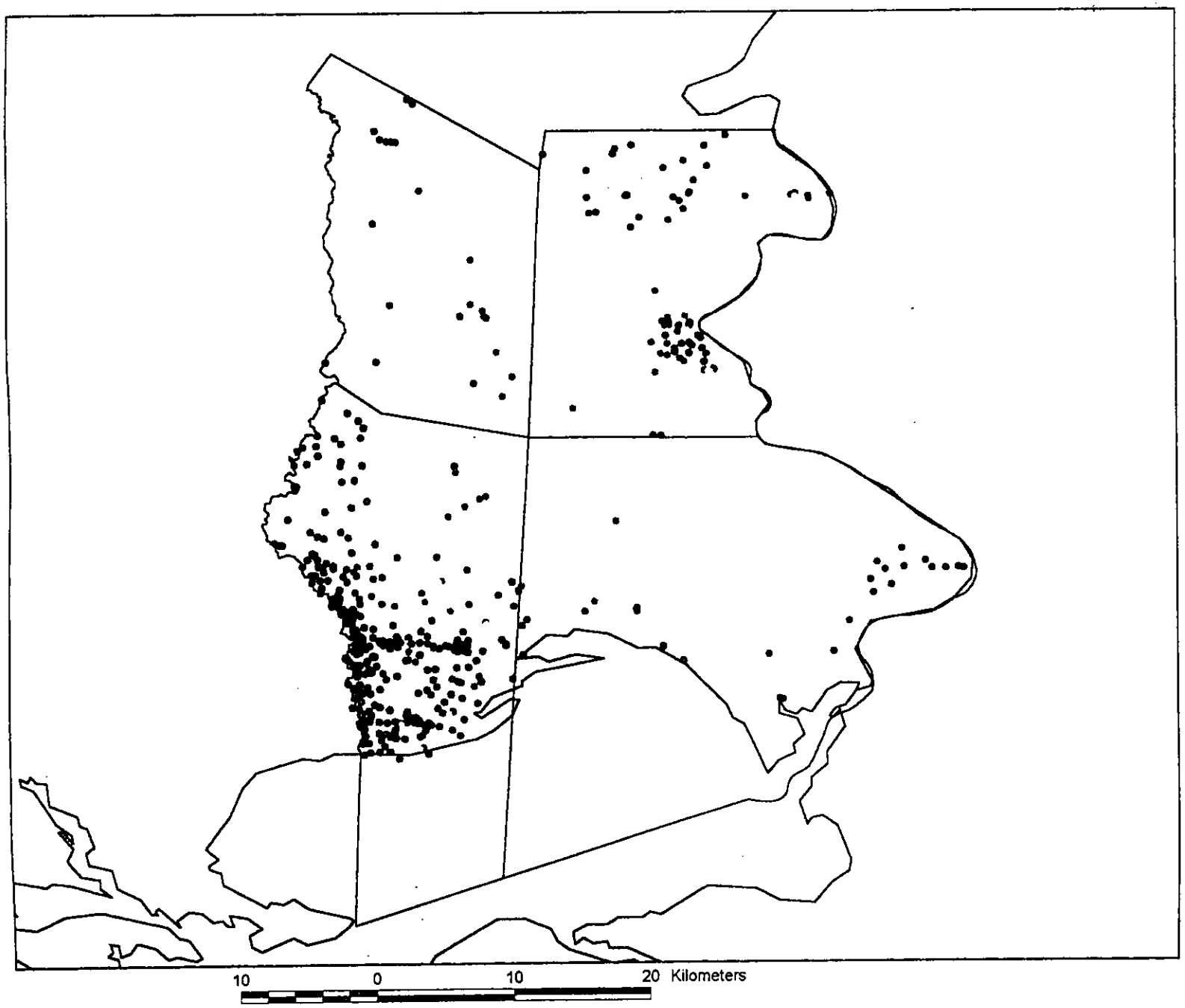
MAP 17 FLEURIEU PENINSULA

GROUNDWATER



MAP 18 CATCHMENTS





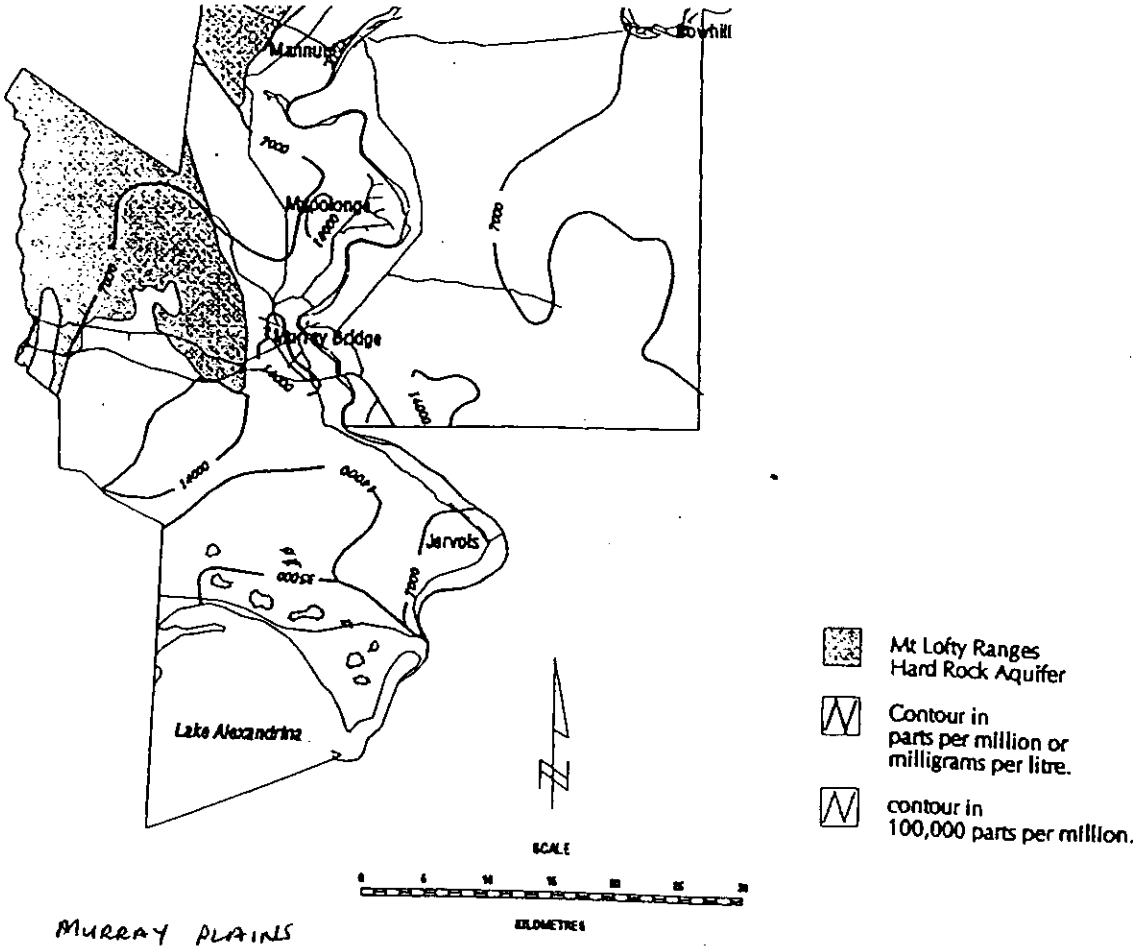
SALINITY

Map 19

N

Hundreds
Drillhole Salinity
0-3000
3000-7000
7000-14000
14000-35000
>35000
Coastline

SRBCJ.apr
2/10/96



MURRAY PLAINS
Map 24

WATER TABLE SALINITY

SALINITY

Land Salinisation

The Working Party on Dryland Salinity in Australia (1982) recognised eight types of salt-affected land:

Natural, without watertable
- saline loams
- saline clays

Natural, with watertable
- coastal salt marshes
- salt pans
- salt flats

Induced, without watertable
- scalds
- dry salinised soil

Induced, with watertable
- saline seepage

Leivers and Luke (1982) in their study of land salinisation in the Victorian mallee identified three common types of salting, which can also be applied to the study area. These are:

- Dune seepage which occurs following the removal of native vegetation and its replacement with cereal crops and pasture. Here the annual rainfall moves beyond the root zone and seeps out at the dunal base along with the dissolved salts. Within a few years of seepage areas forming, evaporation causes salts to accumulate on the surface. This affects plant growth.

- Broad plain salting where watertables are close to the land surface as in the Raak Land System. As a result of extensive clearing regional watertable levels rise rendering low lying areas useless. Such is occurring on properties bordering on Lake Alexandrina.

- Scalding occurs when naturally saline subsoils (B horizons) are exposed by erosion to lighter topsoils (A horizons) as is occurring on Camel Hill and Gifford Hill type soils in the western fringe zone.

Both dune seepage and broad plain salting are aggravated by seepage from riverine domestic stormwater and agricultural practices such as dairying.

SALINITY

(1) Saline seepage

This results from a rising water table which occurs as a result of clearance of deep rooted native vegetation or a change in land use.

Saline seepage can occur as hillside seeps, where the slope of the landscape changes or in valleys and streams. The severity depends on the quality and type of water table, the annual rainfall and the past management of the affected area.

(2) Irrigated Salinity

Irrigated salinity results from the rise of a water table following irrigation or by irrigating with poor quality irrigation water. Small isolated areas occur in the Hills

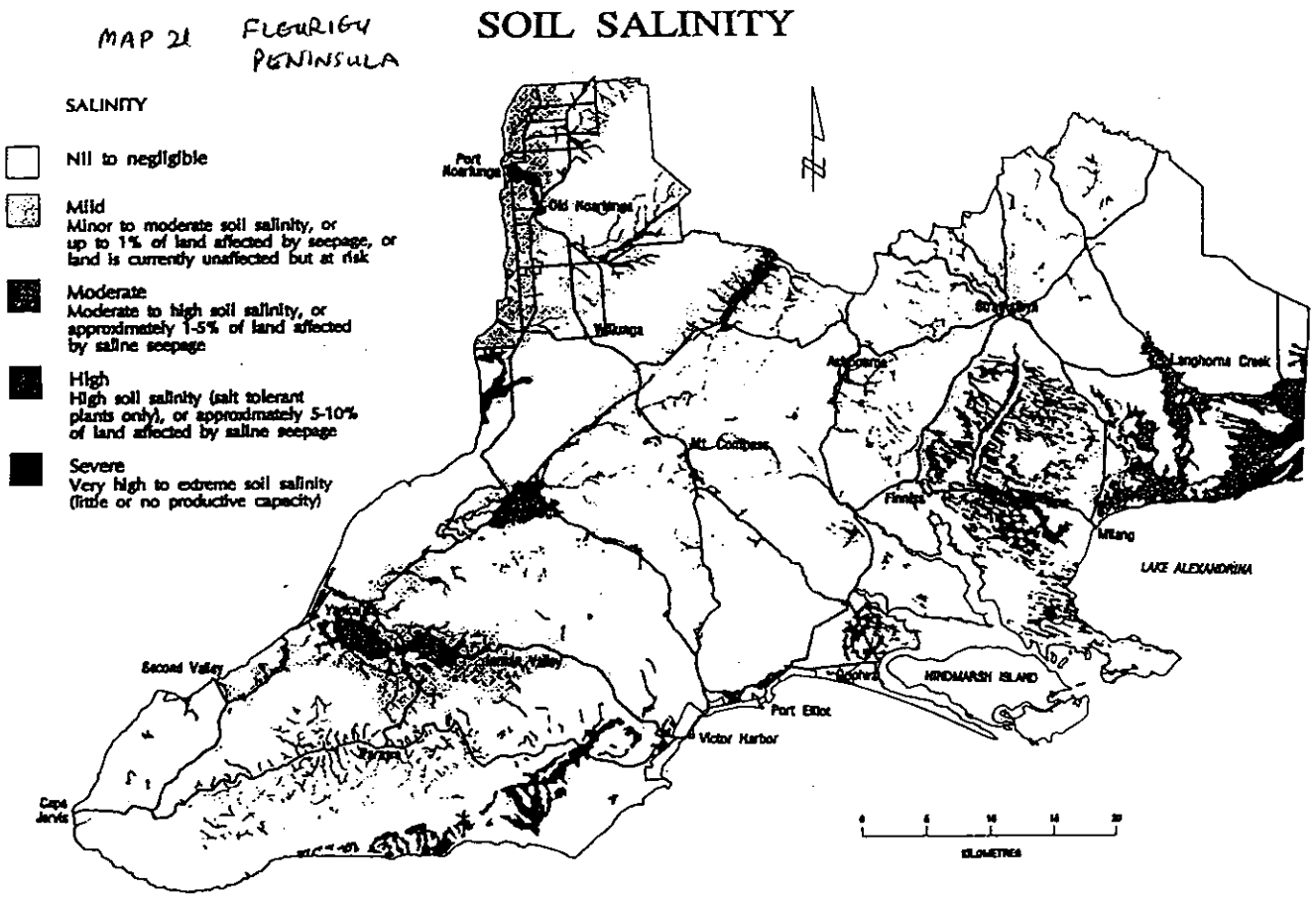
(3) Dry Salinised Land

This includes naturally occurring areas of saline soils or subsoils often occurring over Blanchetown Clay (locally known as 'magnesia patches').

Where surface expression occurs these areas have often deteriorated since clearing by stock camping on them.

(4) Saline Coastal Swamps and Flats

These are naturally saline swamps and small lakes on or close to the coast or Lake Alexandrina. In many cases since clearing they have deteriorated due to groundwater rise, vegetation removal, or erosion.



RIVER SALINITY LEVELS RISING

River salinity in the Murraylands is increasing dramatically. (Jessup,A. EWS pers.comm.) Flood flows reflect on salinity levels. The entitlement flow (a lesser flow than normal floodwaters) of the Murray means higher salinity levels. While a river salinity and drainage strategy is in place, salt interception schemes pump 1100 tonnes of salt away per day. Without this it is suggested that river salinity downstream of Morgan and the level of salt output would increase dramatically.

The strategy is based on a balance between salt interception, land and water management, tackling the concentration of all dissolved solids in the water, and land salinisation issues as well as waterlogging in irrigation areas. The strategy is expected to achieve a significant net reduction in river salinity.

SALTING

Land degraded by saline seepage and a high watertable will exhibit signs of vegetation decline. This occurs principally when salting into the root zone of vegetation occurs.

REVEGETATION STRATEGIES for the management of Salinity

1.Guidelines for Saline seepage

(1) treat salt affected area to reduce effect and provide production

a) control grazing by fencing affected areas and area at risk
b) restrict grazing during wetter periods
c) use surface drains where ponding and surface waterlogging occur
d) consider sub surface drainage on high impact sites
e) revegetate the site with appropriate pasture or tree species (tall wheat grass, puccenelia, salt - bush)

(2) treat catchment to reduce amount of water contributing to water table.

a) determine source of groundwater
b) use high water - use species, including deep rooted perennial pasture, trees and shrubs
c) manage surface water
d) revegetate high recharge/poor producing areas

(3) other recommendations include:

a) monitoring of water tables, creeks and salt affected areas to determine rate of spread
b) evaluate and monitor various treatment options

2. Guidelines for management of irrigated salinity

(1) recommended practices for poor quality irrigation water

a) grow more salt tolerant crops
b) apply leaching irrigations only if drainage below crop root zone is sufficient to prevent a rise in the water table
c) apply leaching irrigations during periods of low crop water use
d) avoid leaving the soil fallow
e) use drip irrigation to avoid foliar damage and to manage salts at root zone
f) use unsaturated flow from irrigation application that rates less than soil infiltration rates

(2) recommended practices where salinity is due to the development of the water table on low lying ground

a) sub surface drainage to maintain a downward movement of water and to keep the water table below the plant root zone
b) monitor water table levels

3. Guidelines for the management of dry salinised land

(1) Control surface dry salinised land to build up an organic surface layer to allow revegetation to occur.

a) fence larger areas
b) spread organic material on bare areas
c) revegetate with salt tolerant perennial vegetation (eg.saltbush)

(2) On subsoil dry salinised land

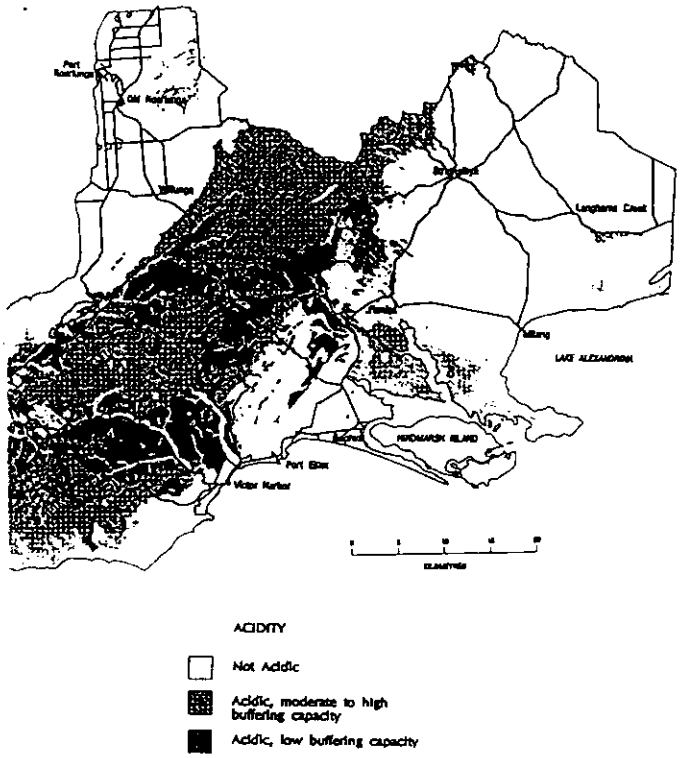
a) determine problem soils by soil testing
b) avoid growing sensitive crops and pastures by selecting salt tolerant varieties

4.Guidelines for Management of Coastal salinity

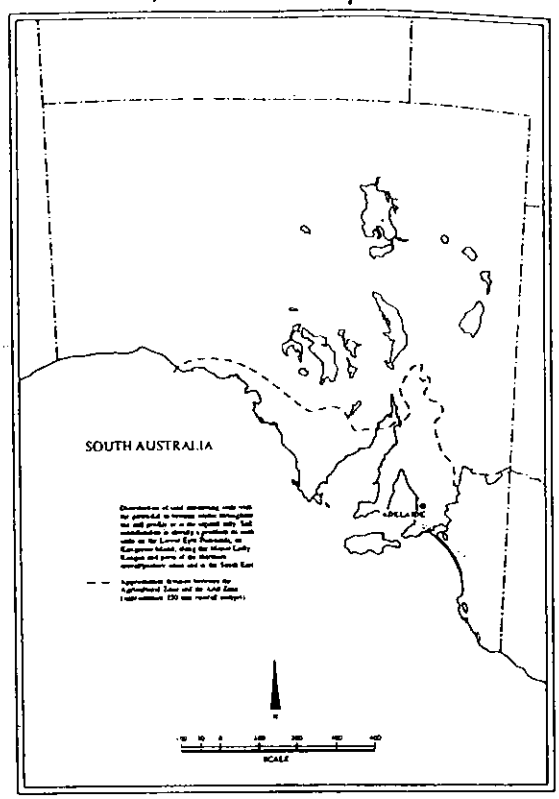
a) fencing to control grazing
b) establishment of salt tolerant vegetation
c) reduce human impact on sites
d) reduce aquifer recharge and water table increases

Map 26 Fleurieu Peninsula

SOIL ACIDITY



Map 27 Acidity in S.A.



Areas of potential soil acidity in South Australia
Source: Working Group of the Natural Resources Management Standing Committee (1991)

ACIDITY

Soil pH is a measure of the acidity or alkalinity of the soil. Soils with a pH less than 7 are acidic, while soils above 7 are alkaline. Acidity is a major issue where soil pH (calcium chloride method) falls below 4.5. In fact, many crops and pastures find slightly acidic soils (pH 6.0 - 7.0) ideal for growth.

Many soils are acidic in their natural state. However, farming practices can contribute to an increase in acid in the soil and a subsequent lowering of soil pH.

Factors which lead to a lowering of pH include nitrate leaching, organic matter build up, produce removal and nitrogen fixation: the result of 'good/productive' farming techniques. These processes are slow and take several decades to occur.

The effects of soil acidity include:

- reduced availability of particular nutrients (in particular potassium, calcium, magnesium, molybdenum);
- toxicity of certain nutrients (for example, aluminium, manganese, iron);
- restriction in suitable and productive plant species;
- poor legume nodulation;
- reduced availability of earthworms and soil microbes;
- long term damage to soil mineralogy and cation exchange capacity.

Source Southern Hills Soil Conservation Board.

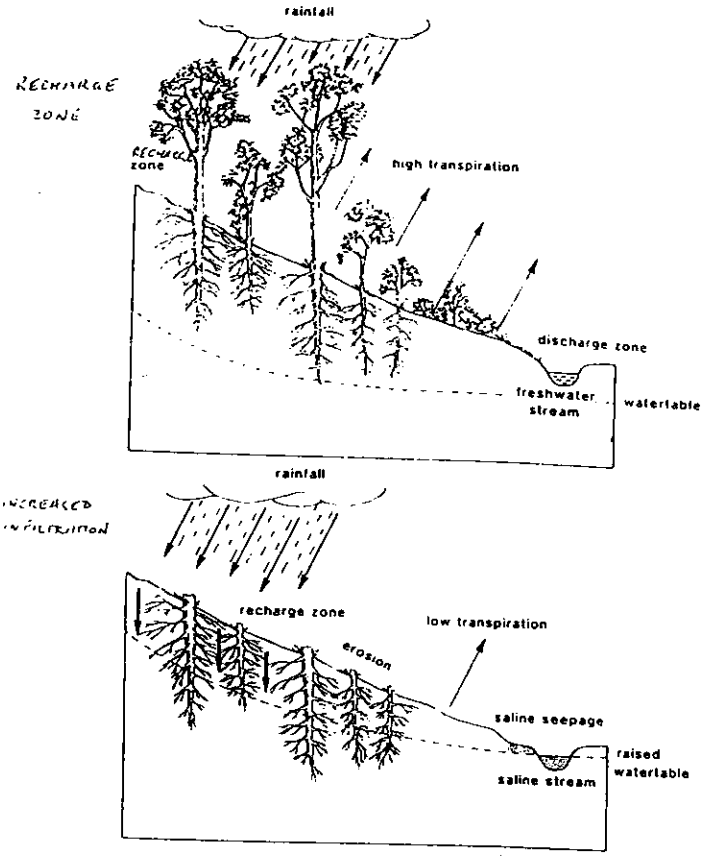


FIG. 3.

VEGETATION AND SALT TOLERANCE

Vegetation clearance resulted in immediate vegetation decline and local extinction, with long term fragmentation and isolation of species populations and habitats. Soil salinisation followed on from the practice of extensive and inappropriate land clearance, even after Native Vegetation Clearance Controls were introduced (1991). In the mallee areas increasing salinisation particularly of lowland discharge areas, and secondly of raised groundwater tables have resulted in the decline of native vegetation remaining in the lowland environments. (Morris and Thomson,1983:151)

Broadscale revegetation practices are required to link remnants, and to assist in the re-establishment of species lost due to fragmentation. The species collected as seed for propagation however must be local, as van der Moezel and Bell point out.(1987:157) They suggest that the use of Eucalyptus and Melaleuca species in the revegetation of salinised agricultural land in the mallee would be more successful if seed material is selected from trees growing near the edge of salt lakes.

Morris and Thomson in their study (1983) suggest that:

> The two main requirements for successful reclamation of saline land by plants are firstly that the planted seedlings survive the conditions throughout all seasons and secondly that the surviving seedlings grow when the conditions are least severe. Species that grow rapidly will develop a root system to utilise groundwater reserves, and this will also reduce competition with crop plants for topsoil moisture. (Morris & Thomson, 1983)'p.155

PART SIX

HUMAN IMPACT

Human impact has resulted in alteration of natural habitats and vegetation. This occurred from firstly the alteration of habitats making them unsuitable for many native species, and secondly by the introduction of plant species which compete and alter natural landscapes.

Jacobs (1981:207) stated:

> European man has had a greater effect on the Australian flora in 200 years than Aboriginal man has had for more than 30,000 years.

Indirect effects

The most significant of the indirect effects has been the introduction of animals that have become naturalised. The rabbit is perhaps the most obvious, followed closely by the hare, goat, buffalo and brumby each causing irreparable damage with devastating results.

> 'By being interdependent of surface water for long periods, grazing selectively, grazing very close to the ground and by ringbarking seedlings of some tree species in dry times, rabbits exerted a more intense and more continuous grazing pressure on many species.' (Jacobs,1981: 207-8)

A second indirect effect has been the establishment of an elaborate network of stock watering points. These have allowed the introduction of domestic livestock, and allowed native grazing and browsing animals to increase in population size and density.

The third and most obvious of the indirect influences is the introduction of exotic species by humans. These have competed successfully with native plants in previously undisturbed habitats.

Direct effects

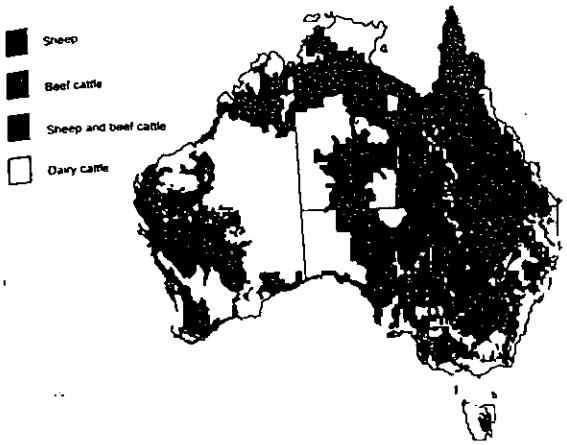
The more direct methods of human interference have significantly altered the natural flora and native vegetation. From the primary utilisation of native species (eg.timber selectively logged), and the introduction of alien species (domestic livestock - which converted the more palatable plants into marketable protein for wool or meat production) are two significant reasons. The enclosed animals altered the natural flora, and their urea contents could not be broken down by native dung beetles. Some native plant species were also removed because they were believed toxic to domestic stock or tainted meat and milk production.

Jacobs (1981:209) further suggests that :

> Palatable plant species are often drastically reduced in number while unpalatable species, those adapted to lower nutrient levels, species readily dispersed by animals, colonising species and those capable of tolerating the heavier grazing levels become more common.

Map 24 AGRICULTURAL PRACTICES - Land Use

Grazing land use in Australia. Sources: National Farmers' Federation (1991) and Australian Bureau of Statistics, Value of Principal Agricultural Commodities Produced, Australia 1988–89, Preliminary (Catalogue No. 7501.0)



Percentages of value of total agricultural production arising from livestock enterprises

%	NSW	VIC	QLD	WA	SA	TAS	AUS
Beef Cattle	19	12	29	6	7	13	15
Sheep Slaught	2	3	1	3	3	3	2
Other livestock SI	8	7	5	4	5	4	6
Wool	31	26	10	37	22	26	25
Milk	4	17	4	2	4	15	7
All other*	36	35	50	48	59	39	45

*Includes all other agricultural enterprises including livestock and cropping enterprises

Percentages of producers involved in livestock enterprises

%	NSW	VIC	QLD	WA	SA	TAS	AUS
Beef Cattle	12	11	20	12	12	18	14
Sheep Slaught	18	15	8	42	41	18	21
Other livestock SI	4	2	3	6	6	4	4
Wool	56	47	11	73	67	53	48
Milk	8	28	9	6	10	28	14

Information Source for Tables: Australian Bureau of Statistics, Value of Principal Agricultural Commodities Produced, Australia 1988-90, Preliminary (Catalogue No. 7501.0)

Map 25 AGRICULTURAL PRACTICES - Land Use

Cropping land use in Australia. Sources: National Farmers' Federation (1991) and Australian Bureau of Statistics, Value of Principal Agricultural Commodities Produced, Australia 1988–89, Preliminary (Catalogue No. 7501.0)

Percentages of value agricultural production arising from cropping enterprises

%	NSW	VIC	QLD	WA	SA	TAS
Wheat	10	8	7	29	22	0.1
Other	fruit 3	fruit 3	fruit 5	grain 3	fruit 4	potato 25
Other	cotton 8	grape 3	sugar 18	vege 2	grape 5	vege 25
All other*	79	86	70	66	69	49.9

*Includes all other agricultural enterprises including livestock and cropping enterprises

Percentages of producers involved in different cropping enterprises

%	NSW	VIC	QLD	WA	SA	TAS
Wheat	28	18	12	43	43	1.5
Other	fruit 6	fruit 5	fruit 26	grain 28	fruit 13	potato 16
Other	cotton 1	grape 5	sugar 20	vege 1	grape 12	vege 23

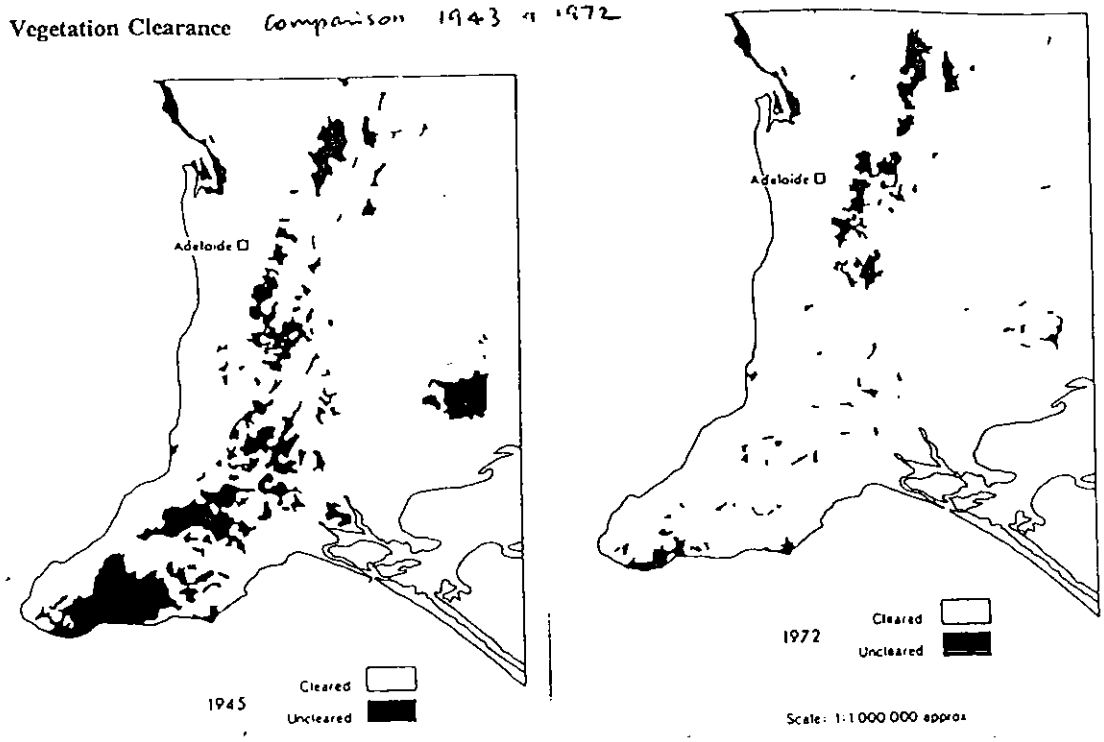
Information Source for Tables: Australian Bureau of Statistics, Value of Principal Agricultural Commodities Produced, Australia 1988-90, Preliminary (Catalogue No. 7501.0)

Along with extensive clearing and cultivation of land there has also been significant alteration of road corridor vegetation. The clearance of vegetation and alteration of the environment is often carried to extremes. Such actions result in reduced rainfall reaching the ground by intercepting rain and altering drainage patterns.

In much of the study area the road margins have been cleared and cropped, with larger trees removed. In other parts trees have been severely cut back to reduce accidents to vehicular traffic, or roads widened destroying native understorey and threatened species. On other road verges throughout the region, the area has been subjected to fertiliser application, weedicide control, controlled burning or mowing, introduced species and pest plants. All of these measures constitute vegetation decline.

In the past few years however change has been apparent with bare roadsides being subject to direct seeding or tubestock plantings of locally indigenous species.

Map 26 Native Vegetation Clearance Comparison 1943 & 1972



VEGETATION CLEARANCE IN SOUTH AUSTRALIA

Changing attitudes in the Murray Mallee and Murray Plains

Large areas of the Murray mallee were extensively cleared for agriculture. These areas were marginal lands experiencing low and erratic rainfall, that were used for cereal growing. Further south the deep sandy country had a high hazard erosion potential, yet faced continual pressure from stone pickers and crushers. (Intergovernmental Report on Vegetation Clearance 1976:12-13)

Factors influencing clearance

Both these groups of marginal lands farmers, were prior to 1976, encouraged to participate in vegetation clearance through economic conditions, Government rural policy and incentives, technological developments in resource extraction and/or utilization, and existing legislative and administrative controls. (IRVG.1976:19)

The committee on Vegetation Clearance discovered that most of the agricultural areas of the state had been cleared, leaving a declining natural resource base. They put into motion a policy that ensured sound land management principles, and established a land use authority that restricted land vegetation clearance further. A change in attitude was seen as a basic tool, and the report states that:

> Conservation of vegetation on private lands is seen as an essential complement to the parks and reserves system administered by Government, and financial and non-financial incentives are expected to make an important contribution to such conservation. (ICVG,1976:52)

AGRICULTURE IN COUNTY STURT

The western fringe zone of the Murray Mallee falls under the County of Sturt. The area extends westwards from the Mt.Lofty ranges to the River Murray, and southwards to include Lake Alexandrina. It is recognised agriculturally for cereal cropping and sheep grazing. The area is managed under two Soil Boards - Murray Plains and the Southern Hills.

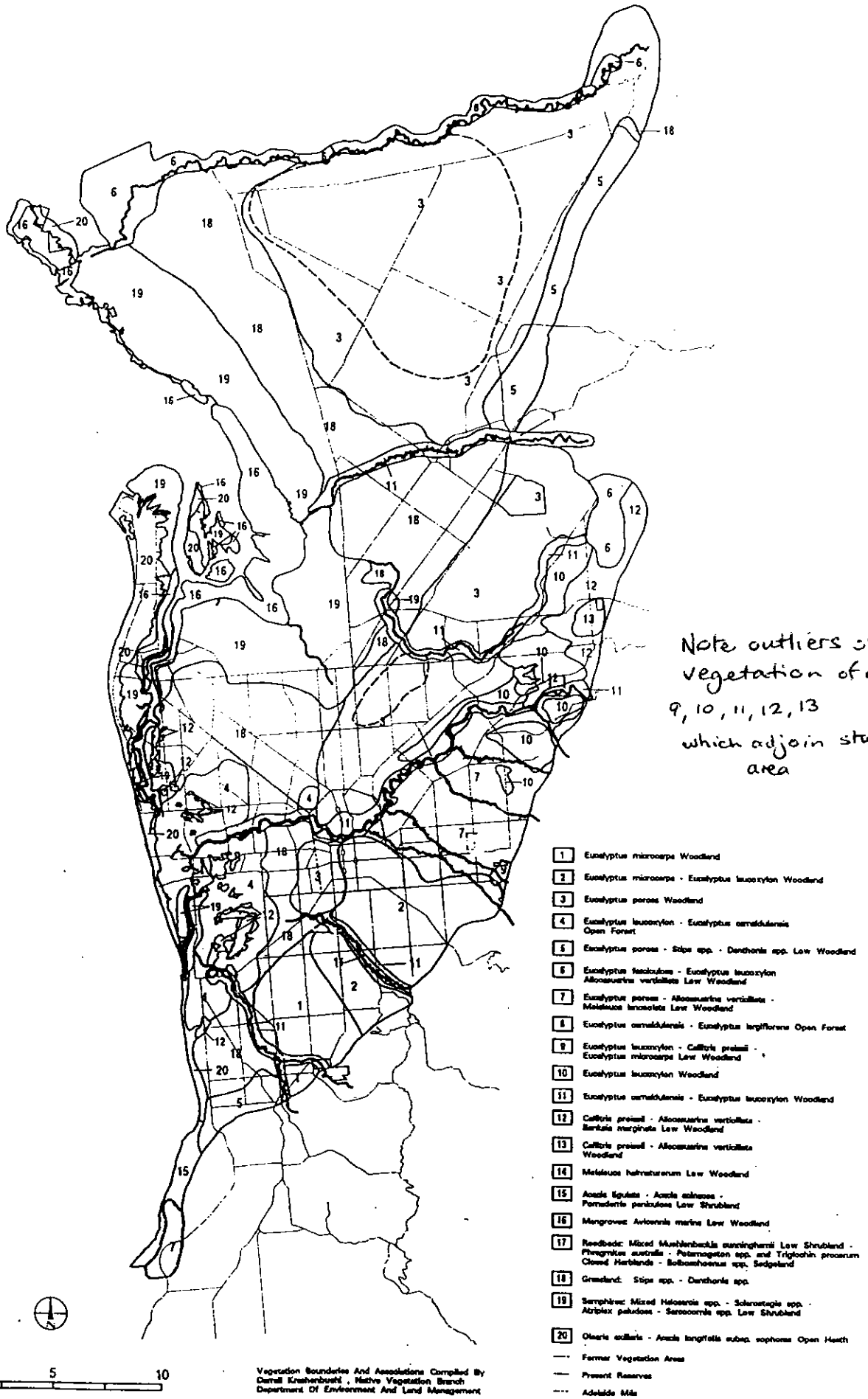
The diversity of the region is most pronounced in its stands of natural vegetation. In the ranges the vegetation comprises of redgums, bluegums, peppermints, sheoaks together with annual and perennial grasses. The remaining area becomes typical mallee with vegetation of eucalyptus and broombush together with shrubs and grasses. The associations are varied with overlap of species representative of the Adelaide Plains (see map), the Coorong and inland dunes, the Lower Murray Mallee, the Upper Murray Mallee and the River Murray wetlands.

The average rainfall of the ranges is about 500 mm whereas the drier mallee area receives 250 - 350 mm. Soils are extremely variable with red-brown to acid-grey soils on the ranges to shallow, sandy soils of the stonier mallee plains.(Williams,1966:169)

Land use varies with rainfall, with wool, fat lamb raising and dairying on higher rainfall areas and irrigated reclaimed swamps, and a predominance of cereal cropping and sheep raising in the lower rainfall districts.

On the Murray Plains the land holding size for sheep grazing varies between 400 and 2000 hectares while combined cereal/sheep farms are much smaller being about 400-800 hectares. In comparison dairy farms in the higher rainfall districts of the Mt.Lofty ranges are much smaller ranging from 20-40 hectares. Cereal crops have predominantly been barley, wheat and oats with annual pastures of Barrel medic, Wimmera rye, lucerne, perennial Veldt grass and Evening Primrose. Other agricultural production includes horticultural crops and viticulture, pigs and poultry production.

Poultry production (broilers and eggs) is high in County Sturt because of the suitability of climate and availability to markets. A large number of commercial poultry units are established, with the largest of these holding 100,000 layers. Broiler production increased from almost nil to half a million birds per annum,in the early period of development. Today, the Monarto/Brinkley area has the largest broiler production in the State. Such agricultural production necessitated the development of industry in the region associated with the area's natural and agricultural resources, and more recently manufacturing.



Note outliers of vegetation of ranges (eas
9, 10, 11, 12, 13
which adjoin study area

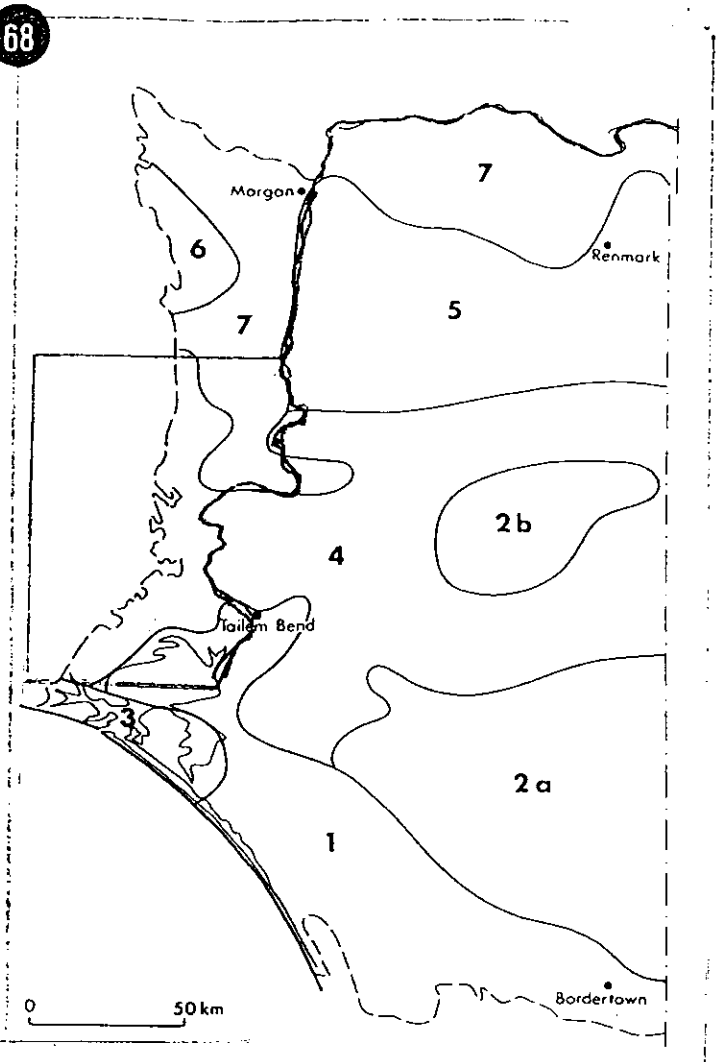
MAP 2

Original flora of the Adelaide plains
Source: Department of Environment and Land Management

Map 2A.

Western Fringe Zone

Agricultural subregions
1, 3, 4, 7

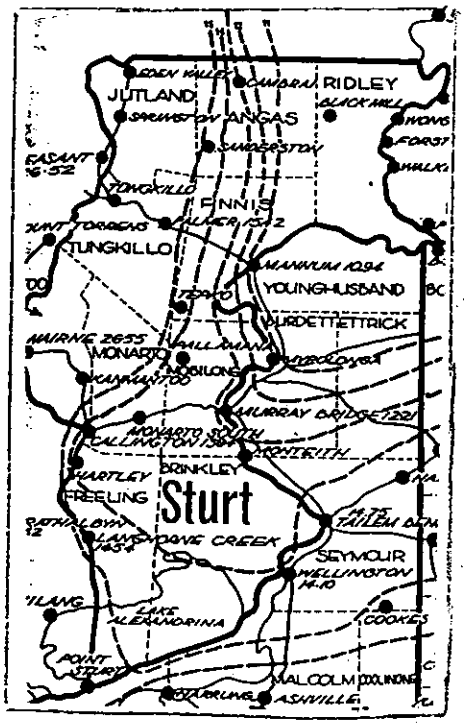


Agricultural subregions.

TABLE B

Agriculture in Murray Mallee Province

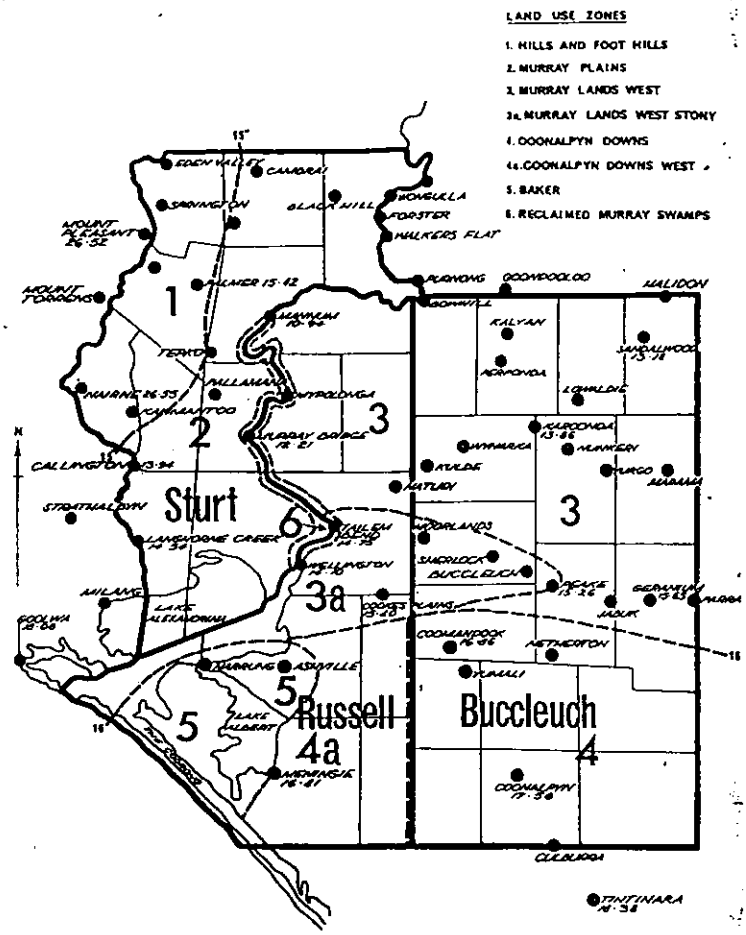
Agricultural subregion*	Agricultural activities	Farm products	Area of rural holding (ha)
1	Grazing	Wool, mutton beef	500-1000
2	Extensive grazing	Wool, beef	1000-2000
3	Grazing	Mutton, dairy products, beef	<500
4	Rotation cereal cultivation and grazing	Barley, wheat, wool, beef	1000-2000
5	Rotation cereal cultivation and grazing	Wheat, wool, beef	1000-2000
6	Grazing	Wool, beef	1000-2000
7	Extensive grazing	Wool, beef	5000 +



MAP 2B

COUNTY STURT

Map 29 Murray Bridge and District

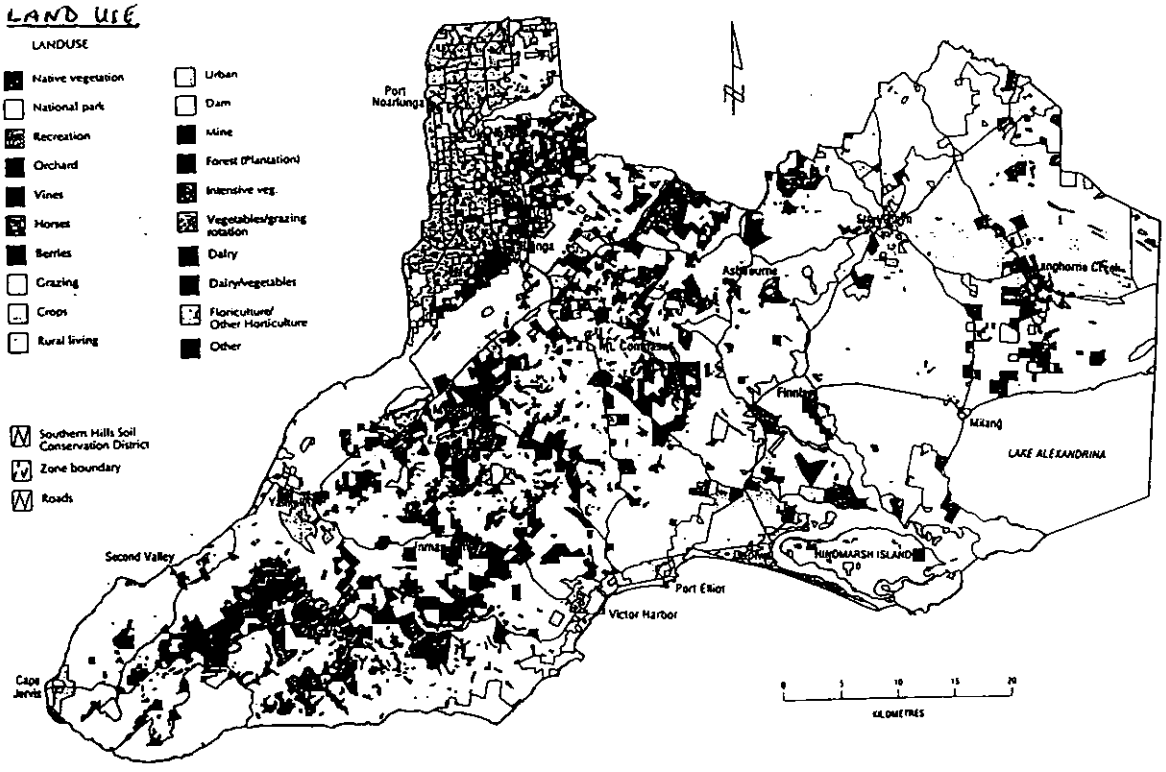


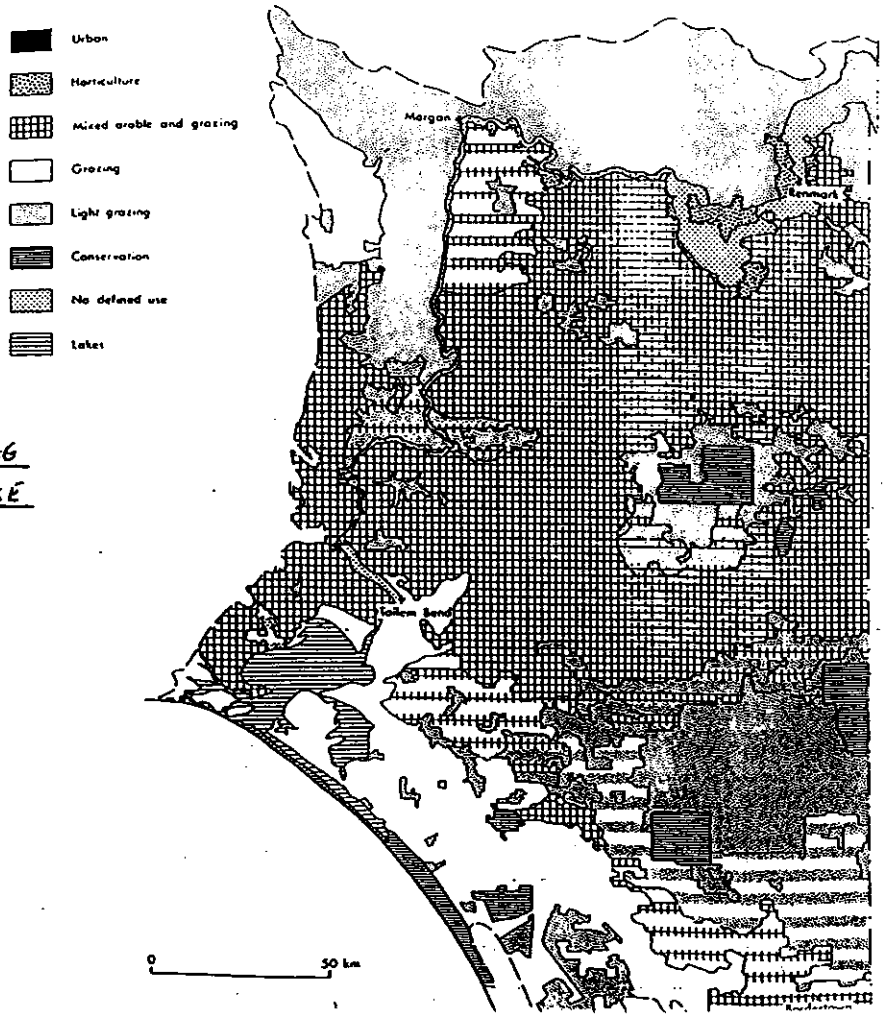
The problems associated with agriculture in this region include weeds, cereal diseases, erosion, and trace elements.

The agricultural weeds include horehound, false caper, onion weed, skeleton weed, and saffron thistle. The cereal problems include rhizoctonia, eelworm, frost and stem rust on wheat, and mildew in wetter areas. Large amounts of superphosphate, copper and zinc need to be applied to the soils in the region with higher amounts for leached soils to enhance soil fertility. Water erosion occurs in the hilly areas and swamplands, with wind erosion and salinity on the lighter soils.

Agricultural practices reflect upon management practices, scale of operation, and local soil and climatic factors. The sustainability of productive capacity therefore needs to address issues relevant to the sustainable use of the land. These issues include the prevention and amelioration of land degradation and soil erosion, effective and appropriate methods of handling stubble residues, the control of weeds, pests and diseases, and the improvement of soil fertility. All of these must be integrated into a sustainable and economically viable system of land management.

Map. 38 FLEURIEU PENINSULA
LAND USE



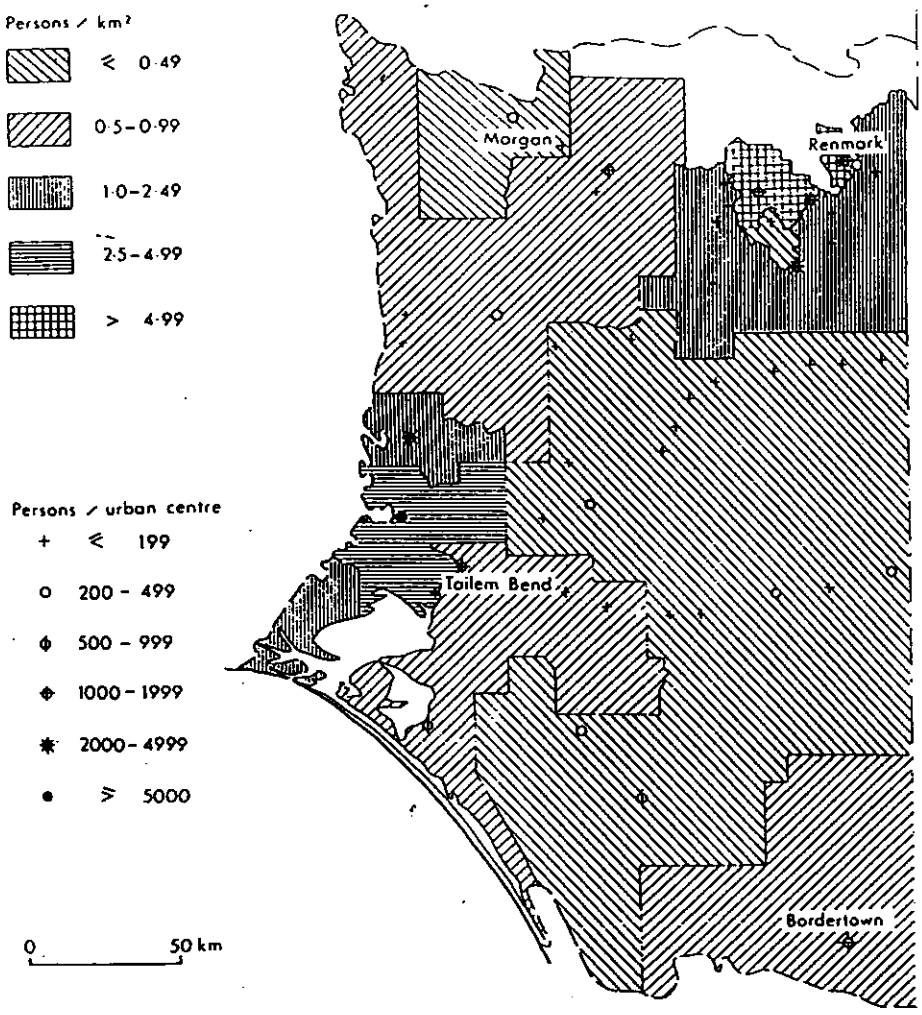


MAP. 39 MURRAY MALLEE
LAND USE

Management practices impact upon the risk of erosion, therefore maintenance and improvement of soil health are vital for the cereal industry. Sustainable cropping systems are those practising conservation farming by such methods as minimum tillage and the use of legume based pastures. Other practices supported by the Southern Hills Soil Board (1995) include:

* retention of crop and pasture residues
* reduced tillage seeding techniques which permit early sowing
* selection of appropriate crop and pasture rotations and varieties
* amendment of limiting factors such as nutrition
* use of land capability to determine limitations and appropriate management to prevent land degradation.

Where cropping is carried out in conjunction with other enterprises, all facets of the operation need to be part of the overall plan to arrest land degradation.

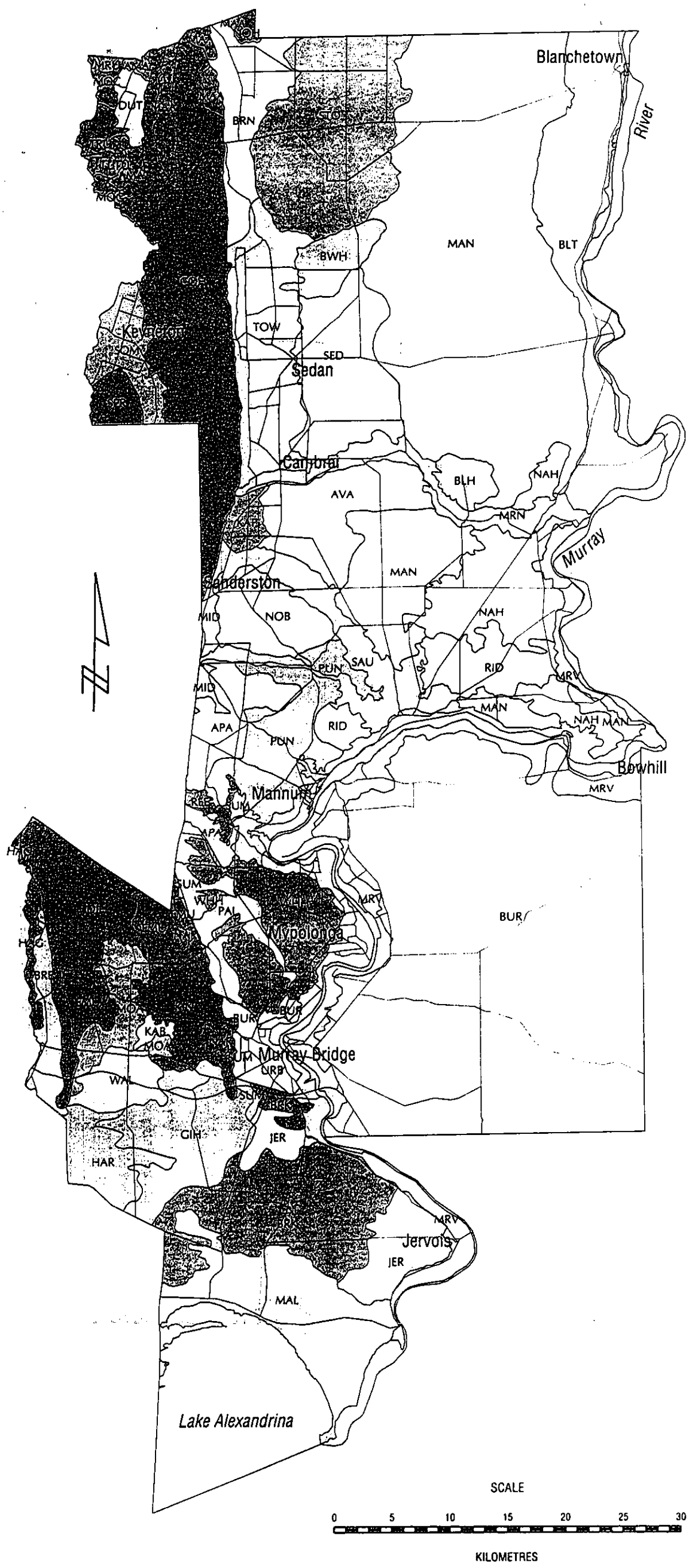


MAP 30 MURRAY MALLEE

Urban settlements and rural population densities.

Map 38

LAND SYSTEMS



WESTERN ZONE - LAND SYSTEMS OF THE RANGES

Rolling to steep, low hills and hills

COH	Cooke Hill
DIH	Disher Hill
HAG	Harrogate
MRU	Mount Rufus
NAR	Narrinyeri
NOH	North Hills
REE	Reedy
SPR	Springton

Undulating to rolling rises and low hills

AMA	Amaroo
EMU	Emu
KIN	Kinchina
MAA	Malabena
MOC	Moculta
TRU	Truro

Broad gentle slopes and undulating rises

MOA	Monarto
SOM	Somme

CENTRAL ZONE - LAND SYSTEMS OF THE OUTWASH SLOPES

Undulating rises

APA	Apamurra
AVA	Avalon
BRN	Brownlow
NOB	North Boundary
SED	Sedan

Alluvial plains and broad gentle slopes

BRE	Bremer
DUT	Dutton
MID	Milendella
PAL	Pallamana
SUM	Summerfield
TOW	Towitta
WAL	Warla

Plains

STO	Stonefield
KAP	Kanappa

EASTERN ZONE - LAND SYSTEMS OF THE MALLEE COUNTRY

Undulating to rolling low hills

BLH	Black Hill
BWH	Black and White Hill
GIH	Gifford Hill
HAR	Hartley
PUN	Punthari

Gently undulating stony plains and undulating rises

BLT	Blanchetown
BUR	Burdett
JER	Jervois
KAB	Kalibar
MAN	Mantung
NAH	Nagel Hill
RID	Ridley

Parallel sand dunes and undulating rises

BRK	Brinkley
WHH	White Hut

Sand plains and saline swamps

MAL	Malcolm

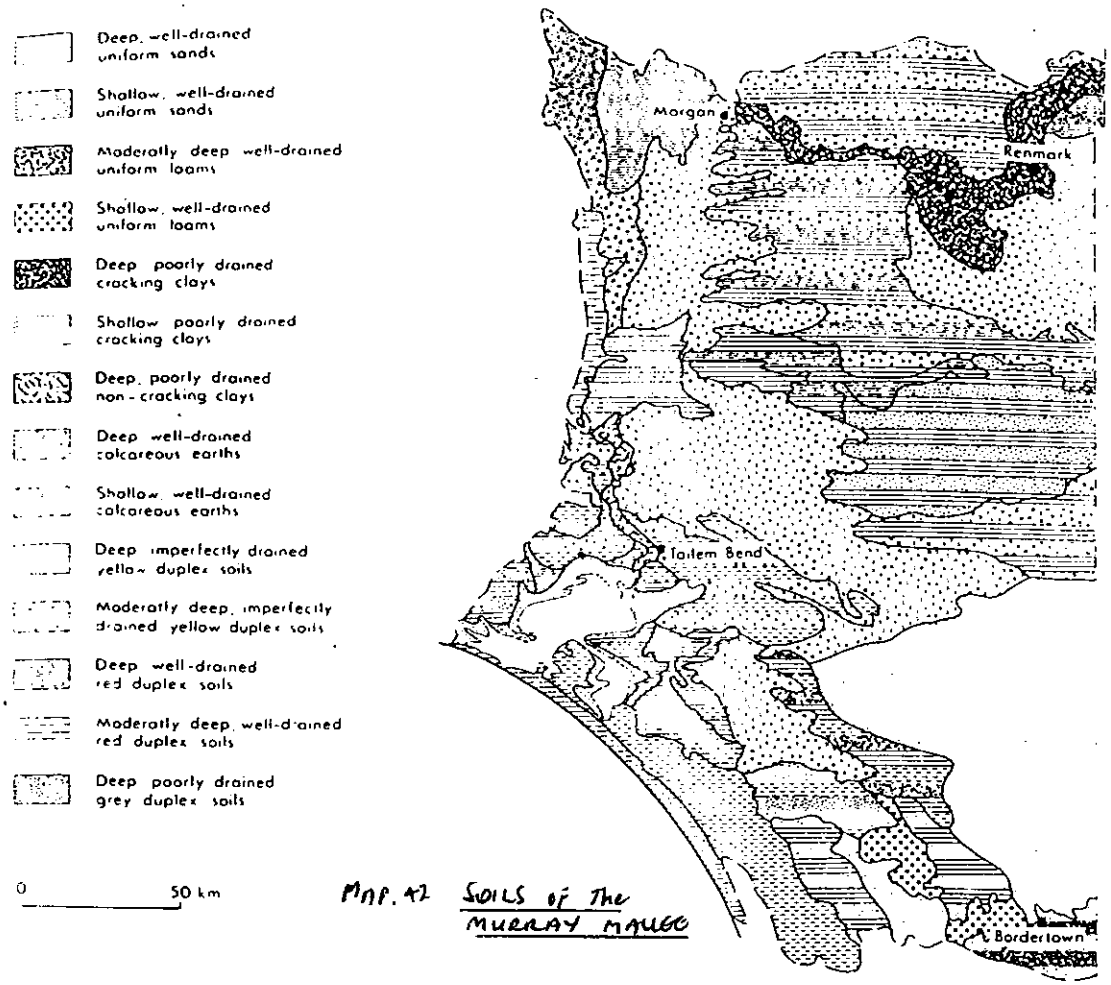
RIVER VALLEYS

MRN	Marne
MRV	Murray River Valley
SAU	Saunders

Land Systems compiled by
C.S. Cichon and P.R. Butler
Primary Industries South Australia

Map Production by
Geographic Information Services Group
Primary Industries South Australia

Land Systems, Murray Plains Soil Conservation District



MAP. 42 SOILS of The MURRAY MALLEE

SOILS

Soils of the Murray Mallee Province.

From the map above it can be observed that the Land Systems and soils of the study area of the Western Fringe Zone of the Murray Mallee Province highlight some diversity. They consist partly of alluvial plains and broad gentle slopes, undulating to rolling hills of shallow calcareous earths, plains of poorly drained sands over stony calcareous deposits with parallel sand dunes and undulating rises. The reader is referred to the map 'Geology of Environs.'

The main land systems in the study area are represented as Brinkley, Hartley, Warla, Gifford Hill, and Monarto. Added to this are impositions of soils of Bremer, Emu, Kalibar and Kinchina.

The area is recognised as consisting of moderate to severe wind and soil erosion potential, with dryland salinity in southern areas, and extensive salinisation in Lake areas. There may also be mass movement on steeper slopes of the ranges.

A brief description provided by Maschmedt (1976) indicates the local soil units present in the Monarto region generally, and the mapped phases and variants of those soil units. The information given is of relevance to the area as many units overlap, and study sites may have a variety of soil types. Of particular relevance however are the soils of Monarto, Kalibar, Lylo, Kornheim, Camel Hill, Gifford Hill, and Ferries McDonald.

MAP 5 FLEURIEU PENINSULA GENERALISED SOIL

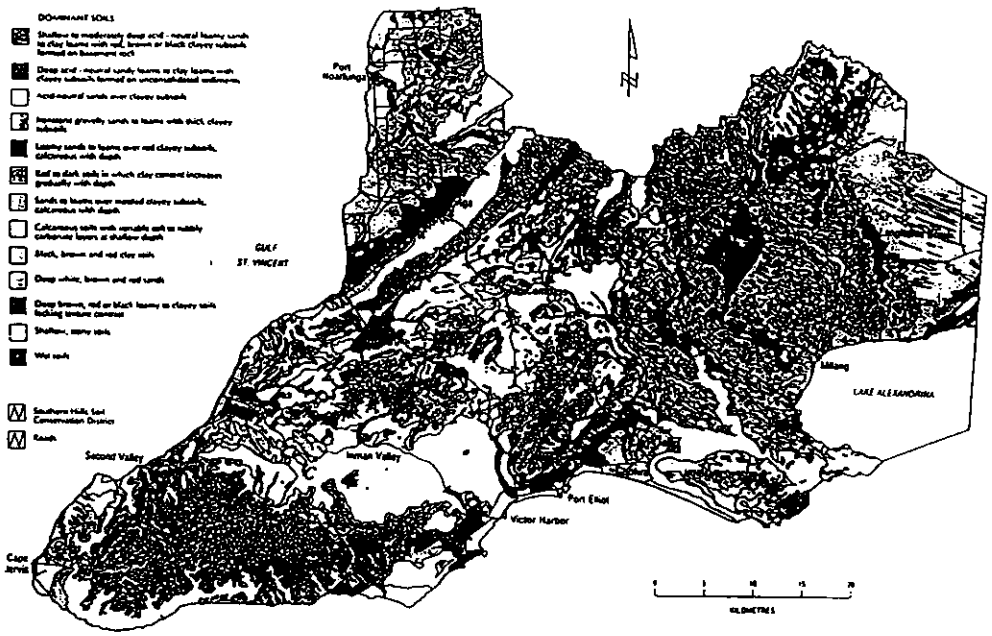


TABLE 9
SOIL UNITS MONARTO

SOIL UNIT	BRIEF DESCRIPTION	MAPPED PHASES AND VARIANTS OF SOIL UNIT
SOILS DEVELOPED OVER SCHISTS, PHYLLITES AND METASANDSTONES OF THE KANMANTOO GROUP		
MONARTO Mo	5-15 cm sandy loam sharply overlying a structured red brown clay, calcareous and highly micaceous at base (Dr2.13). Hill-slopes.	Mo^{sh} Shallow; <40 cm uniform loamy sand overlying rock (Uc1.43). no subsoil clay. Extensive areas of rock outcrop Mo^{dk} Very dark brown subsoil clay horizon (Dd1.13) Mo^{sh} Deep sandy surface (Dr4.53)
KALIBAR Ka	5-15 cm calcareous loamy sand gradational to a moderately calcareous red brown light clay; highly calcareous and micaceous at base (Gc1.12). Hillslopes.	
SOILS DEVELOPED OVER SEDIMENTS OF THE PARILLA SAND AND BLANCHETOWN CLAY FORMATIONS		
LYLO Ly	5-10 cm surface soil over a red brown clay, calcareous at base (Dr2.13). Plains.	Ly^{c} Clay surface (Uf6.11) Ly^{s} Sandy loam surface (Dr2.13)
KORNHEIM Ko	5-10 cm calcareous red sandy loam gradational to a moderately calcareous red brown light clay. Underlain, at 30-40 cm, by a very highly calcareous sandy clay loam (Gc1.12). Plains.	Ko^{g} Grey coloured surface, usually with calcareous nodules (Gc1.11)
CAMEL HILL Ca	10-40 cm grey sand sharp to a yellow brown sandy clay, calcareous at base (Dy5.43). Dune flanks and ridge crests.	Ca^{sh} Shallow, <1 metre soil over bedrock (Dy5.43)
GIFFORD HILL Gi	Thin grey sand over deep (>50 cm) white sand, yellow clayey sand at base (Uc2.21) Dune crests.	
FERRIES-McDONALD Fe	10-30 cm loamy sand, usually with calcrete on surface; sharp to an indurated or nodular calcrete; underlain by a loosely coherent calcareous layer of variable thickness, 50-200 cm (Uc1.33).	
SOILS DEVELOPED OVER GRANITE, LOCAL GRANITIC OUTWASH, GRANITIC GNEISS AND MIGMATITE		
KINCHINA Ki	5-20 cm sandy loam sharp to an unstructured red, coarse sandy clay, calcareous weathering granite at base; profile <1 m deep (Dr2.53).	Ki^{sh} Shallow; <40 cm uniform loamy sand overlying rock; no subsoil clay (Uc1.43) Extensive areas of rock outcrop. Crests, hill-slopes. Ki^{dp} Deep; >2 m soil over rock; weathering granite or granitic outwash >150 cm thick (Dr2.83). Lower slopes of valley bottoms
WHITE HILL Wh	15 cm loamy sand clear or gradational to a calcareous red brown light clay; underlain by a loosely coherent highly calcareous horizon (Gc1.12, Dr2.53). Hillslopes.	
SOILS DEVELOPED OVER QUATERNARY ALLUVIAL AND COLLUVIAL DEPOSITS		
PREAMIMMA Pr	10-30 cm sandy loam, pale coloured at base; sharp to a red brown structured clay, calcareous at base; underlain by lime free alluvial sands or clays (Dr2.43). Terraces.	
PALLAMANA Pa	40 cm red brown loamy sand, clear or gradational to a calcareous sandy light clay; at base lime free alluvial or colluvial sands or sandy loams. (Gc1.12, Dr2.53). Foot-slopes of Pallamana scarp.	Pa^{f} Deep; >60 cm coarse sands. Alluvial fans at base of Pallamana fault.

MISCELLANEOUS LAND TYPES

CALCRETE OUTCROP	K	Calcrete may be rubbly (Balsara Calcrete) or sheet (Ripon Calcrete). Usually there are patches covered with a thin veneer of sand.
GRANITE OUTCROP	G	Often coarse granitic weathering material (grus) is associated with the outcrop.
ALLUVIUM	A	Reddish brown sands, sandy loams and clays. In present drainage lines.
SCHIST AND META-SANDSTONE OUTCROP	E	Shallow, micaceous, loamy sand associated with outcrop.
COARSE SANDSTONE	T	Shallow (<40 cm) uniform textured soils associated with outcrop.

SOIL SURVEY DATA

Stoniness
Sand spots
Scabby spot
Salt scald
Swamp or waterlogged depression
Sampling and/or photo site

LAND SYSTEMS

A land system is an area of land which has generalised typical characteristics such as geology, land form, soils and vegetation. There are a number of different land systems in the Murray Plains district displaying varied characteristics from the Mount Lofty Ranges to the River Murray. Using aerial photographic interpretation and extensive ground truthing the different land systems of the Murray Plains have been recorded.

While each land system has similar characteristics, it may also display some minor inconsistencies. Each land system of the study area has been described according to the following format:

Land System For each land system the following features are described

Symbol	Map symbol given in capital letters for easier cross referencing
Name	Land system name based on a typical location within the land system.
Total area	Given in square kilometres.
Rainfall	Annual average rainfall given as a range or representative total in millimetres
Geology	Typical rock types and symbols of relevant geological formations
Topography	Description of the landform pattern based on relief and slope
Elevation	Elevation range across the land system, given in metres (Australian Height Datum)
Relief	Relief range across the land system, given in metres

Facet *For each facet within the land system (except stream channels and those facets occupying less than 1% of the land system) the following are described:*

% of area	Approximate (~) percentage of land system occupied by this facet
Typical soil	Three common soils are usually described (more in facets with a diverse range of soils). They are described either as a single profile or as a range of profile attributes. Only the extremes of each attribute are described. Order is insignificant.

Land Class	Common land classes within each facet are listed from the most to the least extensive; where the land classes are separated by semi-colons; each classification lists the most severe class and limitation first. Land classes indicate the type and severity of limitations to agriculture. The type of limitation is referred to as the land quality and is given as a lower case letter. The severity of the limitation is indicated by a roman numeral.
Pros	Up to three outstanding, positive features which occur in greater than 50% of the facet are listed.
Cons	Up to three severely limiting features which occur in greater than 50% of the facet are listed.
Land Use	Dominant current land uses are listed, but not ranked.

WAL (Warla)

Total Area: 32 km²
Rainfall: 375-400 mm
Geology: Locally derived outwash sediments and alluvium (Qpp, Qha)
Topography: A long, undissected gentle slope at Monarto South
Elevation: 85-150 m
Relief: 65 m
Facet:

Plain
% of area: ~90
Typical soil:
1. Thin red sandy loam grading to brown clay over sandy clay loam; calcareous throughout
2. Red clay over rubble
3. Red sandy loam over clay over rubble

Land class: II-a; II-p
Pros: Fertile soils with good water holding capacity
Land use: Annual pasture, cereal, grain legume

Sand dune
% of area: ~10
Typical soil:
1. Thin brown sand over bleached sand over columnar brown sandy clay; calcareous with depth

Land class: IV-a (III-n,m); III-a,n,m
Cons: Wind erosion potential, soils with low nutrient fertility and water holding capacity
Land use: Scrub, annual pasture, cereal

HAR (Hartley)

Total Area: 43 km²
Rainfall: 375 mm
Geology: Calcrete (Qca)
Topography: Undulating to rolling calcreted low hills, east of Hartley
Elevation: 40-160 m
Relief: 40-70 m

Facet:

Rise
% of area: ~60
Typical soil:
1. Brown loamy sand grading to a brown rubbly loamy sand on calcrete

Land class: III-r,a,n; IV-r (III-n,m)
Cons: Stony soils with low nutrient fertility and water holding capacity
Land use: Annual pasture

Sand dune
% of area: ~35
Typical soil:
1. Deep sand
2. Thick grey sand over brown sandy clay

Land class: III-a,u,n,m; IV-a (III-u,n,m)
Pros: Drainage
Cons: Wind erosion potential, water repellent soils with low water holding capacity and nutrient fertility
Land use: Annual pasture

Depression
% of area: 5

BRK (Brinkley)

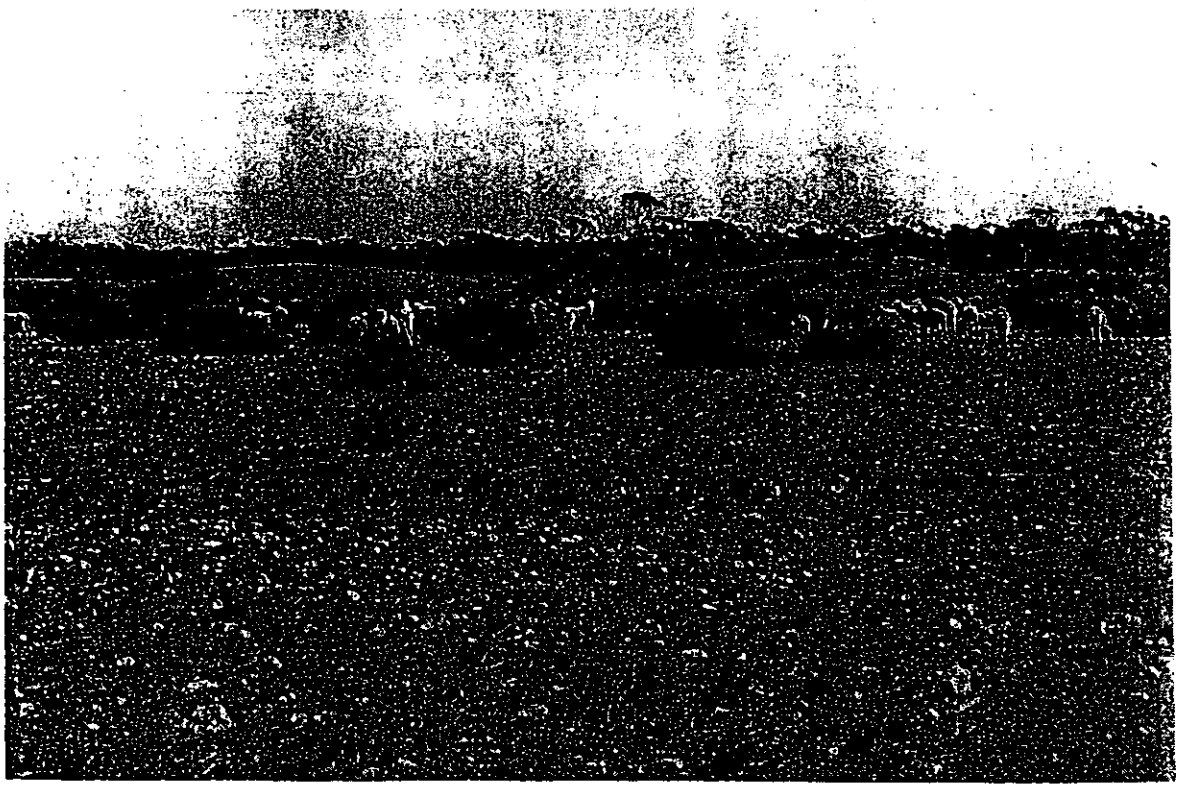
Total Area:	160 km^2	
Rainfall:	350-375 mm	
Geology:	Calcrete and clay (Qca, Qph)	
Topography:	Undulating rises with parallel sand dunes, south of Murray Bridge	
Elevation:	5-30 m	
Relief:	5-25 m	
Facet:		
Swale	% of area:	~45
	Typical soil:	1. Brown sandy clay loam over clay
	Land class:	II-p
	Pros:	Soils with good water holding capacity and nutrient fertility
	Cons:	Shallow water table
	Land use:	Cereals, grain legumes, annual pasture
Stony rise	% of area:	~35
	Typical soil:	1. Sandy loam over calcrete
	Land class:	III-r,m,n
	Cons:	Stony soils with low water holding capacity and nutrient fertility
	Land use:	Cereals, annual pasture
Dune	% of area:	~20
	Typical soil:	1. Sand over clay 2. Deep sand
	Land class:	IV-a (IIIn)
	Pros:	Drainage, workability
	Cons:	High wind erosion potential, water repellent soils with low nutrient fertility
	Land use:	Scrub, annual pasture

GIH (Gifford Hill)

Total Area	95 km^2	
Rainfall	350-375 mm	
Geology	Calcrete (Qca)	
Topography	Undulating to rolling low hills with sand and calcrete, south west of Murray Bridge	
Elevation	20-160 m	
Relief	40-170 m	
Facet		
Hillslope	% of area:	~70
	Typical soil:	1. Thick grey sand over brown sandy clay; calcareous with depth
	Land class:	III-a
	Cons:	Wind erosion potential, water repellent soils with low nutrient fertility
	Land use:	Annual pasture, cereal
Flat	% of area:	~15
	Typical soil:	1. Loamy sand to sandy loam over red clay on weathered metasandstone
	Land class:	II-e (II-a)
	Pros:	Fertile soils with good water holding capacity and workability
	Land use:	Annual pasture, cereal, perennial pasture
Stony rise	% of area:	~5
	Typical soil:	1. Thin loamy sand to sandy loam on calcrete; calcrete surface stones are common
	Land class:	III-r,n,m
	Cons:	Stony soils with low water holding capacity and nutrient fertility
	Land use:	Annual pasture, cereal
Sand dune	% of area:	~5
	Typical soil:	1. Deep sand
	Land class:	IV-a
	Pros:	Drainage
	Cons:	Wind erosion potential, water repellent soils with low nutrient fertility
	Land use:	Annual pasture, cereal
Sand spread	% of area:	~5
	Typical soil:	1. Very thick grey sand on calcrete
	Land class:	IV-a
	Cons:	Wind erosion potential, water repellent soils with low nutrient fertility
	Land use:	Annual pasture, cereal
Drainage depression	% of area:	<1

MOA (Monarto)

Total Area:	40 km^2		
Rainfall:	375-400 mm		
Geology:	Schist and locally derived alluvium and outwash sediments (Ekt, Qha, Qpp)		
Topography:	Undulating rises and broad valleys with gentle slopes, crossed by drainage depressions and watercourses, between Monarto and Callington		
Elevation:	100-170 m		
Relief:	15-25 m		
Facet:			
Pediment	% of area:	~58	
	Typical soil:	1.	Brown loamy sand to sandy loam over brown clay; calcareous with depth on schist
		2.	Thick brown sand over brown sandy clay on schist
	Land class:	II-e	
	Pros:	Fertile soils with good water holding capacity	
	Land use:	Annual pasture, cereal, grain legume	
Rise	% of area:	~40	
	Typical soil:	1.	Shallow brown loamy sand to sandy loam over thin brown clay soil on schist
	Land class:	III-e,m; II-e,m; minor III-r,m; VI-r,m	
	Cons:	Water erosion potential, stony soils with low water holding capacity	
	Land use:	Annual pasture, cereal, grain legume	
Stream channel	% of area:	~2	



BRE (Bremer)

Total Area: 29 km²
Rainfall: 400-475 mm
Geology: Variable outwash sediments from the adjacent ranges, river alluvium, metamorphosed sandstone and schist rock outcrop (Qha, Qpp, Ekt, Ekb)
Topography: Flats, stream channel and low angle slopes of the Bremer River valley with low stony (basement metamorphosed sandstone or schist, calcrete and ironstone) rises
Elevation: 70-200 m
Relief: 20-40 m
Facet:

Footslope

% of area: ~45
Typical soils:
1. Thick loamy sand over red sandy clay; calcareous with depth
2. Sandy loam over red clay; calcareous with depth
3. Deep red sand

Land class: III-e,a (II-a,e,n,m) (IV-a)
Pros: Easily worked soils with good drainage
Cons: Wind erosion potential, water erosion potential, soils with low moisture holding capacity and nutrient fertility
Land use: Annual pasture, cereal, grain legume, permanent annual pasture

Rise

% of area: ~30
Typical soils:
1. Shallow calcareous loamy sand over rubble
2. Loamy sand to loam over red clay; calcareous with depth, on metasandstone, schist or ironstone
3. Stony loam over metasandstone

Land class: IV-r (III-m,n,e) (V-r,m)
Pros: Soils with good drainage
Cons: Rockiness, soils with low moisture holding capacity and low nutrient fertility
Land use: Annual pasture, cereal, grain legume, permanent annual pasture

Alluvial plain

% of area: ~20
Typical soils:
1. Thick loamy sand over a brown sandy loam; calcareous with depth
2. Sandy loam over red sandy clay; calcareous with depth
3. Deep brown silt to loam

Land class: II-m,n,s (I)
Pros: Soils with good drainage
Cons: Minor salinity
Land use: Annual pasture, cereal, grain legume, irrigated pasture

Stream channel

% of area: ~5
Typical soils:
1. Deep alluvial sand and silt with gravel seams
2. Thick loamy sand to silt over red sandy clay loam

Land class: VII-g,f (IV-s)
Cons: Stream bank erosion, flooding, salinity
Land use: Permanent annual pasture, conservation

KAB (Kalibar)

Total Area: 5 km²
Rainfall: 375 mm
Geology: Schist, calcrete, calcarenite and calcareous sandstone (Ekt, Qca, Tmu)
Topography: Undulating calcrete rises east of Monarto
Elevation: 90-110 m
Relief: 20 m
Facet:

Rise
- % of area: ~86
- Typical soil:
  1. Thin brown loamy sand on calcrete
  2. Brown calcareous loamy sand to sandy loam grading to calcareous brown clay on schist
  3. Thin brown loamy sand on schist
  4. Brown loamy sand to sandy loam over brown clay; calcareous with depth, on schist
- Land class: III-r; VI-r (V-m); III-e
- Cons: Shallow, stony soils with low water holding capacity
- Land use: Scrub, annual pasture, cereal

Flat
- % of area: ~10
- Typical soil:
  1. Brown sandy loam over calcareous brown clay loam on schist
  2. Grey sandy clay loam over grey clay; calcareous throughout
  3. Red clay; calcareous with depth
- Land class: II-e
- Pros: Fertile soils with good water holding capacity
- Cons: Waterlogging
- Land use: Cereal, annual pasture

Stream channel
- % of area: ~4

NAR (Narrinyeri)

Total Area: 13 km²
Rainfall: 350 mm
Geology: Metamorphosed sandstone, siltstone and schist (Ekb, Ekc, Ekt)
Topography: Moderately sloping to steep slopes on the eastern edge of the ranges south of Palmer and adjacent to Murray Bridge
Elevation: 30-160 m
Relief: 40-70 m
Facet:

Steep hillslope
- % of area: ~60
- Typical soil: 1. Thin stony, sandy loam on metasandstone or schist
- Land class: VI-r,e,o
- Cons: Rockiness, water erosion potential, steep slopes
- Land use: Annual pasture

Moderate hillslope
- % of area: ~32
- Typical soils:
  1. Thin stony sandy loam on metasandstone or schist
  2. Sandy loam over red clay
- Land class: IV-e, V-e
- Cons: Water erosion potential
- Land use: Annual pasture

Footslope
- % of area: ~7
- Typical soils:
  1. Sandy loam over red clay
  2. Loam over semi-hard calcrete
- Land class: III-e, IV-e, III-a
- Cons: Water erosion potential
- Land use: Annual pasture, cereal

Stream channel
- % of area: ~1

Valley flat
- % of area: <1

KIN (Kinchina)

Total Area:	54 km^2		
Rainfall:	375 mm		
Geology:	Granite and calcrete (Odg, Qca)		
Topography:	Undulating low hills with occasional granite outcrop, moderately dissected by streams, between Monarto and Pallamana; short discontinuous ridges of both calcrete and sand occur as minor components		
Elevation:	80-130 m		
Relief:	30-40 m		
Facet:			
Sandy hillslope	% of area:	~55	
	Typical soil:	1.	Thick grey sand over brown columnar sandy clay; calcareous with depth
	Land class:	III-a,n	
	Land use:	Cereal, annual pasture	
Loamy hillslope	% of area:	~38	
	Typical soil:	1.	Brown loamy sand over red sandy clay on weathered granite; calcareous with depth
		2.	Brown loamy sand to sandy loam over calcareous red sandy clay loam on granite
		3.	Brown loamy sand over granite
	Land class:	III-a,n; II-a; II-e	
	Land use:	Annual pasture, cereal	
Depression	% of area:	~5	
	Typical soil:	1.	Red loamy sand on red clay; calcareous with depth on granite
			Land class: II-e, II-a
	Pros:	Soils with good water holding capacity	
	Land use:	Cereals, annual pasture	
Rocky hillslope	% of area:	~1	
	Typical soil:	1.	Brown loamy sand over granite
		2.	Thin coarse brown loamy sand over granite
	Land class:	VI-r	
	Cons:	Rockiness, soils with low water holding capacity and low nutrient fertility	
	Land use:	Native pasture	
Stream channel	% of area:	~1	

DIH (Disher Hill)

Total Area:	94 km²	
Rainfall:	375-450 mm	
Geology:	Metamorphosed sandstone and schist (Ekt, Ekb)	
Topography:	Moderately steep ridges and valleys north of Monarto	
Elevation:	130-350 m	
Relief:	40-80 m	
Facet:		
Hillslope	% of area:	~75
	Typical soil:	1. Black gravelly sandy loam over red clay; calcareous with depth
		2. Brown sandy loam over red clay on schist; schist surface stones are common
		3. Brown sandy loam over gravelly red clay
	Land class:	VI-o,r,e (V-m)
	Cons:	Steep slopes, rockiness, water erosion potential, soils with low water holding capacity
	Land use:	Annual pasture
Crest	% of area:	~15
	Typical soil:	1. Black sandy loam over brown loamy sand over red clay
		2. Black sandy loam over red clay
	Land class:	V-m,r,e; IV-r,e
	Cons:	Rockiness, soils with low water holding capacity, water erosion potential
	Land use:	Annual pasture
Footslope	% of area:	~5
	Typical soil:	1. Thick red sandy loam over red gravelly, silty loam over red clay loam; calcareous with depth
	Land class:	IV-e,r
	Pros:	Soils with good drainage
	Cons:	Water erosion potential, rockiness
	Land use:	Annual pasture
Valley flat	% of area:	~3
	Typical soil:	1. Thick black loamy sand over red loamy sand over red sandy clay loam
		2. Red sandy loam over red coarse sand
		3. Very thick red loamy sand to sandy loam; quartz surface stones are common
	Land class:	III-f (II-a,e); V-s
	Pros:	Soils with good drainage
	Cons:	Flooding potential, minor salinity
	Land use:	Annual pasture
Stream channel	% of area:	~2
	Cons:	Flooding potential, salinity

SOILS

Red textured contrast soils, calcerous at base

These soils have red sandy to loamy surfaces over red brown clayey subsoils with soft to rubbly carbonate (lime) within a metre of the surface. They generally occur in areas with less than 600mm rainfall. They have moderate to high fertility and are well drained. The main variations are:

Loam over red brown friable clay, with weathering basement rock within a metre of the surface.
These are common in the eastern and western foothills of the Mt.Lofty Ranges, and occur on sloping ground associated with rock, so tend to be shallow and subject to erosion. They are commonly used for rotational cropping and grazing.

Sandy loam to clay loam over thick red brown friable clay on alluvium
These occur in association with the shallow types on bedrock, usually on adjacent slopes and valley floors. Poor surface structure leads to erosion, difficulty of working and surface ponding of water. They are deep and fertile soils used extensively for cropping.

Hard setting sand to sandy clay loam overlying red dispersive, poorly structured clay subsoils on alluvium.
These occur on the flats, imperfectly drained with lower fertility. Soils are cropped but difficult to manage.

Hard setting sandy loam overlying firm blocky red clay, shallow over semi-hard carbonate.
These occur on sloping ground of the south eastern foothills. They are imperfectly drained and have difficult to work surfaces.

Sandy loam over red sandy clay, with sheet calcrete at less than 50cm.
These are limited to flat ground south of Chauncey's Line. They have significant limitations due to low water holding capacity.

Thick sand overlying red sandy clay loam, very deep over coarse grained sediments.
These occur in the Bremer Valley along the eastern foothills. Fertility is low and the soils are prone to both water and wind erosion.

Red to dark soils in which clay content increases gradually with depth

This range of soils does not have a clear cut boundary between layers in the profile. They contain soft to semi-hard carbonate in the lower profile and generally occur where rainfall is less than 500mm. Some are deep over alluvium, others are shallow over carbonate or calcareous rocks. The main variations within the category are:

Red sandy to loamy surface soils grading to red sandy clay loam to sandy clay subsoils, calcareous with depth usually formed on medium to coarse grained alluvium.
These soils are common in the Angas - Bremer flood plains and along the eastern footslopes. They are moderately fertile and used for cropping and grazing.

Reddish brown sandy to loamy surface grading to a massive reddish brown calcareous sandy clay subsoil, becoming very highly calcareous (soft or rubbly carbonate) with depth.
These soils are restricted to the less than 400mm rainfall areas of the eastern foothills and plains where they are used extensively for cropping.

Shallow, crumbly red brown loam over calcrete
These soils occur of the eastern slopes in the less than 500mm rainfall areas. They are fertile and well structured, but too shallow for productive uses other than grazing.

Sand to loam over clay, calcareous with depth

This category includes those soils with a strong texture contrast between sand to loam surface and a clayey subsoil. They have a soft to rubbly carbonate at shallow depth. Subsoils are poorly structured, resulting in poor root growth or waterlogging. Surfaces are either loose and sandy with low fertility or hard setting. Most of the soils occur in the less than 500mm rainfall areas. The main variations in this category are:

Hard setting brown loam sharply overlying a brown mottled, sodic clay with soft carbonate at shallow depth
These soils occur on old alluvial plains such as Lake Plains. They have severe structure problems both at the surface and in the subsoil with waterlogging, poor emergence, low water availability and difficulty of working. They are used for cropping, but are difficult to manage.

Thin grey sandy surface overlying a brown mottled sodic clay with soft carbonate at shallow depth
These soils are similar but have sandy surfaces. They occur in similar areas with similar problems, and suffer from poor fertility and wind erosion.

Grey loamy surface soil overlying very dark brown to black clay with soft carbonate at moderate depth.
These soils occur on the Angas-Bremer-Sandergrove floodplains. They are fertile soils but prone to waterlogging. They are used for cropping and grazing.

Thin to thick red to grey loose sand overlying a thin red or brown sandy clay loam to sandy clay subsoil on rubbly calcrete.
These soils are widespread in the Strathalbyn-Sandergrove-Milang area and scattered along the coast and on the Murray Plains. They have low fertility and water holding capacity and are prone to wind erosion. They are low productivity cropping and grazing soils.

Clay Soils

These soils are clayey throughout the profile and crack on drying in summer. They are deep and have very high water holding capacities, although much of their water is held very tightly and is unavailable to plants. They generally have high natural fertility but are prone to waterlogging and are difficult to work when wet. The main variations are:

Deep black cracking clay with a crumbly self mulching surface and variable soft carbonate through the profile
These soils are limited in total area but are widespread on the alluvial flats of the Angas-Bremer floodplains. They are very fertile and are extremely productive cropping soils and are commonly used for viticulture, although they are difficult to irrigate effectively.

Grey to brown cracking clay with a hard setting blocky surface, variable soft carbonate throughout the profile, and high boron and salt content often at shallow depths.
These soils are most common on the Sandergrove Plains, and are usually associated with gilgai (crabhole) land surfaces. The soils are difficult to work with, poorly drained and have chemical problems. They are marginally arable.

Black,wet clay soils occurring on salt pans and flats in the Pt.Sturt-Clayton-Milang area
These soils are too wet and salty for any uses other than light grazing.

Calcareous soils

This category includes a range of soils which have free carbonate (lime) throughout the profile. This makes the soils alkaline to strongly alkaline, limiting the range of species which can be grown on them, and affecting nutrient availability. Generally the calcareous soils are restricted to the less than 500mm(and commonly less than 400mm) rainfall areas. The main variations in this category are:

Shallow to very shallow, stony, calcareous loamy sand to loam over sheet calcrete
These soils are scattered in an arc from the northern Murray Plains through Monarto to Point Sturt. They are too shallow for most uses and are often rocky.

Shallow stony calcareous loam over calcareous basement rock
These soils occur on moderate to steep hillslopes. They are deeper than the previous type and are semi-arable, however steep slopes often preclude cropping.

Shallow calcareous loam over rubble, grading to soft carbonate overlying clayey sediments
These soils are very common on the Murray Plains and Lake Plains. They have moderate water holding capacity (depending on the depth and thickness of the rubble layer), but have high alkalinity restricting crop types. They are used extensively for cereal crops.

Calcareous loam to clay loam becoming more clayey and very highly calcareous with depth, and usually overlying heavy clay.
These soils are associated with the previous type in mallee country but do not have the rubble., They have high water holding capacities and moderately high fertility although they are alkaline. They usually have toxic levels of boron within the surface metre and are often mildly saline within this depth.

Thin loose sand with a minimal more clayey subsoil, on sheet calcrete.
These soils are restricted to undulating land north of Langhorne Creek. They are too shallow and infertile for cropping.

Calcareous loam to clay loam, more clayey and calcareous with depth, overlying marl at shallow depth
These soils are restricted to salty flats in the Pt.Sturt-Clayton-Milang area and are too saline for cropping.

Deep Sands

These soils are sandy throughout or in the top metre. They are generally low fertility soils prone to moisture deficit and wind erosion. They occur in a variety of situations from high to low rainfall and consequently range from acid to alkaline. The main variations in this category are:

Deep white sand, organically darkened at the surface and becoming yellow, but still sandy with depth
These soils are scattered on rising ground (often sand dunes) particularly evident on the Pt.Sturt peninsula. They are extremely infertile have low water holding capacity and are very susceptible to wind erosion. They have little agricultural value unless irrigation water is available for viticulture or other horticultural crops.

Deep red to brown sand, sometimes becoming more clayey and slightly calcareous with depth
These soils occur on sand rises on the upper Angas-Bremer flood plains and to a minor extent around the Lakes, and on river flats and terraces of the Angas-Bremer floodplain. These sands have a higher fertility than white sands but are of marginal cropping value. They are well suited to irrigation due to their depth and good drainage characteristics.

Deep white sand overlying a yellowish sandy clay loam, calcareous with depth
These soils are common on the sand ridges particularly of the Sandergrove Plains. They have a more clayey subsoil which retains moisture and are therefore slightly more productive although are only semi-arable. Many ridges have been eroded by wind.

Deep shell sand
These soils are restricted to coastal sand dunes and have a scattered distribution. They are very fragile and have no agricultural value.

Deep medium to fine textured soils lacking texture contrast

These soils occur almost exclusively on alluvial flats. They are deep, have loamy to clay loamy surfaces, and are usually well structured and fertile. They are usually neutral to slightly acidic at the surface, and mildly alkaline with depth. Although the soils are the most productive soils of the region they tend to suffer from waterlogging. The main variations are:

Black, well structured clay loam, grading to a black clay, becoming greyer with depth
These soils are limited to the flats of the Langhorne Creek areas. They are extremely fertile, moderately well drained and well structured. They have no limitations other than waterlogging and salinity and are used for grazing, fodder production and viticulture.

Dark grey clay loam grading to a grey and yellow clay, slightly calcareous with depth
These soils occur on poorly drained flats and are prone to waterlogging.

Deep brown sandy loam to clay loam occurring on creek flats
These are modern alluvial soils widely distributed. They are potentially productive and are associated with watercourses and subject to flooding, erosion and accessibility.

Shallow stony soils

Most of these soils occur on steep and/or rocky slopes where basement rocks are very hard and have undergone little weathering, or where slopes are so steep that the soil is washed away. The category also includes minor soils formed on alluvial, stone or boulder beds. Their common feature is shallowness and minimal water holding capacity. Their usual association with rock and steep slopes limits their use to grazing. The main variations are:

Shallow to moderately deep gravelly and stony loam to clay loam forming in weathering siltstone, shale or stone
These soils are common on steeper slopes throughout he hills where fine grained basement rocks are predominant. These soils are moderately fertile however their steepness and shallowness limits their usefulness. Much of the land remains uncleared and where developed is used for grazing.

Shallow to moderately deep gravelly and stony sand to sandy loam forming in sandstone or sandy schist
These soils occur where coarse grained rocks are predominant. They are infertile and have very low water holding capacities. They are usually undeveloped.

Very shallow loamy sand to sandy loam forming in greywacke or schist
These soils are common on the very rocky slopes of the eastern hills, where the basement rocks are very resistant to weathering, resulting in minimal soil development. They are used for rough grazing.

Shallow sandy loam forming in schist with soft carbonate
These soils are similar but are strongly alkaline.

Moderately deep very stony and gravelly sand to sandy loam formed on stone or boulder beds
These soils occur in drainage depressions throughout the hills, and are low in fertility and water holding capacity and are used only for grazing.

Wet Soils
A miscellaneous category of soils which are wet for sufficient periods of the year and have limited productive potential without extensive drainage works. The category includes:

Black sandy loam to sandy clay loam over black clay of the saline swamps in the Pt.Sturt - Clayton - Milang area.

Miscellaneous wet soils of saline seepages in all areas but particularly in the hills and Sandergrove Plains. Acid sulphate conditions are sometimes associated with these soils.

LAND DEGRADATION

WIND EROSION

Wind erosion in the study area has been high in the past two years, and is basically as a result of overcropping and land clearance.

During drought years wind erosion has the potential to remove and deposit tons of topsoil, containing soil and nutrient materials. At one site in the mallee, it was recorded that 56 kilograms of soil per hectare was removed in one minute from an area rated as having low to moderate potential for wind erosion. Such devastating losses become major expenses to the land manager. The adoption of better land management practices to control or reduce the risk of wind erosion is vital.

DRYLAND SALINITY

It is estimated that within thirty years the study area will be affected by groundwater rise with a 50% increase in dryland salinity.

SOIL ACIDIFICATION

While this is mainly a problem of wetter areas of the State, some local areas of the Mt.Lofty Ranges will become affected. The adverse effects of soil acidity (pH below 5.5) are extremely complex, relating to acidification in the root zone. These can range from toxicities of aluminium and manganese to deficiencies of molybdenum and calcium which affect plant growth and production, and increase the likelihood of root diseases and nutrient leaching.

SOIL EROSION

The effects of soil and wind erosion include a loss of topsoil, nutrients and finer soil particles. It is observable in gullying, sand drift, deposition along fence lines, and the increase in cereal diseases through the spread of soil pathogens. The soil's water holding and nutrient retention capacity are also affected.

In the study area with its typical dune and swale country, fencing off dunal areas from the heavier soils of the swales is recommended. These areas often provide 'quick feed' for stock with emergent grasses following rain. However Leivers and Luke (1980) suggested that this may contribute to overgrazing pressures which contribute to soil decline and erodability. The introduction of legumes to improve the nitrogen status of the soils are therefore recommended by Agricultural officers in the adoption of conservation cropping systems.

Scriven (1988) made the following observations :
- wind ersoion occurs on most sandy soils where native pasture has been reduced by grazing or drought
- moderale to severe erosion occurs on dune crests which are poorly vegetated
- scalding and rilling become evident around localised depressions
- localised, but severe scalding may occur where mallee adjoins alluvial features.

Soil salinisation is affecting agricultural and conservation lands. Vegetation in remnant areas need to be protected through reducing grazing pressures, and where appropriate the replanting of salt tolerant species.

PART SEVEN

KEY CAUSES TO DECLINE AND THREATS
Mammals, birds, reptiles, amphibians, vascular plants and communities

No. Cause of decline or threat

1 Habitat degradation through overgrazing by stock, feral animals, kangaroos
a) general effects
b) prevention of tree regeneration
2 Clearing of native vegetation
3 Decline of remnant trees in cleared agricultural areas
4 Timber harvesting
5 Loss of genetic distinctiveness eg.through hybridisation
6 Altered fire regimes
7a Introduced predators foxes and feral cats
7b Native predators
8 Trapping for commercial activitly
9 Habitat modification/competition with introduced weeds
10 Recreational activities
11 Threats to distribution outside mallee region (esp. birds)
12 Hunting
13 Cropping or pasture improvement in native pasture
14 Insecticides/herbicides
15a Competition with intriduced species
15b Competition from other native species
16 Destruction as pest species
17 Road accidents
18 Modification of hydrological conditions
19 Natural popultion fluctuations
20 Declining prey populations
21 Removal of eggs, young or plants for collection/pets/falconry etc
22 Salinisation
23 Drainage of wetlands
24 Pollution
25 Clearing of lignum
26 Blue green algae
27 Mining
28 Decline due to small size of remnant populations making them more vulnerable
29 Urban development
30 Earthworks (eg.road maintenance, firebreak construction & gravel pits)
31 Requirement for habitat of long unburnt areas of mallee

THREATS

Ongoing primary threats in priority order for the study area:
1) Fire resulting in changes to age structure and mosaic of mallee vegetation, and subsequent loss of species
2) Grazing by herbivores resulting in lack of regeneration of native vegetation
3) Salinity

Ongoing secondary threats:
1) Introduced pests and invasion of weeds
2) Competition with introduced animals, eg.bees
3) Illegal human activities (eg.harvesting of brush or timber, bird-trapping, egg-collecting, dumping)

Threatening Processes for the entire South Australian part of the Murray Darling Basin

Rank
1 Invasion of alien plant species
1 Grazing by stock
1 Grazing by rabbits and hares
1 Road works and maintenance
2 Inappropriate fire regimes
2 Changes to hydrological regimes
3 Salinity
4 Plant collectors
4 Land clearance
4 Off road vehicles

Meredith (pers.comm) indicates that the survival of Casuarina and Callitris species in Victorian mallee woodlands is severely threatened because of poor regeneration and loss from fire. This may well be a cause for concern in the study area.

While salinity remains a serious and degrading threat, the continuing activities of sand mining are also of concern.

*

ENDANGERING PROCESSES
P.Copley (pers.comm)
In the past, emphasis for management and research has been species based rather than process based. A total picture would be more realistic when defining endangered species and endangering processes.

Habitat fragmentation increases the probabilities of imbalanced communities and unwittingly leads to the decimation of threatened and unthreatened populations. This occurs through such processes as fire, drought, flood, disease and excessive levels of competition or predation. Such actions limit recolonisation and increase the possibility of inbreeding. Copley suggests that the presence of many species at low densities in relatively small habitat fragmentation may lead to false assessment.

A major threat to species is habitat destruction. In the past this has resulted mainly from vegetation clearance. In the Murray mallee lands this has been a significant cause for decline as clearance occurred for the purposes of agriculture, horticulture, housing, industry and mining. Large tracts of native vegetation however can no longer be cleared because of State legislation. Fragmentation and isolation of ecosystems, communities, habitats and populations has been a major result of native vegetation clearance. The chances of recolonisation and inbreeding appear to be minimal, while problems relating to introduced stock, pests and weed invasion continue. Therefore management of fire and grazing is essential in fragmented areas, with a process of revegetation to link habitats of vital importance.

Grazing by herbivores and feral pests in particular have led to habitat degradation through the inhibition of herbaceous, shrub and tree species to regenerate. The senescence of species has led to serious decline in vegetation and animal species. This has been as a result of the loss of food availability and shelter and the increased vulnerability through predation . and competition. Maintenance of natural areas has been improved by fencing.

Competition from and displacement by introduced species, particularly pasture grasses has restricted regeneration of many native plant species, and also accounts for the loss of species from regions. Invasive agricultural weeds must be controlled by the application of herbicides, fire, and or re-seeding or re-planting of local species once grazing pressures have been removed.

Altered fire patterns through hazard reduction or controlled burns also contribute to species decline, as do particular activities such as the commercial harvesting of fencebrush and timber and the removal of natural materials.

Soil salinisation is affecting agricultural and conservation lands. Vegetation in remnant areas need to be protected through reducing grazing pressures, and where appropriate the replanting of salt tolerant species.

Feral animals need to be controlled through co-ordinated and routine baiting programs. Beekeeping near these remnant areas also needs to be controlled as introduced honeybees compete for food and shelter and may reduce pollination and seed setting of native plant species.

The major aims therefore of conservation of species in the Murraylands should be :
* to prevent further clearance of habitats
* to reduced degradation and encourage rehabilitation of remaining populations, habitats and communities, by removal of grazing pressures of stock and rabbits and to
* re-connect isolated populations, habitats and communities through establishment and improvement of linkages and corridors.

Fire
Each of the threatened mallee bird species is seen to have suffered because of the impact of fire. Data on threatened species indicates that fire frequencies of less than 10-15 years is detrimental, while for malleefowl the period is between 40 and 60 years . These 'first growth' woodlands and scrub areas need to be adequately identified and protected.

DIEBACK

Dieback is recognised as an ecological disaster however remains little understood.

Change in natural systems is inevitable, however human impact on the vegetation has set change into an alarming and often devastating cyclic state. Heatwole (1986:12) suggested that :

> man's increasing population and the attendant development of technology necessary to support high population levels has devastated resources and produced a surplus of waste products which pollute the environment and destroy life.

Agricultural and land clearance practices have altered the ecological balance of nature in this region over a period of time. These actions impact on specific associations and populations, and contribute to species decline, rarity and even extinction. Realistic and practical land management today must consider the environment, how it should be better managed, and the environmental economic costs and benefits of all developmental and agricultural practices.

History highlights that mankind ignores threats to survival until the magnitude of the disaster is almost impossible to remedy, or the remedy is more expensive and less effective. Early awareness of potential problems and actions towards remedying problems are therefore necessary adjuncts to development. Heatwole (1986:12-13) reaffirms this point in stating that:

> The sheer complexity of environmental deterioration and the multitude of interacting influences upon it often make the solving of ecological problems a very long term proposition.

Dieback is such a problem. It affects thousands of individual trees of many different species and has a variety of causes.

What is dieback?

Dieback is a condition where states of decline can be evidenced in individual or whole forests of trees. Initially there is a thinning of the crown, beginning at the tips of the twigs and progressing along branches towards the trunk. Once there has been considerable decline of the tree, the outer part of the tree dies, and new growth from epicormic shoots may occur. This may be the beginning or the end. While the tree maintains sufficient reserves of energy it may continue to fight the disease, where eventually the new growth can form a healthy crown. However if energy reserves are exhausted then death of the tree becomes imminent as no new epicormic shoots can be produced.

Why does it occur?

Dieback may be caused by root fungus disease, increased soil salinity, insect defoliation, drought, altered water tables, nutrient imbalances often caused by accumulation of superphosphates, soil erosion and reduced soil aeration, land clearance, overstocking or a combination of several such factors.

In the Western fringe zone of the Murray Mallee much land (as previously discussed) was subject to clearance for agricultural production. Although some belts of natural scrub were retained, in other areas only a few older trees were kept as shelter for stock or windbreaks. The introduction of stock, and the application of fertilizers would have prevented much re-growth of those species in the cleared areas. Added to this are the conditions of soil and wind erosion, increasing salinity and lowered water tables. As is also currently being considered, natural climatic periods of drought may also predispose trees over a period of time to reduced or increased insect attack.

Revegetation may be the only means to assist the rebalance of reduced natural regeneration levels and the reduction of trees through species decline and such effects as die-back.

Four main causes of tree stress and death

The four main causes of tree stress and death are suggested to be:

1. Natural ageing where decay forms part of the natural cyclical event to maintain a healthy ecosystem;
2. Ecological imbalance of the ecosystem's biological components such as when increased insect attack occurs;
3. Physical change in environmental factors such as climatic variation - drought, flood, temperature extremes, wind, fire;
4. Chemical deficiencies of nutrients or excessive quantities of pollutants and poisons.

FUNGI ASSOCIATED WITH EUCALYPT DIEBACK IN AUSTRALIA

Scientifc name	Part of plant attacked- roots	stems	leaves
OOMYCETES			
Family Pythiaceae			
Phytophthora cinamomi	x		
P. cryptogea	x		
ASCOMYCETES			
Family Asterinaceae			
Aulographina eucalypti			x
Family Mycosphaerellaceae			
Mycosphaerella spp.			x
BASIDIOMYCETES			
Family Agaricaceae			
Armillaria luteobubalina	x		
Armillaria sp.	x		
DEUTEROMYCETES			
Ambrosiella sulphurea		x	
Cylindrocarpon sp.	x		
Leptographium sp.		x	
Seimatosporium falcatum			x
Seimatosporium sp.			x
Sporotrichum destructor		x	

Fungal infestation associated with eucalypt dieback is difficult to detect and identify as pathogens are often disregarded as potential causes when other adverse conditions are apparent. Such factors as insects, land use changes, severe cold, intermittent drought are readily observable and may consequently be linked to dieback, however these stresses and others may also predispose plants to infection and fungal attack.

Fungal attack of wood is most evident by the decay or rot it causes. Hyphae feeding on wood eventually weaken and break it down as a natural process of decay, which in itself changes the wood's characteristics. This includes colour, odour, strength, heat conductivity, water-holding capacity and shape.

Stem and root pathogens such as the Phytophthora attack the roots and prevent them from taking essential water and minerals. Phytophthora is widley distributed throughout the world. Research has shown that over 400 species are susceptible to Phytophthora including many eucalypts. This fungus penetrates and attacks the deeper vertical roots of trees that supply water to the trees during dry periods. The hard soil layers (concreted laterite) seem ideal for spore production by the fungus.

The importance of trees for the rural landowner

Trees play a major role in the agricultural landscape and provide a number of ecological, biological and economic benefits.

Ecologically, trees provide habitat for plants and animals in the ecosystem. In the agricultural areas trees provide shelter for fauna that control pests of pasture and crops. The aesthetic landscape is enriched by trees and the fauna it provides for.

The biological value of trees cannot be underestimated, for their network of roots prevent soil erosion and assist with water retention. Both are necessary for continued agricultural production. Trees provide shade to grazing stock.

The economic benefits of trees are harder to estimate, however it is recognised that trees enhance property values, and are aesthetically pleasing to the visual landscape. A study conducted by the CSIRO Pasture Protection Unit demonstrated that trees contributed to higher lambing success and increased livestock survival. Windbreaks and shelter belts lessen the environmental stresses and extremes of climatic conditions such as wind, temperature, frosts and hail.

Trees have a long term indirect value relating to the stability of the ecosystem. Their direct value cannot often be seen by graziers who believe that clearing land will allow them to pasture more stock for the short-term profits. However in the long term, what dollar value can be placed on loss of income from deteriorated pasture?

It would seem obvious then that the rural landowner has an obligation to replace dying trees, and to promote better management of windbreaks and shelterbelts of natural vegetation (as opposed to exotic introduced species). Fencing off areas to allow for regeneration or revegetation may be seen to be economically not viable to many farmers, although it is one method of managing trees. Another way which may be more practical and beneficial over the long term, would be the establishment of small sized woodlots (agroforestry) or alternative tree crops (horticulture) on areas of lowest stocking capacity.

Fungi, Mistletoe and Dieback

Trees are subjected to many factors which interfere with their normal growth. One such factor is disease from fungal infections.

There are more than 100,000 known species of fungi and a number of classes. However only four of these are associated with dieback.

Other root rotting fungi occur in Australia. Armillaria species are associated with dieback particularly in south eastern Australia (Victoria and Tasmania particularly). Trunks, branches and leaves also may be affected by fungal infection, indicating that the pathogens and host plants affect each other and that their interaction is influenced by the environment. Human disturbances of rural landscapes would appear to have favoured the major outbreaks of leaf pathogens on eucalypts.

Fungi can also be beneficial to plants as they cause infection in some insects that are associated with dieback. A number of Mycorrhizae fungi are also beneficial as they form an association with eucalypt roots and enhance their uptake of water and nutrients.

Mistletoes

There are about 1200 species of mistletoe in the world with about 75 occurring in Australia. There are two families of mistletoe in Australia- the Viscaceae, with only a few species, and the Loranthaceae which contains the majority.

Unlike fungi, mistletoe are flowering plants and reproduce by seeds. They are parasitic on other plants and commonly occur on eucalypts, and may damage, weaken and kill them. Most grow entirely on the host plant and have no roots within the soil.

When trees are host to only a few mistletoe and conditions are favourable, trees are only minimally affected. However during periods of drought or heavy infestation, mistletoes can cause considerable stress. They utilise water taking it from their hosts, and it can often be seen that beyond their point of attachment, the tree branches and leaves will die. By reducing the amount of the host's foliage, they reduce its capacity to make its own food. Heavily infected trees produce fewer flowers and seeds, and the harm caused by mistletoe makes them more susceptible to other environmental stresses, such as infections by fungi and attack by insects. Trees heavily infected may be killed directly, or may die as a result of a combination of stresses, including mistletoe.

In the Monarto woodland mistletoe infestation is high particularly on Acacia and Eucalyptus species. In most instances seen, the heavily infested trees appear to be suffering extreme stress. Death may be imminent for a few, or may have been responsible along with other agents for previous tree decline and death.

In the naturally conserved state, dieback seems to target acacia species, with only minimal infestation of mistletoe, and few recorded deaths.

Environmental Change and dieback.
Such environmental changes as droughts, floods, salinity and fire contribute to tree decline and dieback. However trees have evolved in a changing environment, and those that have survived seem capable of coping with such conditions. Consequently existing vegetation can withstand most environmental fluctuations that normally occur within its habitat. When these limits are exceeded however, trees do succumb to stress and may die.

Extreme conditions may occur as a single, brief episode that has momentary and drastic effects, such as fire, flood, and storms, after which the environment returns to normal. Some factors may be extreme by their very nature of their long duration, such as prolonged drought or increasing salinity. Once a trend has begun it may be prgressive and worsen unless control measures are taken. Removal of some mistletoes, diseased branches or limbs under fungal attack, or chemical treatments may improve the state of the tree in a managed environment. However trees are often unable to return to their previously normal conditions and may die out.

Salinity
There seems to be a greater resistance in mature trees, perhaps because of the adaptations to environmental changes mentioned previously, or because of a more extensive root system that provides the means to avoid salt.

With senescence however comes reduced vigour and greater susceptibility to salt. Additional stresses such as high temperature, bright light and lower atmospheric humidity tends to lower salt resistance, and make trees more susceptible to saline dieback.

The situation in South Australia and the area under study
Much of South Australia has been subjected to vegetation clearance, and only scattered remnants of trees on rural properties remain. These represent an ageing population subjected to increasing periods of critical stress, with some areas subjected to dieback in the past two decades.

Insects are considered to be the main cause of canopy dieback, although many trees left in paddocks have been subjected to stock grazing and trampling of shallow roots. Recovery has therefore been poor among the older trees, with little regeneration occurring on farmlands.

It is possible that a synergistic effect occurs between major climatic fluctuations and insect attack on native eucalypt species.

Regeneration

Where fungal infection has been severe, the pathogen may remain in the soil especially if other susceptible plant species are still present. Attempts at reseeding or replanting of the original species may therefore fail. Research into which species of trees are most resistant is warranted particularly where large areas of forest have disappeared.

INSECTS THAT LIVE ON EUCALYPTS

Insects
The insect kingdom consists of a million species. The following table provides some indication of the types of insects found in Australia and on Australian trees, particularly Eucalypts.
An asterisk indicates those involved in dieback.

(Ack. CSIRO, Insects of Australia. Melb.Uni.Press 1973)

Order	Common name	No.of families	Aust.species
ARCHAEOGNATHA	-	1	3
THYSANURA	Silverfish	3	23
EPHEMEROPTERA	Mayflies	4	124
ODONATA	Dragonflies, Damselflies	16	248
BLATTODEA	Cockroaches	4	439
ISOPTERA	Termites	5	182
MANTODEA	Praying mantids	2	118
DERMAPTERA	Earwigs	5	60
PLECOPTERA	Stoneflies	4	84
ORTHOPTERA	Grasshoppers, locusts,crickets	13	1513
PHASMATODEA *	Stick insects	2	132
EMBIOPTERA	Web spinners foot spinners	3	65
PSOCOPTERA	Booklice	21	120
PHTHIRAPTERA	Lice	10	208
HEMIPTERA *	Bugs, leaf-hoppers aphids, scale insects, psyllids	87	3661
THYSANOPTERA	Thrips	3	287
MEGALOPTERA	Alderflies	2	16
NEUROPTERA	Lacewings	15	396
COLEOPTERA *	Beetles	106	19219
STREPSIPTERA	-	5	93
MECOPTERA	Scorpionflies	5	20
SIPHONAPTERA	Fleas	9	68
DIPTERA	Flies	86	6256
TRICHOPTERA	Caddis-flies	18	260
LEPIDOPTERA *	Moths butterflies	75	11221
HYMENOPTERA *	Ants,wasps,bees	59	8834
TOTAL		563	53650

In South Australia the following insects are known to be involved in Dieback.

Order Hemiptera
Family Eurymelidae Leafhoppers sucking insects
Family Psyllidae Lerp insects sucking insects
Cardaspina albitextura
Cardaspina densitexta
Glycapsis spp

Order Coleoptera
Family Chrysomelidae Leaf beetles defoliators
Paropsis spp.
Family Scarabaeidae Scarab beetles defoliators
Anoplognathus spp Christmas beetle
Dynastinae
Heteronys spp . . stems & roots

Order Lepidoptera Moths, butterflies, caterpillars

Family Geometridae
Mnesampela privata skeletoniser
Family Limacodidae
Doratifera spp. defoliators

PHYTOPHTHORA

Phytophthora diseases have considerable environmental and economic impact. They cause significant losses to horticultural, pastoral, ornamental and forestry operations, and are a serious threat to indigenous flora. *Phytophthora cinnamomi* is the most widely acknowledged pathogen and affects a large host range of native, horticultural and ornamental species. Other widespread species include *P.clandestina* the cause of root rot of subterranean clover and *P.medicaginis* the disease in chickpeas. Phytophthora disease is a major limitation to expansion in horticulture and agriculture and causes heavy losses to the industry.

Phytophthora cinnamomi has been the subject of research over the last two decades in Australia particularly in national parks and state forests. Such research has placed Australia at the forefront of worldwide research, and the results of this work have been applied to other diseases of commodity crops. However, these results and investigations have remained mainly in the research and academic field, with the average person on the land having little knowledge of the disease or its impact.

Control and Management

In horticultural production, hygienic practices in nursery, cut flower and ornamental sectors; irrigation management and good cultural practices in fruit tree and vegetable crops are important measures for control of disease. Unfortunately, the people involved in the grassroots of horticultural industry and forestry management are in the main unaware of the potential problem of Phytophthora disease. Because of this, little action is actually being taken to reduce its incidence. Where awareness does exist the use of systemic fungicides is the most commonly used method of treatment, followed by quarantine and strategies in logging which minimise disease spread.

While authorities fail to address the problem adequately, it will continue to escalate until it reaches major catastrophic proportions or impacts severely on economic returns. By that time, the problem will be even larger and too expensive to tackle. Biological control may be the last resort.

Dr.Eileen Scott of the Department of Crop Protection at Waite Campus provided the following summary of Phytophthora in South Australia. She states:

Phytophthora species cause losses to citrus, pome and stone fruits, chestnut, proteaceous ornamentals and cause problems in both forestry and national parks in South Australia. *P.cambivora*, *P.cinnamomi and P.citricola* are serious pathogens of *Banksia spp.*and chestnut. There are also problems with *P.infestans* in potato growing districts as well as *P.erythroseptica* and *P.cryptogea*. *P.nicotianae* is causing increasing losses in tomatoes. A root disease of grapevines has been associated with *P.cinnamomi and P.medicaginis* is a continual problem and responsible for significant yield losses in lucerne.

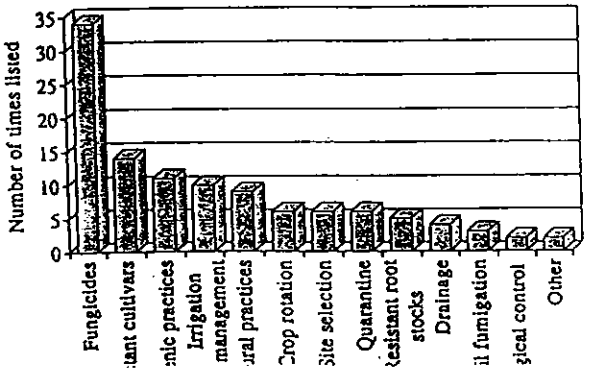
Phytophthora cinnamomi occurs in many national parks and reserves for example on the Fleurieu Peninsula and in the Mount Lofty Ranges ... *Phytophthora cryptogea* and *P.cinnamomi* cause problems in *Pinus radiata* plantations. (Scott,pers.comm.)

In the Western Murraylands Fringe Zone we cannot realistically escape Phytophthora disease problems. The outer parts of the region provide for such agricultural and horticultural production as cereal crops, potatoes, viticulture, ornamental and cut flower production, citrus, pome and stone fruit, and vegetables such as brassicas, peas and onions. The region also contains large areas of remnant and revegetated scrub and woodland forests. Community education and awareness of the problem is justified. Integrated management strategies need to be identified, along with extensive field testing and collaboration between groups so that information gained can be combined into an integrated control package.

Comprehensive integrated management programs have been successful in Queensland and Western Australia already. The QDPI have included the following components into their integrated management program, and it is suggested that these criteria could be utilised locally.

1) Site selection
2) Drainage
3) Exclusion of Phytophthora by quarantine
4) Healthy nursery plants
5) Phytophthora tolerant rootstocks
6) Cover cropping
7) Mulching
8) Soil pH
9) Nutrition and irrigation
10) Fungicides (phosphorus acid)

Management practices used to control Phytophthora diseases



PEST PLANTS

Agriculture and overgrazing are regarded as resulting in the decline of perennial shrubs and grasses, and as a major contributor to soil erosion. The naturally occurring saltbush and bluebush species (Maireana sedifolia, M.brevifolia and Atriplex spp.) in these areas have been replaced by less palatable short-lived perennials and annuals. The repeated cropping practices of agriculture are known to deplete the seedbank of native perennials and support the invasion of weed species. These hinder the establishment of native grasses through competition for soil moisture and nutrients.

In the study area, observation of the poorer, shallow sandy soils has highlighted that when lands previously cleared and cropped, are left for some years, natural regeneration often occurs. Unfortunately, there is also an increased invasion rate of weed species. Such has been the case in Monarto Conservation Park where cleared areas have slowly regenerated with such species as Carpobrotus (pigface) and native herbs (Vittadinia, Podolepis and Senecio spp.) and a proliferation of invasive weed species such as Echium (Salvation jane), Marrubium vulgare (horehound) and Solanum (Apple of Sodom). (Jones 1995) In comparison the areas within Braendler Scrub (also situated in Monarto Conservation Park) which were never cleared, or only cleared in part have regenerated with all upper and understorey layers of mallee vegetation.

In other parts of the study area where cropping has ceased, the first native species colonisers are Dodonaea sp.(hopbush) and Nitraria billardieri (Nitre bush). These are often termed 'woody weeds' in the eastern states. Soil disturbance often encourages weed growth of the deep rooted perennial species and pasture weed proliferation by Chondrilla juncea (Skeleton weed), Solanum elaeagnifolium (silver leaf nightshade) and Asphodelus fistulosus (Onion weed).

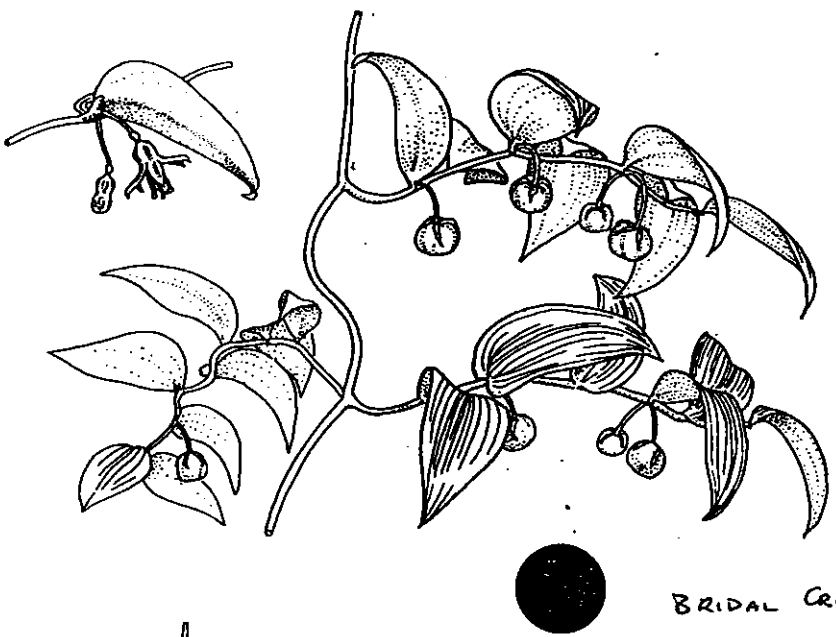
Environmental weeds such as Lycium ferocissimum (Boxthorn) and Myrsiphyllum asparagoides (Bridal creeper) are of great concern due to their ability to invade undisturbed areas.

It is recognised that weeds are an issue in most agricultural areas of the State. They substantially invade and effect areas of native vegetation particularly those that are all ready threatened, rare or vulnerable. It is possible that the occurrence of Bridal Creeper is controlled in cropping/grazing paddocks by the action of herbivores, however roadside management of this weed seems uncontrollable, possibly because of a lack of resources or integrated effort on the part of neighbouring, or adjoining local government areas. As was previously mentioned weeds do not recognise Council boundaries.

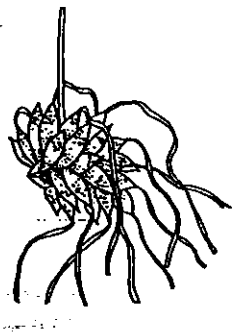
To landholders weeds like feral animal pests are costly, and perhaps more time consuming in control and prevention. Weeds reduce crop yields by contamination and competition, with crops, seedlings, pasture and native vegetation, and also reduce wool quality.

Control measures are various and include mechanical and chemical methods. Whichever method is selected weed spread must be prevented particularly when buying in stock, grain or machinery. Outbreaks of new weeds need to be dealt with while they remain a minor problem, and a combination of methods needs to be practised to prevent herbicide resistance.

With Bridal Creeper control measures need to be applied and re-applied if using chemicals such as RoundUp or BrushOff, and it is important when digging up the matted tubers that all the plant is removed.



BRIDAL CREEPER



The Impact of Bridal Creeper on Endangered Flora Species

It is well documented that grazing by native and/or exotic herbivores, poor land management, soil disturbance by road maintenance activities or burrowing rabbits, and competition from weed species are threats to endangered and native plants.

Weeds compete with native plant species for limited resources such as water, nutrients and sunlight, and can seriously affect the regeneration of a species. Sorensen (1995 pers.comm) states :

> Myrsiphyllum asparagoides is one of many weeds that is a potential threat to endangered species such as Pterostylis arenicola .(Jusaitis & Sorensen,1994), Thelymitra epipactoides, Ptilotus beckerianus, Prasophyllum pallidum (Davies, pers.comm.) Acacia rhetinocarpa (Green, 1993), Pomaderris halmaturina (Jusaitus,1993), Prostanthera euryboides and Acacia pinguifolia. Bridal creeper occurs within close proximity of all these species in the wild, and has the potential to smother them partly or completely.
>
> Bridal creeper is classified as a class 2 noxious weed in South Australia (Parsons & Cuthbertson,1992; Swarbrick & Skarratt,1992) requiring the control or eradication of the species throughout the whole state. It presents a serious threat to native vegetation, and especially to endangered species which may already be under threat as a result of low plant numbers and other threatening factors.

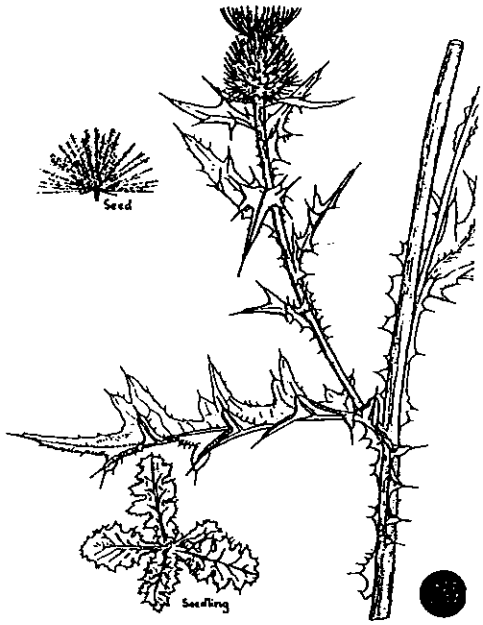
It is a weed of particular concern to the study area, as Monarto has a range of rare, endangered and vulnerable plant species which could disappear if this weed is not controlled adequately.

ed lavender - *Lavandula stoechas*

LABIATAE

Spear thistle - *Cirsium vulgare*

FAMILY COMPOSITAE



Perennial veldt grass - *Ehrharta calycina*

FAMILY GRAMINEAE

can daisy - *Senecio pterophorus*

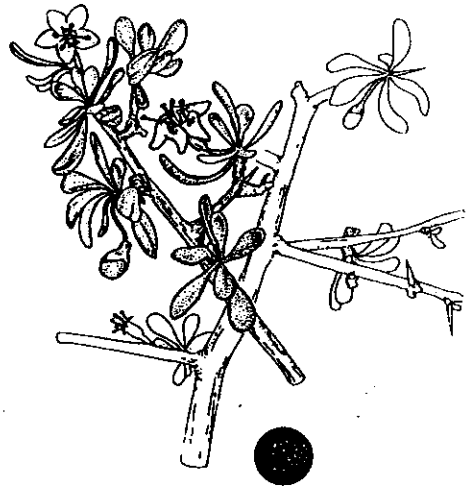
Y COMPOSITAE

Horehound - *Marrubium vulgare*

FAMILY LABIATAE

African boxthorn - *Lycium ferocissimum*

FAMILY SOLANACEAE



(Jack Robertson 1994)

COMMON WEEDS of the STUDY AREA

FERAL PESTS

Rabbits

Rabbits compete with livestock, degrade pasture, damage crops and are a long term threat to native flora. There is an estimated 200 million wild rabbits in Australia.

Landowners can maximise control methods by poison baiting with 1080, followed by fumigation and ripping of warrens to reduce surviving populations. Ideally this should occur in the drier months when rabbits are forced further to forage. Ongoing programs such as these are necessary even though Rabbit calicivirus disease (RCD) when released as a biological control agent will reduce numbers considerably (60-80%). Suspected vectors are mosquitoes and flies with transmission expected during spring.

AIR POLLUTION POTENTIAL

The study area lies in a shallow bowl shaped region and is subject to both nocturnal (radiative) and subsidence type inversions. The climatic and topographic factors are conducive to pollution in most forms. The evidenced problems appear to be relevant to particular and generalised areas. These are listed (not in priority) as

Southern sector to the south, east and west of Old Princes Highway :

1. Stench from saline swamps and marshes.
2. Saline and chemical deposition in river and lake waters conducive to blue green algae growth.
3. Stench from intensive animal-keeping enterprises, particularly piggeries and broileries on hot windy days.
4. Landfill operations (Monarto Landfill site) and quarry blasting operations from nearby quarries (W - Monarto Quarries, SW - Strathalbyn Quarries, NE- Boral Industries) .
5. Mining operations.
6. Creosote and treated pine industrial operations .
7. Intensive animal keeping of introduced and exotic animals at Monarto Zoological Park.
8. Spraydrift from cropping and intensive horticulture.
9. Noise from recreational activities - aerosports and gun clubs.
10. Lead contamination from gun clubs.
11. Noise and heavy chemical pollution from transport along main arterial and feeder roads,Freeway and railway.
12. Fire and smoke pollution from controlled and uncontrolled burning all areas, and from landfill sites. (Smoke and pollutants have been carried across Lake Alexandrina and recorded at Loomooloo in the past).

Northern sector (north of Old Princes Highway)

1. Deposition of sediments, rubbish, chemicals and other pollutants along creek lines and floodplains
2. Rising underground toxic wastes from disused refuse areas eg. Rocky Gully Dump and Abattoirs.
3. Stench from intensive animal-keeping enterprises, particularly broiler hatcheries, piggeries and stables on hot windy days.
4. Blasting operations from nearby quarries (W - Monarto Quarries, NE- Boral Industries) .
5. Chemical residues from mine tailings, industrial and rural operations .
6. Intensive animal keeping at Monarto Zoological Park.
7. Spraydrift from cropping, limited horticulture .
8. Noise from recreational activities particularly aerosports, moto-cross and gun clubs.
9. Lead contamination from gun clubs.
10. Noise and chemical pollution from transport along main arterial roads, feeder roads, freeway and railway.
11. Fire and smoke pollution from controlled and uncontrolled burning.

PART EIGHT

LAND REHABILITATION

Land rehabilitation can include both reclamation and restoration of land. Reclamation is the practice of converting degraded land to economic use. Restoration is the practice of re-establishing the original soil/plant ecosystem, and establishment of locally indigenous species. Both practices occur south of the study area where salt is surface mined (scraped), reclaimed from saline swamps at particular times, and naturally occurring wetlands and bushlands are encouraged to regenerate or are assisted by revegetation practices. The Monarto woodland is also an example of rehabilitated land that was converted from its partly cleared state to one of economic use, with a predominance of naturally occurring local species planted.

The modification of management practices may result in rehabilitation. This occurs in many Crown land areas and national parks where grazing in the past has been permitted, and ceases. Regeneration then occurs through altered patterns of management. In some areas of the Monarto Woodland, stock were allowed to graze, and much damage was caused. A management practice implemented by the Government at the time of land sale, was the introduction of Aesthetic Heritage Agreements which precluded stock from grazing.

Other management practices include revegetation of degraded lands with locally indigenous species. The most suitable species to a particular site are generally those that were indigenous to the site, unless the area is now so saline or waterlogged that other native species must be used. An understorey must be created in an initial attempt to re-establish the original native vegetation, then the tree cover. This was one of the major failings of the Monarto Woodland site, as the understorey was to be created later. Only a few species of saltbush are today found in the understorey of the Woodland.

In agricultural areas the reclamation of land with non-provenance species for specific purposes may still be considered a satisfactory approach. An example of this would be the use of Phalaris, canary grass as a deep rooted pasture to lower water tables, or the planting of Tagasaste to increase nitrogen levels in the soils. In these instances provenance vegetation restoration should be incorporated for ecological sustainability. Economic gains can be had by the inclusion of native vegetation for the purposes of shelter for stock and crops, windbreaks, natural predators of pests, and enhanced environmental and aesthetic values.

The principles of land rehabilitation practice include:
* Maximising plant growth
* Minimising soil disturbance
* Optimising water use by plants
* Regulating grazing pressures.

SUSTAINABLE MANAGEMENT

A realistic goal for landowners must surely be to prevent further land degradation, and move towards a more sustainable management system which uses each hectare of land within its capability.

25% of all farmers plant trees, mainly for agricultural protection and production; such as for windbreaks, shade and shelter. Salinity control and soil conservation are other common reasons for tree planting.

Farmers with cropping/ grazing properties have in recent years become concerned with the amount of topsoil being lost through windstorms, and the increasing loss of income from saline soils. It is evident that national parks and the Monarto woodland do not suffer as much damage from soil erosion, and may in effect act as a buffer zone for neighbouring farming paddocks.

1.Management of native vegetation
* Management of remnant vegetation
* Benefits of property management-social, recreational, aesthetic or economic
* Regeneration of native bushland- problems caused by weeds and feral animals
* Role of wildlife corridors in regional situations, especially which species use them.

2. Establishment
* Low cost methods of establishing vegetation as alternatives to tubestock propogation and refining of direct seeding methods
* Research into survivability of seedlings
* Vegetation for soil and landform anomalies which make establishment difficult eg. dune-swale mallee

3.Inventory and mapping
* Mapping area of remnant vegetation for strategic planning for its conservation
- what remnant vegetation exists where?
- what type?
- remaining areas of remnant vegetation?
- broad scale inventories of biodiversity
* How effective are tree planting and protection programs at maintenance of biodiversity.

4.Economics
* Could the retention of remnant bushland on a property improve resale property values?
* Could a more environmental approach to management of farms and remnant vegetation lead to alternative sources of income?
* The values or remnant vegetation may encourage its retention need to be quantified - eg.shelterbelt, habitat for wildlife, pest control.

5.Species selection
* Local species
* Can native species be used as a source of income eg timber, honey production and other uses?

6.Multipurpose planting
* Farm woodlots
* Multidisciplinary studies to establish principles of landscape plantings to maximise potential for lowering water tables, reducing wind speed, providing viable wildlife corridors etc.
* Incorporating aims of conserving biodiversity in whole farm plans eg. windbreaks with local species to encourage local fauna.

7.Soil
* Are there any alternative crops, shrubs or trees that could be planted to improve the long-term conditions of the soil, while also providing wildlife habitat?
* Soil fauna

8.Extension
* How best might research findings be transferred quickly and efficiently to revegetation practitioners?

9.Salinity/hydrology
* What are the effects of planting density on hydrological balance?

10.Insects
* Is it feasible that attracting native wildlife could result in greater natural insect control for crops and pasture, reducing pesticide needs?

LANDSCAPE ASSESSMENT: The history of, and reasons why.

Landscape 'refers to the visual resources of the physical environment.'(Lothian,1984:1) Because landscape equates in part to the physical and natural resources and therefore to environment, it must be represented in any assessment of environmental management, and included in any efforts of protection or conservation. This quality is often referred to as amenity value.

In Australia, the National Estates Committee recommended in 1974 that the Australian Government ensure adequate funding for:

> the acquisition of scenic easements, covenants, etc. to conserve the scenic or environmental quality of important areas which it is not possible or appropriate to take into public ownership.

Several studies and landscape evaluations resulted from this move, and were of importance to South Australia. In early 1976 Kane reviewed methods of evaluation and developed four methods of assessment for the National Trust. These were based on emotional responses, an objective appraisal, and an equation which objectively appraised landscape components. Following on from this initial work, McBriar (1977) assessed four regions of the State using Kane's methods. Later Dallwitz evaluated the Flinders Ranges with a more subjective assessment, which classified landscape elements such as landform, pictorial composition and transitory elements.

In 1978 Dare adapted Kane's methods to a study of the Fleurieu Peninsula. He divided the region into nine landscape tracts with similar vegetation and landform and then evaluated the landscape, finally producing a map of landscape quality. Revell later continued this work in 1981, and came close to completing a landscape quality map. Heyligers (CSIRO) took up the preliminary works of Litton (1974) and Appleton (1975) and conducted his own landscape studies of the South East-Encounter Bay coastline in 1978. His study was more comprehensive providing descriptions of coastal physiography, geology, landforms and vegetation.

During 1979 Sanderson undertook landscape assessment of the Adelaide Hills, on behalf of the Departments for Environment and Urban and Regional Affairs. This assessment resulted in significant development planning principles and policies for landscape management. In particular the physical character of the landscape was related to sensitivity to visual change of development.

The results of these studies points to the need to take positive action to enhance the visual quality of the South Australian landscape, regardless of location. The responsibility lies not only with the tiers of Government but also with landowners, farmers, urban planners and developers.

Communities should be encouraged to take action over their local area, or their region to ensure appropriate aesthetic visually pleasing landscape. Sensitivity to landscape quality, regeneration of native species in agricultural areas, and forestry management through plantations are all creditable ways of presenting an aesthetic landscape. A unique example to my study is that of the Monarto Woodland, where a Native Plantation was set up. This conserves local native vegetation within an extended woodland setting with other introduced native species, which were specifically selected for their tolerance of the particular conditions of the area. The Monarto Plantation adjoins the South Eastern Freeway, the Old Princes Highway and the Adelaide to Melbourne railway line.

However, these amenity tree plantings of the Monarto Commission have more than just visual appeal, for they are functional. Initially planned as a buffer zone to urban development, they were to divide and separate the residential areas from the industrial areas. They were to be part of a parkland setting which was strategically placed around the perimeter of the planned satellite city area, and across ridge lines. Of particular value they would have reduced noise levels and air pollution from the carriageways and proposed transport terminal, as well as screening unsightly developments. Even though the city never went ahead as planned, the woodland today does reduce the noise levels of the traffic along the South Eastern Freeway and other carriageways. The woodland would have additionally reduced the severity of climatic conditions such as fogs, frosts, and winds. Most importantly the trees were functional in that they addressed the issue of soil stabilisation because the tree roots held fragile soils down and reduced soil erosion.

To the objective observer the view was one which was aesthetically pleasing, it was peaceful, the blossoms encouraged the birdlife and other fauna, and the trees gave the whole area a green garden city value. Today the city may not exist as planned, but the area is enriched by these native plantations, the interesting birdlife, and the pleasant roadside scenery.

In conclusion, the quality of landscape is often referred to as its amenity value. As described that value is worthy of protection and management. The most effective means of enhancing landscape and effective management is through planning initiatives and development control. Landscape assessment and quality is vital to any environmental management decision. As Kane (1976) stated:

> perhaps... not as obvious a natural resource as forest, water supplies, ores, soils and fossil fuels, but they may in the long run be one of the most vital resources in helping to maintain stable and healthy societies.

ENVIRONMENTAL MANAGEMENT RECOMMENDATIONS

Installations

The following installations shuld be provided:

1) A permanent station capable of continuous monitoring of meteorological data and measurement of pollutant levels at Monarto South township, Loomooloo and Mulgundawa.
2) Pluviographs and rain gauges in all areas.
3) A system of piezometers to assess changes in groundwater levels, at various locations in the Hundreds of Freeling, Monarto, Brinkley and Mobilong north of the Langhorne Creek to Wellington Road, and north of Chauncey's Line.

Management

The following actions should be taken:

1) Preserve areas of special geological interest.
2) Direct seeding and tree-planting to eroded areas.
3) Prevent cropping in areas of active erosion.
4) Give priority to retaining stands of existing native vegetation including those along roadsides.
5) Preserve all existing trees, mallees and shrubs under threat.
6) Fence significant areas of native vegetation and protect with buffer zones and firebreaks. Prevent grazing and confine traffic to designated routes.
7) Design broadacre land management to reduce weed growth and invasion, fire hazard and erosion, and encourage regeneration in areas of natural scrub, and promote active revegetation in other areas currently suffering decline, senescence or stress.
8) Give priority to eradication of particular weeds such as Bridal Creeper, caltrop and horehound.
9) Undertake propogation of rare or endangered plant species.
10) Control rabbits by ripping and fumigation of warrens.
11) Restrict use of chemicals particularly 1080 near water catchment areas.
12) Reduce feral pests

APPENDIX

ACTS RELATING TO LAND MANAGEMENT

A brief summary of a number of Acts and how they impinge on land management issues is presented below. These Acts are summarised, identifying the roles of many different organisations and the aims of various legislation as it can impact on land management.

The Acts described often cover overlapping areas, with the result that there are tiers of responsibility within the bureaucracy; this can sometimes result in confusion and conflict for land managers.

The Soil Conservation and Land Care Act 1989

This Act states that land is to be used according to its capability. It includes a concern for the implications arising when land is **not** used according to its capability. It places a duty on the landholder to take all reasonable steps to prevent degradation of the land. It establishes soil conservation districts and Boards responsible for each district. Each Board has to develop a district plan, identifying the extent of degradation, the measures for rehabilitation and best land management practices. From the Boards' perspective land degradation includes soil, water and vegetation issues. It can require a landholder to comply with a soil conservation order, although a right of appeal exists. Within the Act, landholders are to be encouraged to prepare a property plan detailing the proposed management of land, having regard to its capability, use, degradation, preventative measures and rehabilitation.

The Development Act 1993

The Development Act states in part 'that community objectives for the form and character of the area (as stated in the planning strategy or local area plan) are respected'. Under the Act each District Council can amend the Development Plan to reflect local character and planning objectives providing the amendments are compatible with the Planning Strategy and the overall objectives as stated in the Development Plan. Land can be managed to prevent land degradation but the property may not conform in appearance to the character of the area. The purpose is to ensure complying use, to encourage community harmony and to maintain property values. A rural landholder, like any other owner of land, must apply to the District Council or to the South Australian Planning Commission for permission to erect a building, to divide land or to change the use of the land. under this Act

The Water Resources Act 1990

This Act provides for the assessment, conservation and development of the water resources of South Australia. It relates in particular to watercourses. It also provides for proclaimed watercourses. The Water Resources Branch of the Department of Environment and Natural Resources can advise if a particular watercourse is such a watercourse. Among other rivers, the Murray is a proclaimed watercourse. Section 26 of the Act provides that it is an offence to divert or take water from a proclaimed watercourse; however, an owner of any land upon or adjacent to a proclaimed watercourse has the right to divert to take, without charge, water from that watercourse for domestic purposes and for providing drinking water for grazing stock on that land. A person may apply for a licence to divert or take water from a proclaimed watercourse from the Water Resources Branch of the Department of Environment and Natural Resources. It is an offence under the water resources protection provisions of the Act to do the following without a licence from the Minister:

(a) Dispose of or permit the escape of any material directly into surface or underground water.

(b) Dispose of, or permit the escape of material onto land, or from land, if any of the material subsequently enters and degrades surface or underground water.

(c) Store, or dispose of or permit the storage of disposal of material at 2.5 metres or greater depth below ground level.

There are exemptions from the need to obtain a licence, including the storage of water in a dam or underground tank. Other exemptions, for example, in relation to piggery and dairy waste, will expire soon. Primary producers may carry out works involving lakes and watercourses necessary in the normal course of primary production, provided nothing is done which restricts or accelerates the flow of water, or alters the course of a watercourse.

The Native Vegetation Act 1991

The Native Vegetation Act regulates the clearance of native vegetation and makes it an offence to clear native vegetation contrary to the Act. It is necessary to make application to the Native Vegetation Council for approval to clear any native vegetation. The Council is unlikely to grant consent for broadacre clearance of native vegetation. It should be noted that clearance of vegetation means:

> 'The killing or destruction; the removal; the severing of branches, limbs, stems or trunks; the burning of native vegetation or any other substantial damage to it.'

Certain exemptions to this Act apply for certain types of clearance; the Native Vegetation Branch can be contacted.

The Animal and Plant Control (Agricultural Protection and Other Purposes) Act 1986

This Act imposes a duty on landholders to destroy or control pest plants and animals as scheduled. Golden dodder, poison ivy, perennial thistle and rhus are examples of plants that must be destroyed. Pest animals include goats, rabbits and dingos. Under the Act, local Animal and Plant Control Boards are established, usually being responsible for the local council area. Each Board is empowered to enforce the provisions of the Act within its area.

The Country Fires Act 1989

Under this Act a landholder must take reasonable steps to protect property on the land from fire, and prevent or inhibit the outbreak or spread of fire on the land. The local council may give notice to a landholder requiring specified action to be taken to remedy a potential hazard. Failure to comply is an offence and the council may carry out the work and recover the cost from the landholder. There are limitations on using certain vehicles and appliances in the open during the fire danger season.

The Agricultural Chemicals Act 1955

Agricultural chemicals are governed by this Act under which it is an offence to offer agricultural chemicals for sale unless they have a registered label attached to them and meet governmental standards laid down with regard to the chemical in question. Under the Act a landholder is required to use the chemical only for the purpose stated on the label.

The Environment Protection Act 1993

The aim of the Environment Protection Act is to bring together the following essential goals within a strategic framework, incorporating principles of ecologically sustainable development. It aims to:

- protect air quality from motor vehicle, factory and other emissions;
- protect water quality from discharges affecting rivers, catchments, marine and groundwaters;
- guard against land contamination from landfills, industrial sites and other activities;
- protect the community from excessive noise;
- conserve natural resources by minimising industrial and domestic waste, encouragement of recycling and the wise use of resources.

The legislation governing environment protection has become streamlined, where the effects on land, air and water are considered simultaneously. This approach will greatly reduce the need for business to chase permits and allow for a focus on effective environmental outcomes, enhancing communication between government and licensees.

The Mining Act 1971

The Mining Act provides that the property in all minerals is vested in the Crown, and 'minerals' are given a very wide definition in the Act to include any naturally occurring deposit of metal or precious stones or any other mineral (sand, gravel, shale, clay etc) and any other tailings or other materials from mining operations. A Miners Right is required to prospect for minerals (other than precious stones) and to peg out a mineral claim which can lead to the grant of a mining lease enabling mining operations to occur. A Miners Right is required for landholders as well as for mining operators, as landholders do not own the minerals in the land. A mining operator must notify the landholder of the intention to enter the land and to carry out mining operations. Fossickers are not prospectors and need a landholder's permission to enter the property. Quarrying, that is, the removal of sand, gravel, loam, metal and clay - extractive minerals - does not require the landholder to obtain a lease to recover extractive minerals from his own land for personal use. Landholders wanting to quarry their own land for commercial purposes must apply for development approval.

The Waste Management Act 1987:
Through the Waste Management Commission the Government has established a coordinated approach to waste disposal and minimisation, closely linked with strategies for the development of re-cycling initiatives.

The Pastoral Land Management and Conservation Act 1989:
Sustainable management of our arid lands is being pursued, through a comprehensive program of rangeland assessment and monitoring by the Pastoral Board.

The Marine Environment Protection Act 1990:
The Marine Environment Protection Committee has developed a licensing program to guarantee environmental improvement programs for industries discharging into the ocean.

The Soil Conservation and Landcare Act 1990:
Integrated soil conservation and landcare programs have facilitated a massive increase in community involvement in land conservation.

The Native Vegetation Act 1991:
Australia's most successful native vegetation retention program encompasses hundreds of heritage agreements and stringent protection measures for remaining native vegetation.

The Wilderness Act 1992:
Pioneering legislation to protect the special wilderness qualities of pristine areas now being implemented through the establishment of wilderness protection zones and areas.

The Heritage Act 1993:
Revised legislation to protect our built historic heritage ensures a cooperative, consultative system of heritage protection.

NATIONAL WEEDS STRATEGY

Mission Statement

The purpose of the National Weeds Strategy is to reduce the detrimental impact of weeds on the sustainability of Australia's productive capacity and natural ecosystems.

Principles

The National Weeds Strategy is based on the recognition and acceptance of four principles:

1. Weed management is an essential and integral part of the sustainable management of natural resources and the environment, and requires and integrated, multidisciplinary approach.

2. Prevention and early intervention are the most cost-effective techniques that can be deployed against weeds.

3. Successful weed management requires a co-ordinated approach which involves all levels of government in establishing appropriate legislative, educational and co-ordination frameworks in partnership with industry, landholders and the community.

4. The primary responsibility for weed management rests with landholders/land managers and collective action is necessary where the problem transcends the capacity of the individual landholder/land manager to address it adequately.

Goals and Objectives

Goal 1. To prevent the development of new weeds problems

1.1 To prevent the introduction of new plant species with weed potential.
1.2 To ensure early detection of new plant species with weed potential.
1.3 To reduce weed spread to new areas within Australia.

Goal 2. To reduce the impact of existing weed problems of national significance

2.1 To facilitate the identification and assessment of weed problems of national significance
2.2 To deal with established weed problems of national significance through integrated and cost-effective weed management

Goal 3. To provide cost-efficient and effective means for harnessing national action on weed management.

3.1 To strengthen the national research, education and training capacity to ensure ongoing cost-effective, efficient and sustainable weed management.
3.2 To encourage the development of strategic plans for weed management at all levels, with input from all stakeholders.
3.3 To establish institutional arrangements to ensure ongoing, co-ordinated management of weed problems of national significance.

Vision and Objectives of a Weed Management Strategy For South Australia

Vision

For the South Australian Government to have a co-ordinated approach to efficiently reduce the biological, social and economic impact of weeds.

Objectives

To determine the need for government involvement in weed management in South Australia and develop a strategy to integrate government resources for efficient weed management.

This objective should be achieved, by consultation with clients and partners to :-

- assess the major weed issues affecting South Australia
- identify Government responsibilities (including roles and functions which should not be a government responsibility)
- identify responsible lead agencies
- encourage inter-agency discussion groups and projects
- provide a concerted government position on weed management to access funds that may become available through the National Weeds Strategy
- provide a sound basis to attract funds for weed management, research or extension projects for SA

Appendix 2
Conservation and Reservation of Mallee Ecosystems - Detailed Recommendations to CONCOM

I. Resource Inventory

Australia's mallee systems, with their unique geological and geomorphological features, biotic communities and cultural heritage values are of national and international significance.

Effective conservation of the full range of mallee systems and features necessitates:

* clear definition of the systems
* knowledge of the components, communities and species present, as well as their requirements
* reservation of fully representative, large and viable areas
* maintenance of the reserves, together with other areas not reserved and linking corridors between these in their natural condition.

Recommendations

a) Survey and Research

* That more comprehensive and systematic surveys of mallee systems, communities and their species be conducted to provide an improved basis for the setting of conservation and land management priorities.
* That CONCOM encourages further development and maintenance of common approaches to mallee resource surveys between States. Consistency of conservation objectives is desirable for the effective setting of conservation and management priorities, since mallee communities are not constrained by State borders.
* To achieve the above objective it is further recommended that standardised lists of rare and endangered mallee communities, and species, be adopted.

b) Reserve Selection and Reservation

* That the criteria for the selection of representative and viable mallee reserves be developed.
* That a national register of mallee ecosystems, classifying their current conservation status be established.
* That a computerised data base for reserved and non-reserved lands be developed to facilitate reserve selection.
* That size, location and linking of reserves be planned to cater adequately for faunal requirements, where faunal distribution does not correspond strictly to reserved vegetation communities.
* That on the basis of the above, a comprehensive and viable reserve system, including wilderness, be established as a matter of urgency.

c) Management

* That a data base be compiled to establish conservation and management requirements of species and communities, particularly for those that are endangered.
* That management regimes enabling conservation be devised for non-reserved areas of public and private land, with special emphasis for corridors linking conservation areas.
* That planning controls, financial incentives and direct assistance to private land managers be provided to conserve natural areas on private land.
* That joint State management agreements for all mallee reserves with common State boundaries be established.

II. Wilderness Conservation

Areas of high wilderness quality (i.e. extensive, substantially unmodified tracts with high aesthetic and biophysical naturalness, remote from settlement and access) are scarce and prone to human modification or exploitation.

Mallee lands contain some of the largest remaining areas of highest wilderness quality in southern Australia.

Unless urgent action is taken on a national basis to maintain, and where possible enhance, wilderness quality, the remaining areas of wilderness will be depleted and the opportunity to develop viable wilderness reserves will be lost.

Recommendations

* That CONCOM facilitates the development of a national code for the protection and management of wilderness in the mallee, through consultation involving State and Commonwealth authorities and non-government organisations.
* That a national workshop be initiated to formulate such a code, building upon the code presented to the Mallee Conference by the Wilderness Society and the guidelines for reservation and management of wilderness developed by the CONCOM Working Group on Management of National Parks.
* That the code developed be applied to:
  - survey and identify the wilderness quality of mallee in all States
  - declare the areas of high quality as Wilderness parks or reserves
  - manage these areas to protect them from external and deleterious influences, in particular the use of fire and provision of access. This will require setting limits of acceptable change and minimal impact codes for recreation.

III. Land Degradation, Salinity and Erosion

Closer settlement and the associated extensive clearance of vegetation has led to major land degradation problems in the mallee.

Soil erosion has been of major concern particularly during droughts. However, more effective farming practices such as minimum tillage, stubble retention and the establishment of deep-rooted perennial pastures, provide scope for maintaining adequate soil surface cover and greater stability.

Another serious problem is the growth of dryland salinity and increasing stream salinity, resulting from a steady rise in groundwater tables following clearance of the vegetation. Although only discrete areas have so far been seriously affected in the mallee, extensive areas are threatened because of the time lag involved in achieving any improvements in watertable levels.

Consequently, improved farming practice and restoration of vegetation have to be undertaken quickly before watertables reach the surface over wide areas of the mallee. Such measures should take into account nature conservation requirements, particularly the re-establishment of locally-adapted native plants and the restoration of habitats and linking corridors for maintenance of viable faunal populations.

Recommendations

* That CONCOM in association with other appropriate Ministerial Councils ensures no further land clearance is undertaken in mallee lands.
* That CONCOM promote the development of a protocol for the design and implementation of large-scale native vegetation restoration measures in mallee. Bodies representing other important national interests, particularly Ministerial Councils such as the Agriculture, Forestry, and Soil Conservation Councils, together with the Murray Darling Ministerial Council, should be fully involved

IV. Fire Managment and Research

Fire is a predominant disturbance in most mallee landscapes and one of the most important processes influencing mallee communities. The occurrences and extent of fires are irregular in time and space. Sources of fire are also varied, such as lightning or ignitions (for a variety of reasons) by humans. Managers of mallee reserves have the dual responsibility to provide for the protection of lives and property and to conserve native species and communities. To fulfil these responsibilities managers need to be able to predict the risk and the likely consequences of a fire in mallee at a given time and place. Such predictions have as their basis, a comprehensive understanding of:

i) fuel and fire behaviour characteristics in mallee;
ii) species and community responses to a wide range of fire regimes.

While an enormous amount of work needs to be done on these topics, some evidence from existing research in both mallee and other similar ecosystems indicates that frequent fires may be deleterious to the long-term conservation of plants and animals. Many large mallee reserves have been extensively burnt in recent time and in some instances there are few remaining examples of long unburnt mallee. Action is therefire needed to prevent fires of excessive frequency from burning extensive areas of mallee.

Some large mallee areas are contiguous across State boundaries, but there is evidence that fire-management practices may differ substantially between adjacent reserves in different States. As fires do not observe State boundaries, there is a need in such inter-State reserve systems to co-ordinate all aspects of fire management in mallee.

Recommendations

That CONCOM promotes and endorses the following:

1. Management
   * Deliberate burning for fuel reduction should not be carried out on a broadscale in conservation areas.
   * Deliberate burning for ecological purposes should only be carried out if there is a thorough and extensive understanding of its long-term consequences.
   * Fire protection measures such as watering points, breaks, tracks and burning for fuel reduction should be concentrated on the boundaries of reserves.
   * The suppression of wildfires in large mallee reserves should not be initiated without consideration of both nature conservation and protection priorities. If it is anticipated that a particular fire will pose little risk to life and property or nature conservation values, the option of letting the fire burn should be favoured.
   * The preparation of management plans for mallee areas should specify explicit objectives for the use and control of fire in relation to natre conservation as well as the protection of lives and property.
2. Research
   * Research into the nature of fuel characteristics and their dynamics. Such research should account for differences stemming from the diverse structure of different types of mallee communities.
   * Research into the description and prediction of fire behavious in mallee. Such reseatch should test the adequacy of existing fire-behaviour models and investigate the need for the development of new, predictive models to suit the charactistics of mallee fuels.
   * Research into the dynamics of mallee flora and fauna (vertebrate and invertebrate) in relation to fire. Emphasis should be placed on understanding the effects of excluding fire, short-rotation burning and fire-suppression techniques such as fire retardant chemicals and earth moving equipment. The development of predictive models of species and community dynamics should be a priority. Models of this kind must be used to define those fire regimes which are compatible with nature conservation.
   * Development and integration of models of fuel, fire and biological dynamics that provide predictions which are accessible to and useable by managers to meet specific protection and nature conservation goals. These models must be amenable to scientific testing.
   * Development of techniques to monitor changes in biological populations and communities and of fuel changes. Such information is vital to enable managers to know the state of natural resources and to test the accuracy of predictive models.
3. Research and Management
   * Inter-State communication on all aspects of fire research and management. Priority should be given to the establishment of a consultative process between managers of neighbouring, inter-State reserves. A further priority should be the organisation of workshops on specific aspects of fire research and management.

V. Management of Animal Pests

There is widespread recognition that both introduced and in some situations, native species of animals are pests within the context of nature conservation. Pest animals of this kind can be categorized as follows:

i) Grazers and Browsers, whose feeding activity is deleterious to the long-term survival and reproduction of plants of the mallee. Lack of recruitment in populations of native plants may be due to grazing by exotic species such as the rabbit and goat, and native species such as the kangaroo.

ii) Feral Predators, which have a deleterious impact on native species. For example the decline and extinction of native mammals and the Malleefowl may be in part or directly due to predation by the fox.

In many cases though, the status of both native and exotic animal species as pests and their impact in terms of conservation are unknown. The effective control of pests in either category may be costly and difficult because of the potential for complex interactions between predators and prey. For example, the staple diet of foxes in mallee lands is rabbits and mice. High numbers of such prey promote an increase in fox numbers. Rare wildlife are substituted as prey, most acutely when high rabbit and mice populations collapse. Conservation of rare mallee fauna cannot be achieved without addressing the issue of introduced predators and rabbits together. Improved, longer-lasting control measures for these introduced pests must be found.

iii) Feral Bees, there is growing evidence that feral honeybees are incompatible with nature conservation and recreation activities, however little is known of the scale of the problem and possible control measures.

Recommendations

That CONCOM promote:

* Research on the effects on native plant species

in the mallee. Such research must identify the circumstances in which grazing may threaten plants, such as herbivore density and relationships with rainfall.

* Research to identify the relative effects on plants of native and exotic herbivore species.
* Complementary control of introduced predators and their main prey, rabbits and mice, and the integration of these measures with management of endangered wildlife in mallee lands.
* Integrated studies of predator/prey systems with a view to improving conventional control measures for introduced predators and prey in the short-term.
* The search for, and testing of, biological controls as a matter of urgency.
* Research on the extent and effects of feral honeybees on native flora and fauna and possible methods of control.

VI. Management of Plant Pests

Exotic plants are pests if they threaten the biological integrity of mallee communities, for instance an exotic which aggressively excludes species of native plants or which adversely affects native animals.

When left undisturbed, mallee communities appear to be resistant to invasion by pest plants. However, significant disturbance by humans and herbivores, particularly introduced stock or feral animals such as goats, promotes the entry of weeds. Much of the exotic flora is the result of past and present agricultural and pastoral activity plus associated disturbances such as roading. There are substantial infestations of pest plants within conservation reserves because many areas now reserved or targeted for reservation in the mallee were used initially for primary production. These infestations need to be monitored to determine whether expansion or contraction is occurring.

Priorities and methods for control may need to be different on lands reserved for conservation, as opposed to land used for primary production.

Recommendations

That CONCOM promote:

* Appropriate planning to ensure that physical disturbances in natural and semi-natural areas are minimised.
* Development and adoption of techniques of active rehabilitation of native plants and control of exotic pests where disturbance is unavoidable.
* Development of a survey and monitoring program to clarify the status of exotic infestations within reserves and other natural areas.
* Development of appropriate biological controls to meet nature conservation objectives.

VII. Vistor Management

Recreational use and appreciation of the mallee, compatible with its conservation, is commonly a key objective of public land management.

Visitor use is increasing and the activities of visitors and the levels of use require control to minimise adverse impact on environmental values. Specific limits of acceptable visitor impact in the various environments need to be set and management undertaken accordingly.

Tourism, if well managed, potentially provides an economic basis for increased management to maintain natural values and for the development of appropriate facilities.

A key aspect of meeting public expectations and facilitating increased environmental care by visitors is a comprehensive education and interpretation program.

Recommendations

* That CONCOM initiates the development between States of joint standards, relating to different environments or zones, for tourism and recreation developments which are sensitive to conservation values and maintain environmental quality.
* That States work together to develop a code of recreation practice and care for the mallee environment, and associated information and interpretation programs.

VIII. Commercial uses of Mallee Resources

Activities involving the exploitation of resources such as stock grazing, broombush harvesting, bee keeping and mineral and oil exploration and extraction cause major disturbance and long term changes to mallee ecosystems. These lead to loss of plant and animal species, altered species composition, invasion by pest plants and animals, reduced wilderness quality and altered landscapes.

Such activities are commonly incompatible with nature conservation and the maintenance of areas in their natural state.

Comprehensive and uniform environmental standards are required, that limit exploitation activities and define constraints necessary to achieve the objectives for land category or reserve type.

Recommendations

* That CONCOM initiates the development of comprehensive environmental standards to apply to all States for mineral and oil exploration and extraction. Similar standards are also required for the rehabilitation of areas utilised, particularly those with potential wilderness values.
* That CONCOM initiaties a comprehensive review of the impact of grazing by domestic stock on nature conservation values in order to help define areas appropriate to be grazed and stocking levels which conserve soil and vegetation. No commercial grazing should be permitted in areas reserved or important for nature conservation or wilderness.
* That CONCOM instigates a comprehensive research program to study the effect of honeybees on native flora and fauna.
* That broombush harvesting should not be permitted to continue on mallee lands of high conservation value or wilderness quality, and that administrative practices between States be standardised in order to phase out inappropriate harvesting and stop illegal broombush harvesting.

GLOSSARY

Aggregate -	A cluster of soil particles, held together by inter-particle forces or bonds.
Agroforesty -	The integration of commercial tree growing into the operation of a farming enterprise.
Alkaline -	A pH of greater than 7.0 in water.
Amendment -	The alteration of the properties of a soil by the addition of substances such as lime, gypsum and sawdust, for the purpose of making the soil more suitable for plant growth.
Aquifer -	A porous soil or geological formation, often lying between impermeable sub-surface strata, which holds water and through which water can percolate slowly over long distances and which yields groundwater to springs and wells.
Arable -	Describes land suitable for the economic production of crops, usually involving regular cultivation.
Batter -	The excavated or constructed face of a dam wall, embankment or cutting, produced as a result of earthmoving operations involving cutting and filling.
Buffer capacity -	The ability of a soil to resist changes in pH.
Buffer zone -	Any area of land used or designed to isolate one area of land from another so that adverse effects arising from one area do not affect the other.
Calcareous -	Soil containing sufficient calcium and/or magnesium carbonate to 'fizz' (effervesce) visibly when treated with dilute hydrochloric acid.
Catchment -	That area determined by topographic features within which rainfall will contribute to runoff at a particular point under consideration.
Cation exchange capacity -	Measure of the number of sites on the clay in the soil available for exchanging positive atoms (cations).
Clay -	Soil particles of less than .002 mm in diameter; descriptive term of a soil containing predominantly clay sized particles.
Colluvial -	Material transported largely by gravity, that is, downslope.
Conglomerate -	Coarse grained sedimentary rock composed of gravel sized particles cemented together by different natural materials.
Conservation -	The management of human use of the biosphere so that it may yield the greatest sustainable benefit to present generations while maintaining its potential to meet the needs and aspirations of future generations. Thus conservation is positive, embracing preservation, maintenance, sustainable utilisation, restoration, and enhancement of the natural environment.

Contour Bank - Ridge or bank of earth constructed across a slope to collect and direct water flow; usually constructed with small longitudinal gradient, for example, 0.5% slope.

Cover crop - A temporary vegetable cover which is grown to provide protection for the soil and the establishment of plants, particularly those which are slow to establish.

Crest - Top or rise of a hill.

Degradation - Decline in the quality of natural resources commonly caused by human activities.

Diversion bank - A bank specifically designed to divert water, normally to protect a cultivated area, a gully, eroded area, work or facility below, or to carry runoff to or from a dam or waterway away from the natural drainage line.

Drainage - The interception and removal of excess surface and/or sub-surface water from land, using artificial or natural means.

Erosion - Physical breaking down or wearing away of the land surface by rain, running water or wind.

Estuarine - In an estuary ('lake' where a river meets the sea).

Fallow - Period during which land is devoid of vegetation; in agriculture this is achieved by repeated tillage operations or knockdown herbicide applications.

Fertiliser - Any substance, natural or manufactured, added to the soil to supply essential plant nutrients for plant growth, and thereby either maintain or increase the general level of crop yield and pasture productivity.

Grade furrow - A narrow longitudinal channel or trench made by a plough or grader.

Granite - Igneous rock composed of feldspar, quartz and mica.

Gully head - The upstream end of a gully where runoff from the catchment above falls to the gully floor.

Gullying - A complex of processes whereby the removal of soil is characterised by large incised channels in the landscape.

Gypsum - Material containing predominantly calcium sulphate.

Hard setting - A characteristic of some soils to become hard when dry, but may soften upon wetting.

Harrow - Light tillage implement with tynes or fingers designed to operate at shallow depth, for example, 1 - 5 cm.

Herbicide - Chemical that weakens growth of, or kills plants.

Isohyets - Points on a map showing areas which receive equal amounts of rainfall within a given period of time.

Kaolinite - Type of clay with low shrink-swell behaviour.

Land degradation - The decline in quality of natural land resources, commonly caused through improper use of the land by humans.

Landform - Any of the various features that comprise the surface character of land.

Landscape - Visually distinguishable set of natural features or characteristics of land.

Land system - An area of land, distinct from surrounding terrain, within which there are particular land characteristics or components that occur repeatedly in sequence.

Leaching - Movement or removal of a substance by water from or within a deposit or soil profile.

Lime - A naturally occurring calcareous material used to raise the pH of acid soils and/or supply nutrient calcium for plant growth.

Limestone - A sedimentary rock consisting predominantly of calcium carbonate.

Loam - A soil intermediate in texture between a sand and a clay, containing approximately equal proportions of sand, silt and clay sized particles.

Minimum tillage - A general term describing a conservation tillage system in which the crop is grown with the fewest possible tillage operations.

Mound - An artificial elevation of earth, proportionally similar in length and width, typically constructed as a temporary storage of soil materials or permanently constructed for landscaping purposes during the rehabilitation of disturbed terrain.

Mulch - A natural or artificial layer of plant residue or other material on the soil surface, which provides protection against erosion and aids plant establishment mainly by restricting moisture loss.

Native vegetation - Indigenous pasture, bushland and/or timber species adapted to the prevailing environmental conditions including climate, soils and natural grazing patterns.

Nutrient - Any element essential to the growth of plants or which can be beneficially utilised by them. Such nutrients are supplied from the soil or from application of fertiliser.

Overgrazing - Grazing of pasture which reduces surface vegetative cover to a level where the soil is vulnerable to erosion.

Perennial plant - A plant whose life cycle extends for more than two years and continues to live from year to year.

pH - A measure of soil acidity or alkalinity. pH 7 = neutral; less than 7 = acidic; greater than 7 = alkaline.

Piedmont - Gentle sloping landform at the foot of hill or range formed by erosion and deposition over time.

Proterozoic - Geological age of less than 1 million years.

Quartzite - Fine grained quartz mineral formed by metamorphic (heat and pressure) processes.

Recharge area - An area where water is absorbed to be added to a geologic zone of saturation or aquifer.

Rehabilitation - The treatment of degraded or disturbed land to achieve an agreed level of capability and stability, preferably at least equal to that which existed prior to degradation or disturbance.

Revegetation - The re-establishment of plants on an area of ground that is depleted or devoid of vegetation.

Rill - A small channel, cut by concentrated runoff, through which water flows during and immediately after rain.

Runoff - That portion of precipitation not immediately absorbed into or detained upon the soil and which thus becomes surface flow.

Saline soil - Soil containing sufficient soluble salt, usually predominantly sodium chloride, to impair normal plant growth.

Sand - Soil particles of 0.02 mm to 2 mm in diameter; (fine sand 0.02 - 0.2 mm, coarse sand 0.2 - 2 mm diameter); a soil containing predominantly sand-sized particles.

Savannah - Open, grassy woodlands.

Schist - Metamorphic (heat and pressure) rock containing visibly foliated (flakes) minerals such as mica, chlorite.

Sclerophyllous - Forest-based vegetation associations.

Sediment - Material deposited as a result of transportation by wind, water or gravitational processes or a combination of these.

Seepage - The process by which water percolates downwards and/or laterally through the soil, often emerging at ground level lower down a slope.

Senescence - Death of plant tissue at the end of the growing season.

Sheet erosion - The removal of a fairly uniform layer of soil from the land surface by raindrop splash and/or runoff.

Shelter belt - An area of living trees and/or shrubs established and maintained for the protection of grazing animals from adverse climatic conditions.

Silt - Soil particle of 0.002 mm to 0.02 mm diameter; deposited soil particles in creek, dam, etc.

Skeletal - A shallow soil with minimal development from parent material, such as at the crest of a rock outcrop.

Sodic soil - A soil containing sufficient exchangeable sodium to adversely affect soil stability, plant growth and/or land use.

Soil compaction -	The process whereby the density of soils is increased by tillage, stock trampling and/or vehicular traffic.
Soil conservation -	The prevention, mitigation or control of soil erosion and degradation through the application to land of cultural, vegetative, structural and land management measures, either singly or in combination, which enable stability and productivity to be maintained for future generations.
Soil degradation -	Decline in soil quality commonly caused through its improper use by humans.
Soil erodibility -	The susceptibility of a soil to the detachment and transportation of soil particles by erosive agents.
Soil fertility -	The capacity of the soil to provide adequate supplies of nutrients in proper balance for the growth of specified plants, when other growth factors, such as light, moisture and temperature are favourable.
Spillway -	An open or enclosed channel, or a combination of both, used to convey excess water from a dam or similar storage.
Stream bank -	A laterally extensive, moderately inclined to precipitous slope forming the margin of a stream channel and resulting from erosion or aggradation by channelled stream flow.
Structure, soil -	Combination or arrangement of primary particles and pores in a soil that affect its dynamic and hydraulic properties.
Stubble clearance -	Design of tillage and/or seeding machinery to perform adequately in the presence of specified amounts or lengths of stubble on the soil surface, and to cause minimal burial or incorporation of the stubble.
Tertiary plateau -	Characteristic flat topped hills formed over rocks of the Tertiary age.
Texture, soil -	The relative proportions of sand, silt and clay.
Tillage -	A field operation to loosen soil, for seedbed preparation, weed control or incorporation of stubbles.
Topography -	Relief and form of a land surface.
Topsoil -	That part of the soil profile containing material which is usually more fertile and better structured than underlying layers.
Toxicity -	The characteristic of a soil relating to its content of elements or minerals which adversely affects plant growth.
Tunnelling -	The removal of sub-surface soil by water while the surface soil remains relatively intact.
Watercourse -	Any river, stream, creek or channel in which water is contained or flows whether permanently, intermittently or occasionally.
Waterlogging -	The condition of a soil which is saturated with water and in which most or all of the soil air has been replaced by water.
Water repellence -	'Non wetting' property of a soil or material that slows or prevents entry of water (when initially dry).
Watershed -	The dividing ridge between two catchments.
Water table -	The upper surface of unconfined groundwater below which the pores of rock or soil are saturated.
Waterway -	A stable longitudinally-sloping water disposal area of sufficient capacity, used to discharge surplus runoff and to allow it to flow to a lower level without causing erosion.

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BOOK TWO REFERENCES

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